ARTERIAL OCCLUSION: A RADIOLOGICAL STUDY OF A SERIES OF PATIENTS WITH PERIPHERAL ARTERIAL DISEASE

- - - - - - - -

George F.A. Howie.

M.D.

University of Edinburgh

September 1968.

C O N T E N T S

SUMMARY

SUMMARY

1. An unselected series of 546 patients, on whom 946 arteriograms were performed is considered.

2. 1250 complete arterial occlusions were found. The incidence was 2.3 per patient, both in men and in women.

3. It is suggested that the sex distribution of peripheral vascular disease in a population is more accurately indicated by the findings in gangrene and pregangrene where there are 2.3 and 2 men, respectively to 1 woman, than by those in intermittent claudication where the sex ratio is 4.8 men to 1 woman.

4. Aortographic evidence is presented to suggest that aortic occlusion may originate directly in the aorta itself, in women, more commonly than previously believed.

5. On the symptomatic side occlusion in the femoro-popliteal segment alone occurs in only 43.5% of the occluded symptomatic limbs in men, and in only 34.6% of those in women.

Femoro-popliteal occlusion with leg artery occlusion occurs in 43.2% of the occluded symptomatic limbs in men, and in 40.7% of those in women.

Leg artery occlusion alone occurs in 13.3% of the occluded symptomatic limbs in men, and in 24.7% of those in women.

On the asymptomatic side femoro-popliteal artery occlusion alone occurs in 19.8% of the occluded limbs of men and in 9.7% in women. Femoro-popliteal occlusions with associated leg artery occlusion occurs in 20.7% of the occluded asymptomatic limbs in men, and in 25.8% of those in women. Leg artery occlusion alone occurs in 59.5% of the occluded asymptomatic limbs in men and in 64.5% of those in women.

6. The patterns of occlusion in the lower limbs are recorded. The commonest pattern is occlusion of the superficial femoral artery alone, in both women and men. Second most common is occlusion of the anterior tibial artery alone in men, and of the posterior tibial artery alone in women.

7. The occlusion patterns in men and women are considered in intermittent claudication, gangrene and pregangrene.

8. Patients with complete occlusion in the aorto-iliac group are younger than those with complete occlusion in the femoro-popliteal group.

9. The patients with complete occlusion in the femoro-popliteal group are older than those without complete occlusion. In the aorto-iliac group those with complete occlusion are younger than those without.

10. The incidence of leg artery occlusion is the same in the symptomatic and asymptomatic limbs in intermittent claudication.

    It is suggested that there is evidence that the first artery to show complete occlusion in the lower limb tends to be a leg artery.

11. The incidence of complete occlusion is higher in limbs in patients with unilateral symptoms, than in those with bilateral symptoms.

12. The peak incidence of occlusion in the femoro-popliteal segment in women is more proximal in the adductor canal than in men.

13. The femoro-popliteal occlusions in the limbs with leg artery occlusion are longer than in those without, and show a greater tendency to popliteal artery involvement.

14. The occlusions in the symptomatic and asymptomatic limbs are considered. They are, very broadly, similar in their histographic appearances.

- - - -

INTRODUCTION

INTRODUCTION

The Houston group of vascular surgeons, who have contributed so much to vascular surgery, have written extensively on many aspects of degenerative vascular disease. They have repeatedly commented on the localised nature of arterial occlusion. "It is now well established that the obstructing lesion in chronic arteriosclerotic occlusive disease of the lower extremity is frequently well localised and segmental with a relatively normal patent lumen above and below the occlusive process. This concept has been developing in recent years as a result of certain pathologic and arteriographic studies." (DeBakey, Crawford, Cooley and Morris, 1958). Again in 1961 "recently it has become generally realised that in many forms of this dease the atherosclerotic occlusive lesion is well localised and segmental in nature with relatively normal arteries proximal and distal to the diseased vessel". (Crawford, DeBakey, Cooley and Morris, 1961). Similarly in 1963, DeBakey commented "certain concepts have been developed concerning disease of the aorta and major arteries, providing the basis for rational and more effective therapy. Most important among these has been the emphasis placed on the anatomico-pathological characteristics of the lesion and its haemodynamic functional effects rather than upon the causation.

From studies along these lines, the concept has evolved that, regardless of aetiology the lesion in many forms of aortic and arterial disease may be well localised and segmental in nature with a relatively normal, patent proximal and distal arterial bed." In 1966 Crawford, Garrett, DeBakey and Howell noted that more than 90% of their patients with occlusive disease of the femoral artery and its branches had segmental lesions.

A similar description has come from other North American workers. Edwards (1957) said that it was "recognised that arteriosclerosis may be quite localised or segmental in parts of the arterial tree". A year later Kincaid and Davis (1958) wrote that "experience in angiography has shown that the obliterative process, in many cases may be short and limited to relatively short arterial segments". A similar view was expressed in 1959 by Szilagyi "peripheral occlusive arteriopathy has become a surgical disease only during the past decade. This change of status has come about through recognition mainly by the use of clinical angiography, of the essentially segmental character of the pathologic processes leading to stenosing and occlusive arterial lesions."

The clinical impression in this unit was that these descriptions did not apply to the angiographic appearances found in the patients here with peripheral vascular disease.

The arteriograms performed upon an unselected group of patients, with degenerative vascular disease, collected over a period of $5\frac{1}{2}$ years have therefore been examined to see if this clinical impression was correct. Patients with thromboangitis obliterans were excluded from the series, as were patients with arterial occlusion following trauma.

The patterns of occlusion in the symptomatic and asymptomatic limbs have been considered.

HISTORY

HISTORY

In January 1896, a few weeks after Roentgen's first communication on a "new kind of rays" to the Medical Physical Society in Wurzburg on the 28th December 1895, Haschek and Lindenthal published a report of their arteriographic study of an amputated hand injected with Teichman's mixture - a mixture of petroleum, lime and cinnabar. Some weeks later, on 22nd February 1896, the British Medical Journal reported that Addison in Sheffield was injecting cadaveric specimens with red lead, and radiographing them. Radiographs of an injected hand and of an injected kidney - the same radiograph as that used for the frontispiece of Sutton's "Arteriography" in 1962 - are reproduced in the journal. In November 1896, Destot and Berard published two short reports (a and b) of their study of the renal arterial tree examined by radiography after intra-arterial injection of an unspecified radio-opaque substance, using anatomical specimens. Dutto (1896 a and b) published two papers on cadaveric brachial artery injection with calcium sulphate suspension and subsequent radiography. Both his papers appear to refer to the same study.

Cadaveric studies, such as these early ones, undoubtedly became more frequent during the succeeding years in

Anatomy Departments, but there was no major publication in this field until 1919, when Orrin (1919) produced his paper on "the x-ray demonstration of the vascular system by injection", followed in 1920 by his book "An Atlas of Systemic Arteries of the Body". Each was based on a radiographic study of the arteries of a full term foetus and of an amputated adult hand, after injection into them of a radio-opaque substance. Orrin gave no details of his injection technique, nor of the injection material used, on the grounds that they were both still experimental.

It was not until 1923, just over a quarter of a century after the discovery of x-rays, that the first intra-arterial injection of radio-opaque material with radiography was reported in the living patient. Berberich and Hirsch (1923) using 20% strontium bromide as their contrast medium, obtained arteriograms and venograms in the upper limbs, and were the first to publish details of successful arteriography in man. Also in 1923, Sicard and Forrestier who had, for the preceeding eighteen months been exploring radiologically in patients, the subarachnoid space, the epidural space, the bronchial tree and abscess cavities with iodised oil ("lipiodol"), turned their attention to the blood vessels.

Initially they performed venography in dogs, watching the movement of the oil on a fluoroscopic screen. After carrying out at least one femoral arteriogram on a dog, they injected "lipiodol" intravenously in a man. They do not, in this paper, report any human arteriography but in their book on "The use of Lipiodol in Diagnosis and Treatment", published in English translation in 1932, they discuss the location of arterial obliteration in gangrene by the intra-arterial injection of 1 cc. of "lipiodol", after percutaneous puncture of the femoral artery in Scarpa's triangle.

Meanwhile, in 1924, Brooks reported three patients in whom lower limb arteriography had been carried out. One of these patients, a fifty year old diabetic man had gangrene ofthe right foot, and the other two - a sixty-two year old woman and a fifty-three year old diabetic man - both presented with lower limb ulceration. Brooks used as his contrast medium 10 cc. of a preparation of 100 gms. of sodium iodide in 100 cc. distilled water, and injected it through a needle introduced into the exposed femoral artery. Nitrous oxide anaesthesia was used during the period of injection because of the pain caused by the injection. Four arteriograms showing the vessels in the calf of the leg are reproduced. They are the first published arteriograms of the living lower limb. Brooks commented "an exact knowledge of the site and extent of occlusion of arteries of the extremity is of great value in the prognosis and treatment of disease of the extremities due to deficient arterial blood supply."

Later, Brooks and Jostes (1924) discussed temperature change as an index of arterial disease. Four of their eight patients were examined arteriographically. Case 1 and case 3 appear to be cases 2 and 3 respectively in Brook's original paper (1924) but it is clear that by 1924 Brooks had been involved in arteriographic studies of the lower limbs in not less than five patients.

In 1927 Moniz produced his early paper on carotid arteriography, and Carnett and Greenbaum (1927) reported their experience with femoral arteriography in ten male patients, using iodised oil injected into the exposed femoral artery.

Singleton (1928) reported five femoral arteriograms and one injection study of an axillary artery aneurysm. He followed Brooks using 100% sodium iodide. All of the punctures were made percutaneously. Three of the patients who had gangrene of the lower limbs showed a rapid extension of the lesion following arteriography, and of these patients, two died.

In 1929 dos Santos, Lamas and Caldas began to publish their work on the translumbar approach to the aorta, work which culminated in 1931 in the publication of their classic "Arteriographie des membres et de l'aorte abdominale" (Figure /). This was followed by papers in 1932 (dos Santos, Lamas and Caldas, 1932) (a and b) and by a further report in 1935, (dos Santos, 1935).

Charbonnel and Masse, (1932) reported three femoral arteriograms in three patients with gangrene of the toes using Sodium iodide the contrast medium. None of these patients deteriorated following arteriography in contrast with those reported by Singleton (1928). Duval (1931), discussing this report, reviewed the development of arteriography up to that time. He opposed the use of arterial compression above the puncture site in an attempt to improve arteriographic detail feeling that this method of slowing the rate of dissipation of the contrast was hazardous, in that endothelial damage might result from the transient stagnation of sodium iodide in an artery.

By this time, then, in 1929, it seems that arteriography was slowly being accepted as a practicable technique and in that year Greig in Edinburgh, published a short review of its use in clinical practice.

Various modifications in technique were now being developed. Saito, Kamikawa, and Yanagizawa, in 1930, using a variety of lipiodol emulsions, avoiding puncturing the main vessel by exposing and puncturing a branch - the external pudendal for examination of the thigh and the lateral or medial superior geniculate in the examination of the popliteal artery and calf vessels and injecting contrast medium retrogradely. They mention the use of arteriography in determining the level of amputation in gangrene.

In 1931 Pearse and Warren reported eight patients on whom arteriography had been performed at open exposure of the femoral artery, using 40% sodium monoiodo methane sulphonate (Methiodol).

Saito and Kamikawa in 1932 reported their method of "injection in refluence", where, at open exposure of the femoral artery, they punctured it proximal to an occluding clamp in the groin, and injected contrast medium in order to show the iliac arteries and distal aorta. This technique was rather similar to the counter-current method of aortography introduced by Castellanos and Pereiras (1940, 1950).

Osorio (1932) reported 100 translumbar aortograms. He felt that the main use of aortography lay in the study of aneurysm, anomalies of circulation, renal tumours and tumours in the left hypochondrium.

Allen and Camp from the Mayo Clinic reported on their series of 25 arteriograms in November 1932. The series was a mixed one of brachial and femoral arteriograms. They mentioned extension of gangrene as a complication of the intra-arterial injection of sodium iodide, as well as the occasional occurrence of iodism. The hazard of oil embolism was quoted against the use of iodised oil. They used "Thorotrast" - 25% thorium dioxide in the colloidal state and comment that "absence of harmful radioactivity of the substance had been noted", but added that the effects of prolonged deposition in the body were unknown. They seem to have used a percutaneous approach to the femoral artery. In a further paper, two months later, in January 1933, Allen reviewed the use of thorotrast in arteriography.

By 1934 Veal and McFetridge had carried out 150 arteriograms, mostly of the lower limbs, using up to 30 cc. of Thorotrast at one injection. They punctured the femoral artery in the femoral triangle or in the adductor canal. Almost all the punctures were percutaneous, but one or two were by open exposure of the artery. They made it quite clear that open exposure was used only as a last resort. In 1935 the same two authors reported their experience with arteriography in patients with gangrene. Allen and Camp (1935) reported 100 arteriograms performed during a period of 18 months. By this time they had become anxious about the possible hazards of thorium dioxide, and had restricted their study to the upper limbs where adequate arteriography could be performed with a smaller volume of contrast than in the lower limbs. In discussion of this paper, Maes (1935) said that Veal was able to determine amputation levels in gangrene from arteriographic studies.

Yater (1936), using thorotrast, felt that the greatest practical value of arteriography lay in determining the site of amputation in arteriosclerotic gangrene.

One of the most unfortunate episodes in the history of arteriography in general, and translumbar aortography in particular, occurred in 1936 with the publication of Henline's and Moore's paper "Renal arteriography, preliminary report of an experimental study." They, thirteen years before dos Santos's comment (1949) that the dog was an unsuitable subject, both anatomically and physiologically, for direct aortic puncture and aortography, carried out aortic puncture on 20 dogs and transfemoral aortic catheterisation in one, injecting various solutions. (They had 19 dogs, and used 2 for two separate experiments.)

They then extrapolated their animal results to man. The needle size used was large in relation to the canine aorta, and certainly proportionately much larger than that used in man. Equally, the dose of contrast medium was grossly out of proportion to that used in man, but Henline and Moore noted this themselves saying "it should be noted that our dosage of sodium iodide was greater per kilogram than dos Santos's; this was probably a factor in the causing of death." Little credit has been given them by later writers for having made this point, and they have suffered from frequent misquotation. (Wagner (1946) and Shapiro (1953) noted that the dose of sodium iodide used by Henline and Moore was equivalent to six times the dose used in man.) Henline and Moore say that five dogs died with evidence of traumatic haemorrhage due to the puncture itself (one of these dogs had been eviscerated before aortic puncture and was sacrificed) and three apparently because of the toxicity of the medium injected. The single dog which recovered, died some 25 days after a further experiment. A total of twelve dogs died at varying intervals from 9 to 63 days after aortography. In these animals no ill effects were found which could be related to the procedure, and here the authors made no suggestion about the cause of death. It seems doubtful if these deaths can be ascribed with any certainty to the procedure. Towards the end of their report Henline and Moore comment "because of the danger of haemorrhage and the toxicity of the solutions required for arteriography we feel that further experimentation is necessary before the use of this procedure in humans can be advocated". Following this paper there was to have been marked reluctance to use translumbar aortography in the United States.

In 1941 Farinas described his method of catheterisation of the abdominal aorta and its branches, remarking that dos Santos's method of translumbar puncture had not become routine because of the difficulties of the blind aortic puncture. He exposed the femoral artery in the groin under local anaesthesia and punctured it with a trocar through which a number 7 or 8 Porges rubber urethral catheter was passed to the desired level. During the injection of 20 to 30 ccs. of 70% diodrast the contralateral femoral artery was compressed, in order to prevent loss of contrast down the lower limbs. No attempt was made to repair the vessel wall after withdrawal of the catheter, the adventitia alone being sutured. This technique was developed by Farinas in order to inject drugs directly at the origin of the arterial supply in the treatment of abdominal neoplasia, rather than for arteriographic examination.

In 1942 Nelson reported his series of 73 "reno-abdominal arteriograms". His technique was a routine translumbar aortogram using 80% sodium iodide. Apart from two extravasations of contrast in early cases, he had no complications. Doss, Thomas and Bond (1942) detailed their technique of translumbar aortography, drawing attention to the value of renal arteriography in the diagnosis of various anomalies and pathological processes in the upper urinary tract.

Farinas (1945 and 1946) was forced to modify his method because of the war-time difficulty of obtaining rubber catheters. The modification consisted of introducing a trocar 1.5 mm. in diameter retrogradely into an exposed femoral artery at the groin and injecting 50 cc. of 70% diodrast through it, in 2.5 to 3 seconds with a pressure injector of his own design. Basically this was counter-current aortography, so long associated with

Castellanos and Pereiras, (1940, 1950). His technique of closure of the arterial wound was unchanged, as was his use of femoral artery compression to minimise rapid loss of contrast from the abdominal aorta.

Sulamaa (1946) discussing arteriography of the pelvic arteries in circulatory impairment of the lower limbs described his technique which included compression of the abdominal aorta and tourniquet occlusion of the femoral arteries in order to ensure good contrast filling of the pelvic arteries. Also in 1946 Wagner reported 18 successful translumbar aortograms out of 23 attempts on 17 patients. With Price and Swenson (1947) he published a report of 26 translumbar aortograms. Like dos Santos, Lamas and Caldas (1931) they varied their level of puncture of the abdominal aorta. They punctured high, in the region of the 12th thoracic vertebra for study of the coeliac axis and renal arteries, and low, at the 3rd lumbar level for the iliac arteries. They were not in favour of direct femoral arteriography because of the danger of causing vasospasm in lower limbs in which the circulation was impaired.

In 1948 Malick and Vitt reviewed the status of aortography at that time, describing their technique of aortic puncture. Although their work deals with the urological use of aortography, they mention, very briefly, that they had carried out aortography in the investigation of pelvic and lower limb arterial occlusion.

Lindbom from the Karolinska Sjukhuset, in 1950, published his monograph "Arteriosclerosis and Arterial Thrombosis in the Lower Limb - a Roentgenological Study", reviewing the arteriographic findings in 295 living limbs, and in 356 autopsy limbs. He gave a detailed account of his technique of arteriography. This painstaking and careful work stands as a landmark in the development and application of arteriography, for since dos Santos's work some 20 years before, the main interest and use of arteriography had been in urological diagnosis, and this work drew attention to the place of arteriography in the study of atheroma. This development took place almost simultaneously with a rapid advance in percutaneous carotid arteriography and with the original work on percutaneous splenoportography in man (Leger, 1951). These major advances in vascular radiology were associated with the development of less toxic contrast media, and, perhaps above all, by the demand from physicians and surgeons for more precise diagnosis, and accurate localisation, as more active surgical treatment of vascular disease because possible. Helmsworth, McGuire and Felson (1950) used a catheterisation technique, exposing the femoral artery below the origin of profunda femoris, and inserting a polyethylene catheter.

In the United Kingdom the first report of a series of aortograms came from the Middlesex Hospital, when Griffiths (1950) reported 25 patients from the urological unit there, in whom translumbar aortography had been performed. A year later in 1951 Semple and Whiteside (also at the Middlesex Hospital) gave a short report on aortography in vascular disease.

Peirce (1951) reported his method of arterial catheterisation, which had been developed in an attempt to facilitate experimental work on dogs, and then used in man. He passed a polyethylene catheter through a needle - in essence the same technique as Farinas (1941).

Several arteriographic techniques described in the past have never been generally accepted into clinical practice. Cuellar (1956) reported a method of introducing a silver trocar 1.7 mms. in external diameter into the abdominal aorta. Through this he passed a number 4 Cournand catheter which could then be manipulated in the aorta. Another catheter technique was reported by Amplatz (1963), who punctured the aorta with a catheter fitted closely over the shaft of a translumbar needle, removed the needle, leaving the catheter in the aorta, and coult then manoeuvre it in the aortic lumen with the aid of a very flexible, sharply curved guide wire. It seems likely that the slightly increased complexity of these techniques was not justified by their end results. Neither Cuellar, reporting 15 cases, nor Amplatz, reporting 85, described any complications. Other methods have been used for arteriography, and many of these have given adequate results in some hands, particularly those of their originators. Bernstein, Greenspan and Loken (1958) describing their technique of aortography using a large intravenous dose of contrast, believed it would supplant translumbar aortography. It certainly has not done so in Europe, nor in the United States where Newton (1963) said that it rarely gave sufficient clarity to permit necessary evaluation of the degree and extent of an obscructive lesion. Beall, Henly, Morris, Crawford, Cooley and DeBakey (1963) felt that intravenous aortography was frequently substandard, particularly where the aortic branches were concerned. (Viega-Pires and Godfrey (1960) labelled their contrast material to increase their accuracy of exposure timing and even attempted to make their exposure automatically from a Geiger counter-controlled switch.)

Sammons and Mahin (1959), Conley and Kennedy (1960), Schobinger (1961), Waldhausen and Klatte Carlsson (1965) and Friedenburg and Perez (1965) were among those who used a retrograde injection of contrast into one or both femoral arteries, in order to show the iliac arteries and distal aorta, as well as the arteries in the lower limbs. These techniques can probably be regarded as developments of the counter-current aortography technique in children described so many years before by Castellanos and Pereiras (1940).

In January 1952, Smith, Rush and Evans, discussing the technique of translumbar aortography, reported their series of 668 aortic punctures, without a death, and with no extra-aortic haemorrhage at operation. In order to confirm their belief in the safety of aortic puncture they carried out a series of aortic punctures on the moribund, and it is of some interest to quote them. "We have performed aortic punctures on approximately 70 patients who were dying of uraemia, cancer or malignant hypertension. Autopsies were obtained in 36 cases . The punctures were performed as short a time as possible before the anticipated death of the patient. In the 36 patients death occurred six hour to twenty-four days after puncture. In only 6 patients was there blood outside the aorta, at the puncture site, and in none of these was the area larger than a golf ball. In the majority the puncture site was not detectable. Three of the 36 patients had punctures through an atheromatous plaque and in none was there haemorrhage."

In 1952, Kekwick, McDonald and Semple of the Middlesex Hospital described a small series of patients with obliterative disease of the abdominal aorta, and iliac arteries, who had intermittent claudication.

Peirce and Ramey in 1953 reported again on the method described by Peirce (1951) in which catherisation was performed via a needle. 25 successful renal arteriograms out of 26 attempts were discussed.

In that year came a major advance in arteriographic technique with the publication of Seldinger's classic "Catheter replacement of the needle in percutaneous arteriography". This elegant technique permitted easy insertion of arterial catheters, paving the way for Odman (1956) who developed a technique for selective catheterisation of the branches of the aorta, using radio-opaque moulded catheters, introduced by Seldinger's technique.

- - - -

MATERIAL

CLINICAL MATERIAL

The patients in this series were, in the great majority, referred from the Peripheral Vascular Disease Clinic in Dundee Royal Infirmary. The remainder of the patients were referred directly to the X-Ray Department for arteriography from other medical and surgical units in the Eastern Region of Scotland.

Those patients on whom arteriograms were performed in the investigation of peripheral vascular disease, between 1st May 1960 and 31st December 1965, and whose arteriogram films and case records were available for retrospective study are considered. Any patient for whom no films, nor case notes, were available has been excluded. Similarly, any patient in whom aorto-iliac or lower limb arterial occlusive disease was found incidentally in arteriographic examination for some reason, such as a renal mass, has been excluded. Two patients in whom arterial occlusion followed trauma have also been excluded.

During the years of this survey the Radiodiagnostic Department in Dundee Royal Infirmary was the only place in the Eastern Regional Hospital Board area in which routine arteriography was performed (Campbell 1967; Meikle 1967). This series thus embraces all the arteriograms performed in the study of peripheral vascular disease in this region, in which the population is just over 400,000. No record is available of how many patients were referred from other hospitals in the region to centres outside the region, for the investigation and treatment of peripheral vascular disease. The wide geographical scatter of the patients in the series suggests that this number is small.

It has been the policy of the surgeons in charge of the Peripheral Vascular Disease Unit to ask for arteriographic examination of all their patients with peripheral arterial disease, apart from a small number severely disabled by some condition, such as cardiac failure or cerebro-vascular disease, in addition to peripheral vascular disease.

Unfortunately it has not been possible to find out with any accuracy how much selection of patients there has been in the other units in the area. It does seem, though, that most of the patients with peripheral vascular disease have been seen by the surgeons particularly interested in this field following direct referral from general practitioners, or in consultation with other hospital units. Consequently arteriographic examination has been carried out on most of the Eastern Region patients with peripheral vascular disease, and these patients form the basis for this study.

TABLE 1.

Sex and Age Distribution of the Patients in the Series.

Age	Male	Female	Total
21 - 30	3	1	4
31 - 40	10	8	18
41 - 50	58	21	79
51 - 60	146	27	173
61 - 70	160	37	197
71 - 80	47	21	68
81 +	6	1	7
TOTAL	430	116	546

TABLE 2.

Source of Patients.

Source	Number	Percent of Total
Patients referred from Peripheral Vascular Disease Unit.	497	91
Patients referred from other Units	49	9
TOTAL	546	100.00

TABLE 3.

Number of Patients in the Series.

The patients in the series can be divided into two groups.

1. Those on whom translumbar aortography was performed.

2. Those on whom direct femoral arteriography was performed.

Group	Female	Male	Total
Translumbar Group	21	63	84
Direct Femoral Group	95	367	462
TOTAL	116	430	546

TABLE 4.

Numbers of examinations Performed

	T.L.A.	Direct Rt. Fem. Arterio-graphy	Direct Lt. Fem. Arterio-graphy	Total Examin.
Examination in Women	21	89	87	197
Examination in Men	63	343	343	749
TOTAL	84	432	430	946

TABLE 5.

Number of Diabetic Patients

	Total Series	Inter. Claud-ication	Gangrene	Pre-Gangr-ene
a) All Patients				
Number of patients	546	411	70	47
Number of diabetic patients	30	9	12	4
% of diabetic patients	5.5	2.2	17.1	8.5
b) Men				
Number of men	430	340	49	32
Number of diabetic men	18	5	8	2
% of diabetic men	4.2	1.5	16.3	6.3
c) Women				
Number of women	116	71	21	15
Number of diabetic women	12	4	4	2
% of diabetic women	10.3	5.6	19.0	13.3

TABLE 6.

Clinical Presentation in the Patients in the Series

	Series	Intermittent Claudication	Gangrene	Pregangrene	Ulceration	Cold Feet
Number of Patients	546	411	70	48	10	7
Number of Men	430	340	49	32	5	4
Number of Women	116	71	21	16	5	3
Ratio of Men : Women	3.7:1	4.8:1	2.3:1	2:1	1:1	1.3:1
Men as % of Total	78.8	82.7	70.0	66.7	50.0	57.1
Women as % of Total	21.3	17.3	30.0	33.3	50.0	42.9

TABLE 7.

Age and Sex Distribution of the Patients in the Translumbar Group

Age Group	Female	Male	Total
21 - 30	-	-	-
31 - 40	2	1	3
41 - 50	8	13	21
51 - 60	4	24	28
61 - 70	4	22	26
71 - 80	3	3	6
81 +	-	-	-
TOTAL	21	63	84

TABLE 8.

Clinical Presentation in the Male Patients in the Translumbar Group.

Age Group	Right Claudication	Left Claudication	Bilateral Claudication	Right Gangrene	Left Gangrene	Bilateral Gangrene	Left Pregangrene	TOTAL
21 - 30	-	-	-	-	-	-	-	-
31 - 40	-	-	-	1	-	-	-	1
41 - 50	6	3	3	-	-	-	1	13
51 - 60	9	8	6	-	-	-	1	24
61 - 70	6	6	4	3	2	1	-	22
71 - 80	-	1	1	-	1	-	-	3
81 +	-	-	-	-	-	-	-	-
TOTAL	21	18	14	4	3	1	2	63

TABLE 9.

Clinical Presentation in the Female Patients in the Translumbar Group.

Age Group	Right Claudic-ation	Left Claudic-ation	Bilateral Claudic-ation	Left Gangrene	Right Pregang-rene	TOTAL
21 - 30	-	-	-	-	-	-
31 - 40	-	1	1	-	-	2
41 - 50	1	1	6	-	-	8
51 - 60	-	1	3	-	-	4
61 - 70	1	2	1	-	-	4
71 - 80	-	-	1	1	1	3
81 +	-	-	-	-	-	-
TOTAL	2	5	12	1	1	21

TABLE 10

(a) Age and Distribution of the Female Patients Examined by Direct Femoral Arteriography

Age Group	Female Patients	% of Female Patients exam. by femoral art'gphy	% of all Patients exam. by femoral art'phy
21 - 30	1	1.1	0.2
31 - 40	6	6.3	1.3
41 - 50	13	13.7	2.8
51 - 60	23	24.2	5.0
61 - 70	33	34.7	7.1
71 - 80	18	18.9	3.9
81 +	1	1.1	0.2
TOTAL	95	100.0	20.5

TABLE 10

(b) Age and Distribution of Male Patients Examined by Direct Femoral Arteriography

Age Group	Male Patients	% of Male Patients examined by Femoral art'phy	% of All Patients examined by Femoral art'phy
21 - 30	3	0.8	0.6
31 - 40	9	2.5	1.9
41 - 50	45	12.3	9.7
51 - 60	122	33.2	26.4
61 - 70	138	37.6	30.0
71 - 80	44	12.0	9.5
80 +	6	1.6	1.3
TOTAL	367	100.0	79.4

TABLE 10.

(c) Age and Distribution of All Patients examined by Direct Femoral Arteriography

Age Group	Total Number of Patients	% of All Patients Examined by Femoral Arteriography
21 - 30	4	0.9
31 - 40	15	3.2
41 - 50	58	12.6
51 - 60	145	31.4
61 - 70	171	37.0
71 - 80	62	13.4
81 +	7	1.5
TOTAL	462	100.0

TABLE 11

Distribution of Direct Femoral Arteriography in Male Patients

Femoral Arteriograms

Age Group	Right Only	Left Only	Bilateral	No. of Patients	No. of Arteriograms
21 - 30	-	-	3	3	6
31 - 40	-	-	9	9	18
41 - 50	2	3	40	45	85
51 - 60	6	6	110	122	232
61 - 70	9	6	123	138	261
71 - 80	6	5	33	44	77
81 +	1	4	1	6	7
TOTAL	24	24	319	367	686

TABLE 12.

Distribution of Direct Femoral Arteriography in Female Patients

Femoral Arteriograms

Age Group	Right Only	Left Only	Bilateral	No. of Patients	No. of Arteriograms
21 - 30	1	-	-	1	1
31 - 40	1	1	4	6	10
41 - 50	-	-	13	13	26
51 - 60	1	1	21	23	44
61 - 70	1	2	30	33	63
71 - 80	4	2	12	18	30
81 +	-	-	1	1	2
TOTAL	8	6	81	95	176

TABLE 13.

Number of Direct Femoral Arteriograms

Patients	Right	Left	TOTAL
Number in Female Patients	89	87	176
Number in Male Patients	343	343	686
TOTAL	432	430	862

TABLE 14

Clinical Presentation in the Male Patients Examined by Direct Femoral Arteriography

Male	Claudication			Gangrene			Pre-Gangrene			Ulceration			Cold Feet		
	Right Only	Left Only	Bilateral	Right Only	Left Only	Bilateral	Right Only	Left Only	Bilateral	Right Only	Left Only	Bilateral	Right Only	Left Only	Bilateral
21 - 30	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-
31 - 40	3	3	1	-	1	-	1	-	-	-	-	-	-	-	-
41 - 50	12	15	13	2	-	1	1	1	-	-	-	-	-	-	-
51 - 60	45	36	29	2	-	-	4	3	-	-	-	-	1	-	2
61 - 70	35	40	33	10	4	2	8	4	-	-	1	-	1	-	-
71 - 80	7	8	5	7	7	-	4	4	-	1	1	-	-	-	-
80 +	-	-	-	1	3	-	-	-	-	1	1	-	-	-	-
TOTAL	102	104	81	23	15	3	18	12	-	2	3	-	2	-	2

TABLE 15

Clinical Presentation in the Female Patients Examined by Direct Femoral Arteriography

Female	Claudic-ation			Gangrene			Pre-Gangrene			Ulcer-ation			Cold Feet		
	Right Only	Left Only	Bilateral	Right Only	Left Only	Bilateral	Right Only	Left Only	Bilateral	Right Only	Left Only	Bilateral	Right Only	Left Only	Bilateral
21 - 30	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31 - 40	1	1	1	2	1	-	-	-	-	-	-	-	-	-	-
41 - 50	4	2	5	-	1	-	-	-	-	-	-	-	-	-	1
51 - 60	2	6	5	2	3	1	1	-	-	1	1	1	-	-	-
61 - 70	6	7	7	2	2	-	3	4	1	-	-	-	-	-	1
71 - 80	1	1	2	3	3	-	2	3	-	1	1	-	1	-	-
80 +	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
TOTAL	15	17	20	9	10	1	6	8	1	2	2	1	1	-	2

TABLE 16

Presenting Symptoms in the Femoro-Popliteal-Tibial Group

	Men (367 patients)			Women (95 patients)		
	Number	% of Men in the Fem. Pop. Tib. Group	% of Men with this presenting Symptom	Number	% of Women in the Fem. Pop. Tib. Group	% of Women with this presenting Symptom.
Intermittent Claudication						
Right sided	102	27.8	35.5	15	15.8	28.8
Left sided	104	28.3	36.2	17	17.9	32.7
Bilateral	81	22.1	28.2	20	21.1	38.5
TOTAL	287	78.2	99.9	52	54.8	100.0
Gangrene						
Right sided	23	6.2	56.1	9	9.5	45.0
Left sided	15	4.1	36.6	10	10.5	50.0
Bileteral	3	0.8	7.3	1	1.1	5.0
TOTAL	41	11.1	100.0	20	21.1	100.0

TABLE 16 (continued)

	Men (367 patients)			Women (95 patients)		
	Number	% of Men in the Fem. Pop Tib. Group	% of Men with this presenting Sympson	Number	% of Women in the Fem.Pop Tib. Group	% ofWomen with this presenting Sympton
<u>Pregangrene</u>						
Right sided	18	4.9	60.0	6	6.3	40.0
Left sided	12	3.3	40.0	8	8.4	53.3
Bilateral	-	-	-	1	1.1	6.7
TOTAL	30	8.2	100	15	15.8	100
<u>Ulceration</u>						
Right sided	2	0.5	40.0	2	2.1	40.0
Left sided	3	0.8	60.0	2	2.1	40.0
Bilateral	-	-	-	1	1.1	20.0
TOTAL	5	1.3	100	5	5.3	100
<u>Cold Feet</u>						
Right sided	2	0.5	50.0	1	1.1	33.3
Left sided	-	-	-	-	-	-
Bilateral	2	0.5	50.0	2	2.1	66.7
TOTAL	4	1	100	3	3.2	100

The 862 direct femoral arteriograms can be subdivided into those performed on the symptomatic limbs and those on the asymptomatic side. This is shown in the following table.-

TABLE 17

	Limbs Examined
MEN: 367 patients.	
Symptomatic limbs	453
Asymptomatic Limbs	233
TOTAL	686
WOMEN: 95 patients.	
Symptomatic limbs	120
Asymptomatic limbs	56
TOTAL	176

86 men (i.e. 23.4% of the men) had bilateral symptoms - 81 with intermittent claudication, 3 with gangrene and 2 with cold feet. They account for 172 arteriograms, i.e. 25.1% of all the arteriograms on men.

The other 281 men had unilateral symptoms, and on these men 514 arteriograms were performed, 281 on the symptomatic side and 233 on the asymptomatic side. Therefore 82.9% of the men with unilateral symptoms were examined on the asymptomatic side.

In the different clinical presentations the numbers of asymptomatic limbs examined were.-

TABLE 18

Number	Asymptomatic Limbs examined	Percentage
206 men with unilateral claudication	188	91.3
38 men with unilateral gangrene	24	63.2
30 men with unilateral pregangrene	16	53.3
5 men with unilateral ulceration	3	60.0
2 men with unilateral cold foot	2	100.0
281	233	

25 women i.e. 26.3% of the women had bilateral symptoms - 20 with intermittent claudication, 1 with gangrene, 1 with pregangrene, 1 with ulceration and 2 with cold feet.

In the remaining 70 women, who had unilateral symptoms, 126 anteriograms were performed, 70 on symptomatic limbs and 56 on asymptomatic limbs. Therefore 80% of the asymptomatic limbs were examined.

The numbers of asymptomatic limbs examined in the different clinical presentation were.-

TABLE 19.

Number	Asymptomatic Limbs examined	Percentage
32 women with unilateral claudication	29	90.6
19 women with unilateral gangrene	12	63.2
14 women with unilateral pregangrene	11	78.6
4 women with unilateral ulceration	3	75.0
1 woman with unilateral cold foot	1	100.0
70	56	

METHOD

METHOD

1. Examination ofthe Patient

The patients reported in this series were all examined radiologically as in-patients. Each was seen before arteriography, by the radiologist and a history taken with special reference to vascular conditions of the lower limbs, buttocks, heart and central nervous system. Clinical examination was made, particular attention being paid to the peripheral pulses.

In those patients in whom a clear history of calf claudication was obtained, with no suggestion of symptoms in the buttocks or thighs and in whom the femoral pulses were easily felt, and were equal, and in whom no bruit was heard over the groins and iliac fossae, direct femoral arteriography was carried out. For the first two years local anaesthesia after premedication with "Omnopon" 20 mgms. and scopolamine 0.4 mgm. was employed, except in the apprehensive, and in those with gangrene. In those a general anaesthetic was given. After the first two years a general anaesthetic was given as a routine in all patients.

Arteriography was carried out with the patient supine on a radiolucent table over a Passler-Wentzlik casette changer, (Wellauer, 1958), with which a series of four films can be obtained. The film used was "Blue Brand" (Kodak) and the intensifying screens were high definition (Siemen's "ruby"). Although the intensifying screens covered the entire 96 x 20 cm. length of the casette, films were used in 48 x 20 cm. sections, being placed in the casettes as follows: the first casette had a film in it at the proximal end to show the thigh; in the second casette the film was centred approximately at the mid point, covering the knee area, overlapping the part of the thigh covered by the lower end of the first film and overlapping the upper calf, which was shown on the third and fourth films, both of which were placed at the extreme distal end of these last two casettes. Preliminary films were taken of the more severely affected limb and processed in the Kodak X-Omat automatic processing unit, although in the first two years they were processed by hand. The radiographic factors could then be altered if necessary. Normally these are 65-70 Kv., 0.3 second at 300 milliamperes (i.e. 90 mas.) at 60 inches anode film distance. A wedge filter tapering from 10 mm. is attached to the lightbeam diaphragm, the 10 mm. end of the wedge being at the foot end, in order to compensate for the diminishing radiographic density of the lower limb distally.

After the patient was anaesthetised the shaved inguinal region on the side to be examined was cleaned with spirit and chlorhexidine digluconate (Hibitane I.C.I.) o.5% in 70% alcohol. The patient was then draped with sterile towels. In those patients in whom local anaesthesia was used, the area over the relevant external iliac artery, distally, was infiltrated with 1% "Xylocaine". A short bevelled size 18 Lindgren needle was then introduced into the distal external iliac artery or proximal common femoral artery through a skin puncture about 5 cms. above the inguinal ligament. It is desirable whenever possible to introduce the needle in an antegrade direction, i.e. in the direction of blood flow rather than retrogradely in order to avoid loss of contrast medium into the pelvis through the internal iliac artery, and even into the opposite lower limb over the aortic bifurcation. This method of high puncture ensures that profunda femoris is not overlapped on the films by the butt of the needle and connecting tubing, and most important of all, that the common femoral artery is entered and not the superficial femoral artery distal to the origin of profunda femoris. It also allows the injector to keep his hands as far as possible from the primary beams of x-rays. The main disadvantage of the antegrade puncture is that it is easy for the inexperienced to puncture profunda femoris or the proximal superficial femoral artery, rather than the common femoral, with resulting unsatisfactory arteriography. Puncture of the uncommonly diseased common femoral artery, using an antegrade puncture, can be achieved with complete success if the needle is introduced through the skin at a sufficiently cephalic level. This is ensured by tracing arterial pulsation at the groin superiorly, and puncturing at the most superior point at which arterial pulsation is readily felt, usually some 5 cms. above the inguinal ligament. Puncture carried out in this way, has, in our experience, always been proximal to the origin of profunda femoris.

In the obese patient it is usually impossible to introduce the needle in this way, and a retrograde puncture is made. Here the needle is passed through the skin just inferior to the inguinal ligament and directed proximally. Again puncture of the common femoral artery has been invariable.

The actual technique of puncture has been a very standard one. A skin puncture is made with a cutting needle at the site at which the arteriogram needle is to be introduced. This allows a non-forcible passage of the needle through the skin, avoiding first, blunting the needle (albeit minimally), and secondly, any risk of skin embolism. The needle is connected to a 20 cc. syringe by a 20 cm. long polyvinyl tube with simple leak-proof jam-type adaptors (Renton, 1952; Luke, 153). This entire "system" is filled with warm normal saline, no anti-coagulant being added. The needle, attached to the "system" is advanced steadily and gently into the common femoral artery, which is held between the fingers of the other hand. The writer's experience has been that, regardless of the gentleness of the advance of the needle, almost invariably the artery has been transfixed. After transfixing the artery, the syringe is deatached from the system and the needle slowly withdrawn, with its butt depressed, until a distinct click is felt as its point comes through the posterior arterial wall. This is followed by a free flow of blood from the end of the polyvinyl connecting tube. The syringe is then reattached and the whole system flushed through until the radiographers are ready. Two points are, the writer believes of importance. Firstly no attempt has been made to thread the needle along the arterial lumen in an effort to obtain a more secure and stable position of the needle. We have had no problem with instability of the needle. Secondly, there has been a constant awareness of the hazard of over enthusiastic flushing of the system, with consequent rapid increase in circulating volume. The quantity of saline used has been kept to a minimum, by slow flushing. 20 cc. can be injected over a period of 5 minutes and is perfectly adequate to keep the needle patent.

Throughout the series injection of contrast has been manual. A glass-barrelled syringe of 30 cc. capacity with a metal plunger is used. This plunger has a mushroom top of 3.5 cms. diameter, this expanded top filling very comfortably into the heel of the operator's hand. Because of the risk of injury to the operator's hand should the syringe break, the barrel is sheathed in a hinged metal jacket which has a long narrow cut-out section in it through which the contents of the syringe can be seen. Air bubbles can thus be seen and expelled. The injection of contrast is not at all a forced one and it takes about 3 or 4 seconds to inject the usual volume of 25 cc. 45% sodium diatrizoate (45% "Hypaque" - Bayer) which has been used throughout.

The position of the limb during the examination is of some importance. It has seemed rather more simple to puncture the artery at the groin (particularly in the rather high antegrade method) when the limb has been externally rotated. The practice has been where possible, to puncture the artery with the limb internally rotated, since all the arteriograms have been carried out in that position, in which the leg arteries are very clearly shown, projected into the tibio-fibular gap, rather than superimposed on the tibia in external rotation of the limb (Rogoff, 1956).

Exposure of the first film is made when 20 cc. of contrast have been injected. This film shows the common femoral and superficial femoral arteries, profunda femoris artery and the proximal popliteal artery. The casette carrier is then rapidly rotated and the second film, centred on the knee, exposed. This film overlaps the area shown on the first film, showing the distal superficial femoral artery, the entire course of the popliteal artery and the proximal parts of the leg arteries. After a further turn of the casette carrier the third film is exposed. Again there is overlap of the area shown on the previous film. The distal popliteal artery is again shown on this film which is intended to show the leg arteries. The fourth turn of the casette carrier is followed by exposure of the fourth film centred like the third over the leg, and on which the distal parts of the leg arteries are shown.

The needle is left in the artery and kept patent by slow perfusion with warm normal saline until the films have been seen. A repeat injection of contrast medium may have to be made to show more clearly any given part of the arterial tree.

In the aged, the frail, and those with a history of myocardial ischaemia or ventricular failure the needle is withdrawn following the injection of contrast in order to minimise any increase in the volume of circulating fluid. If a further injection of contrast is needed in these patients the artery is repunctured. It has not been noted that repeated injections were in any way harmful from the point of view of the clinical state of the limb.

After withdrawal of the needle, pressure is maintained over the puncture site for five minutes, sufficient to prevent the development of a haematoma, but not enough to occlude the common femoral artery completely.

No dressing is applied to the tiny puncture.

When the first limb - the more severly affected one, or the symptomatic one in patients with unilateral symptoms - has been adequately examined, the patient is moved over the couch and the other limb examined in the same way.

Bilateral examination was performed in all, except the frail and elderly, many patients with gangrene (usually elderly) and those about whom the anaesthetist had any anxiety.

A point which appears to the writer of some importance is that the needles are sharpened after each arteriogram, no artery being punctured with an unsharpened needle. This has appeared to make the arterial puncture easier and less traumatic.

As a routine the patient remains in hospital for eighteen to twenty-four hours after the arteriogram, being kept in bed for the first six.

Those patients who gave a history of effort induced discomfort or claudication in the buttocks or thighs; in whom there was absence of one or both femoral pulses in the groin; in whom one or both femoral pulses were diminished, or in whom a bruit was heard in the inguinal region were examined by translumber aortography.

The examination was carried out in a conventional manner. The patient lies prone on a simple table, which has a manually moved sliding top, over a single plane 14 x 14 inch out film changer of the standard Schonander AOT type. A preliminary film is exposed, with three metal markers (ordinary ampoule files are very suitable) placed on the mid-line of the back (FIG. 2). The most inferior marker is at the level of the iliac crest, the upper over the 12th thoracic vertebral body and the third mid-way between these. The skin of the right side of the patient's back is marked with ink, these markings coinciding exactly with the metal markers. This preliminary film is processed in the Kodak X-Omat unit and seen before anaesthesia is induced. Several points are looked for on this film. Obviously the film is a check on the correctness of the radiographic factors - these can be readily adjusted. Heavy faecal loading of the colon or extensive gaseous distension of the gut, which might obscure fine arteriographic detail, would be seen on this film. These have not been a problem in this series, even without preparation of the bowel. This may be because most of the patients have been ambulant out-patients until admission a few hours before aortography. The three most important points shown on the preliminary film are:-

1. The relationship of the individual vertebrae to the markers on the patient's back.

2. The presence of calcification in the aortic wall, and -

3. Any aneurysmal dilatation of the aorta.

The first point is of importance in that the needle can be aimed to enter the arota at any given vertebral level, using the skin markers as index points. For example, puncture at the level of the disc between the 12th thoracic and the first lumbar vertebrae may result in heavy contrast flooding of the coeliac axis and superior mesenteric artery. The wide variation in the position of the aortic branches in relation to the vertebral column means that the actual level of punctureis not an adequate protection against injection immediately at the origin of a major branch and is a good reason for the use of a test injection (vide infra).

Calcification in the aortic wall, not infrequently found in the elderly in the infrarenal aortay, necessitates puncture at a distance from the calcified part. In such cases our practice has been to puncture the aorta at the level of the twelfth thoracic vertebra. A similar high puncture would be made in any patient in whom a low aortic aneurysm was found, but none has occurred in this series.

When the plain film has been examined and these points considered, the patient is anaesthetised. A point of detail here helps to ensure that the aortogram films do not have an increased amount of intestinal gas, compared with the preliminary film. An increase in the gas content seen on the preliminary film can be avoided if the anaesthetist does not inflate the patient with a simple face mask before intubation. In this way no gas is driven down the oesophagus to distend the stomach and proximal small intestine.

As a routine two sites of puncture are employed - - one low in the region of the third lumbar vertebra in those patients in whom one femoral pulse is absent or diminished and the second, high, at the level of the twelfth thoracic vertebra in those in whom both femoral pulses are absent, where there is aortic calcification inferiorly, and if there should be any suggestion of an aortic aneurysm. Broadly speaking this means a low puncture in these patients who clinically appear to be suffering from iliac artery occlusion, and high puncture in those with possible aortic occlusion. In those in whom both femoral pulses are diminished but palpable, it has seemed wiser to puncture the aorta at the higher level, since on clinical grounds it is not possible to distinguish accurately between aortic stenosis and bilateral common or external iliac stenosis and a low puncture entering the arota below an aortic stenosis could well result in a false aortographic picture. The variation in puncture level depending on the clinical picture means that the contrast medium is injected as close as possible to the site of occlusion, and that filling of the major visceral branches of the aorta can be avoided by using the low puncture site wherever possible - a point noted by dos Santos, Lamas and Caldas (1931).

A small pillow is placed under the upper chest in order to reduce the direct pressure on it and lessen the undoubted difficulties of anaesthesia in the prone position. The upper limbs are brought up, the shoulders abducted, the elbows flexed and the hands prone. The head is turned to one side, usually the right.

The skin is cleaned with spirit and chlorhexidine digluconate ("Hibitane" I.C.I.) 0.5% in 70% alcohol. Sterile towels are placed on the patient's back, care being taken not to obscure the ink marks. The site of introduction of the needle through the skin varies, depending on whether a high or low puncture is being carried out. In the high puncture group, a small stab wound is made in the skin with a fine-pointed scalpel, about one centimetre inferior to the twelfth left rib and rather less than one handsbreadth to the left of the spinous processes. In practice this means that 9 centimetres from the median plane. For the low punctures a similar stab wound is made about 1 centimetre superior to the left iliac crest, more laterally than in the high puncture - rather more than a handsbreadth to the left of the spinous process, at about 11 centimetres from the mid-line.

The following table shows the level of aortic puncture in the 84 translumber aortograms in this series.

Level	All Patients	% of all Punctures	Women	% of punctures in women	Men	% of punctures in Men
D.11	1	1.2	-	-	1	1.6
D.11/12 disc	1	1.2	-	-	1	1.6
D.12	13	15.3	7	33.3	6	9.5
D.12/L.1 disc	1	1.2	1	4.8	-	-
L.1	2	2.4	1	4.8	1	1.6
L.1/L.2 disc	-	-	-	-	-	-
L.2	10	12.0	2	9.5	8	12.7
L.2/L.3 disc	6	7.1	1	4.8	5	7.9
L.3	35	41.7	6	28.6	29	46.0
L.3/L.4 disc	3	3.6	-	-	3	4.8
L.4	7	8.3	1	4.8	6	9.5
Needle point Not shown	4	4.8	2	9.5	2	3.2
Failure to puncture	1	1.2	-	-	1	1.6
TOTAL	84	100.2	21	100.1	63	100.0

A short bevelled, end opening translumbar aortogram needle, of 16 s.w.g. and 20 centimetres in length is then introduced through the stab wound. The direction in which the needle is aimed varies with the level of puncture. In the high aortograms the needle is introduced to lie at approximately 45 degrees from the median plane and in the low punctures is kept at a much smaller angle. The angle of approach in the poster-anterior plane varies with the patient's build, being steeper in the heavily built and less steep in the slighter patient. The classic approach to the aorta, by advancing the needle until the lateral aspect of a vertebral body is reached with the needle point, withdrawing some 5 centimetres, angling the needle more anteriorly and advancing the needle round the antero-lateral aspect of the vertebral column until the aortic pulsations are felt, has not been followed as a routine the writer believing that repeated contact with the vertebral column is a factor in post-aortography discomfort, and that suchcontact may "burr" the needle point, with possible aortic damage on puncture. It has been our experience that a very accurate assessment of the correct line of the needle can be made on looking at the patient as he lies prone on the examination table. The needle can then be passed through the lumbar tissues, without contacting the spine, until the knocking pulsations of the aorta are felt, when it is advanced into the aorta with a short, quick stabbing movement. Every effort is made to avoid transfixing the aorta. If this technique fails at the third attempt, the classic method, using a vertebral body as a landmark is used.

The same saline-containing "system" of a 20 cc. syringe and polyvinyl tubing is used as in femoral arteriography. On entering the aorta, the syringe is detached and a strong flow of blood obtained. Again warm normal saline is used to keep the needle patent.

In order to check the position of the needle, relative to the lumen, and to the origin of the major branches a test injection of 5 ccs. of 45% sodium diatrizoate (45% "Hypaque" - Bayer) is injected manually and a film exposed just before the end of the injection. This film is over exposed and under developed, so that it is available as rapidly as possible. Originally the film used was "Blue Brand" (Kodak) in a 15 x 12 inch grid casette with high definition screens (Siemen's "ruby") the radiographic factors being 105 to 120 Kv., 300 milliamperes, at an exposure time of 40 to 50 milliseconds (i.e. 12 to 15 mas.) at an anode film distance of 36 inches. Development was in "Exprol" developer (May and Baker). This film was available for inspection in a minute and a half. Polaroid film was used for over a year. Apart from a reduction to 70 to 75 Kv. the radiographic factors are unchanged. It has the great advantage that processing does not require a dark room, and that processing time is only 10 seconds.

If the needle point is to one side or other of the aorta it is withdrawn or advanced as required, and the test dose repeated to confirm the change in position. Ideally the needle point should lie in the middle third of the aorta as seen on the test film. Should the needle point be at the origin of a major aortic branch, such as the superior mesenteric artery or renal artery it is withdrawn completely from the patient and re-introduced at a different level. Similarly, if it lies in a branch itself, it is withdrawn and re-introduced at a different level.

Once the position of the needle point has been checked on the test films, the table top is slid over the film changer and the final positioning of the patient in the supero-inferior axis carried out, so that the needle point is included on the upper part of the film. No movement of the patient on the table top is permitted after introduction of the needle.

Muscle relaxants are not used, apnoea not being induced before the injection of contrast, the patient being allowed to breathe normally throughout the examination.

25 cc. of 45% sodium diatrizoate (45% "Hypaque" - Bayer) are injected manually as rapidly as possible using the same guarded syringe as in femoral arteriography. Six exposures are made at a rate of 1 per second, the first exposure being made about half-way through the injection. Kodak "Blue Brand" film is used, at an exposure 85 to 100 Kv., and 12 to 15 mas. with an anode film distance of 36 inches.

Because of the inability to move the table top of the film changer during the examination it is impossible to follow the contrast material distally in the arterial tree. Hence a second and even a third injection must be made, after repositioning the patient, in order to demonstrate the femoral and popliteal arteries. As soon as films showing adequate contrast in the aorta are seen the needle is withdrawn and a small dressing strapped over the stab wound.

The patient remains in bed for eighteen hours after the examination.

2. METHOD OF EXAMINATION OF THE FILMS

a. Translumber Aortograms

Each patient's films were examined on standard x-ray viewing boxes. Complete occlusion only was considered, all grades of atheroma and atheromatous encroachment on the lumen - no matter how severe - short of complete occlusion, being classified as 'No occlusion'.

The majority of the preliminary films of the abdomen taken just before the translumber aortograms were missing. It was therefore not felt possible to record the presence or degree of aortic wall calcification.

The site of occlusion was determined on simple anatomical grounds and located in aorta, common and external iliac arteries or in the common femoral artery. It was assumed that the line of the inguinal ligament was a straight one between the pubic tubercle and the anterior superior iliac spine. Early in the collection of this group of patients a single injection only was made, and because of the immobility of the radiographic couch and film changer, no films were taken to show the arterial tree more than one

14 inch square film breadth distal to the needle point. Repeat injections were made later in the period during which the series was collected and the femoral and popliteal arteries shown. Since this had not been the invariable practice it was felt unjustifiable to consider the arteries distal to the origin of profunda femoris in the group of patients examined by translumbar aortography. Hence the arteries considered in the translumbar group are those between the needle point (or the cephalic end of the film in the four patients in whom the needle point was not shown) and the level of the inferior border of profunda femoris where it is projected immediately lateral to the line of the contrast filled lumen of the superficial femoral artery. In those patients in whom the superficial femoral artery was occluded proximally the inferior margin of profunda femoris was taken to be where the contrast column angled laterally ay about 120^{o} from the line of the common femoral artery. The exact point taken was the acute angle inferiorly between the profunda femoris artery and the continuation, in a straight line, of the lateral edge of common femoral artery.

The puncture site was regarded as being at the level where needle and the left lateral wall of aorta were superimposed.

b. Femoral Arteriograms

These films were examined on standard viewing boxes, and in this group a series of measurements was made. The base line taken was the horizontal line running through the superior cortical margin of the tibia at its most inferior point between the two tibial spines, seen in the antero-posterior and internally rotated arteriogram film. Lindbom (1950) used the "proximal tip of the inter-condyloid eminence". Kennedy Watt (1965) chose as his base line a point mid way between the femoral and tibial condyles. The difference between the base lines used by these workers and the one chosen in the present series is a matter of only a few millimetres. Linear measurements were then made from this base line, both proximally and distally, and were recorded as + and - respectively.

First, the distance to the inferior margin of the origin of profunda femoris was measured. This was taken, as in the aortogram group, to be at the apex of the inferior angle between the contrast filled lumen of profunda femoris and superficial femoral arteries. As in the aortogram group, this point was assessed in those patients in whom the proximal superficial femoral artery was occluded. No correction was made in order to compensate for the error involved in this method in that it regards the origin of profunda femoris as being from the lateral aspect of the common femoral artery rather than postero-lateral. This has meant that the origin of profunda femoris has been recorded as more distal than it is anatomically, by a few millimetres. Similarly, no correction was introduced to allow for the posterior course of the superficial femoral artery throughout the thigh. Again this means that the length recorded of the superficial femoral artery (and occlusions in it) are slightly smaller than they would be by direct measurement of the dissected vessel.

The distance of the origin of profunda femoris above the base line was measured by laying a non-elastic thread along the mid-line of the contrast filled lumen of the superficial femoral and popliteal arteries and marking it with a pin at the base line and at the inferior margin of profunda femoris origin. The distance between these pins was then measured in centimetres. In those patients in whom there was occlusion of part or all of the superficial femoral and popliteal arteries, the length of the occluded segment was measured by taking a straight line between the upper and lower ends of occlusion. In this way also the measurements obtained were slightly less than these which would have been attained on direct anatomical measurement.

The origin of the popliteal artery was taken to be the point where the contrast filled lumen crossed the medial aspect of the femur. The precise point chosen was the mid point of the lumen. Measurements were made along the line of patent vessels and in those limbs in which there was occlusion at the "arterio-osseous crossing", an approximation was made.

The distal end of the popliteal artery was taken to be at the inferior angle of the bifurcation into anterior and posterior tibial arteries. It was realised that, strictly speaking, the distal end of the popliteal artery is at the upper margin of the bifurcation, but since this is not such a clear end-point arteriographically, the one chosen was felt to be acceptable. It has a very slight (less than 5 mms.) effect on the measurements. The origin of the peroneal artery was similarly taken to be at the inferior angle of the bifurcation between peroneal and posterior tibial arteries. Henry's (1948) terminology, where he describes the popliteal artery giving a branch anteriorly - the anterior tibial artery - and continuing as the tibio-peroneal stem until its termination at the "fork" where the posterior tibial and peroneal arteries have their origin has not been used in this study. Clinically it has been found convenient to use it. The distances of the distal end of the popliteal artery, which is synonomous with the origin of the anterior tibial artery, and of the bifurcation of peroneal and posterior tibial arteries were recorded as minus quantities.

Because the anode film and the table-top film distances were constant throughout the series, these measurements can be regarded as comparable from patient to patient, the only variable being the thickness of the limb.

A mean and standard deviation was calculated for both men and women and in either limbs, for these points at the origin of the leg arteries.

Site	Mean	Standard Deviation
Men		
Left anterior tibial artery origin	-5.96	1.43
Left peroneal & posterior tibial artery bifurcation	-9.53	1.44
Right anterior tibial artery origin	-6.08	1.29
Right peroneal & posterior tibial artery bifurcation	-9.82	1.62
Women		
Left anterior tibial artery origin	-5.59	1.82
Left peroneal & posterior tibial artery bifurcation	-9.13	1.44
Right anterior tibial artery origin	-5.68	0.93
Right peroneal & posterior tibial artery bifurcation	-9.34	1.72

The mean was used as the level of origin of the anterior tibial artery, and of the posterior tibial artery and peroneal artery bifurcation in all calculations and graphs in these patients in whom these points were not seen because of local occlusion.

The level of the ankle joint was noted and the point taken was the distal cortical margin at the mid point of the articular surface of distal tibia. The distance between this point and the cortical edge of upper tibia at its lowest point between the spines was measured in centimetres. In those patients in whom the distal end of tibia was not shown, the distance from the base line to the film edge at the mid-point of the tibial shaft was recorded.

A series of charts was made showing the occlusions in the femoro-popliteal arteries and in each of the leg arteries. It was felt that separation of the femoral and politeal arteries in separate charts and histograms was undesirable, particularly as previously published histograms (lindbom 1950, Kennedy Watt, 1965) had shown both femoral and popliteal arteries together. In order to make the charts of the occlusions less visually irritating the occlusions were placed in order, with the most superior proximal end of an occlusion to the left and the most inferior proximal end to the right. For each proximal end measurement the occlusions were placed in decreasing length as one reads from left to right. The charts showing the occlusions were drawn on centimetre graph paper. The occlusions were each drawn to the exact measurement in centimetres and millimetres. Histograms were constructed by adding the numbers of occlusions at each interval on the charts of the occlusions (Lindbom 1950). Although the occlusions were measured to the nearest millimetre the histograms were constructed to the nearest 0.5 centimetre.

The charts of the occlusions in the femoral and popliteal arteries are illustrated in Figures 3,4,5,6, 7,8,9 and 10. . The anterior tibial artery occlusions are shown in Figures 11 and 12, those in the posterior tibial artery in Figures 13,14 and 15 and those in the peroneal artery in Figures 16 and 17

Figure 18 shows the histogram of all the femoro-popliteal artery occlusions; Figure 19 that of all the occlusions in the anterior tibial artery; Figure 20, the posterior tibial artery occlusions, and Figure 21, the occlusions in the peroneal artery.

COMPLICATIONS

COMPLICATIONS

Two patients died within one week of bilateral femoral arteriography.

The first patient was a 61 year old male farm labourer with a history of intermittent claudication in the left calf for two years, and in the right calf for one year. Premedication was with "omnopon" 20 mgms. and scopolamine 0.4 mgms. The patient was examined under local anaesthesia, 1% "Xylocaine" without adrenalin, being used. Arteriography showed an occlusion of the complete length of the left femoral artery, with diffuse atheroma throughout the other arteries on that side. On the right, there was no occlusion, but generalised atheroma was present. A note made immediately after the examination was completed, comments that the patient was very restless throughout the examination and perspired heavily. His blood pressure was recorded as 160/90 - on admission it had been 170/95.

About six hours after the arteriograms had been performed he complained of a gripping central chest pain which did not radiate and persisted for ten minutes. His blood pressure was 170/90. Twelve hours later (eighteen hours after arteriography) he again had central chest pain. The electrocardiogram (Figure 22) at that time was reported as follows (Dr. Emslie-Smith):-

24.2.62 Sinus rhythm. T waves inverted in Leads I, aVL, V_4 and V_6 and flat in Leads II and aVF. In Lead V_4 the ST take-off is depressed 2 mm below the iso-electric line.

Comment. This is an abnormal record. If the patient has not been digitalized the changes suggest myocardial ischaemia.

Forty eight hours later (sixty-six hours after arteriography) there was a further episode of chest pain, lasting for half an hour. His blood pressure was 165/95. The electrocardiogram (Figure 23) at that time was reported as follows (Dr. Emslie-Smith):-

26.2.62 Sinus rhythm. T wave flat in Lead I. ST elevation in Leads V_2, V_3 and aVL; ST depression in Leads III and aVF. Terminal inversion of T wave in Leads V_2 and V_3.

Comment. The record has changed since 24.2.62 and now suggests recent anterior myocardial injury, compatible with early infarction.

Twelve hours later (seventy-eight hours after arteriography) the patient died suddenly. There was no postmortem.

- - - -

The second death occurred in a 62 year old male commercial traveller with gangrene of the right foot of about six weeks duration. He had mild diabetes, controlled by diet. Repeated venesections had been performed during the previous year because of polycythaemia.

Bilateral femoral arteriography was carried out under general anaesthesia. At the end of the examination the patient developed auricular fibrillation. He was digitalised and within twelve hours was again in sinus rhythm. At this time he was noted to be confused. His blood urea was 98 mgm %. The following day his blood urea was 120 mgm % and he was more confused. His blood urea rose to 150, 176 and 223 mgm % over the next three days, when the patient became comatose and died.

At port mortem (Dr. Barclay), patchy consolidation was found in the right lower lobe. His report reads "the kidneys (450 and 460 gm) are both grossly cystic. The remaining parenchyma that is recognisable as renal is markedly congested and many of the cysts contain dark cloudy foul-smelling material. The ureters contain pus as does the bladder but there is little mucosal congestion in either."

The histological report on the kidneys is:-

"There is autolytic change in the cystic kidneys. Marked pericapsular thickening and vascular sclerosis are noted. There is a moderate degree of chronic inflammatory cell infiltration but no evidence of acute infection."

The pathologist felt that this patient, who was uraemic as a result of congenital cystic kidneys, died of inhalational bronchopneumonia.

\- - - -

There was one major non-fatal complication.

This occurred in a 43 year old man who had had intermittent claudication for about a year in the right buttock and calf. The right femoral pulse was diminished, and there was a systolic bruit over the right femoral artery. Translumbar aortography was carried out in the usual way. The test injection film was satisfactory (Figure 24), but the entire main injection was extravasated (Figure 25). On recovery from his anaesthetic the patient complained of backache for a few hours. No impairment of circulation was detected.

Four weeks later another translumbar aortogram was carried out, without any difficulty, and showed atheromatous stenosis of the right common iliac artery and stenosis distally in the right external iliac artery (Figure 26).

In one patient there was failure to puncture the aorta. This patient was a 42 year old schoolmaster, referred to the Vascular Clinic because of aching in both lower limbs. He had a right sided hemiplegia of eighteen months duration, apparently of sudden onset. No pulsations were felt in either groin or lower limb, and a diagnosis of aortic occlusion or bilateral common or external iliac artery occlusion was made. The pulses in the left upper limb, although present, were much diminished compared with those on the right.

An attempt to puncture the aorta at the level of the twelfth thoracic vertebra failed. Thoracic aortography was then performed with catheterisation of the ascending aorta from the right arm. The left subclavian artery was found to be occluded from its origin to the origin of the vertebral artery, and contrast medium reached the distal subclavian artery by retrograde flow in the vertebral artery. Examination of the abdominal aorta showed complete occlusion at the level of the second lumbar vertebra. There was no abnormality in the position of the aorta, nor in its size, to account for the failure to puncture.

This patient is illustrated in the section on aorto-iliac disease.

- - - -

In a 72 year old woman with right-sided pregangrene, the test injection was followed by a fall in systolic blood pressure from 180 to 90 mms. of mercury, and the examination was abandoned.

- - - -

There were no other complications in the translumbar series.

- - - -

Apart from the two deaths there have been no complications in the patients examined by femoral arteriography. Some induration and tenderness is common at the puncture site and persists for about 24 hours. Minor degress of bruising have been seen at the puncture site, but there has been no large haematoma.

- - - -

OCCLUSIONS

Occlusions

The numbers of occlusions found in the 946 examinations carried out on the 546 patients in this series are shown in Table 20

It is important to remember that there is an error inherent in the figures of the numbers of occlusions. It will be remembered that in the translumbar group, examination was not invariably continued to include the arterial tree distal to the part shown at the first injection of contrast medium. This has meant that the superficial femoral artery and the other arteries in the lower limb have not been demonstrated in all the translumbar patients. Because of this it has seemed less misleading to disregard all occlusions seen distal to the line of the inguinal ligament in those patients examined by translumbar aortography. Although it does seem of value to tabulate the occlusions in the series in one table, it must be remembered that had the examination been continued distal to t he inguinal ligament in every patient in the translumbar group, the numbers of occlusions in the lower limb arteries would have been much higher and that the incidence of occlusion in the aorto-iliac tree relatively smaller.

Because of this error it seemed wiser to consider the patients examined by translumbar aortography, (that is to say those who clinically fell into the aorto-iliac group), and those examined by direct femoral arteriography, (those clinically with femoro-popliteal-tibial artery disease) as separate groups so far as the examination of the patterns of association of occlusions is concerned.

It is obvious from the Table that the men, who account for 78.8% of the series, account for 78.6% of the numbers of occlusions, and that the women, forming 21.2% of patients in the series, account for 21.3% of occlusions.

The average number of occlusions in men and in women is identical at 2.3 per patient.

In this series therefore the incidence of occlusion at some level in the arterial tree is identical in men and in women, as is the average number of occlusions per patient.

TABLE 20

Artery	NUMBER OF COMPLETE OCCLUSIONS	PERCENTAGE OF ALL COMPLETE OCCLUSIONS	NUMBER OF COMPLETE OCCLUSIONS IN MEN	PERCENTAGE OF ALL COMPLETE OCCLUSIONS	PERCENTAGE OF ALL COMPLETE OCCLUSIONS IN MEN	PERCENTAGE OF ALL COMPLETE OCCLUSIONS IN YHAT ARTERY	NUMBER OF COMPLETE OCCLUSIONS IN WOMEN	PERCENTAGE OF ALL COMPLETE OCCLUSIONS	PERCENTAGE OF ALL COMPLETE OCCLUSIONS IN WOMEN	PERCENTAGE OF ALL COMPLETE OCCLUSIONS IN THAT ARTERY
AORTA	8	0.6	4	0.3	0.4	50	4	0.3	1.5	50
RIGHT COMMON ILIAC	14	1.1	11	0.9	1.1	78.6	3	0.2	1.1	21.4
LEFT COMMON ILIAC	17	1.4	13	1.0	1.3	76.5	4	0.3	1.5	23.5
RIGHT EXTERNAL ILIAC	10	0.8	9	0.7	0.9	90	1	0.1	0.4	10
LEFT EXTERNAL ILIAC	20	1.6	17	1.4	1.7	85	3	0.2	1.1	15
RIGHT COMMON FEMORAL	13	1.0	11	0.9	1.1	84.6	2	0.2	0.8	15.4
LEFT COMMON FEMORAL	15	1.2	14	1.1	1.4	93.3	1	0.1	0.4	6.7
RIGHT PROFUNDA FEMORAL	22	1.8	17	1.4	1.7	77.3	5	0.4	1.9	22.7
LEFT PROFUNDA FEMORAL	17	1.4	13	1.0	1.3	76.5	4	0.3	1.5	23.5

TABLE 20 (continued)

Artery	NUMBER OF COMPLETE OCCLUSIONS	PERCENTAGE OF ALL COMPLETE OCCLUSIONS	NUMBER OF COMPLETE OCCLUSIONS IN MEN	PERCENTAGE OF ALL COMPLETE OCCLUSIONS	PERCENTAGE OF ALL COMPLETE OCCLUSIONS IN MEN	PERCENTAGE OF ALL COMPLETE OCCLUSIONS IN THAT ARTERY	NUMBER OF COMPLETE OCCLUSIONS IN WOMEN	PERCENTAGE OF ALL COMPLETE OCCLUSIONS	PERCENTAGE OF ALL COMPLETE OCCLUSIONS IN WOMEN	PERCENTAGE OF ALL COMPLETE OCCLUSIONS IN THAT ARTERY
Rt. Superficial femoral	156	12.5	130	10.4	13.2	83.3	26	2.1	9.8	16.7
Lt. Superficial femoral	161	12.9	133	10.6	13.5	82.6	28	2.2	10.5	17.4
Right Popliteal	96	7.7	78	6.2	7.9	81.3	18	1.4	6.8	18.7
Left Popliteal	87	7	68	5.4	6.9	78.2	19	1.5	7.1	21.8
Right Anterior Tibial	109	8.7	87	7.0	8.8	79.8	22	1.8	8.3	20.2
Left Anterior Tibial	109	8.7	90	7.2	9.1	82.6	19	1.5	7.1	17.4
Right Posterior Tibial	137	11	99	7.9	10.1	72.3	38	3	13.9	27.7
Left Posterior Tibial	133	10.6	98	7.8	10	73.7	35	2.8	13.2	26.3

TABLE 20 (continued)

Artery	NUMBER OF COMPLETE OCCLUSIONS	PERCENTAGE OF ALL COMPLETE OCCLUSIONS	NUMBER OF COMPLETE OCCLUSIONS IN MEN	PERCENTAGE OF ALL COMPLETE OCCLUSIONS	PERCENTAGE OF ALL COMPLETE OCCLUSIONS IN MEN	PERCENTAGE OF ALL COMPLETE OCCLUSIONS IN THAT ARTERY	NUMBER OF COMPLETE OCCLUSIONS IN WOMEN	PERCENTAGE OF ALL COMPLETE OCCLUSIONS	PERCENTAGE OF ALL COMPLETE OCCLUSIONS IN WOMEN	PERCENTAGE OF ALL COMPLETE OCCLUSIONS IN THAT ARTERY
RIGHT PERONEAL	63	5	45	3.6	4.6	71.4	18	1.4	6.8	28.6
LEFT PERONEAL	63	5	47	3.8	4.8	74.6	16	1.3	6	25.4
	1250	100	984	78.6	99.8		266	21.1	99.7	

MALE OCCLUSIONS AS PERCENTAGE OF ALL OCCLUSIONS = 78.7%

FEMALE OCCLUSIONS AS PERCENTAGE OF ALL OCCLUSIONS = 21.3%

LEG OCCLUSIONS AS PERCENTAGE OF ALL OCCLUSIONS * 49.1%

MALE LEG OCCLUSIONS AS PERCENTAGE OF ALL MALE OCCLUSIONS = 47.4%

FEMALE LEG OCCLUSIONS AS PERCENTAGE OF ALL FEMALE OCCLUSIONS = 55.6%

NUMBER OF MEN = 430 i.e. 78.8% OF ALL PATIENTS

NUMBER OF WOMEN = 116 i.e. 21.2% OF ALL PATIENTS

AVERAGE NUMBER OF OCCLUSIONS PER MAN = 2.3

AVERAGE NUMBER OF OCCLUSIONS PER WOMAN = 2.3

TABLE 21

Order of frequency of occlusion in different arteries

Series	Men	Women
Superficial Femoral	Superficial Femoral	Superficial Femoral
Posterior Tibial	Posterior Tibial	Posterior Tibial
Anterior Tibial	Anterior Tibial	Anterior Tibial
Popliteal	Popliteal	Popliteal
Peroneal	Peroneal	Peroneal
Profunda	Profunda	Profunda
Common iliac	External Iliac	Common iliac
External iliac	Common femoral	External iliac } equal
Common femoral	Common iliac	Aorta } equal
Aorta	Aorta	Common femoral

The following table shows the number of patients showing complete occlusion in those examined by translumbar aortography, and in those examined by direct femoral arteriography. A further breakdown of these figures is found in the section on the patients in the aorto-iliac group, and in the femoro-popliteal-tibial group.

TABLE 22

Examination	Complete Occlusion		No complete Occlusion		Total
	Women	Men	Women	Men	
Translumbar aortography	11	42	10	21	84
Direct femoral arteriography	121	469	55	217	862
TOTAL	132	511	65	238	946
	643		303		

The percentage incidence of complete occlusion in women and in men is shown in the following table.

TABLE 23

Group	% examinations showing occlusion
Translumbar aortography group in women	52.4
Translumbar aortography group in men	66.7
Direct femoral group in women	68.8
Direct femoral group in men	68.4

Femoro-Popliteal Group

In the Appendix is a complete breakdown of the numbers of occlusions in eac h artery in claudication, pregangrene, ulceration and cold feet, both in men and in women. The findings in the symptomatic and the asymptomatic limbs are recorded. It is not felt either suitable or necessary to insert these tables here but they are presented because they form the basis for the following summary tables.

The numbers of occlusions in each artery shown in Table 24.

TABLE 24

ARTERY	All Limbs in the direct femoral anteriogram group: NO. OCCLUDED	All Limbs in the direct femoral anteriogram group: % INCIDENCE	MEN: NO. OCCLUDED	MEN: % OF OCCNS. IN MEN IN FEM. POP. GROUP I.E. % 915	MEN Symptomatic Limbs: NO. OCCLUDED	MEN Symptomatic Limbs: % OF OCCNS. IN MEN IN SYMPTOMATIC SIDE IN THE FEM. POPL. GROUP I.E. % of 707	MEN Asymptomatic Limbs: NO. OCCLUDED	MEN Asymptomatic Limbs: % OF OCCNS. IN MEN IN ASYMPTOMATIC SIDE IN THE FEM. POP. GROUP I.E. % of 208	WOMEN: NO. OCCLUDED	WOMEN: % OF OCCNS. IN WOMEN IN THE FEM. POPL. GROUP I.E. % of 250	WOMEN Symptomatic Limbs: NO. OCCLUDED	WOMEN Symptomatic Limbs: % OF OCCNS. IN WOMEN IN SYMPTOMATIC SIDE I.E. % of 191	WOMEN Asymptomatic Limbs: NO. OCCLUDED	WOMEN Asymptomatic Limbs: % OF OCCNS. IN WOMEN IN THE ASYMPTOMATIC SIDE i.e. % OF 59
COMMON FEMORAL	12	1.	10	1.1	8	1.1	2	1.	2	0.8	2	1.	-	-
SUPERFICIAL FEMORAL	317	27.2	263	28.7	227	32.1	36	17.3	54	21.6	47	24.6	7	11.9
POPLITEAL	183	15.7	146	16.0	128	18.1	18	8.7	37	14.8	33	17.3	4	6.8
ANTERIOR TIBIAL	218	18.7	177	19.3	122	17.3	55	26.4	41	16.4	32	16.8	9	15.3
POSTERIOR TIBIAL	270	23.2	197	21.5	133	18.8	64	30.8	73	29.2	45	23.6	28	47.5
PERONEAL	126	10.8	92	10.1	65	9.2	27	13.0	34	13.6	24	12.6	10	16.9
PROFUNDA FEMORIS	39	3.3	30	3.3	24	3.4	6	2.9	9	3.6	8	4.2	1	1.7
TOTAL	1165	99.9	915	100	707	100	208	100.1	250	100	191	100.1	59	100.1

TABLE 25

Order of Frequency of Occlusion in the Women in the Femoro-Popliteal-Tibial Group

All female limbs Artery	No.	Symptomatic Limbs Artery	No.	Asymptomatic Limbs Artery	No.
Posterior Tib.	73	Superficial Fem	47	Posterior Tib	28
Superficial Fem.	54	Posterior Tib.	45	Peroneal	10
Anterior Tib.	41	Popliteal	33	Anterior Tib.	9
Popliteal	37	Anterior Tib.	32	Superfic. Fem.	7
Peroneal	34	Peroneal	24	Popliteal	4
Profunda Femoris	9	Profunda Femoris	8	Profunda Fem.	1
Common Fem.	2	Common Fem.	2	Common Fem.	-
	250		191		59

TABLE 26

Order of frequency of Occlusion in the Men in the Femoro-Popliteal-Tibial Group

All Male Limbs		Symptomatic Limbs		Asymptomatic Limbs	
Artery	No.	Artery	No.	Artery	No.
Superficial Fem.	263	Superficial Fem.	227	Posterior Tib.	64
Posterior Tib.	197	Posterior Tib.	133	Anterior Tib.	55
Anterior Tib.	177	Popliteal	128	Superfic. Fem.	36
Popliteal	146	Anterior Tib.	122	Peroneal	27
Peroneal	92	Peroneal	65	Popliteal	18
Profunda Femoris	30	Profunda femoris	24	Profunda Femoris	6
Common Femoral	10	Common femoral	8	Common Femoral	2
	915		707		208

The various associations of occlusions (the "patterns of occlusion") are shown in Table 27 for women and in Table 28 for men.

Both these tables have been arranged for ease of reading in an anatomical order rather than in order of frequency of occurrence in which it would be less simple to examine the various patterns of occlusion involving any one artery. The occlusion also demonstrated diagramatically in the same order as in the Tables in Figures 62 and 63 for women and in Figures 64, 65, 66 and 67 for men. The diagrams are of the right limb in men and of the left in women.

TABLE 27

Occlusion patterns in the women examined by direct femoral arteriography i.e. those patients in the femoro-popliteal group.

Occlusion Pattern	Total No.
Common femoral, superficial femoral, anterior tibial and profunda femoris arteries.	1
Common femoral, superficial femoral, popliteal and profunda arteries	1
Superficial artery alone - femoral	22
Superficial femoral and profunda femoris arteries	1
Superficial femoral and anterior tibial arteries	3
Superficial femoral and posterior tibial arteries	6
Superficial femoral and peroneal arteries	1
Superficial femoral, posterior tibial and peroneal arteries	1
Superficial femoral and popliteal arteries	5
Superficial femoral, popliteal and posterior tibial arteries	4
Superficial femoral, popliteal, anterior tibial and posterior tibial arteries	3

TABLE 27 (continued)

Occlusion Pattern	Total No.
Superficial femoral, popliteal, posterior tibial and peroneal arteries	2
Superficial femoral, popliteal, anterior tibial, posterior tibial and peroneal arteries.	3
Superficial femoral, popliteal, anterior tibial, posterior tibial, peroneal and profunda femoris arteries.	1
Popliteal artery	3
Popliteal and posterior tibial arteries	1
Popliteal, anterior tibial and posterior tibial arteries	4
Popliteal, posterior tibial and peroneal arteries	2
Popliteal, anterior tibial, posterior tibial and peroneal arteries	5
Popliteal, peroneal and profunda femoris arteries	1
Popliteal, anterior tibial, peroneal and profunda femoris arteries	1
Popliteal, anterior tibial, posterior tibial, peroneal and profunda femoris arteries	1

TABLE 27 (continued)

Occlusion Pattern	Total No.
Anterior tibial artery	8
Posterior tibial artery	19
Peroneal artery	1
Anterior tibial and posterior tibial arteries	6
Posterior tibial and peroneal arteries	8
Anterior tibial, posterior tibial and peroneal arteries	5
Posterior tibial, peroneal and profunda femoris arteries	2

TABLE 28

Occlusion patterns in the men examined by direct femoral anteriography, i.e. those patients in the femoro-popliteal group.

Occlusion Pattern	Total No.
Common femoral artery	4
Common femoral and profunda femoris arteries	1
Common femoral and superficial femoral arteries	1
Common femoral, superficial femoral, posterior tibial and profunda femoris arteries	1
Common femoral, popliteal and posterior tibial arteries	1
Common femoral, superficial femoral,popliteal and posterior tibial arteries	1
Common femoral, superficial femoral, popliteal, posterior tibial and profunda femoris arteries	1
Superficial femoral artery	117
Superficial femoral and profunda femoris arteries	1
Superficial femoral and anterior tibial arteries	24
Superficial femoral and posterior tibial arteries	22

TABLE 28 (continued)

Occlusion Pattern	Total No.
Superficial femoral and peroneal arteries	6
Superficial femoral, anterior tibial and posterior tibial arteries	8
Superficial femoral, anterior tibial and peroneal arteries	1
Superficial femoral posterior tibial and peroneal arteries	4
Superficial femoral, anterior tibial posterior tibial and peroneal arteries	3
Superficial femoral, posterior tibial, and profunda femoris arteries	1
Superficial femoral, anterior tibial, posterior tibial and profunda femoris arteries	3
Superficial femoral, anterior tibial, peroneal and profunda femoris arteries	1
Superficial femoral, posterior tibial, peroneal and profunda femoris arteries	1
Popliteal artery	26

TABLE 28 (continued)

Occlusion Pattern	Total No.
Popliteal and anterior tibial arteries	8
Popliteal and posterior tibial arteries	10
Popliteal, anterior and posterior tibial arteries	11
Popliteal, anterior tibial and peroneal arteries	1
Popliteal, posterior tibial and peroneal arteries	4
Popliteal, anterior tibial, posterior tibial and peroneal arteries	8
Popliteal and profunda femoris arteries	1
Popliteal, posterior tibial and profunda femoris arteries	1
Popliteal, posterior tibial peroneal and profunda femoris arteries	1
Popliteal, anterior tibial, posterior tibial and peroneal and profunda femoris arteries	5
Superficial femoral and popliteal arteries	20
Superficial femoral, popliteal and anterior tibial arteries	12

TABLE 28 (continued)

Occlusion Pattern	Total No.
Superficial femoral, popliteal and posterior tibial arteries	6
Superficial femoral, popliteal and peroneal arteries	1
Superficial femoral, popliteal, anterior and posterior tibial arteries	8
Superficial femoral, popliteal, anterior tibial and peroneal arteries	1
Superficial femoral, popliteal, posterior tibial and peroneal	5
Superficial femoral, popliteal, anterior tibial, posterior tibial and peroneal arteries	7
Superficial femoral, popliteal and profunda femoris arteries	1
Superficial femoral, popliteal, anterior tibial and profunda femoris arteries	3
Superficial femoral, popliteal, anterior tibial, posterior tibial and profunda femoris arteries	1
Superficial femoral, popliteal, peroneal and profunda femoris arteries	1

TABLE 28 (CONTINUED)

Occlusion Pattern	Total No.
Superficial femoral, popliteal, anterior tibial, posterior tibial peroneal and profunda femoris arteries	1
Anterior tibial artery	30
Posterior tibial artery	29
Peroneal artery	6
Anterior tibial and posterior tibial arteries	22
Posterior tibial and peroneal arteries	15
Anterior tibial and peroneal arteries	4
Anterior tibial, posterior tibial and peroneal arteries	13
Profunda femoris artery	1
Posterior tibial and profunda femoris arteries	1
Posterior tibial, peroneal and profunda femoris arteries	1
Anterior tibial, posterior tibial, peroneal and profunda femoris arteries	2

Men.

55 occlusion patterns occurred.

The commonest pattern is occlusion of the superficial femoral artery alone (Figure 68), occurring in 117 limbs, i.e. in 24.9% of the occluded limbs.

The next most frequent was occlusion of the anterior tibial artery (Figure 69) found in 30 limbs i.e. in 6.4% of those limbs with occlusion.

Third most frequent was occlusion of the posterior tibial artery (Figure 70) which occurred in 29 limbs i.e. in 6.2% of the limbs with occlusion.

Popliteal artery occlusion alone (Figure 71) was the fourth most frequent occlusion. 26 instances of this occlusion pattern were found i.e. it oocurred in 5.5% of the occluded limbs.

The fifth most common pattern was occlusion of the superficial femoral artery plus anterior tibial artery (Figure 72). This was found in 24 limbs i.e. in 5.1% of the occluded limbs.

In the sixth place came two patterns of occlusion -

(a) occlusion of the superficial femoral and posterior tibial arteries (Figure 73).

(b) occlusion of the anterior and posterior tibial arteries (Figure 74).

22 instances of both these patterns were found, i.e. both occurred in 5% of the occluded limbs.

In each of 24 limbs, an occlusion pattern was found which occurred once only. Together these 24 patterns accounted for the appearances in only 5.1% of the occluded limbs.

Women

29 occlusion patterns occurred.

The commonest occlusion pattern was occlusion of the superficial femoral artery alone (Figure 75). This was found in 22 limbs, i.e. in 18.2% of those with occlusion.

Next in order of frequency came occlusion of the posterior tibial artery alone (Figure 76). 19 examples were found i.e. it occurred in 17·7% of occluded limbs.

In third place were two occlusion patterns -

(a) occlusion of the anterior tibial artery alone (Figure 77).

(b) occlusion of the posterior tibial and peroneal arteries (Figure 78).

Each of these patterns occurred 8 times, i.e. they each occurred in 6.6% of the occluded limbs.

In fourth place were a further two occlusion patterns -

(a) occlusion of the anterior and posterior tibial arteries (Figure 79).

(b) occlusion of the superficial femoral and posterior tibial arteries (Figure 80).

Each pattern was found in 6 limbs, i.e. each was found in

5% of the occluded limbs.

11 occlusion patterns occurred once only i.e. these 11 patterns together were found in 9.1% of the occluded limbs.

The following tables are summary tables of the series of tables in the appendix and show the number and sites of occlusions in the patients in the femoro-popliteal-tibial group. The findings in the symptomatic limbs and in the asymptomatic limbs are recorded. Intermittent claudication, gangrene, pregangrene, ulceration and cold feet are considered.

Only in men with intermittent claudication were there a large enough number of limbs to consider an analysis of the numbers and sites of occlusion in the patients with right-sided, left sided and bilateral symptoms. It was therefore decided to group all the symptomatic and the asymptomatic limbs together in the clinical groups. The results are shown in Tables 29 and 30.

TABLE 29

	Common Fem.	Superf. Fem.	Profunda	Popliteal	Anterior Tib.	Posterior Tib	Peroneal	No. Occln.	No. of Pat-ients	No. of arteriograms
Symptomatic side in MALE patients										
Claudication										
Right	2	52	3	36	25	25	11	17	102	102
left	1	57	4	30	25	27	15	20	104	104
Bi-lateral	1	86	10	31	35	31	13	51	81	162
Total	4	195	17	97	85	83	39	88	287	368
Gangrene										
Right	1	7	2	6	11	13	8	5	23	23
Left	-	10	-	4	10	11	6	-	15	15
Bi-lateral	-	3	2	3	3	3	1	2	3	6
Total	1	20	4	13	24	27	15	7	41	44

TABLE 29 (continued)

	Common Fem.	Superf. Fem.	Profunda	Popliteal	Anterior Tib.	Posterior Tib.	Peroneal	No. Occlns.	No. Patients	No. of arteriograms
Pregangrene										
Right	1	6	2	10	7	14	4	1	18	18
Left	2	4	1	5	3	6	5	1	12	12
Total	3	10	3	15	10	20	9	2	30	30
Ulceration										
Right	-	1	-	2	2	1	1	-	2	2
Left	-	1	-	1	1	1	-	1	3	3
Total	-	2	-	3	3	2	1	1	5	5
Cold Feet										
Right	-	-	-	-	-	-	-	2	2	2
Bilateral	-	-	-	-	-	1	1	3	2	4
Total	-	-	-	-	-	1	1	5	4	6

TABLE 29 (Continued)

	Common Fem.	Superf. Fem.	Profunda	Popliteal	Anterior Tib.	Posterior Tib	Peroneal	No. occlns.	No. of patients	No. of arteriograms
Asymptomatic side in MALE patients										
Claudication										
Right	-	13	1	2	21	20	5	55	94	94
Left	1	12	2	6	19	20	9	49	94	94
Total	1	25	3	8	40	40	14	104	188	188
Gangrene										
Right	1	3	1	3	7	9	4	4	17	17
Left	-	4	-	3	3	5	3	-	7	7
Total	1	7	1	6	10	14	7	4	24	24
Pregangrene										
Right	-	2	1	3	1	6	4	2	9	9
Left	-	2	1	-	1	3	2	2	7	7
Total	-	4	2	3	2	9	6	4	16	16
Ulceration										
Right	-	-	-	-	1	1	-	-	1	1
Left	-	-	-	1	1	-	-	1	2	2
Total	-	-	-	1	2	1	-	1	3	3

TABLE 30

	Common Fem.	Superf. Fem.	Profunda	Popliteal	Anterior Tib.	Posterior Tib.	Peroneal	No. Occlns.	No. Patients	No. of anteriograms
Symptomatic Side in FEMALE patients										
Claudication										
Right	-	7	-	4	3	5	3	2	15	15
Left	-	11	-	4	3	6	2	4	17	17
Bi-lateral	-	15	1	7	9	9	4	14	20	40
Total	-	33	1	15	15	20	9	20	52	72
Gangrene										
Right	-	2	2	3	3	6	5	2	9	9
Left	1	4	1	3	3	2	1	3	10	10
Bi-lateral	1	1	2	1	1	-	1	-	1	2
Total	2	7	5	7	7	8	7	5	20	21
Pregangrene										
Right	-	4	1	3	3	5	3	1	6	6
Left	-	1	1	6	5	6	4	-	8	8
Bi-lateral	-	-	-	-	-	-	-	2	1	2
Total	-	5	2	9	8	11	7	3	15	16

TABLE 30 (continued)

	Common Fem.	Superf. Fem.	Profunda	Popliteal	Anterior Tib.	Posterior Tib.	Peroneal	No. Occlns.	No. Patients	no. of anter-iograms
Ulceration										
Right	-	-	-	-	1	1	-	1	2	2
Left	-	1	-	1	1	2	-	-	2	2
Bi-lateral	-	-	-	-	-	2	-	-	1	2
Total	-	1	-	1	2	5	-	1	5	6
Cold Feet										
Right	-	1	-	1	-	1	1	-	1	1
Bi-lateral	-	-	-	-	-	-	-	4	2	4
Total	-	1	-	1	-	1	1	4	3	5

TABLE 30(continued)

	Common[1] Fem.	Superf. Fem.	Profunda	Popliteal	Anterior Tib	Posterior Tib	Peroneal	No Occlns.	No. Patients	No. of arteriograms
Asymptomatic side in FEMALE patients										
Claudication										
Right	-	3	-	1	1	5	2	6	14	14
Left	-	1	-	1	2	6	2	8	15	15
Total	-	4	-	2	3	11	4	14	29	29
Gangrene										
Right	-	-	-	-	-	3	1	1	4	4
Left	-	-	-	-	2	3	-	5	8	8
Total	-	-	-	-	2	6	1	6	12	12
Pregangrene										
Right	-	1	1	-	2	4	3	1	5	5
Left	-	1	-	2	2	5	2	-	6	6
Total	-	2	1	2	4	9	5	1	11	11
Ulceration										
Right	-	-	-	-	-	-	-	1	1	1
Left	-	-	-	-	-	2	-	-	2	2
Total	-	-	-	-	-	2	-	1	3	3
Cold Feet										
Right	-	1	-	-	-	-	-	-	1	1

AORTO-ILIAC GROUP

Aorto-iliac group.

84 (15.4%) of the 546 patients with degenerative arterial disease fell clinically into the aorto-iliac group, and were examined by translumbar aortography. 21 (25%) were women, compared with 95 (20.6%) of the 462 patients in the femoro-popliteal-tibial group.

11 (52.4%) of the 21 women in this group showed complete arterial occlusion of one or more arteries, compared with 42 (66.7%) of the 63 men.

TABLE 31

Numbers and Sites of Complete Occlusion

Site	Number in the 23 women	Number in the 63 men
Aorta	4	4
Right common iliac artery	3	11
Left common iliac artery	4	13
Right external iliac artery	1	9
Left external iliac artery	3	17
Right common femoral artery	1	6
Left common femoral artery	-	9
TOTAL	16	69

TABLE 32

Number of Women in the Aorto-Iliac Group with and without Complete Occlusion

Site	AGE GROUP							
	21-30	31-40	41-50	51-60	61-70	71-80	TOTAL	%
With complete occlusion	-	1	3	2	4	1	11	52.4
Without complete occlusion	-	1	5	2	-	2	10	47.6
TOTAL	-	2	8	4	4	3	21	100.0

TABLE 33

Number of Men in the Aorto-Iliac Group With and Without Complete Occlusion

Site	AGE GROUP 21-30	31-40	41-50	51-60	61-70	71-80	TOTAL	%
With complete Occlusion	-	1	8	19	12	2	42	66.7
Without complete Occlusion	-	-	5	5	10	1	21	33.3
TOTAL	-	1	13	24	22	3	63	100.0

TABLE 34

Incidence of Solitary and Multiple Occlusion in the 21 Women in the Aorto-Iliac Group

	Number	% of total Number of women in the aorto-iliac group
Number of women in the aorto-iliac group with single artery occlusion	7	33.3
Number of women in the aorto-iliac group with multiple artery occlusion	4	19.0
Total number of women in the aorto-iliac group with arterial occlusion	11	52.4

TABLE 35

Incidence of Solitary and Multiple Occlusion in the 63 Men in the Aorto-Iliac Group

	Number	% of total number of men in the aorto-iliac group
Number of men in the aorto-iliac group with single artery occlusion	24	38.1
Number of men in the aorto-iliac group with multiple artery occlusion	18	28.6
Total number of men in the aorto-iliac group with arterial occlusion	42	66.7

TABLE 36

Distribution of Solitary Arterial Occlusion in the Women in the Aorto-Iliac Group.

Site	AGE GROUP							
	21-30	31-40	41-50	51-60	61-70	71-80	No. of patients	No. of occlusions
Aorta	-	-	2	1	-	-	3	3
Right common iliac artery	-	-	1	-	-	-	1	1
Left common iliac artery	-	-	-	-	1	-	1	1
Right external iliac artery	-	-	-	-	-	-	-	-
Left external iliac artery	-	-	-	-	1	-	1	1
Right common femoral artery	-	-	-	-	1	-	1	1
Left common femoral artery	-	-	-	-	-	-	-	-
TOTAL	-	-	3	1	3	-	7	7

i.e. Single artery occlusion occurred in 33.3% of the women in the aorto-iliac group.

TABLE 37

Distribution of Solitary Arterial Occlusion in the Men Aorto-Iliac Group

Site	AGE GROUP						No. of patients	No. of Occlusions
	21-30	31-40	41-50	51-60	61-70	71-80		
Aorta	-	-	1	2	-	-	3	3
Right common iliac artery	-	-	3	4	2	-	9	9
Left common iliac artery	-	-	-	3	-	-	3	3
Right external iliac artery	-	-	-	2	1	-	3	3
Left external iliac artery	-	-	1	3	-	-	4	4
Right common femoral artery	-	-	-	-	1	-	1	1
Left common femoral artery	-	1	-	-	-	-	1	1
TOTAL	-	1	5	14	4	-	24	24

i.e. Single artery occlusion occurred in 38.1% of the men in the aorto-iliac group.

TABLE 38

Distribution of Multiple Artery Occlusions in Women in the Aorto-Iliac Group

Site	AGE GROUP 21-30	31-40	41-50	51-60	61-70	71-80	No. of patients	No. of Occlusions
Aorta and both common iliac arteries	-	1	-	-	-	-	1	3
Right and left common iliac arteries	-	-	-	1	-	-	1	2
Left common and left external iliac arteries	-	-	-	-	-	1	1	2
Right and left external iliac arteries	-	-	-	-	1	-	1	2
TOTAL	-	1	-	1	1	1	4	9

i.e. Multiple artery occlusion occurred in 19.0% of the women in the aorto-iliac group.

TABLE 39

Distribution of Multiple Arterial Occlusions in Men in the Aorto-Iliac Group

Site	AGE GROUP 21-30	31-40	41-50	51-60	61-70	71-80	No. of patients	No. of Occlusions
Aorta & both common iliac arteries	-	-	-	-	1	-	1	3
Right common & right external iliac arteries	-	-	-	-	1	-	1	2
Left common & left external iliac arteries.	-	-	2	2	1	1	6	12
Left common, left external iliac, & left common femoral arteries	-	-	-	1	-	1	2	6
Left common iliac, left external iliac & left common femoral arteries with right external iliac artery	-	-	-	-	1	-	1	4
Right external iliac & right common femoral arteries	-	-	1	-	1	-	2	4

TABLE 39 (continued)

Site	AGE GROUP 21-30	31-40	41-50	51-60	61-70	71-80	No. of patients	No. of Occlusions
Right external iliac & right common femoral arteries with left external iliac & left common femoral arteries	-	-	-	1	1	-	2	8
Left external iliac & left common femoral arteries	-	-	-	1	1	-	2	4
Right & left common femoral arteries	-	-	-	-	1	-	1	2
TOTAL	-	-	3	5	8	2	18	45

i.e. Multiple artery occlusion occurred in 28.6% of the men in the aorto-iliac group.

Aortic Occlusion

In this series there were 8 patients with aortic occlusion - four women and four men.

Women

i. E.F., aged 36 years. This patient showed aortic occlusion from the level of the fourth pair of lumbar arteries, with marked stenosis of a 1.75 cm. long portion of aorta at the level of the third lumbar vertebra. Both common iliac arteries filled with contrast medium distally, immediately above their bifurcation, (Figure 27) being patent distally. The external iliac arteries were both patent.

ii. J.M., aged 41 years. In this patient the occlusion extended from the second pair of lumbar arteries and extended to about 2 cms. superior to the aortic bifurcation at the upper border of the fourth lumbar vertebra. The aortic bifurcation and common iliac arteries were essentially normal. (Figure 28).

iii. B.B., aged 45 years. This patient showed a short occlusion from the level of the lower border of the third lumbar vertebra, to the level of the mid point of the fourth lumbar vertebra. Again the aortic bifurcation and common iliac arteries were normal (Figure 29).

iv. R.C., aged 55 years. This patient showed a thrombus in the abdominal aorta, with its inferior margin at the third/fourth lumbar intervertebral disc. It extended upwards on the right side to about the level of the mid point of the third lumbar vertebra. The aortic bifurcation and iliac arteries were normal (Figure 30).

Each of these patients complained of intermittent claudication, and none had mitral valve disease.

<u>Men</u>

i. W.K., aged 42 years. This was the patient in whom translumbar aortography failed. As well as increased fatiguability in the lower limbs this patient had a right hemiplegia. Examination of the thoracic aorta and abdominal aorta was carried out at the one examination by right brachial artery catheterisation. A left "subclavian steal" was demonstrated.* (Reivich, Holling, Roberts and Toole, 1961; annotation, New Engl. J. Med., 1961; Philp, Samuel and Duncan 1963). There was also stenosis of the origin of the right subclavian artery. The abdominal aorta was

* Figure 31.

completely occluded below the level of the second pair of lumbar arteries (Figure 32). No contrast medium filling was demonstrated in the distal aorta, nor in the iliac arteries.

ii. W.M., aged 52 years. In this patient there was complete occlusion ofthe aorta from the level of the lower margins of the renal artery origins, at the level of the mid point of the first lumbar vertebrae. No filling with contrast medium occurred distal to this in the main arterial tree (Figure 33).

iii. P.McD., aged 55 years. This patient also showed complete aortic occlusion from the origin of the renal arteries at the level of the second lumbar vertebra. Large superior mesenteric collateral vessels were shown, but no filling with contrast medium occurred in the distal or iliac arteries (Figure 34).

iv. W.H., aged 61 years. This patient had complete aortic occlusion from the level of the lower border of the second lumbar vertebral body. In this patient refilling of each common iliac artery a short distance proximal to its bifurcation was clearly shown (Figure 35).

The absence of refilling of the iliac arteries in the first three men is not conclusive evidence that these arteries are, in fact, completely occluded. For this reason therefore these iliac arteries are not considered in the total of the vessels unequivocally occluded, in the table of occlusions. It does seem likely that they were indeed occluded, particularly in the light of many previous reports (vide infra)., and the external iliac arteries were shown in all the women with aortic occlusion, bearing in mind that the arteriographic technique was the same in men and women.

These last three men each complained of intermittent claudication, and none had mitral valve disease.

In summary, then, of the four men with aortic occlusion, only one showed any contrast medium filling in the common iliac arteries and three did not. The aortic bifurcation was not shown in any of the four male patients. In the four women with aortic occlusion all showed common iliac artery refilling bilaterally. Three of the women showed a normal aortic bifurcation.

Common Iliac Artery Occlusion

There were 14 patients with solitary common iliac artery occlusion.

TABLE 40

Solitary Common Iliac Artery Occlusions

	Right Common Iliac	Left Common Iliac
Women		
41 - 50	1	-
51 - 60	-	-
61 - 70	-	1
Men		
41 - 50	3	-
51 - 60	4	3
61 - 70	2	-
TOTAL	10	4

TABLE 41

Common Iliac Artery Occlusions in Association with other Occlusions

	BILATERAL COMMON ILIAC	RIGHT COMMON AND AND EXTERNAL ILIAC	LEFT COMMON AND EXTERNAL ILIAC	LEFT COMMON & EXT. ILIAC WITH LEFT COMMON FEMORAL & RT. EXTERNAL ILIAC	LEFT COMMON ILIAC LEFT EXTERNAL ILIAC AND LEFT COMMON FEMORAL	AORTA AND BOTH COMMON ILIACS
WOMEN						
31-40	-	-	-	-	-	1
41-50	-	-	-	-	-	-
51-60	1	-	-	-	-	-
61-70	-	-	-	-	-	-
71-80	-	-	1	-	-	-
MEN						
41-50	-	-	2	-	-	-
51-60	-	-	2	-	1	-
61-70	-	1	1	1	-	1
71-80	-	-	1	-	1	-
TOTAL	1	1	7	1	2	2

Two of the three women with common iliac artery occlusion as part of multiple arterial occlusion presented with intermittent claudication. One of these, in whom the aorta and both common iliac arteries were occluded, has previously been discussed in the aortic occlusion group (Figure 27). The second patient, aged 53 years, who complained of bilateral intermittent claudication, showed bilateral common iliac artery occlusion throughout the entire artery on each side (Figure 36). Ten months later she was re-examined. The upper end of her occlusion was then in the aorta at the level of the second/third lumbar intervertebral disc. On the left, the level of the distal end of the occlusion was unchanged, but on the right it had extended inferiorly about 5 cms. inferiorly (Figure 37). (This patient is considered in the discussion of aortic occlusion.)

The third patient, aged 76 years, was a diabetic with gangrene of the left foot. The left common and external iliac arteries were completely occluded (Figure 38). Collateral circulation was sparse. No filling occurred in the upper left femoral artery. No attempt was made to obtain films more distally.

\- - - -

Of the 12 men with solitary common iliac artery occlusion, 9 were right sided and 3 were left sided. 11 Patients complained of intermittent claudication and one had gangrene of the right foot. The patient with gangrene showed occlusion along the entire course of the right common iliac artery (Figure 39). Three of the eleven patients with claudication showed occlusion along the entire course of the common iliac artery. The other occlusions measured 0.5, 1, 1.2, 1.4, 3.5, 3.8, 4 and 5.8 cms.

There was obvious atheroma in the contralateral common iliac artery in these patients (Figure 40) but two patients showed particularly interesting change there. Figure 41 shows a thrombus medially in the left common iliac artery in a patient with a 5.8 cm. long occlusion in his right common iliac artery. Figure 42 shows a "web" medially in the right common iliac artery in a patient with an occlusion of the entire length of the left common iliac artery. These two patients illustrate lesions found unexpectedly on the asymptomatic side, of the type which the writer believes make retrograde catheterisation of the "normal" side potentially hazardous.

Eleven men showed common iliac artery occlusion as a part of multiple arterial occlusion. The association of occlusions is shown in Table 39. Of the seven patients with intermittent claudication five showed left common and external iliac artery occlusion. In four of the five with left common and external iliac artery occlusion, the occlusion extended from the origin of the affected common iliac artery to the line of the inguinal ligament (Figure 43). The fifth patient showed a shorter common iliac artery occlusion beginning 3.6 cms. from the aortic bifurcation and extending to the inguinal ligament (Figure 44). The sixth patient with intermittent claudication showed occlusion of the left common and external iliac arteries, and the left common femoral artery (Figure 45). This occlusion started 4 mms. from the aortic bifurcation and continued to the origin of profunda femoris. In the seventh patient there was aortic and bilateral common iliac artery occlusion. The patient has been considered as number iv. of the male aortic occlusion group - see Figure 35 previously.

Three men with multiple arterial occlusion involving the common iliac artery, presented with gangrene. One, showed occlusion of the entire left common and external iliac arteries, with extension into the left common femoral artery. The right external iliac artery was occluded from the origin of the internal iliac artery, the occlusion extending into the common femoral artery (Figure 46). The second patient with gangrene showed occlusion of the right common iliac artery starting about 4 mms. from the aortic bifurcation, extending through the common iliac and external iliac arteries as far as the inguinal ligament. He also had scattered thrombi in the left common iliac artery (Figure 47). In the third patient, there was complete occlusion of the left common and external iliac arteries, with extension into the common femoral artery (Figure 48). There was an aneurysm at the bifurcation of the right common iliac artery.

One patient had pregangrene. He had left common iliac artery occlusion beginning about 2 cms. from the aortic bifurcation and extending through the external iliac artery (Figure 49). No arterial filling was demonstrated distally. The absence of a sharply defined upper end of the occlusion plus the complete absence of collateral arteries was felt to favour a recent occlusion, probably following an embolus.

External Iliac Artery Occlusion

8 patients showed solitary external artery occlusion.

TABLE 42

Solitary External Iliac Artery Occlusion

	Right External Iliac	Left External Iliac
Women		
61 - 70	-	1
Men		
41 - 50	-	1
51 - 60	2	3
61 - 70	1	-
TOTAL	3	5

TABLE 43

18 Patients showed External Iliac Artery Occlusion in Association with Other Occlusions

	BILATERAL EXTERNAL ILIAC	RIGHT COMMON AND EXTERNAL ILIAC ARTERIES	LEFT COMMON AND EXTERNAL ILIAC ARTERIES	LEFT COMMON AND EXTERNAL ILIAC ARTERIES AND LEFT COMMON FEMORAL	LEFT COMMON & EXTERNAL ILIAC ARTERIES; LEFT COMMON FEMORAL AND RIGHT EXTERNAL ILIAC	RIGHT EXTERNAL ILIAC AND RIGHT COMMON FEMORAL	LEFT EXTERNAL ILIAC AND LEFT COMMON FEMORAL	BILATERAL EXTERNAL ILIAC AND BILATERAL COMMON FEMORAL
WOMEN								
61-70	1	-	-	-	-	-	-	-
71-80	-	-	1	-	-	-	-	-
MEN								
41-50	-	-	2	-	-	1	-	-
51-60	-	-	2	1	-	-	1	1
61-70	-	1	1	-	1	1	1	1
71-80	-	-	1	1	-	-	-	-
TOTAL	1	1	7	2	1	2	2	2

WOMEN

The 61 year old woman in whom the left external iliac artery was occluded from 0.5 mms. from its origin to the line of the inguinal ligament complained of left intermittent claudication. She also showed atheroma in the aorta and the other pelvic arteries, with a "web" medially in the right common iliac artery from 3.5 cms. from the aortic bifurcation - another example of a source of possible hazard in the use of a catheter passed from the "normal" femoral artery. In this patient the collaterals were from the left internal iliac artery and the lumbar arteries (Figure 50).

The younger of the two women in whom external iliac artery occlusion occurred as part of a multiple arterial occlusion picture was aged 65. She complained of bilateral claudication. Aortography showed bilateral external iliac artery occlusion, the left over a length of 2.1 cms. and the right for 5.8 cms. The right internal iliac artery was also occluded. Collateral flow was via the left internal iliac artery, and from the third right lumbar artery (Figure 51). Atheroma was shown elsewhere in the aorto-iliac arteries.

The third patient was aged 76 years and was a diabetic with left sided gangrene, involving the foot. Aortography showed complete occlusion of the entire course of the left common and external iliac arteries. This patient has already been considered (Figure 52) in the account of common iliac artery occlusion.

- - -

MEN

23 men had external iliac artery occlusion, seven (four on the left and three on the right) being solitary occlusions. Sixteen patients had external iliac artery occlusion as part of a multiple arterial occlusion picture.

As a solitary lesion:

All the patients in this group complained of intermittent claudication. In each patient the occlusion extended from the origin of the artery to the line of the inguinal ligament, no short occlusions being seen. An example is shown in Figure 53.

External iliac artery occlusion as part of a multiple occlusion picture see Table 43.

16 men showed this arteriographic pattern. In seven, the common and external iliac arteries were occluded together on one side - one on the right, where the 70 year old patient had gangrene of the foot and six on the left, where one of the patients aged 42, had pregangrene. The other five patients aged 48, 56, 58, 64 and 76 years each complained of claudication. These patients have been discussed in the common iliac artery occlusion group.

In two patients external iliac artery occlusion was associated with occlusion of the ipsilateral common iliac and common femoral arteries. One patient, aged 54 years complained of intermittent claudication and the other, aged 72, of the left foot had gangrene. In eachpatient the occlusion began at the origin of the common iliac artery, and extended throughout the common and external iliac arteries to involve the common femoral artery. This was completely occluded to the origin of profunda femoris in the patient with claudication (Figure 45) but in the patient with gangrene the distal common femoral artery was patent. This patient also had an aneurysm of the right common iliac artery, and the right common femoral artery (Figure 48). In both of these patients the ipsilateral internal iliac artery was occluded.

In a 62 year old patient with gangrene of the left foot there was complete occlusion of the entire course of the left common and external iliac arteries, and the left common femoral artery, with an associated occlusion of the ipsilateral internal iliac artery. On the right side the external iliac artery was occluded throughout (Figure 46) - the right internal iliac artery was patent. Collateral filling was poor.

Occlusion of the external iliac artery and ipsilateral common femoral artery was found in six men. In four, this occlusion pattern was unilateral, and in two, was bilateral. The unilateral ones were associated with claudication in three patients , they were left sided in two. In the fourth patient, with left external iliac and common femoral artery occlusion, the clinical presentation was pregangrene. In one patient (Figure 54) with claudication the occlusion involved the entire length of the right external iliac and common femoral arteries. The other two patients with claudication showed occlusion of the external iliac artery, sparing the proximal portion, and extending distally through the common femoral artery (Figure 55). Occlusion extending throughout the external iliac and common femoral arteries was found in the patient with pregangrene, (Figure 56).

Internal iliac artery collaterals were seen in the patients with claudication, but the patient with gangrene had only sparse collaterals.

Bilateral external iliac and common femoral artery occlusion occurred in two patients, aged 58 and 62, both with claudication. In the younger patient the occlusion started at the origin of the external iliac artery on the right and extended to the origin of profunda femoris. On the left the occlusion extended from 3 cms. distal to the origin of the external iliac artery to the origin of profunda femoris (Figure 57). In the second man the occlusions began a few mms. distal to origin of the external iliac artery, and extended to the origin of profunda femoris (Figure 58).

FEMORO-POPLITEAL GROUP

FEMORO-POPLITEAL SERIES

In this section the limbs examined by direct femoral arteriography are considered in men and women, presenting with intermittent claudication, gangrene and pregangrene.

Histograms have been constructed to show the incidence of occlusion at different levels in the arteries throughout the limbs. The histograms of occlusions in the symptomatic limbs are shown as black, while the histograms of the occlusions in the asymptomatic limbs are illustrated as white areas superimposed on these black histograms - forming filling defects at the base of the histograms of the appearances in the symptomatic limbs.

The occlusion patterns in the limbs are tabulated.

CLAUDICATION

287 men presented with a history of intermittent claudication, 102 (35.5%) with right sided claudication, 104 (36.2%) with left sided claudication, and 81 (28.2%) with bilateral claudication. The total number of symptomatic limbs examined in men, with intermittent claudication was therefore 368.

188 asymptomatic limbs were examined in these 287 men, 94 left limbs in men with right sided claudication and 94 right limbs in men with left sided claudication.

556 arteriograms are thus available in men with claudication.

- - - -

52 women presented with intermittent claudication, 15 (28.8%) on the right, 17 (32.7%) on the left, and 20 (38.5%) with bilateral claudication.

72 symptomatic limbs were therefore examined.

29 asymptomatic limbs were examined, 14 left limbs in women with right sided claudication, and 15 right limbs in women with left claudication.

101 arteriograms are therefore available in women with claudication.

- - - -

Men

Symptomatic Side.

Of the 368 limbs examined, 280 (76.1%) showed complete occlusion at some level.

In the 102 men with right sided claudication, 85 (83.3%) showed occlusion on that side, and in the 104 men with left sided claudication 84 (80.8%) had occlusion on their symptomatic side. The 81 patients with bilateral claudication (i.e. 162 symptomatic limbs) showed complete occlusion in 111 limbs (68.5%).

What are the occlusion patterns seen in the symptomatic limbs of men with claudication?

These are shown in Table 44.

TABLE 44

Symptomatic Limbs in Men with Intermittent Claudication

Occlusion Pattern	Number	% of all male limbs in the fem pop. tib grp. with inter. claud i.e. % of 368	% of all male limbs in the fem pop tib group with inter. claud. and complete occl. i.e. % of 280
Common femoral	2	0.5	0.7
Common femoral and profunda femoris	1	0.3	0.4
Common femoral and Superficial femoral	1	0.3	0.4
Superficial femoral alone	98	26.6	35
Superficial femoral and anterior tibial	19	5.2	6.8
Superficial femoral and posterior tibial	16	4.3	5.7
Superficial femoral and peroneal	3	0.8	1.1
Superficial femoral, anterior tibial and posterior tibial	8	2.2	2.9
Superficial femoral, anterior tibial and peroneal	1	0.3	0.4

TABLE 44 (continued)

Occlusion Pattern	Number	% of all male limbs in fem. pop.tib. group with inter. claud. i.e. % of 368	% of all male limbs in fem. pop. tib. group with inter cl. i.e. % of 280
Superficial femoral, posterior tibial and peroneal	4	1.1	1.4
Superficial femoral plus anterior tibial, posterior tibial and peroneal	1	0.3	0.4
Superficial femoral, anterior tibial, posterior tibial and profunda femoris	2	0.5	0.7
Superficial femoral, anterior tibial, peroneal and profunda femoris	1	0.3	0.4
Superficial femoral, posterior tibial, peroneal and profunda femoris	1	0.3	0.4
Popliteal alone	24	6.5	8.6
Popliteal and anterior tibial	6	1.6	2.1
Popliteal and posterior tibial	6	1.6	2.1

TABLE 44 (continued)

Occlusion pattern	Number	% of all male limbs in fem. pop. tib. group with int. claud i.e. % of 368	% of all male limbs in fem. pop. tib group with in. cl. & com. occln. i.e. % of 280
Popliteal, anterior tibial and posterior tibial	9	2.4	3.2
Popliteal, posterior tibial and peroneal	2	0.5	0.7
Popliteal, anterior tibial, posterior tibial and peroneal	4	1.1	1.4
Popliteal, profunda femoris	1	0.3	0.4
Popliteal, posterior tibial and profunda femoris	1	0.3	0.4
Popliteal, posterior tibial, peroneal and profunda femoris	1	0.3	0.4
Popliteal, anterior tibial, posterior tibial, peroneal and profunda femoris	3	0.8	1.1
Superficial femoral and popliteal	16	4.3	5.7
Superficial femoral, popliteal & anterior tibial	6	1.6	2.1

TABLE 44 (CONTINUED)

Occlusion pattern	Number	% of all male limbs in fem. pop. tib group with int. claud. i.e. % of 368	% of all male limbs in fem.pop tib group with in. cl. & com. occln. i.e. % 280
Superficial femoral, popliteal & posterior tibial	2	0.5	0.7
Superficial femoral, popliteal and peroneal	1	0.3	0.4
Superficial femoral, popliteal, anterior tibial and posterior tibial	3	0.8	1.1
Superficial femoral, popliteal, anterior tibial and peroneal	1	0.3	0.4
Superficial femoral, popliteal, posterior tibial and peroneal	3	0.8	1.1
Superficial femoral, popliteal, anterior tibial, posterior tibial and peroneal	3	0.8	1.1
Superficial femoral, popliteal, anterior tibial and profunda femoris	2	0.5	0.7
Superficial femoral, popliteal, peroneal & profunda femoris	1	0.3	0.4

TABLE 44 (continued)

Occlusion Pattern	Number	% of all male limbs in fem.pop tib group with int. cl. i.e.% of 368	% of all male limbs in fem. pop group with int. cl. & com. occl. i.e. % 280
Superficial femoral, popliteal, anterior tibial posterior tibial and profunda femoris	1	0.3	o.4
Superficial femoral, popliteal, anterior tibiail anterior tibial, posterior tibial, peroneal and profunda femoris	1	0.3	0.4
Anterior tibial	10	2.7	3.6
Posterior tibial	6	1.6	2.1
Peroneal	1	0.3	0.4
Anterior tibial and peroneal	1	0.3	0.4
Posterior tibial and peroneal	3	0.8	1.1
Anterior tibial, posterior tibial and peroneal	3	0.8	1.1
Profunda femoris	1	0.3	0.4

43 different occlusion patterns occurred.

The commonest occlusion, occurring in 26.6% of all the symptomatic limbs in men with claudication, and in 35% of these limbs which showed occlusion, was of the superficial femoral artery alone.

The second commonest occlusion, occurring in 6.5% of all the symptomatic limbs with claudication, and in 8.6% of these with occlusion, was of the popliteal artery alone.

Occlusion of the superficial femoral artery plus the anterior tibial artery, the third commonest occlusion pattern, occurred in 5.2% of all the claudicating limbs examined and in 6.8% of those with occlusion.

Two occlusion patterns -

(a) superficial femoral and popliteal artery occlusion

(b) superficial femoral and posterior tibial artery occlusion

were equally as common, in the fourth place. These occurred in 4.3% of all the limbs in this group, and in 5.7% of all the occluded limbs.

Anterior tibial artery occlusion alone, occurring in 2.7% of the limbs examined in this group, and in 3.6% of all the occluded limbs, was the sixth commonest occlusion.

These six occlusion patterns, found in 10 or more instances, together account for the lesions found in 183 limbs, i.e. in 49.7% of all the symptomatic male claudicating limbs and in 65.4% of all the occluded limbs in this diagnostic group.

The other 38 occlusion patterns occurred in less than 10 limbs, 17 of the occlusion patterns being found once only and because of their infrequency, have, although recorded, not been detailed.

- - - -

The numbers and incidence of occlusion in individual arteries on the symptomatic side in men with claudication is shown in the following table.

TABLE 45

Artery	No. of Occl.	% of all occls in the symptomatic limbs i.e. % of 520	% incidence in all symptomatic limbs i.e. % of 368	% incidence in the occluded symptomatic limbs i.e. % of 280
Common femoral	4	0.8	1.1	1.4
Superficial femoral	195	37.5	53	69.6
Popliteal	97	18.7	26.4	34.6
Anterior tibial	85	16.3	23.1	30.4
Posterior tibial	83	16	22.6	29.6
Peroneal	39	7.5	10.6	13.9
Profunda femoris	17	3.3	4.6	6.1
	520	100.1		

Leg artery occlusion occurred in 136 symptomatic limbs i.e. in 37% of all symptomatic limbs and in 48.6% of the occluded symptomatic limbs.

In 24 limbs leg artery occlusion occurred in the absence of occlusion in the femoro-popliteal segment or profunda femoris, i.e. in 6.5% of all limbs, and in 8.6% of the occluded limbs. Leg artery occlusion occurred in a single artery, as the sole occlusion in the limb in 17 limbs (i.e. in 4.6% of the symptomatic limbs, and in 6.1% of those with occlusion.)
The ratio of occlusion incidence in the three arteries in these patients was 10 anterior tibial: 6 posterior tibial: 1 peroneal. In the 7 limbs (i.e. 1.9% of all limbs and 2.5% of those with occlusion), in which multiple leg artery occlusion occurred as the only occlusions in the limbs the ratio was 0.6 anterior tibial: 0.9 posterior tibial: 1 peroneal.

In 112 limbs there was leg artery occlusion in association with occlusion elsewhere in the limb, i.e. in 30.4% of all symptomatic limbs, and in 40% of all the occluded limbs. 63 (56.3%) of these 112 limbs (i.e. 17.1% of all the claudicating limbs and 22.5% of these with occlusion), showed occlusion in a single leg artery,33 (11.8% of the occluded limbs) in the anterior tibial, 25 (8.9% of the occluded limbs) in the posterior tibial and 5 (1.8% of the occluded limbs) in the peroneal i.e. a ratio of 6.6 : 5 : 1.

Double leg artery occlusion in association with occlusion proximally in the limb occurred in 37 limbs, i.e. in 10.1% of all symptomatic limbs, and in 13.2% of the occluded limbs. There were 23 anterior plus posterior tibial artery occlusions, 3 anterior tibial plus peroneal artery occlusions, and 11 posterior tibial plus peroneal artery occlusions. In this group of double leg artery occlusions with proximal occlusion there were 26 anterior tibial artery occlusions, 34 posterior tibial artery occlusions and 14 peroneal occlusions i.e. a ratio of 1.9 : 2.4 : 1.

Occlusion of all three leg arteries in association with occlusion elsewhere occurred in 12 limbs - in 3.3% of all symptomatic limbs and in 4.3% of the occluded limbs in this clinical group. In this group, obviously, the numbers of occlusion in each leg artery were identical.

- - - -

Proximal occlusion, i.e. occlusion in the common femoral, superficial femoral, popliteal and profunda femoris arteries, without leg artery occlusion, was found in 144 limbs, i.e. in 39.1% of the symptomatic limbs and in 51.4% of those with occlusion.

- - - -

Occlusion Length.

The mean length of the 292 occlusions involving the femoro-popliteal segment was 14.5 cms.

The histogram (Figure 85) of femoro-popliteal occlusions shows, in men with claudication, on the symptomatic side, a clear peak between 15 and 25 cms. above the knee joint, demonstrating the most frequent incidence of occlusions at this level, which is approximately the level of the opening in the tendon of adductor magnus. A second smaller peak is shown about the 30 cm. level above the knee joint, but this peak over a distance of 1.5 cms. is caused by a very small number of occlusions (5 at the lower end of the peak).

The steep slope in the contour of the histogram between 42 and 50 cms. above the knee joint reflects the varying level above the knee joint of the origin of profunda femoris, to which the long femoral artery occlusions extend. This has been previously shown in the histogram (Figure 18) of all femoro- popliteal occlusions. The steep form of the histogram throughout demonstrates the presence of relatively short occlusions in the femoro-popliteal segment - occlusions which did not extend to the origin of profunda femoris.

The markedly rapid fall in the number of occlusions below the 19 cm. level illustrates the relative infrequency - particularly inferiorly - of popliteal artery occlusion and illustrates the rapidly diminishing incidence of occlusion as the distance increases below the adductor magnus hiatus.

\- - - -

The average length of anterior tibial artery occlusion in these symptomatic claudicating limbs was 20.9 cms. In the histogram of occlusions in this artery (Figure 86) no clear peak is shown, the summit of the curve being very smoothly curved. The highest part of the curve is between the 17 and 26 centimetre levels below the knee joint. The sharp increase in the number of occlusions at the 6 centimetre level is accounted for by those patients in whom the occlusive process involved the origin of the anterior tibial artery. In those patients the mean level of the lower margin of the anterior tibial origin was used in the construction of the histograms.

This was - 6 cms. on the left and - 6.1 cms. on the right.

The histogram shows a steadily rising incidence of occlusion in the anterior tibial artery from the - 6 to the - 17 centimetre level, with a very constant incidence between - 17 and - 27 cms. Below - 27 cms. the incidence of occlusion declines rapidly but too much stress cannot be laid on this decline since in many of the limbs the ankle joint was not demonstrated and hence the entire course of the anterior tibial artery could not be recorded.

- - - -

The average length of posterior tibial artery occlusions in the symptomatic limbs of men with intermittent claudication was 17.7 cms.

In the histogram (Figure 87) of occlusions in this artery no clear peak is seen. Rather, there is a slowly increasing incidence of occlusion with increasing distance from the origin of the artery. The abrupt increase in the number of occlusions at - 6 cm. is, like the similar appearance in the anterior tibial artery occlusion histogram, due to the calculated level of the anterior tibial artery origin (and hence the posterior tibial origin) being used in the construction of the histogram. Like the anterior tibial artery occlusions, the rapid fall in the number of occlusions over 30 cms. from the knee joint is not truly representative, since the entire course of the distal posterior tibial artery has not been shown in all the limbs examined.

- - - -

The average length of peroneal occlusion is the symptomatic limbs with claudication was 16.1 cms.

The histogram (Figure 88) of peroneal occlusions in claudicating limbs in men shows an abrupt proximal limit due to the calculated mean level of the peroneal origin, (- 9.5 cms. on the left and - 9.8 cms. on the right) being used in the construction of the histogram as the level of origin of peroneal arteries occluded at their origins.

The summit of the histogram is almost flat with no peak. Below the 27 to 28 cms. level from the knee joint the numbers of occlusions drop steadily, but this cannot be regarded as an accurate demonstration since, as in the other leg arteries, the ankle joint was not invariably shown. This histogram shows no site of predilection for occlusion in the peroneal artery, but rather a constant incidence throughout.

- - - -

Asymptomatic Side

188 asymptomatic limbs were examined, 84 (44.7%) showing complete occlusion. Of the 94 asymptomatic (i.e. left) limbs examined in men with right sided claudication, 39 (41.5%) were completely occluded, as were 45 (47.9%) of the 94 asymptomatic (right) limbs in men with left claudication.

- - - -

What occlusion patterns occurred in the asymptomatic limbs of men with claudication?

These are shown in Table 46

TABLE 46

Asymptomatic Limbs in Men with Intermittent Claudication

Occlusion Patterns	Number	% of all asymptomatic limbs in men with inter. claud. i.e. % of 188	% of completely occ. asymptomatic limbs in men with inter. claud i.e. % of 84
Common femoral	1	0.5	1.2
Superficial femoral	14	7.4	16.7
Superficial femoral and anterior tibial	2	1.1	2.4
Superficial femoral and posterior tibial	3	1.6	3.6
Superficial femoral and peroneal	2	1.1	2.4
Superficial femoral, anterior tibial; posterior tibial and profunda femoris	1	0.5	1.2
Popliteal	2	1.1	2.4
Popliteal and anterior tibial	1	0.5	1.2
Popliteal plus anterior tibial and posterior tibial	1	0.5	1.2

TABLE 46 (continued)

Occlusion Pattern	Number	% of all asymptomatic limbs in men with inter. claud. i.e. % of 188.	% of completely occ. asymptomatic limbs in men with inter. claud. i.e. % of 84
Popliteal, anterior tibial, posteriortibial, peroneal and profunda femoris	1	0.5	1.2
Superficial femoral and popliteal	1	0.5	1.2
Superficial femoral, popliteal and anterior tibial	2	1.1	2.4.
Anterior tibial	15	8.0	17.9
Posterior tibial	15	8.0	17.9
Peroneal	2	1.1	2.4
Anterior tibial and posterior tibial	12	6.4	14.3
Posterior tibial and peroneal	3	1.6	3.6
Anterior tibial and peroneal	2	1.1	2.4

TABLE 46 (continued)

Occlusion Patterns	Number	% of all asymptomatic limbs in men with inter. claud. i.e. % of 188.	% of completely occ. asymptomatic limbs in men with inter. claud i.e. % of 84
Anterior tibial, posterior tibial and peroneal	3	1.6	3.6
Posterior tibial, peroneal and profunda femoris	1	0.5	1.2
TOTAL	84	44.7	100.4

20 different occlusion patterns occurred.

The commonest occlusion pattersn were

(a) anterior tibial artery occlusion alone,

(b) posterior tibial artery occlusion alone.

These two occlusion patterns were equally as common, occurring in 8.0% of the asymptomatic limbs examined and in 17.9% of the asymptomatic limbs with complete occlusion.

The next commonest occlusion pattern was occlusion of the superficial femoral artery alone. Present in one less limb than either of the two previous occlusion patterns, it occurred in 7.4% of all the asymptomatic limbs, and in 16.7% of those with occlusion.

The fourth commonest occlusion pattern was of the anterior tibial plus the posterior tibial artery. This occurred in 6.4% of all the asymptomatic limbs and in 14.3% of the occluded ones.

The other 16 occlusion patterns were present in three or fewer limbs.

The numbers and incidence of occlusion in individual arteries, on the asymptomatic side, in men with claudication, is shown in the following table.

TABLE 47

Artery	Number of Occ.	% of all occ. in the asymptomatic limbs i.e. % of 131	% incidence in all asymptomatic limbs i.e. % of 188	% incidence in the occluded asymptomatic limbs i.e. % of 84
Common femoral	1	0.8	0.5	1.2
Superficial femoral	25	19.1	13.3	29.8
Popliteal	8	6.1	4.3	9.5
Anterior tibial	40	30.5	21.3	47.6
Posterior tibial	40	30.5	21.3	47.6
Peroneal	14	10.7	7.4	16.7
Profunda femoris	3	2.3	1.6	3.6
	131	100.0		

Leg artery occlusion was present in 66 asymptomatic limbs, i.e. in 35.1%, of the asymptomatic limbs examined, and in 78.6% of the occluded asymptomatic limbs.

In 52 limbs, leg artery occlusion occurred in the absence of complete occlusion in femoro-popliteal segment or in the profunda femoris, i.e. in 27.7% of all the asymptomatic limbs examined and in 61.9% of those with occlusion.

Single leg artery occlusion occurred as the sole occlusion in the asymptomatic limb in 32 limbs, i.e. in 17% of the asymptomatic limbs, and in 38.1% of those with occlusion, In these limbs the ratio of occlusion in the three arteries was 7.5 anterior tibial : 7.7 posterior tibial : 1 peroneal. In 20 limbs (i.e. 10.6% of the asymptomatic ones examined), multiple leg artery occlusion occurred in the absence of proximal occlusion. Here the ratio of occlusions was 2.1 anterior tibial : 2.3 posterior tibial : 1 peroneal.

\- - - -

In 14 limbs - 7.4% of all the asymptomatic limbs, and 16.7% of those with occlusion - leg artery occlusion occurred with femoro-popliteal and/or profunda femoris occlusion.

In 10 (71.4%) of these 14 limbs (i.e. in 5.3% of all asymptomatic limbs and in 11.9% of the occluded asymptomatic limbs) the occlusion involved a single leg artery, 5 in the anterior tibial, 3 in the posterior tibial and 2 in the peroneal i.e. a ratio of 2.5 : 1.5 : 1.

Multiple leg artery occlusion in association with femoro-popliteal occlusion, or occlusion in profunda femoris, occurred in 4 (28.6%) of these 14 limbs (i.e. in 2.1% of the asymptomatic limbs and in 6.9% of the occluded asymptomatic limbs). In this group there were three double leg artery occlusions, with two anterior tibial occlusions, 3 posterior tibial occlusions and one peroneal occlusion - ratio of 2 : 3 : 1.

Occlusion of all three leg arteries occurred once (i.e. in 0.5% of the asymptomatic limbs and in 1.2% of these with occlusion).

Proximal artery occlusion occurred on its own, without leg artery occlusion in 18 limbs, i.e. in 9.6% of all limbs and in 21.4% of these with occlusion.

- - - -

Occlusion Length.

The mean length of the 33 occlusions involving the femoro-popliteal segment was 12.8 cms.

The histogram (Figure 85) of the femoro-popliteal occlusions on the asymptomatic side in men with claudication shows a more shallow form than on the symptomatic side with a low peak of incidence of occlusion around the 25 cm. level, - some five cms. proximal to that on the symptomatic side. There is, of course, the possibility that the difference in form of the histograms for the symptomatic and the asymptomatic side may be due simply to the marked disparity.in the numbers of occlusions found, but the summits of the two curves are not parallel. The appearances suggest that the occlusions on the symptomatic side have a less marked tendency to be especially prevalent at the adductor opening but are more scattered throughout the femoral artery, and to be infrequent in the popliteal artery.

The average length of anterior tibial occlusion in the asymptomatic side was 21.3 cms.

The histogram of occlusions in this artery in these limbs (Figure 86) shows a summit curve which is flatter than that of the occlusions on the symptomatic side, with no peak. The number of occlusions rises steadily and rapidly from the origin of the artery to the - 9 cm. level and shows only a very minimal increase from there to the - 27 cm. level, in contrast to the symptomatic side where the number of occlusions did not cease to increase until about - 17 cms. A similar fall-off in the number of occlusions is seen below the 30 cm. level. Again this may be caused by the lack of demonstration of many of the distal anterior tibial arteries.

The average length of posterior tibial occlusions in the asymptomatic limbs in claudicating men was 18.4 cms.

The histogram of occlusions in this artery (Figure 87) shows the summit curve to be almost identical with that in the symptomatic limb. The same slowly increasing number of occlusions with increasing distance from the knee joint occurs in both the symptomatic and the asymptomatic limbs. Similarly the decrease in numbers of occlusions below the - 30 cms. level takes a strikingly similar curve in both symptomatic and asymptomatic limbs.

In the peroneal artery the average length of occlusion was 14.9 cms. The curve of the summit of the histogram (Figure 88) is similar to that of the symptomatic side - flat, with no peak.

- - - -

Women

Symptomatic

52 (72.2%) of the 72 symptomatic limbs examined in women with claudication showed complete occlusion at some level.

In the 15 women with right sided claudication, 13 (86.7%) showed occlusion on that side, while in the 17 with left sided claudication 13 (76.5%) showed occlusion. The 20 patients with bilateral claudication had complete occlusion in 26 (65%) of the 40 symptomatic limbs.

What occlusion patterns occurred in the symptomatic limbs of women with claudication?

These are shown in Table 48.

TABLE 48

Symptomatic Limbs in Women with claudication

Occlusion Patterns	Number	% of all symtomatic limbs in inter. claud. in women i.e. % of 72.	% of all symtomatic limbs in inter. claud. in women i.e. % of 52. (with occlusion.)
Superficial femoral alone	17	23.6	32.7
Superficial femoral and profunda femoris	1	1.4	1.9
Superficial femoral and anterior tibial	2	2.8	3.8
Superficial femoral and posterior tibial	4	5.6	7.7
Superficial femoral and peroneal	1	1.4	1.9
Superficial femoral, popliteal	4	5.6	7.7
Superficial femoral, popliteal and posterior tibial	1	1.4	1.9
Superficial femoral, popliteal, anterior tibial and posterior tibial	2	2.8	3.8
Superficial femoral, popliteal, posterior tibial and peroneal	1	1.4	1.9

TABLE 48 (continued)

Occlusion Patterns	Number	% of all symtomatic limbs in inter. claud. in women i.e.% of 72.	% of all symtomatic limbs in inter. claud. in women i.e.% of 52. (with occlusion)
Popliteal alone	2	2.8	3.8
Popliteal, anterior tibial and posterior tibial	1	1.4	1.9
Popliteal, posterior tibial and peroneal	1	1.4	1.9
Popliteal, anterior tibial, posterior tibial and peroneal	3	4.2	5.8
Anterior tibial	5	6.9	9.6
Posterior tibial alone	4	5.6	7.7
Posterior tibial and peroneal	1	1.4	1.9
Anterior tibial, posterior tibial and peroneal	2	2.8	3.8
TOTAL	52	77.5	99.7

17 different occlusion patterns occurred.

The commonest occlusion pattern was occlusion of the superficial femoral artery alone. This occurred 17 times - in 23.6% of all the symptomatic limbs in this group, and in 32.7% of those with complete occlusion.

The second commonest occlusion pattern, seen 5 times was occlusion of the anterior tibial artery alone. This was present in 6.9% of all the symptomatic limbs, and in 9.6% of those with occlusion.

Three occlusion patterns, each occurring in four limbs, were the third commonest. These were -

(a) superficial femoral plus popliteal artery occlusion;

(b) superficial femoral plus posterior tibial artery occlusion;

(c) posterior tibial artery occlusion alone.

Each of these patterns occurred in 5.6% of all the symptomatic limbs, and in 7.7% of those with occlusion.

The sixth commonest pattern, seen 3 times, in 4.2% of all the symptomatic limbs, and in 5.8% of those with occlusion, was occlusion of the popliteal artery, plus all three leg arteries.

These six patterns account for the occlusions in 37 limbs, i.e. in 51.4% of all the symptomatic limbs and in 71.2% of the occluded limbs.

The other 11 occlusion patterns were found in either 1 or 2 limbs only.

The number and incidence of occlusion in individual arteries on the symptomatic side in women with claudication is shown in the following Table.

TABLE 49

Artery	No. of Occls.	% of all occlns. in the symptomatic limbs i.e. % of 93	% incidence in all symptomatic limbs i.e. % of 72	% incidence in the occluded symptomatic limbs i.e. % of 52
Common femoral	-	-	-	-
Superficial femoral	33	35.4	45.8	63.5
Popliteal	15	16.1	20.8	28.8
Anterior tibial	15	16.1	20.8	28.8
Posterior tibial	20	21.5	27.8	38.5
Peroneal	9	9.7	12.5	17.3
Profunda femoris	1	1.1	1.4	1.9
	93	99.9		

Leg artery occlusion occurred in 28 limbs, i.e. in 38.9% of the symptomatic limbs and in 53.8% of those with occlusion.

In 12 limbs, i.e. in 16.7% of the symptomatic limbs and in 23.1% of the occluded ones, leg artery occlusion occurred in the absence of occlusion elsewhere in the lower limb. When leg artery occlusion was unassociated with proximal occlusion the ratio of anterior tibial: posterior tibial: peroneal occlusion was 2.3 : 2.3 : 1, where only one leg artery was occluded the ratio was 5 : 4 : 1 and where multiple leg artery occlusions were present the ratio was 0.7 : 1 : 1.

\- - - -

In 16 limbs (i.e. 22.2% of all limbs and in 30.8% of those with occlusion) leg artery occlusion occurred in association with occlusion in the femoro-popliteal segment or profunda femoris. 8 of these 16 limbs (i.e. 50%) showed occlusion of one leg artery - 2 in the anterior tibial artery, 5 in the posterior tibial artery and 1 in the peroneal artery. The ratio of occlusion in these limbs was 2 : 5 : 1.

A further 5 limbs (31.3% of these 16 limbs) showed double leg artery occlusion (3 anterior plus posterior tibial artery occlusion, and 2 posterior tibial plus peroneal artery occlusions) with femoro-popliteal occlusion. The ratio of anterior tibial: posterior tibial: peroneal occlusion was 1.5 : 2.5 : 1.

In three patients occlusion of the three leg arteries was found in association with femoro-popliteal occlusion.

\- - - -

Occlusion of the proximal arteries alone occurred in 24 limbs, i.e. in 33.3% of all the symptomatic limbs in this group, and in 46.2% of those with occlusion.

\- - - -

Occlusion Lengths

The mean length of the 48 occlusions in the femoro-popliteal segment was 15.6 cms.

The histogram (Figure 85) of the femoro-popliteal occlusions shows, on the symptomatic side, in women with claudication, a much flatter summit curve than is seen in men in the similar group. The peak of the curve is small compared with the men and more diffuse, occurring over the segment between 20 and 26 cms. above the knee, i.e. at a more proximal level than in the men.

In these limbs the rapid decrease in occlusion numbers between the 20 cm. level and the knee joint which occurs in the symptomatic limbs of the claudicating men, is not seen. The histogram in the women shows a steep drop betwenn the 20 and 17 cm. levels, and below that, a slow decrease in numbers of occlusions, demonstrating a tendency to a more diffuse popliteal artery occlusion rather than the predominance of occlusion in the upper popliteal artery seen in the men.

\- - - -

The average length of the anterior tibial artery occlusions on the symptomatic side in women with claudication was 17.5 cms.

In the histogram (Figure 86) of these occlusions the appearances are different from those in the symptomatic male limbs. The number of occlusions rises rapidly from the origin of the artery to the - 12 cm. level and then slowly, but steadily decreases through the remainder of the artery. This is in contrast to the male limbs in which the number of occlusions increases to the - 17 cm. level, remains virtually static for 10 cms. and then decreases.

\- - - -

The average length of posterior tibial artery occlusion in the symptomatic limbs of women with claudication was 19.4 cms.

In the histogram (Figure 87) the number of occlusions is seen to rise rapidly from the origin of the artery to the - 13 cm. level and to remain almost steady to the - 29 cm. level, when it falls rapidly. It has a different summit curve from the histogram of the male limbs where the number of occlusions continue to rise to the - 30 cm. level.

\- - - -

The average length of peroneal artery occlusion on the symptomatic side in women with claudication was 14.1 cms.

There were only 9 occlusions in this artery and little can be deduced from the histogram (Figure 88) other than the absence of any clear peak.

- - - -

Asymptomatic Side

29 asymptomatic limbs were examined, 15 (51.7%) showing complete occlusion. Of the 14 left limbs examined in women with right sided claudication, 8 (57.1%) showed complete occlusion, as did 7 (46.7%) of the 15 right limbs examined in women with left sided claudication.

The 9 occlusion patterns which occurred are shown in Table 50.

TABLE 50

Asymptomatic Limbs in Claudication in Women

Occlusion Patterns	Number	% of allasym-tomatic limbs in women with inter. claud. i.e. % of 29	% of all asym-tomatic limbs occluded in women with claudication i.e. % of 15.
Superficial femoral	2	6.9	13.3
Superficial femoral and anterior tibial	1	3.4	6.7
Superficial femoral and posterior tibial	1	3.4	6.7
Popliteal	1	3.4	6.7
Popliteal, posterior tibial and peroneal	1	3.4	6.7
Posterior tibial	5	17.2	33.3
Anterior tibial and posterior tibial	1	3.4	6.7
Posterior tibial, peroneal	2	6.9	13.3
Anterior tibial, posterior tibial and peroneal	1	3.4	6.7
TOTAL	15	51.4	100.1

Only three patterns were found more than once.

Posterior tibial occlusion on its own was found in 5 limbs, i.e. in 17.2% of all the limbs examined and in 33.3% of those with occlusion. This was the commonest occlusion.

Occlusion of the superficial femoral artery alone, and of the posterior tibial plus peroneal arteries each occurred in two limbs i.e. in 6.9% of all the symptomatic limbs and in 13.3% of those with occlusion.

Occlusion of the leg arteries was present in 12 of the asymptomatic limbs i.e. in 41.4% of all the asymptomatic limbs and in 80% of those with occlusion.

In 9 limbs i.e. in 31% of all the asymptomatic limbs in this group, and in 60% of the occluded limbs, leg artery occlusion occurred in the absence of femoro-popliteal or profunda femoris occlusion. The numbers are felt to be too small to break up into single and multiple artery occlusion, butthe ratio of anterior tibial: posterior tibial: peroneal artery occlusion in this group is 0.75 : 2.75 : 1.

In 3 limbs i.e. in 10.3% of the asymptomatic limbs and in 20% of those with occlusion, the leg arteries were occluded in association with proximal occlusion. Occlusion of the proximal arteries alone occurred in 3 limbs, i.e. in 10.3% of the asymptomatic limbs and in 20% of those with occlusion.

- - - -

The number and incidence of occlusion in the asymptomatic limbs in women with claudication is shown in the following table -

TABLE 51

Artery	No. of Occl.	% of all occns. in the asymptomatic limbs i.e. % of 24	% incidence in all asymptomatic limbs i.e. % of 29	% incidence in the occluded asymptomatic limbs i.e. % of 15
Common femoral	-	-	-	-
Superficial femoral	4	16.7	13.8	26.7
Popliteal	2	8.3	6.9	13.3
Anterior tibial	3	12.5	10.3	20
Posterior tibial	11	45.8	37.9	73.3
Peroneal	4	16.7	13.8	26.7
Profunda femoris	-	-	-	-
	24	100		

Occlusion Lengths.

The mean length of the 6 occlusions in the femoro-popliteal segment was 14.1 cms.

With this small number of occlusions little can be deduced from the histogram (Figure 85) except that the occlusions are well scattered throughout the segment.

In the anterior tibial artery, where the mean length of the 3 occlusions was 17.5 cms. nothing can be deduced from the histogram (Figure 86). Similarly with the 4 peroneal occlusions, which averaged 14.1 cms. in length (Figure 88).

There were 11 posterior tibial occlusions, the average length of which was 19.4 cms. In this histogram (Figure 87) the summit curve shows a low, wide-based peak between - 20 to - 32 cms. indicating an increased number of occlusions distally in these limbs. This curve is similar to that in this artery in the symptomatic and asymptomatic male limbs.

- - - -

GANGRENE

41 men in the femoro-popliteal tibial group presented with gangrene, 23 (56.1%) with right gangrene. 15 (36.6%) with left gangrene, and 3 (7.3%) with bilateral gangrene. The total number of symptomatic limbs examined in men with gangrene was thus 44.

In these 41 men with gangrene, 24 asymptomatic limbs were examined - 17 left limbs in men with right gangrene, and 7 right limbs in patients with left gangrene.

The number of arteriograms available in men with gangrene is thus 68.

- - - -

20 women presented with gangrene, 9 (45%) on the right, 10 (50%) on the left and 1 (5%) with bilateral gangrene. The total number of symptomatic limbs in women was therefore 21.

12 asymptomatic limbs were examined, 4 left limbs in right sided gangrene and 8 right limbs in left gangrene.

There are thus 33 arteriograms in women with gangrene.

Men

Symptomatic Side.

37 (i.e. 84.1%) of the 44 arteriograms showed complete occlusion at same level.

13 (76.5%) of the 17 limbs examined for right sided gangrene showed occlusion, as did all of the 7 limbs with left sided gangrene. The 3 patients with bilateral gangrene showed occlusion in 4 (66.7%) of the 6 symptomatic limbs.

\- - - -

What occlusion patterns occurred in the symptomatic limbs of men with gangrene?

These are shown in Table 52.

TABLE 52

Symptomatic Limbs in Male Patients with Gangrene

Occlusion Patterns	Number	% of all gangrenous limbs in men i.e. % of 44.	% of all gangrenous limbs in men showing occlusions i.e. % of 37
Common femoral; Superficial femoral posterior tibial and profunda femoris	1	2.3	2.7
Superficial femoral	1	2.3	2.7
Superficial femoral and anterior tibial	3	6.8	8.1
Superficial femoral and posterior tibial	1	2.3	2.7
Superficial femoral, anterior tibial, posterior tibial and peroneal	2	4.5	5.4
Superficial femoral; posterior tibial and profunda femoris	1	2.3	2.7
Popliteal, anterior tibial, posterior tibial	1	2.3	2.7
Popliteal, anterior tibial, posterior tibial and peroneal	1	2.3	2.7

TABLE 52 (continued)

Occlusion Patterns	Number	% pf all gangrenous limbs in men i.e. % of 44.	% of all gangrenous limbs in men showing occlusion i.e. % of 37
Superficial femoral and popliteal	2	4.5	5.4
Superficial femoral, popliteal and anterior tibial	1	2.3	2.7
Superficial femoral, popliteal and posterior tibial	2	4.5	5.4
Superficial femoral, popliteal; anterior tibial and posterior tibial	3	6.8	8.1
Superficial femoral, popliteal, anterior tibial; posterior tibial and peroneal	2	4.5	5.4
Superficial femoral, popliteal, anterior tibial and profunda femoris	1	2.3	2.7
Anterior tibial	1	2.3	2.7
Posterior tibial	1	2.3	2.7

TABLE 52 (CONTINUED)

Occlusion Patterns	Number	% of all gangrenous limbs in men i.e. % of 44	% of all gangrenous limbs in men showing occlusion i.e. % of 37
Peroneal	1	2.3	2.7
Anterior tibial and posterior tibial	3	6.8	8.1
Posterior tibial and peroneal	3	6.8	8.1
Anterior tibial, posterior tibial and peroneal	5	11.4	13.5
Anterior tibial, posteriot tibial, peroneal and profunda femoris	1	2.3	2.7
TOTAL	37	84.2	99.9

There were 21 patterns.

The commonest occlusion pattern occurring in 5 limbs, was occlusion of all three leg arteries with no associated occlusion. This occurred in 11.4% of the symptomatic gangrenous limbs and in 13.5% of those with occlusion.

Four different patterns of occlusion were second in incidence. These were -

(a) anterior tibial, plus posterior tibial artery occlusion.

(b) posterior tibial, plus peroneal artery occlusion.

(c) superficial femoral plus anterior tibial artery occlusion.

(d) superficial femoral, popliteal, anterior and posterior tibial artery occlusion.

They each occurred in 3 limbs, i.e. 6.8% of all limbs and18.1% of those with odusion.

A further four patterns were third in incidence.

These were -

(a) superficial femoral and all three leg artery occlusion.

(b) superficial femoral and popliteal artery occlusion.

(c) superficial femoral, popliteal and posterior tibial artery occlusion.

(d) superficial femoral, popliteal and all three leg artery occlusion.

These each occurred in 2 limbs i.e. in 4.5% of all the symptomatic limbs and in 5.4% of those with occlusion. The other 12 occlusion patterns occurred in one limb only, i.e. in 2.3% of the symptomatic limbs, and in 2.7% of those with occlusion.

- - - -

The number and incidence of occlusion in the symptomatic side, in men with gangrene, is shown in the following Table 53.

TABLE 53.

Artery	No. of Occl.	% of all symptomatic limbs occlusions in men with gangrene i.e. % of 104	% of all symptomatic limbs in men with gangrene i.e. % of 44.	% of all symptomatic occluded limbs in men with gangrene i.e. % of 37
Common femoral	1	1	2.3	2.7
Superficial femoral	20	19.2	45.5	54.1
Popliteal	13	12.5	29.5	35.1
Anterior tibial	24	23.1	54.5	64.9
Posterior tibial	27	26	61.4	73
Peroneal	15	14.4	34.1	40.5
Profunda femoris	4	3.8	9.1	10.8
	104	100.0		

Leg artery occlusion was present in 34 symptomatic limbs, i.e. in 77.3% of all the symptomatic gangrenous limbs and in 91.9% of all the occluded ones.

Occlusion of one or more leg arteries in the absence of occlusion elsewhere was found in 14 limbs i.e. in 31.8% of all the symptomatic gangrenous limbs and in 37.8% of those with occlusion. The ratio of occlusions was anterior tibial: posterior tibial: peroneal = 1 : 1.3 : 1.

Occlusion of a single leg artery as the sole occlusion in the limb was found 3 times, once in each artery.

Multiple leg artery occlusion in the absence of occlusion elsewhere was found in 11 limbs, the ratio of anterior tibial: peroneal occlusion being 1 : 1.4 : 1.

In 20 limbs i.e. 45.5% of all limbs, and in 54.1% of the limbs with occlusion, leg artery occlusion occurred in association with occlusion elsewhere.

Single leg artery occlusion was found in 10 (50%) of these 20 limbs (i.e. in 22.7% of the symptomatic limbs and in 27% of those with occlusion), anterior tibial and posterior tibial each being occluded 5 times.

No peroneal artery occlusion was seen in this group.

Double leg artery occlusion, in association with proximal occlusion, was seen 4 times i.e. in 9.1% of the symptomatic limbs, and in 10.8% of those with occlusion, anterior and posterior tibial arteries being involved in each limb.

Occlusion of all three leg arteries in association with proximal occlusion was found in three limbs i.e. in 6.8% of the symptomatic limbs and 8.1% of those with occlusion.

- - - -

Occlusion of the proximal arteries alone occurred in 3 limbs i.e. in 6.8% of the symptomatic limbs examined and 8.1% of those with occlusion.

- - - -

Occlusion Length.

The mean length of the 33 occlusions in the femoro-popliteal segment in the occluded symptomatic limbs in men with gangrene was 18.5 cms. The histogram of femoro-popliteal occlusions (Figure 85) shows a summit curve which is almost flat between the 20 cm. and 40 cm. level above the knee joint. There is a minimal peak of only three occlusions at the 20 cm. level - at almost the same level as the high peak seen in the occluded limbs in men with claudication. Below this very shallow peak in occlusion numbers, at the inferior end of the plateau of the almost constant number of occlusions between the 20 and the 40 cm. level, the summit of the histogram drops slightly over a distance of 5 cms. and then slowly drops to - 6 cms. The curve of the histogram shows, in its absence of a clear cut peak, the occlusions in the femoro-popliteal segment in the occluded symptomatic limbs of men with gangrene to be generalised and to have no clear cut site of election.

- - - -

The average length of the 24 anterior tibial artery occlusions on the symptomatic side in men with gangrene was 26.3 cms.

The histogram of anterior tibial artery occlusions (Figure 86) shows the summit curve of the numbers of occlusions at each level to be similar to that of the occlusions in the male claudicating limb.
The steady rise in the number of occlusions from the origin of the artery to the - 20 cm. level is similar to but less rapid than in the claudicating limbs. The summit inferior to the - 20 cm. level remains virtually level - indicating a constant number of occlusions from - 20 to - 35 cms., and then falls off, parallel to the fall off shown in the claudicating limbs below 34 cms. But this is the segment of the artery not invariably shown on the original films, and cannot be regarded as an accurate representation of the true radiological pathology.

- - - -

The average length of the 27 posterior tibial artery occlusions was 19.4 cms.

Here the histogram (Figure 87) of the occlusions is different in outline from that of the occlusions in claudication. In gangrene the histogram lacks the steady rise in the number of occlusions from 10 to 30 cms. from theknee joint, seen in claudication. Here the numbers are almost the same at the 10 and 30 cms. levels. (There are 3 more occlusions at the lower level.) Between these levels the numbers of occluded arteries varies dropping slightly between 10 and 15 cms. and between 20 and 27 cms. This histogram suggests that the occlusions are widespread throughout the artery lacking the increasing incidence distally seen in the claudicating limbs. The summit curve, being relatively flat, but with three low peaks due to small local increases in the numbers of occlusions shows that although in general the occlusions are long, there are a number of short occlusions, especially distally below the 27 cms. level.

- - - -

The average length of the 15 peroneal artery occlusions in these limbs is 16.2 cms.

Because of the small numbers too much stress cannot be put on the histogram (Figure 88). It does seem that there is a small peak (5 occlusions more than elsewhere) at 12 cms. below the knee, and that the rest of the histogram summit is almost flat, suggesting in general long occlusions with some short ones near the origin of the artery.

Asymptomatic.

24 asymptomatic limbs were examined in men with gangrene and of these 20 (83.3%) were occluded. 17 left limbs were examined in patients with right sided gangrene, and of these 13 (76.5%) were occluded, while all of the 7 right limbs examined in patients with left sided gangrene were occluded.

Table 54 shows the 14 occlusion patterns shown in these asymptomatic limbs in men with gangrene.

TABLE 54

Asymptomatic Limbs in Male Patients with Gangrene

Occlusion Patterns	Number	% of all asymptomatic limbs examined in men with gangrene i.e. % of 24	% of all asymptomatic limbs in men with gangrene showing occlusion i.e. % of 20
Common femoral, Superficial Femoral, Popliteal and Posterior tibial	1	4.2	5
Superficial femoral alone	1	4.2	5
Superficial femoral and posterior tibial	1	4.2	5
Popliteal, anterior tibial, posterior tibial and peroneal	1	4.2	5
Superficial femoral and popliteal	1	4.2	5
Superficial femoral, popliteal, anterior tibial, posterior tibial and peroneal	2	8.3	10
Superficial femoral, popliteal and profunda femoris	1	4.2	5

TABLE 54 (continued)

Occlusion Patterns	Number	% of all asymptomatic limbs examined in men with gangrene i.e. % of 24	% of all asymptomatic limbs in men with gangrene showing occlusion i.e. % of 20
Anterior tibial	1	4.2	5
Posterior tibial	3	12.5	15
Peroneal	1	4.2	5
Anterior tibial & posterior tibial	4	16.7	20
Posterior tibial and peroneal	1	4.2	5
Anterior tibial and peroneal	1	4.2	5
Anterior tibial, posterior tibial and peroneal	1	4.2	5
TOTAL	20	83.7	100

Eleven patterns occurred once and only three patterns occurred more than once.

The commonest pattern occurring 4 times, i.e. in 16.7% of the asymptomatic limbs and in 20% of those with occlusion was occlusion of the anterior and posterior tibial arteries together.

The next commonest was occlusion of the posterior tibial artery alone, found in 3 limbs i.e. in 12.5% of the asymptomatic limbs and in 15% of the occluded limbs.

Occurring twice, as the third commonest occlusion, was occlusion of the superficial femoral, popliteal and all three leg arteries. This occurred in 8.3% of all the asymptomatic limbs and in 10% of those with occlusion.

- - - -

The numbers of occlusions in individual arteries are shown in the following Table 55.

TABLE 55

Artery	Number	% of all occlusions in the asymptomatic limbs in men with gangrene i.e. % of 46	% incidence in all asymptomatic limbs exam. in men with gangrene i.e. % of 24	% incidence in the asymptomatic limbs in men with gangrene i.e. % of 20 with oclusion
Common femoral	1	2.2	4.2	5
Superficial femoral	7	15.2	29.2	35
Popliteal	6	13	25	30
Anterior tibial	10	21.7	41.7	50
Posterior tibial	14	30.4	58.3	70
Peroneal	7	15.2	29.2	35
Profunda femoris	1	2.2	4.2	5
	46	99.9		

Leg artery occlusion was present in 17 asymptomatic limbs i.e. in 70.8% of all the asymptomatic limbs examined in men with gangrene and in 85% of the occluded limbs.

Occlusion of leg arteries with no occlusion proximally in the limb occurred in 12 limbs, i.e. in 50% of the asymptomatic limbs and in 60% of those with occlusion. The ratio of occlusion was 1.8 anterior tibial : 2.3 posterior tibial : 1 peroneal.

When single leg artery occlusion occurred without proximal occlusion the ratio of anterior tibial occlusion: posterior tibial occlusion: peroneal occlusion was 1 : 3 : 1. In leg occlusion without proximal occlusion this ratio was 1.8 : 2. 3 : 1.

Proximal and leg artery occlusion occurred in 5 limbs, i.e. in 20.8% of the asymptomatic limbs, and in 25% of those with occlusion.

In leg artery occlusion with associated proximal occlusion the ratio was 1 : 1.7 : 1.

- - - -

Femoro-popliteal occlusion, without leg occlusion was present in 3 limbs, i.e. in 12.5% of the asymptomatic limbs and in 15% of these with occlusion.

Occlusion Length

The average length of the 13 femoro-popliteal occlusions in the asymptomatic limbs in men with gangrene was 19.5 cms.

The histogram (Figure 85) of the occlusions in the femoro-popliteal artery in the asymptomatic limbs shows a small peak (3 occlusions) at the 20 cm. level, but otherwise is flat throughout the entire length, indicating that the occlusions are long with a few short bloks at the distal and of the adductor canal.

- - - -

Figure 86 shows the histogram of the 10 anterior tibial artery occlusions in these limbs. The average length of these occlusions was 22.2 cms. Compared with that of the symptomatic limbs, this histogram shows the same pattern of increase in the number of occlusions in the upper 10 cms. of the artery, beyond which the number of occlusions remains virtually constant. This illustrates a tendency for these occlusions to be scattered throughout the artery, rather than be more frequent between 20 and 35 cms. from the knee, as in the symptomatic limbs.

This illustrates a tendency for these occlusions to be scattered throughout the artery, rather than be more frequent between 20 and 35 cms. from the knee, as in the symptomatic limbs.

The average length of the 14 posterior tibial artery occlusions was 19.9 cms. The histogram of the occlusions in this artery (Figure 87) is shown with minor differences of 2 or 3 occlusions, to be identical in outline with that on the symptomatic side. It shows a steadily increasing number of occlusions over the upper 10 cms. of the artery, to the flat summit line, indicating a generalised distribution of occlusion in this artery.

The peroneal artery, occluded in 7 limbs, showed an average occlusion length of 21.3 cms.

These numbers are so small that little can be deduced from the histogram (Figure 88) of these occlusions. The summit line is flat, broken only by differences of one occlusion, between 10 and 35 cms. from the knee joint. Below the 35 cm. level the numbers of occlusions decreases, but, like the other leg arteries, this is unrealistic as a demonstration of the occlusion distally in the artery, since so many legs were not shown in their entirety.

Women

Symptomatic Side

21 symptomatic limbs with gangrene were examined and of these, 16 (76.2%) showed occlusion.

Of the 9 limbs examined in right sided gangrene, 7 (77.8%) were occluded, while 7 (70%) of the 10 limbs with left gangrene were, as were both limbs in the patient with bilateral gangrene.

Table 56 shows the 11 occlusion patterns found in these limbs.

TABLE 56

Female - Symptomatic Limbs in Gangrene

Occlusion Patterns	Number	% of all symptomatic gangrenous limbs in women i.e. % of 21	% of all symptomatic and occluded limbs gangrenous in women i.e. % of 16
Common femoral, Superficial femoral, anterior tibial and profunda femoris	1	4.8	6.3
Common femoral, Superficial femoral, popliteal and profunda femoris	1	4.8	6.3
Superficial femoral alone	2	9.5	12.5
Superficial femoral, popliteal and posterior tibial	1	4.8	6.3
Superficial femoral, popliteal, anterior tibial, posterior tibial and peroneal	2	9.5	12.5
Popliteal and posterior tibial	1	4.8	6.3
Popliteal, peroneal and profunda femoris	1	4.8	6.3
Popliteal, anterior tibial, posterior tibial, peroneal &prpfunda femoris	1	4.8	6.3

TABLE 56 (continued)

Occlusion Patterns	Number	% of all symptomatic gangrenous limbs in women i.e. % of 21	% of all occl. symptomatic gangrenous limbs in women i.e. % of 16
Anterior tibial	3	14.3	18.8
Posterior tibial and peroneal	2	9.5	12.5
Posterior tibial, peroneal and profunda femoris	1	4.8	6.3
TOTAL	16	76.4	100.4

The commonest occlusion pattern was occlusion of the anterior tibial artery alone. This was seen in 3 limbs, i.e. in 14.3% of the limbs examined, and in 18.8% of those with occlusion.

Three occlusion patterns occurred in 2 limbs each.

These were -

(a) superficial femoral artery alone

(b) posterior tibial and peroneal arteries.

(c) superficial femoral and popliteal arteries, with all three arteries in the leg occluded also.

These three patterns were the second most frequent in this group, each occurring in 2 limbs, i.e. in 9.5% of the limbs and in 12.5% of those with occlusion

The other 7 occlusion patterns were each seen in only one limb, i.e. in each 4.8% of the symptomatic limbs and in 6.3% of those with occlusion.

- - - -

The other 7 occlusion patterns were each seen in only one limb, i.e. each in 4.8% of the symptomatic limbs and in 6.3% of those with occlusion.

The number and incidence of occlusions in the symptomatic limbs of women with gangrene is shown in the following table.

TABLE 57

Artery	Number	% of all occls. in the symptomatic limbs of women with gangrene i.e.% of 43	% of all symptomatic limbs in women with gangrene i.e. % of 21	% of all symptomatic limbs with occlusion in women with gangrene % of 16
Common femoral	2	4.7	9.5	12.5
Superficial femoral	7	16.3	33.3	43.8
Popliteal	7	16.3	33.3	43.8
Anterior tibial	7	16.3	33.3	43.8
Posterior tibial	8	18.6	38.1	50
Peroneal	7	16.3	33.3	43.8
Profunda	5	11.6	23.8	31.3
	43	100.1		

Leg artery occlusion was present in 13 symptomatic limbs, i.e. in 61.2% of the symptomatic limbs and in 81.3% of the occluded ones.

Occlusion of one or more leg arteries in the absence of occlusion elsewhere was found in 5 limbs i.e. in 23.8% of the symptomatic limbs and in 31.3% of the occluded limbs. The ratio of occlusions in anterior tibial: posterior tibial: peroneal: was 1.5 : 1 : 1.

A further breakdown of leg artery occlusion seems unhelpful, in view of the small numbers.

- - - -

In 8 limbs i.e. in 38.1% of the symptomatic limbs, and in 50% of those with occlusion, occlusion was present in the proximal arteries, as well as in the leg. Single leg artery occlusion was found in 4 of these limbs i.e. in 19% of all the asymptomatic limbs and in 25% of those with occlusion. Occlusion of two leg arteries in association with proximal occlusion was found once, and occlusion of all three leg arteries with proximal occlusion, in three limbs. In these limbs the ratio of anterior tibial: posterior tibial: peroneal occlusion was 0.8 : 1.2 : 1.

Proximal occlusion i.e. of the femoro-popliteal segment and/or profunda femoris without distal occlusion occurred in 3 limbs, i.e. in 14.3% of all the symptomatic limbs and in 18.8% of those with occlusion.

- - - -

<u>Occlusion Lengths</u>

The average length of the 14 occlusions in the femoro-popliteal segment was 20.4 cms.

So far as the histogram of these occlusions (Figure 85) is concerned it seems unwise to attempt to draw much from this small number, but there is a slightly increased incidence of occlusion at 25 cms. above the knee, in the upper popliteal artery, and at and just inferior to the knee joint.

The average length of the 7 anterior tibial artery occlusions was 24.8 cms. Again the inadvisability of attempting to draw conclusions from the histogram (Figure 86) of these few occlusions must be borne in mind. All that can be taken from the histogram is that there is a minimal increase in the number of occlusions in the middle third of the artery, from the 17 to the 25 cm. level below the knee.

Similarly with the 8 posterior tibial artery occlusions, the average length of which was 16.1 cms., no attempt has been made to draw conclusions from the histogram (Figure 87). It is shown that, here, as in the anterior tibial artery, there is a slightly larger number of occlusions in the middle third of the artery, with a slow decrease in numbers proximally and distally.

The histogram (Figure 88) of the 7 peroneal occlusions, the average length of which was 21.4 cms. shows a flat summit line between 10.5 and 32.5 cms. from the knee joint, indicating a generalised incidence of occlusion throughout that artery. Again as in the other arteries in this group, little can be deduced from these small numbers.

- - - -

Asymptomatic Limbs.

12 asymptomatic limbs were examined in women with gangrene, and of these 6 (50%) showed occlusion. 3 (75%) of the 4 left limbs examined in patients with gangrene on the right side were occluded, as were 3 (37.5%) of the 8 right limbs examined in women with left sided gangrene.

The three occlusion patterns seen in these 6 limbs are shown in Table 58.

TABLE 58

Female - Asymptomatic Limbs in Gangrene

Occlusions Patterns	Number	% of all asymptomatic limbs in women with gangrene i.e. % of 12	% of all asymptomatic limbs in women with occlusions with gangrene i.e. % of 6
Posterior tibial	3	25	50
Anterior tibial and posterior tibial	2	16.7	33.3
Posterior and peroneal	1	8.3	16.7
TOTAL	6	50.0	100.0

With this tiny number of limbs it seems worthless to attempt to break down these occlusions further.

In the occluded limbs the occlusion was of leg arteries only, the ratio of anterior tibial: posterior tibial: peroneal occlusion being 2 : 6 : 1.

The numbers of occlusions in individual arteries are shown in the following Table 59.

TABLE 59

Artery	Number	% of occlusions at the asympto-matic limbs of women with gangrene i.e. % of 9	% incidence in all asymptomatic limbs in women with gangrene i.e. % of 12	% incidence in all asymptomatic limbs with occlusion in women with gangrene i.e. % of 6
Common femoral	-	-	-	-
Superficial femoral	-	-	-	-
Popliteal	-	-	-	-
Anterior tibial	2	22.2	16.7	33.3
Posterior tibial	6	66.7	50	100
Peroneal	1	11.1	8.3	16.7
Profunda femoris	-	-	-	-
	9	100		

Occlusion length.

The two anterior tibial artery occlusions averaged 26.5 cms. and each is shown in the histogram (Figure 86) to be long.

In the 6 posterior tibial artery occlusions, the average length was 16.8 cms. The histogram (Figure 87) shows these to be a minimal preponderance of occlusion in the lower half of the artery with a peak at - 20 cms., but the numbers are so small that they must be regarded as of little significance.

The single peroneal artery occlusion was 22.5 cms. long and situated in the symmetrical mid part of the artery (Figure 88).

- - - -

Pregangrene.

30 men presented in the femoro-popliteal tibial group with pregangrene, 18 (60%) on the right, and 12 (40%) on the left. There were no men with bilateral pregangrene. There were thus 30 symptomatic limbs in men with pregangrene.

Only 16 (53.3%) of these men were examined on the asymptomatic side, 9 (56.3%) on the left side in right pregangrene, and 7 (43.8%) on the right side in left pregangrene.

There were then 46 arteriograms available in these 30 men with pregangrene.

15 women were examined because of pregangrene, 6 (40%) involving the right side, 8 (53.3%) on the left, and 1 (6.7%) bilateral. There were therefore 16 symptomatic limbs in women with pregangrene.

11 asymptomatic limbs were examined in women with pregangrene, 5 (45.5%) on the left in patients with right sided pregangrene, and 6 (54.5%) right limbs in women with left pregangrene.

27 limbs were thus examined in women with pregangrene.

- - - -

Men

Symptomatic

28 (93.3%) of the 30 symptomatic limbs examined showed complete occlusion, 17 (94.4%) of the 18 limbs with right sided pregangrene were occluded, as were 11 (91.7%) of the 12 with left pregangrene.

The occlusion patterns found in these limbs are shown in Table 60.

TABLE 60

Symptomatic Limbs in Men with Pregangrene

Occlusion Patterns	Number	% of all symptomatic limbs in men with pregangrene i.e. % of 30	% of all occluded symptomatic limbs in men with pregangrene i.e. % of 28
Common femoral	1	3.3	3.6
Common femoral, popliteal and posterior tibial	1	3.3	3.6
Common femoral, superficial femoral posterior tibial and profunda femoris, popliteal.	1	3.3	3.6
Superficial femoral	2	6.7	7.1
Superficial femoral and posterior tibial	1	3.3	3.6
Popliteal and posterior tibial	4	13.3	14.3
Popliteal, anterior tibial and peroneal	1	3.3	3.6
Popliteal, anteriot tibial, posterior tibial and peroneal	1	3.3.	3.6

TABLE 60 (continued)

Occlusion Patterns	Number	% of all symptomatic limbs in men with pre-gangrene i.e. % of 30	% of all occluded symptomatic limbs in men with pre-gangrene i.e. % of 28
Popliteal, anterior tibial, posterior tibial, peroneal & profunda femoris	1	3.3	3.6
Superficial femoral, popliteal and anterior tibial	1	3.3	3.6
Superficial femoral, popliteal and posterior tibial	2	6.7	7.1
Superficial femoral popliteal, anterior tibial and posterior tibial	2	6.7	7.1
Superficial femoral, popliteal, posterior tibial and peroneal	1	3.3	3.6
Anterior tibial	2	6.7	7.1
Posterior tibial	1	3.3	3.6
Peroneal	1	3.3	3.6

TABLE 60 (continued)

Occlusion Patterns	Number	% of all symptomatic limbs in men with pre-gangrene i.e. % of 30	% of all occluded symptomatic limbs in men with pre-gangrene i.e. % of 28
Anterior tibial and posterior tibial	1	3.3	3.6
Posterior tibial and peroneal	3	10	10.7
Anterior tibial, posterior tibial; peroneal and profunda femoris	1	3.3	3.6
TOTAL	28	93.0	100.2

There were 19 occlusion patterns.

The commonest occlusion pattern, occurring in 4 limbs, i.e. in 13.3% of the limbs examined and in 14.3% of those with occlusion, was occlusion of the popliteal and posterior tibial arteries together.

The next commonest occlusion pattern seen in 3 limbs i.e. in 10% of the limbs examined and in 10.7% of those with occlusion, was occlusion of the posterior tibial and peroneal arteries together.

Four occlusion patterns, each found in 2 limbs, i.e. in 6.7% of all the limbs and in 7.1% of those with occlusion, come third in order of frequency.

These were occlusions of -

(a) superficial femoral artery alone.

(b) superficial femoral, popliteal and posterior tibial arteries.

(c) superficial femoral, popliteal, anterior and posterior tibial arteries.

(d) anterior tibial artery occlusion alone.

The remaining 13 occlusion patterns were found in one limb only, i.e. in 3.3% of the symptomatic limbs, and in 3.6% of these with occlusion.

- - - -

The number and incidence of occlusions in individual arteries is shown in the following table.

TABLE 61

Artery	Number	% of all symptomatic limbs occlusions in men with pre-gangrene i.e. % of 70	% incidence in all symptomatic limbs in men with pregangrene i.e. % of 30	% incidence in all occluded symptomatic limbs in men with pregangrene i.e. % of 28
Common femoral	3	4.3	10	10.7
Superficial femoral	10	14.3	33.3	35.7
Popliteal	15	21.4	50	53.6
Anterior tibial	10	14.3	33.3	35.7
Posterior tibial	20	28.6	66.7	71.4
Peroneal	9	12.9	30	32.1
Profunda femoris	3	4.3	10	10.7
	70	100.1		

Leg artery occlusion was present in 25 limbs i.e. in 83.3% of all symptomatic limbs and in 89.3% of those with occlusion.

Occlusion of leg arteries in the absence of occlusion proximally in the limb was present in 8 limbs i.e. in 26.7% of all limbs, and in 28.6% of those with occlusion. The ratio of occlusion in the anterior tibial: posterior tibial: peroneal arteries was 0.8 : 1.3 : 1.

Single leg artery occlusion occurred 4 times, the ratio of occlusions being 2 : 1 : 1.

Multiple leg artery occlusion occurred 4 times, the ratio of occlusinns being 0.3 anterior tibial : 1.3 posterior tibial : 1 peroneal.

- - - -

Leg artery occlusion plus occlusion in the femoro-popliteal and profunda segments was found in 17 limbs, i.e. in 56.7% of all the limbs examined and in 60.7% of those with occlusion. In these limbs, single leg artery occlusion was seen 10 times i.e. in 33.3% of all the limbs examined, and 35.7% of those with occlusion. There were 9 posterior tibial artery occlusions to 1 anterior tibial artery occlusion. No peroneal artery occlusion occurred in this group. Double leg artery occlusion occurred 4 times i.e. in 13.2% of the symptomatic limbs and in 14.3% of the occluded limbs. In these limbs the ratio of occlusions was 1.5 anterior tibial : 1.5 posterior tibial : 1 peroneal. Occlusion of all three arteries was found in 3 limbs i.e. in 10% of the symptomatic limbs and in 10.7% of these with occlusion.

\- - - -

Proximal occlusion in the absence of leg occlusion occurred in 3 limbs, i.e. in 10% of the limbs examined and in 10.7% of those with occlusion.

\- - - -

Occlusion Length.

The average length of the 25 femoro-popliteal occlusions was 19.3 cms.

The histogram (Figure 85) of these occlusions shows a slowly increasing number of occlusions from the proximal end of the superficial femoral artery to the 20 cm. level above the knee, with a relatively static number of occlusions from there to - 5 cms. with a low peak at 5 cms. The appearances show there to be a tendency for the occlusions to involve the distal femoral and popliteal arteries more than the proximal superficial femoral artery.

The average length of the 10 anterior tibial occlusions was 17.4 cms. The histogram (Figure 86) of these occlusions shows a very constant number of occlusions throughout the artery, with a slight increase between the 25 and 30 cms. level from the knee joint.

The histogram of the 20 posterior tibial artery occlusions (Figure 87) the average length of which was 19.7 cms., shows a rising number of occlusions from the 0 to 13 cm. level below the knee joint and from there to the 31 cm. level, a level incidence of occlusion, with a decrease in the number of occlusions, below the 32 cm. level, again the fallacy in this segment must be borne in mind. There is no clear cut peak incidence of occlusion.

The average length of the 9 peroneal occlusion was 20.7 cms. Here, the histogram of occlusions (Figure 88) shows that the number of occlusions slowly increases in the upper 5 cms. of the artery, remains almost level for over 30 cms. and then falls off. The histogram shows no peak in incidence of occlusion, but the numbers are too small for this histogram to be regarded as reliable.

- - - -

Asymptomatic Limbs.

16 asymptomatic limbs in men with pregangrene were examined. 12 (75%) were occluded.

Of the 9 left limbs examined in patients with right pregangrene, 7 (77.8%) were occluded, and of the 7 right limbs examined in patients with left pregangrene 5 (71.4%) were occluded.

10 occlusion patterns were found in these limbs and are shown in Table 62.

TABLE 62

Asymptomatic Limbs in Men with Pregangrene

Occlusions patterns	Number	% of all asymptomatic limbs in men with pregangrene i.e. % of 16	% of all asymptomatic limbs with occlusion in men withpregangrene i.e. % of 12
Superficial femoral	1	6.3	8.3
Superficial femoral and profunda femoris	1	6.3	8.3
Superficial femoral and peroneal	1	6.3	8.3
Popliteal, posterior tibial and peroneal	2	12.5	16.7
Superficial femoral, popliteal, posterior tibial & peroneal	1	6.3	8.3
Posterior tibial	2	12.5	16.7
Anterior tibial and posterior tibial	1	6.3	8.3
Posterior tibial and peroneal	1	6.3	8.3

TABLE 62 (continued)

Occlusion Patterns	Number	% of all asymptomatic limbs in men with pre-gangrene i.e. % of 16	% of all asymptomatic limbs with occlusion in men with pre-gangrene i.e. % of 12
Anterior tibial, posterior tibial and peroneal	1	6.3	8.3
Posterior tibial and profunda femoris	1	6.3	8.3
TOTAL	12	75.4	99.8

Two patterns occurred in two limbs. These were -

(a) posterior tibial artery occlusion.

(b) popliteal, posterior tibial and peroneal artery occlusion.

These were the two commonest patterns each occurring in 12.5% of the symptomatic limbs and 16.7% of those with occlusion.

The other 8 patterns each occurred in one limb only, i.e. each in 6.3% of the asymptomatic limbs and in 8.3% of those with occlusion.

The numbers and incidence of occlusion in individual arteries is shown in the following table.

TABLE 63

Artery	No. of Occls.	% of all asymptomatic limb occ. in men with pregangrene i.e. % of 26	% incidence in all asymptomatic limbs in men with pregangrene i.e. % of 16	% incidence in all asymptmatic limbs with occl. in men with pregangrene i.e. % of 12
Common femoral	-	-	-	-
Superficial femoral	4	15.4	2.5	33.3
Popliteal	3	11.5	18.8	25
Anterior Tibial	2	7.7	12.5	16.7
Posterior Tibial	9	34.6	56.3	75
Peroneal	6	23.1	37.5	50
Profunda femoris	2	7.7	12.5	16.7
	26	100		

Leg artery occlusion was present in 10 limbs, i.e. in 62.5% of all the asymptomatic limbs, and in 83.3% of those with occlusion.

The numbers are so small that it seems enough to compare the limbs in which there was leg artery occlusion alone, and those with leg and proximal artery occlusion. Leg artery occlusion alone, and leg artery occlusion in association with proximal occlusions each occurred in 5 limbs, i.e. in 31.3% of all the asymptomatic limbs, and in 41.7% of those with occlusion. In those in whom leg artery occlusion occurred alone, the occlusion ratio was 1 anterior tibial : 2.5 posterior tibial : 1 peroneal, while in those limbs where leg and proximal occlusion occurred together the ration was 0 : 1 : 1.

Proximal occlusion alone occurred in 2 limbs, i.e. in 12.5% of all the asymptomatic limbs examined and in 16.7% of those with occlusion.

- - - -

Occlusion Lengths.

The average length of the 7 occlusions in the femoro-popliteal segment in the asymptomatic limbs of men with pregangrene was 15.6 cms. With this small number it is impossible to conclude more from the histogram (Figure 85) than that these few occlusions are spread generally throughout the artery, with no peak incidence at any site.

The average length of the 2 anterior tibial occlusions was 17.3 cms. Again, with this number, no conclusion can be drawn from the histogram (Figure 86).

The average length of the 9 posterior tibial occlusions was 23.2 cms. From the histogram (Figure 87) the curve of the summit line is seen to be parallel to that of the histogram of the occlusions on the symptomatic side. There is no peak, simply a general distribution of occlusions throughout the artery.

In the peroneal artery the average length of the 6 occlusions was 9.7 cms. The histogram (Figure 88) shows a general distribution of the occlusions, but a small peak of incidence is shown at - 12 cms. from the base line.

3 - - - -

Women

Symptomatic side.

13 (i.e. 81.3%) of the 16 limbs examined showed complete occlusion at some level.

5 (83.3%) of the 6 limbs examined because of right pregangrene, were occluded, and all (100%) of the 8 left limbs with pregangrene were occluded. Neither of the 2 limbs examined in bilateral pregangrene was occluded.

What occlusion patterns were found in these limbs?

There were 10, shown in Table 64.

TABLE 64

Symptomatic Limbs in Women with Pregangrene

Occlusion Patterns	Number	% of all symptomatic limbs in women with pregangrene i.e. % of 16	% of all symptomatic limbs in women with complete occlusion with pregangrene i.e. % of 13
Superficial femoral and posterior tibial	1	6.3	7.7
Superficial femoral and popliteal	1	6.3	7.7
Superficial femoral; popliteal; anterior tibial and posterior tibial	1	6.3	7.7
Superficial femoral, popliteal, anterior tibial, posterior tibial and peroneal	1	6.3	7.7
Superficial femoral, popliteal, anterior tibial, posterior tibial peroneal and profunda femoris	1	6.3	7.7
Popliteal, anterior tibial and posterior tibial	2	12.5	15.4

TABLE 64 (continued)

Occlusion Patterns	Number	% of all symptomatic limbs in women with pre-gangrene i.e. % of 16	% of all symptomatic limbs in women with complete occlusion with pregangrene i.e. % of 13
Popliteal, anterior tibial, posterior tibial and peroneal	2	12.5	15.4
Popliteal, anterior tibial, peroneal and profunda femoris	1	6.3	7.7
Posterior tibial	1	6.3	7.7
Posterior tibial and peroneal	2	12.5	15.4
TOTAL	13	81.6	100.1

Three occlusion patterns occurred in 2 limbs each i.e. in 12.5% of the limbs examined and in 15.4% of those with occlusion.

These were -

(a) popliteal, anterior tibial and posterior tibial artery occlusion.

(b) popliteal, anterior tibial, posterior tibial and peroneal artery occlusion.

(c) posterior tibial and peroneal artery occlusion.

The other 7 occlusion patterns occurred once only, i.e. 6.3% of all limbs and in 7.7% of those with occlusion.

The number and incidence of occlusion in individual arteries is shown in the following table.-

TABLE 65

Artery	No. of Occlns.	% of all symptomatic limb occlusions in women with pre-gangrene i.e.% of 42	% incidence in all symptomatic limbs in women with pregangrene i.e. % of 16	% incidence in all symptomatic limbs in women with pregangrene i.e. % of 13 (occlusion)
Common femoral	-	-	-	-
Superficial femoral	5	11.9	31.3	38.5
Popliteal	9	21.4	56.3	69.2
Anterior tibial	8	19	50	61.5
Posterior tibial	11	26.2	68.8	84.6
Peroneal	7	16.7	43.8	53.8
Profunda femoris	2	4.8	12.5	15.4
	42	100		

Leg artery occlusion occurred in 12 limbs i.e. in 75% of the symptomatic limbs and in 92.3% of those with occlusion.

Occlusion of leg arteries without proximal occlusion was found in 3 limbs i.e. in 18.8% of all the symptomatic limbs and in 23.% of those with occlusion. The ratio of occlusions was 0 anterior tibial : 1.5 posterior tibial : 1 peroneal.

The co-existence of leg and proximal artery occlusion was found in 9 limbs i.e. in 56.3% of all the symptomatic limbs examined and in 69.2% of all those with occlusion. The ratio of occlusions in this group was 1.6 anterior tibial : 1.6 posterior tibial ; 1 peroneal.

\- - - -

Proximal occlusion alone was found in 1 limb i.e. in 6.3% of the symptomatic limbs and in 7.7% of those with occlusion.

\- - - -

Occlusion Length

The average length of the 14 occlusions in the femoro-popliteal segment was 16.1 cms. The histogram (Figure 85) shows a very slight increase in the number of occlusions between the 7 and 12 cm. level demonstrating a minimal increased incidence of occlusion in the upper popliteal artery.

In the anterior tibial artery, the average length of the 8 occlusions was 12.3 cms.

The histogram (Figure 86) shows a slight tendency to an increase in the number of occlusions between 7.5 and 13 cms. below the knee, but the numbers are small and do not justify emphasis.

There were 11 posterior tibial artery occlusions, the average length of which was 23.4 cms. The histogram (Figure 87) of these occlusions shows a rather general distribution of occlusions throughout the artery, the highest incidence being between 16 and 17 cms. from the base line. No real peak was shown.

Peroneal artery occlusions were found 7 times, their average length being 18 cms. The histogram (Figure 88) shows a general distribution of occlusion throughout the artery, with the greatest incidence proximally between 10 and 17 cms. Again no peak was shown.

- - - -

Asymptomatic Limbs.

11 asymptomatic limbs were examined, and of these 10 (90.9%) showed occlusion, 4 (80%) of the 4 left limbs examined in women with right pregangrene were occluded, as were all (100%) of the 6 right limbs examined in patients with left sided pregangrene.

8 occlusion patterns were found in these 10 limbs. These are shown in Table 66 .

TABLE 66

Asymptomatic Limbs in Women with Pregangrene

Occludion Patterns	Number	% of all asymptomatic limbs in women with pregangrene i.e. % of 11	% of all asymptomatic limbs with occlusion in women with pregangrene i.e. % of 10
Superficial femoral; posterior tibial and peroneal	1	9.1	10
Superficial femoral; popliteal and posterior tibial	1	9.1	10
Popliteal; anterior tibial and posterior tibial	1	9.1	10
Posterior tibial	2	18.2	20
Peroneal alone	1	9.1	10
Anterior tibial and posterior tibial	1	9.1	10
Anterior tibial; posterior tibial and peroneal	2	18.2	20
Posterior tibial; peroneal & profunda femoris	1	9.1	10
TOTAL	10	91.0	100

Two occlusion patterns were found in 2 limbs each i.e. in 18.2% of the asymptomatic limbs and in 20% of those with occlusion.

These were -

(a) occlusion of the posterior tibial artery alone.

(b) occlusion of the anterior tibial, posterior tibial and peroneal arteries.

The other 6 occlusion patterns each occurred in 11 limbs i.e. each in 9.1% of the limbs examined and in 10% of the limbs with occlusion.

The incidence of occlusion in individual arteries is as shown in the following Table

TABLE 67

Artery	Number	% of all asymptomatic limb occlns. in women with pregangre i.e. % of 23	% incidence in all asymptomatic limb occlns. in women with pregangrene i.e. % of 11	% incidence in all asymptomatic limb occlns. in women with pregangrene i.e. % of 10
Common femoral	-	-	-	-
Superficial femoral	2	8.7	18.2	20
Popliteal	2	8.7	18.2	20
Anterior tibial	4	17.4	36.4	40
Posterior tibial	9	39.1	81.8	90
Peroneal	5	21.7	45.5	50
Profunda femoris	1	4.3	9.1	10
	23	99.9		

Leg artery occlusion was found in 10 limbs, i.e. in 90.9% of the asymptomatic limbs examined in women with pregangrene, and in 100% of those with occlusion. In 5 limbs (i.e. in 45.5% of all the asymptomatic limbs, and in 50% of those with occlusion) leg artery occlusion occurred without proximal occlusion. In this group the ratio of occlusion in the anterior tibial artery to that in the posterior tibial artery, to that in the peroneal was 1 : 1.7 : 1.

- - - -

In a further 5 limbs leg artery occlusion was found with proximal occlusion. Here the ratio of occlusions was 0.5 anterior tibial : 2 posterior tibial : 1 peroneal.

- - - -

Proximal artery occlusion was not found on its own.

- - - -

Occlusion Length

The average length of the 4 femoro-popliteal occlusions was 22.6 cms. Apart from showing a general distribution of these occlusions, the histogram (Figure 85) does not contribute anything, because of the small numbers.

- - - -

With the 4 anterior tibial artery occlusions, averaging 18 cms. in length and the 5 peroneal occlusions, where the average length was 15.9 cms. the same limitation applies to the histograms (Figures 86 and 88).

- - - -

The 9 posterior tibial artery occlusions had an average length of 24.8 cms. All that the histogram (Figure 87) demonstrates is a general distribution of occlusions throughout the artery.

- - - -

HISTOGRAMS

Superficial Femoral Artery Occlusions.

All the superficial femoral artery occlusions found in the patients examined by direct femoral arteriography were summated into one histogram (Figure 81). This histogram shows a steep, rapid rise in the number of occlusions from the 56.5 cm. level above the base line to the 42 cm. level. From 42 to 19 cms. above the base line the rate of increase in the number of occlusions remains rapid but this is a little less marked than in the upper section.

At the 19 cms. above the base line the apex of a sharp peak in the number of occlusions is demonstrated.

Below the peak there is a precipitous fall in the number of occlusions over a distance of 3.5 cms., a fall which continues - at a much lower rate - to 8 cms. above the base line, and then returns to a faster rate of decline to 2.5 cms. above the base line.

Between 2.5 cm. and - 6 cm. the summit of the histogram becomes much flatter - the flattest section of the entire histogram summit curve showing a slowly diminishing number of occlusions in the region of the knee joint.

The steep two-step fall in occlusion numbers at the - 6cm. level is accounted for by the use of the calculated mean point for the origin of the anterior tibial artery being used in the construction of the histogram in those patients in whom the distal end of the popliteal artery was not shown because of occlusion.

This histogram shows a rapid increase in the number of occlusions in the femoro-popliteal segment to a peak incidence in the segment of artery about 19 cms. from the base line i.e. at the distal end of the adductor canal, (Lindbom, 1950), with a general rapid decrease in the number of occlusions throughout the popliteal artery, the rate of decrease being slower over the 5 cms. on either side of the knee joint. In general this shows a higher incidence of popliteal artery occlusion proximally than distally.

- - - -

A further histogram (Figure 82) was then constructed in order to compare the incidence of occlusion in the femoro-popliteal segment, at varying levels, in men and in women. The histogram of the occlusions in men is virtually identical with that (Figure 81) of the occlusions in the entire series, except that the numbers are smaller.

The histogram of the occlusions in the women patients is strikingly different. The steep rise in the number of occlusions in the artery superiorly is replaced by a slower increase in incidence, rising to a shallow peak centered on the 25 cms. level - i.e. over 5 cms. more proximal than in the men. Below this peak there is a slow decrease in occlusions numbers to the 3 cm. level, without any evidence of the rapid decrease, seen in men, in the equivalent segment. The occlusion numbers between 2 and - 5 cms. are very constant, compared with the decreasing numbers seen in the same segment in men.

These appearances show that in the men there are many short occlusions (causing the steepness of the summit curve) and that the peak incidence of occlusion is around 19 cms. above the base line. A decreasing incidence of occlusion is shown as the artery passes distally through the popliteal fossa. In women the occlusions seem to be longer - shown by the absence of steepness in the summit line, with a peak incidence of a minor degree compared with that in men, almost 6 cms. more proximally than in the male limbs.

This peak incidence proximal to that in the male limbs suggests that there is a tendency in women for the greatest incidence of occlusion in the femoro-popliteal artery to be more proximally in the adductor canal than in men.

No decrease in occlusion numbers is seen immediately around the knee joint, although a general decrease in occlusion numbers in the upper popliteal artery is shown similar to that in men.

A third set of histograms (Figure 83) was then made to examine the occlusion numbers at different levels on either side, in both men and women. No difference was shown between right and left in men. On the right side in women there was no evidence of a peak in occlusion numbers in the 25 cm. level area as there is on the left side. The numbers involved are so small that the "peak" on the left side is caused by only 5 occlusions and hence little stress can be placed on this finding.

- - - -

The fourth set of histograms (Figure 84) was constructed to show the number of occlusions at different levels in the femoro-popliteal segment, in limbs in which there was no associated leg artery occlusion, and those in which there was. No breakdown was made here in regard to sex or side. The histogram of the femoro-popliteal occlusions in the limbs where there was no associated leg artery occlusion is very similar in contour to that shown in all femoro-popliteal occlusions (Figure 81). There are some minor differences. The slight slowing in the rate of increase in the numbers of occlusions below the 40 cm. level in the histogram (Figure 81) of all femoro-popliteal occlusions is not shown in these limbs. There is a steady fall in the numbers of occlusions below the peak level at 19 cms. - compared with the varying rate of decrease in occlusion numbers over this segment in the histogram of all occlusions. It is also shown that the incidence of popliteal artery occlusions is low in the limbs where no associated leg artery occlusion is present. The steepness of the histogram contour indicates that there are many short occlusions, particularly around the 20 cm. level.

The histogram in these limbs where associated leg artery occlusion occurred is strikingly different. There is a more rapid increase in the numbers of occlusion between the 50 and 40 cm. levels indicating a greater tendency for the occlusions in these limbs to involve the upper limit of the femoro-popliteal segment. Between the 40 and 25 cm. levels the rate of increase in the number of occlusions is low. The narrow peak in the 20 cm. level region in the histogram of occlusions without associated leg artery occlusions is replaced by a plateau between the 25 and 18 cm. levels. The decrease in the numbers of occlusions below the 18 cm. level is less marked than in the limbs without leg artery occlusion and is broken by two further plateaux indicating an almost static level of occlusion numbers. These are between 13 and 10 cms. above the base line, and from 2.5 cm. above the base line to 4 cm. below the base line. This demonstrates a high incidence of popliteal artery occlusion in these limbs. The abrupt fall in the numbers of occlusions in the - 6 to - 7 cm. levels is caused by the calculated mean point of the level of the anterior tibial artery origin being used in the construction of the histogram in those patients in whom it was obliterated.

It is obvious from these two histograms that the numbers of popliteal artery occlusions are much higher (about 5 times in the region of the knee joint) in limbs with associated leg artery occlusion than in those without. The histograms demonstrate that the femoro-popliteal occlusions in those limbs in which leg artery occlusion co-exists, have a greater tendency to be long, than in those limbs where leg artery occlusion does not co-exist.

- - - -

A further series of histograms (Figure 85) was then constructed in order to show the numbers of femoro-popliteal occlusions at each level, occurring in association with the seven possible combinations of leg artery occlusion.

(a) Associated anterior tibial artery occlusion

Here the histogram shows a rapid increase in the numbers of occlusions from the 50 to 40 cm. level with a very slow increase from 40 to 25 cms. above the base line.
The number of occlusions then decreases to the 15 cm. level with a plateau in the numbers around the 10 to 15 cm. level.
Below the 10 cm. level the number of occlusions steadily

falls until, at and below the base line, there are only 5.

The appearances are those of long occlusions extending from the 17.5 cm. level into the upper segments of the femoral artery, with less frequent involvement of the artery below this level, and a diminishing number of occlusions as the artery passes inferiorly through the popliteal fossa.

(b) Associated posterior tibial artery occlusion.

The histogram of these femoro-popliteal artery occlusions is similar to that of the occlusions seen in association with anterior tibial artery occlusion, above the 40 cm. level. Between 40 and 5 cms. above the base line the numbers of occlusions show a slight preponderance around the 20 cm. level. Below the 5 cm. level the number of occlusions decreases, but this is less striking than in the occlusions in association with anterior tibial artery occlusion, slightly more popliteal artery occlusions being found.

The appearances are those of long occlusions extending above and below the adductor opening and involving the upper popliteal artery almost as commonly as the superficial femoral artery. The extent of popliteal artery involvement is more marked than in the limbs where anterior tibial artery occlusion co-exists.

(c) Associated peroneal artery occlusion

The number of femoro-popliteal occlusions found in association with occlusion in the peroneal artery alone is small and little can be deduced from the histogram. All that can be shown is a slow increase in the numbers of occlusions from the 50 cm. level, with the highest incidence around the 25 cm. level, and a similar rate of decrease in occlusion numbers to 5 cm. from the base line. This is the only noticeable feature in this histogram, but is of doubtful value in view of the small numbers of limbs with femoro-popliteal occlusion with peroneal occlusion.

(d) Associated anterior and posterior tibial artery occlusion

In this histogram a very slow increase occurs in the numbers of occlusions from the 50 to the 10 cm. level with a similarly slow decrease below the 10 cm. level. The maximum incidence of occlusion is in the popliteal artery, 10 cms. above the knee joint. The popliteal artery is occluded as frequently below the knee joint as above. (In the limbs with anterior tibial and posterior tibial artery occlusion separately the popliteal artery is occluded much less frequently below the knee joint than above.)

The flatness of the summit curve shows the femoro-popliteal occlusions to tend to be long, involving both the femoral and

and popliteal arteries.

(e) Associated posterior tibial and peroneal artery occlusion.

The histogram of these femoro-popliteal artery occlusions is virtually flat in its summit contour below the 44 cm. level, above which is a segment over which the numbers of occlusions rises rapidly - due to the variation in the level of the origin of profunda femoris. Below the 10 cm. level the number of occlusions falls to become very small below the level of the knee joint. In this group of limbs the flatness of the summit curve of the histogram is in keeping with long occlusions, in the femoral and upper popliteal arteries, with little involvement of the lower popliteal artery.

(f) Associated anterior tibial and peroneal artery occlusion.

Only 4 femoro-popliteal occlusions were found in this group.

No conclusions can be drawn from this small number.

(g) Associated anterior tibial posterior tibial and peroneal artery occlusion.

The histogram is strikingly different in contour from the others. A steady rise in the number of occlusions occurs from the 50 cm. level to the 12 cm. level. From 12 to 7 cms. the number of occlusions remains constant. A minimal fall - of 3 occlusions - exists around the 5 cm. level, followed by a further rise to the base line. For 6 cms. below the base line the number of occlusions remains constant, the abrupt decrease in numbers below - 6 cm. being caused by the method of construction of the histogram.

The flatness of the summit line superiorly shows the occlusions to be long with an increased incidence of occlusions in the popliteal artery, most marked below the knee joint. These appearances show the maximum incidence of femoro-popliteal occlusion in limbs where all the leg arteries are occluded to be in the popliteal artery, particularly distally and that the frequency of popliteal artery occlusion is more marked here than in any of the other combinations of leg artery occlusion.

- - - -

Leg Artery Occlusions

Histograms were constructed of the occlusions at different levels in each of the three leg arteries. In considering these histograms it has to be remembered that, because of the fixed field size in the radiographic equipment used in the examination of the patients in the direct femoral arteriogram group, the ankle joint was not invariably seen.
The number of patients in whom the ankle joint was demonstrated is shown in the following table.

TABLE 68

Occluded artery	Number of limbs with occlusion	Number in which the ankle joint was shown	% in which the ankle jointwas shown
Anterior tibial	218	113	51.8
Posterior tibial	270	142	52.6
Peroneal	126	71	56.3
TOTAL	614	326	53.1

This infrequency of demonstration of the ankle joint, and hence of the entire course of the arteries in the leg, is naturally commoner in the tall patients. As a corollary it is a reasonable assumption that, apart from those instances where the positioning of the patient on the radiographic couch was incorrect the patients in whom the ankle joint was shown were those of short stature, and that whomen form a large proportion of these patients. Since there was in this way some form of selection of the patients in the demonstration of the leg inferiorly, it was not felt justifiable to construct a variety of histograms of leg artery occlusions in different circumstances, such as those in association with occlusions elsewhere, since the appearances in the histograms of the occlusions in the distal part of the leg may well be misleading.

This fallacy - that the lower end of the histograms of the leg arteries is probably an inaccurate representation of the true pattern of occlusion in the individual arteries - must be borne in mind in considering the histograms of the leg artery occlusions.

- - - -

Anterior tibial artery occlusion.

The histogram (Figure 86) of these occlusions shows a rapid rise in the numbers of occlusions between 5 and 10 cms. below the base line. (The two abrupt increases at the 6 cm. level are due to the calculated point of the anterior tibial artery origin being used in preparing these histograms, where the origin of the artery could not be located because of occlusion.) A slower rate of increase in occlusion numbers is shown from 10 to 24 cms. below the base line. Distal to 24 cms. from the base line the numbers of occlusions falls, but this is in the area in which the fallacy operates.

No peak incidence of occlusion has been shown, of the type seen in femoro-popliteal occlusions at the adductor opening. There is evidence from the histogram to suggest that the frequency of occlusion increases directly with distance from the knee joint. The steepness in the rise in the numbers of occlusions from the base line to 10 cm. from the base line can be accounted for, in part, by the scatter of levels of origins of the anterior tibial artery. The flatness of the summit curve from 16 to 26 cms. from the knee suggests that, in this region, the occlusions are long.

- - - -

Posterior tibial artery.

The histogram of these occlusions (Figure 81) shows a rapid rise in the number of occlusions from the 5 to 11 cm. level below the base line. A slower rise in the number occurs from the 11 to 27 cm. levels below the base line. Below this point the numbers of occlusions rapidly falls - this is the area of the fallacy.

It appears from the histogram, and taking the mean point of the origin of the peroneal artery to lie between 9 and 10 cms. below the base line, that apart from slightly more rapid increase in occlusion numbers above this point, i.e. in the "tibio-peroneal stem", there is no striking difference in the occlusion incidence in the artery above and below the origin of the peroneal artery. The appearances suggest that the re is a steadily increasing number of occlusions along the course of the artery reaching a maximum at a peak some 5 cms. further from the knee joint than in the anterior tibial artery. The steepness of the summit line suggests that many of the occlusions are short.

- - - -

Peroneal artery.

In this histogram (Figure 88) of occlusions in this artery a rapid increase in the occlusion numbers occurs between 9 and 10 cms. from the base line - where the mean point for the peroneal artery origin has been used in those patients in whom this area was occluded. From 10 to 13 cms. from the base line there is a rapid increase in the numbers of occlusions, with a small peak in occlusion numbers at 13 cms. From 13 cms. to 34 cms. below the base line is a steady slow decrease in the numbers of occlusions, becoming rapid below the 34 cm. level - in the site of the fallacy.

This histogram shows a peak incidence of occlusion proximally in the peroneal artery, with a steadily decreasing incidence throughout the artery distally.

- - - -

DISCUSSION

DISCUSSION - MATERIAL

DISCUSSION

It is a familiar observation that there is a considerable male preponderance in degenerative vascular disease. Heberden (1710-1801), describing 100 patients with angina pectoris, noted only 3 women among them. A century and a half later Wood (1957) gave the male to female ratio in patients under the age of 60, with ischaemic heart disease as between 7 and 8 to 1. Seldinger (1964) noted male to female ratio of 4 to 1 in patients with athero-sclerotic circulatory change in the lower limbs.

In the present series male to female ratio is 3.7 to 1.

In the translumbar aortogram group (or aorto-iliac group) the male to female ratio is 3 to 1. In the direct femoral arteriogram (or femoro-popliteal) group the male to female ratio is 3.9 to 1.

This shows a slightly increased female incidence in the aorto-iliac group compared with the femoro-popliteal group, but the difference in sex incidence between the two groups is not significant ($x^2 < 1$).

What are the sex ratios in the reported series?

Authors Series apparently including all clinical presentations.	Male to Female Ratio
Foster & Killen (1959	11.9 : 1
Julian, Javid, Dye & Issa (1959)	4 : 1
Conley & Kennedy (1960)	4 : 1
Juergens, Barker & Hintes (1960) excluding diabetics, patients over 60 years old, embolism and thromboangitis.	11.4 : 1
Szilagyi, Smith & Whitcomb (1960)	6.1 : 1
Davidson, Gudbderg & Thomsen (1960)	4.6 : 1
Schadt, Hines, Juergens and Barker (1961)	9.5 : 1
Taylor & Calo (1962)	11.5 : 1
Friedman, Holling & Roberts (1964)	3.7 : 1
Inada, Hayashi & Okatani (1964) -	19.7 : 1
clinical series examined by arteriography	5.3 : 1
Kohler & Viljanen (1964)	12.2 : 1
DeBakey, Crawford, Morris, Cooley & Garrett (1964)	6 : 1

Authors Aorto-iliac group only	Male to Female Ratio
Edwards and LeMay (1955)	8.3 : 1
Brown, Grant, Key, Wilson & Bigelow (1957)	9 : 1
Massarelli and Estes (1957)	8.3 : 1
Foster and Killen (1959)	15.7 : 1
Shepherd and Warren (1960)	6.4 : 1
Singer and Rob (1960) (claudication only)	6.3 : 1
Friedman, Holling and Roberts (1964)	2.6 : 1
Femoro-popliteal group only	
Mavor (excluding gangrene) (1956)	10.1 : 1
Margulis, Nice & Murphy (1957)	3.4 : 1
Foster and Killen (1959)	8 : 1
Haimovici, Shopiro & Jacobson (1960)	2.4 : 1
Singer & Rob (claudication only) (1960)	7.9 : 1
Tillgen, Stenson and Lund (1963)	8.3 : 1
Friedman, Holling & Roberts (1964)	5 : 1

Author	Male to Female Ratio
Claudication only	
Singer & Rob (1960)	7.4 : 1
Bloor (1961)	8.5 : 1
Begg and Richards (1962)	13.1 : 1
Boyd (1962) (same series as Bloor)	8.5 : 1
Severe ischaemia (pregangrene or gangrene)	
Taylor (1962)	6.4 : 1

These ratios from reported series show a sex ratio (male : female) ranging from 2.4 : 1 (Haimovici, Sharpiro and Jacobsen 1960) to 19.7 : 1 (Inada, Hayashi and Okatani, 1964). The ratio in the present series of 3.7 : 1 in the entire series (<u>not</u> the completely occluded patients only) of 3.1 in the aorto-iliac group,and 3.9 : 1 in the femoro-popliteal group is among those showing the lowest male preponderance. It is virtually impossible to compare figures of sex incidence, and indeed of the anatomical distribution of complete occlusion in various series, since most, if not all series, are selected in some way. Bloor (1964) made this point, feeling that many series were very highly selected, and contained patients referred to units with a particular interest, in whom the diagnosis was already made and who had possibly surgically operable lesions. For example, Crawford, DeBakey, Cooley and Morris (1961) reporting a ten year series of patients in whom surgery had been performed, recorded 952 with aorto-iliac occlusion, 774 with femoro-popliteal occlusion - an aorto-iliac preponderance higher than any other series - and no less than 1242 aortic and peripheral aneurysms. This undoubtedly is a very high selected and quite unrepresentative series.

Unfortunately it is almost inevitable that some form of selection will creep into any series, from the time when the patient first presents to his general practioner, until the time when arteriography is performed. Almost all the patients referred to the Vascular Clinic in this area have been examined arteriographically, but it is clear that a number of patients are referred to physicians and surgeons in other units, who, for one reason or another, have not requested angiography.

It is striking that the male patients, who form 78.8% of the total patients in this series, account for 82.7% of the patients with intermittent claudication, but only 70% of those with gangrene and 66.7% of those with pregangrene. Statistically there is very strong evidence ($p < 0.001$) that the difference in sex incidence between the patients with intermittent claudication, and those with gangrene and with pregangrene is significant.

These figures show that in intermittent claudication - the least dramatic of the various clinical presentations of peripheral vascular disease - the male incidence, in this series, is almost five times that in women. In the severe forms of peripheral vascular disease such as gangrene and pregangrene, the male incidence is only 2.3 and 2 times as high as the female.

Can this variation in the sex incidence be accounted for by arterial occlusive disease having a different natural history in men and women? (The different occlusion patterns in men and in women are considered in sections on aorto-iliac disease and on femoro-popliteal disease.)

Is it merely that men, perhaps walking longer distances at a time, present with intermittent claudication earlier in the disease process than women? Are the women, walking short distances about the house, and relatively short distances while shopping, only rarely reaching that distance at which they claudicate?

Does the known effect of reduction in the walking rate affect the clinical presentation? Cranley, Buchanan, Simeone and Linton (1952) noted that a reduction in walking rate from 120 to 100 steps per minute increased the walking distance of claudicating patients by 33%. In 1955 Cranley commented that walking distance "might" be doubled by the same reduction in walking rate. Presumably a normally slow walking rate would delay the onset of intermittent claudication until a later stage in the natural history of the arterial occlusive disease.

It is clear that when a patient has gangrene or pregangrene, he or she almost invariably is admitted to hospital, whilst those with intermittent claudication may never go to their general medical practitioner, much less arrive at at Vascular Clinic. Taylor (1962) noted a male : female ratio of 6.4 : 1 in his group of 67 patients with gangrene, but, like Bloor (1964) the writer doubts if a series from a London Teaching Hospital is in any representative of the distribution of a disease in a community, being almost inevitably highly selected.

These sex incidences raise a wider issue. Is it possible that the true relative sex incidence of occlusive vascular disease in the aorto-iliac and lower limb arteries in a community is indicated by the figures for gangrene and pregangrene - the severe ischaemic lesions demanding admission to hospital - rather than by those for the less clamant intermittent claudication? In intermittent claudication it seems that some form of selection will occur at some level - patient, general practitioner or indeed, hospital.

- - - -

Diabetes.

There were 30 diabetic patients - 18 men and 12 women. The male to female ratio in the entire series of patients is 3.7 : 1, but in the diabetic patients this falls to only 1.5 : 1. This shows a higher relative incidence of diabetes in the women with peripheral vascular disease, compared with the men. Table 5 shows the highest incidence of diabetic patients, as one would anticipate, in gangrene, where 16% of the men are diabetic and 19% of the women.

Curiously the incidence of diabetes in the patients with pregangrene is lower than in those with gangrene, but the numbers involved are so small that they are statistically not significant.

Since in the entire series of 546 patients there were only 30 patients (i.e. 5.5%) with proven diabetes it was not felt of value to consider them in detail. Hoar, Wheelock, Kellett, Koch and Gwggenheim (1966) discussed the anteriographic appearances in the 245 diabetic patients in their series of 1500 patients i.e. 16.3% of their patients were diabetic. 117 were men and 128 women i.e. a male : female ratio of 9 : 1.

Haimovici (1967) reporting the anteriographic appearances in 321 limbs of 189 patients with athero-sclerotic notes that 91 (i.e. 48.1%) of the patients had "overt or potential diabetes".

- - - -

Other Endocrinopathies

None of the patients was clinically hypothyroid.

Unfortunately no record was made of the women patients menstrual history. Hence the number who were post-menopausal or pre-menopausal is unknown.

No note was made of previous ovariectomy, so that no relationship between bitareral ovariectomy and peripheral vascular disease can be demonstrated, as was shown by Oliver and Boyd (1959) for coronary artery disease.

- - - -

DISCUSSION OF METHOD

DISCUSSION OF METHOD

The surgical techniques used in the past in arteriographic examination of degenerative vascular disease have, in general, been abandoned, with the notable exception of Sones's technique (Sones and Shirey, 1962; Sones, 1966) of coronary arteriography.

In the spring of 1960 when the examination of this group of patients was started, the proven and reliable techniques used in the arteriographic examination of peripheral vascular disease involving the aorto-iliac and lower limb arteries were:

1. Arterial catheterisation by the Seldinger technique.
2. Translumbar aortography.
3. Direct femoral arteriography.

Seldinger's method was welcomed by many radiologists in the hope that it would replace the blind approach of translumbar aortography, and that the ease of adjustment of the level of the catheter tip (and hence the site of contrast injection), would be a great advance on the relative inflexibility of translumbar aortography. Undoubtedly it has these advantages, and has been used widely, internationally, since its description.

In the late 1950's when the present writer had the opportunity of working in the Diagnostic X-Ray Department at St. Mary's Hospital, where Sutton was responsible for the angiographic service, he (Sutton) while using Seldinger's technique freely, had reservations about its use in degenerative vascular disease. He felt that translumbar aortography was preferable in atheromatous vascular disease (Sutton 1962) believing that catheterisation of atheromatous iliac and femoral arteries carried an increased risk of local thrombosis at the puncture site, and of peripheral embolism with fragments of atheromatous material or thrombi. The writer accepted this, adopting Sutton's method of arteriography in peripheral vascular disease, with some modifications.

It is only just to add that many have had trouble-free experience with retrograde femoral catheterisation in a wide range of patients.

In 1957 Bagger and his co-authors from twelve Swedish hospitals reported their experience in the methods and complications in catheterisation of the heart and great vessels, with and without the injection of contrast media. Their fatality rate in thoracic aortography was 5 in 340. They did not describe but there is no mention of any local complication at the puncture site, nor aortic dissection.

Samuel and Denny (1958) discussing the hazards of translumbar aortography, with reference to a report by Conger, Reardon and Arey (1957), of renal failure occurring in a 12 year old girl, following translumbar aortography used in the investigation of a renal lesion, said "We consider that translumbar aortography is contraindicated in renal disease and that a greater and more general use should be made of Seldinger's method in both abdominal aortography and peripheral vascular disease." There is no doubt that a movement away from translumbar aortography towards the more frequent use of the Seldinger method took place about this time.

In 1961 Boijsen and Feinstein, reviewing the development of arterial catheterisation, noted that the femoral arteries were easily studied by passing the standard PE 205 catheter to the aortic bifurcation, and making the injection of contrast there. Mackey (1961), speaking at a Conference on Atherosclerosis in Glasgow, and discussing radiological investigation of peripheral vascular disease, remarked that translumbar aortography or retrograde catheterisation from the femoral artery were both used. He felt that the former method carried the risk of intimal stripping and that the catheterisation technique was probably safer.

Kohler and Viljanen (1964) reported a series of 158 patients with occlusive vascular disease in the distal aorta or lower limbs, examined between 1st January 1960 and 30th May 1962. 91% were examined by Seldinger catheterisation of a femoral artery, 3% by left brachial catheterisation and 6% by translumbar aortography. They made no mention of any complications.

A year later, Granger (1965) reviewed the complication of cardiovascular radiological investigation. He recorded four femoral artery thromboses in 250 left ventricular and thoracic aorta catheterisation with resulting claudication, and a further incident in a 70 year old man who developed a femoral artery thrombosis, treated by thrombo-endarterectomy, but where the limb became gangrenous and has to be amputated. He comments, "we have no known case of femoral artery thrombosis after retrograde lumbar aortography which generally requires less catheter manipulation" (than left ventricular or aortic arch catheterisation).

These writers, then, from various centres, record no complications in their experience with retrograde femoral artery catheterisation, in the investigation of aortic and peripheral vascular disease in the lower limbs.

Several reports have been made emphasising the possible hazards of retrograde catheterisation. Leriche, Beaconsfield and Boely (1952) reviewing 200 aortograms, 175 for the investigation of peripheral vascular disease, (before Seldinger described his technique) felt that retrograde catheterisation might dislodge a thrombus, producing embolism. Admittedly the techniques of arterial catheterisation available to them were by open arteriotomy but the opinion of one of the great figures in vascular surgery cannot be dismissed lightly.

Wulff and Eiken (1959) reporting 174 patients with lower limb ischaemia, examined them angiographically either by Seldinger technique, translumbar aortography, femoral or popliteal artery puncture. "In principle" they write "we believe direct arterial puncture to be preferable to the catheter method, particularly when Buerger's disease is suspected". Possible extension of gangrene following arteriography is the single complication mentioned, but is not detailed.

Aagaard, Davidsen and Andreassen (1960), discussing the complications in their series of percutaneous arteriograms by means of a polyethylene catheter in 535 patients, many of whom were elderly males, changed from the standard Seldinger type guide wire to a number 4 Cournand cardiac catheter, which they felt had less tendency to produce arterial spasm. 239 of these patients had peripheral arterial disease and were examined by transfemoral catheterisation. They had 41 complications, 37 of which had no sequelae. Two patients had lasting disability, one from a transverse medullary lesion, with a resultant flaccid paraplegia, the other, in whom amputation became necessary following breakage of the catheter tip. There were 2 deaths, 1 from coronary thrombosis, and 1 from a retroperitoneal haemorrhage after anti-coagulant therapy for popliteal artery thrombosis following the examination.

In 1961 Gudbjerg and Christensen reported dissection of the aortic wall as a complication of retrograde lumbar arteriography. 451 aortograms, both retrograde from the femoral artery in 419 and translumbar in 32 carried out between 1953 and 1959 were reviewed.

All the sub-intimal dissections occurred in patients with pre-existing clinical evidence of arterial disease. The incidence of intimal damage was higher in the retrograde series (28.6% of 126 patients with peripheral vascular disease) than in the translumbar group (19.4% of 31 patients with peripheral vascular disease). Their figure of 9.3% intimal damage in their complete series (those with diseases other than peripheral vascular disease included) is almost exactly that reported by McAfee (1956) in translumbar aortography. 8.6% of their patients examined by transfemoral catheterisation showed intimal damage.

Gudjerg and Christensen believe that the mechanism of this injury is that the catheter tip is caught by an atheromatous plaque, passes beneath the plaque and then along the subintimal plane. They point out that the injury always occurs in the region of the catheter tip. In 27 of the 36 patients examined retrogradely, in whom intimal damage occurred, there had been difficulty in passing the catheter, varying from a sensation of resistance, to a complete inability to pass the catheter to the desired level. Seven of the patients complained of slight pain at the time of examination, and in four of these this persisted in the in the low lumbar region for a day. These workers believe that such intimal injury may contribute to the development of dissecting aneurysm.

Davidson, Gudjerg and Thomsen (1961) reported on the last 500 examinations in their series of 950 selective angiograms and percutaneous transarterial aortograms. They, like Aagaard, Davidsen and Andreassen (1960) used a number 4 Cournand cardiac catheter instead of the standard Seldinger-type guide wire. 254 of these examinations were combined ones of the lower aorta and the arteries of the lower limb, and 407 were transfemoral. 282 patients had arterial insufficiency in the lower extremities. A total of 31 subintimal injections of contrast medium occurred, 24 in arteriosclerotic patients and typically involved the lower aorta and common iliac artery. No local arterial thrombosis at the puncture site was recorded. Haemorrhage or haematoma formation occurred in 17 of their 86 brachial catheterisations, five times the incidence found in the femoral catheterisation group. Consequently, they recommend that the femoral route be used in preference to the brachial whenever possible.

Treleaven and Copestake (1962) reported their experience of 76 examinations using the Seldinger technique, 59 of their examinations being transfemoral, and 17 transbrachial. In five of the patients catheterised by the transfemoral route, arterial dissection occurred - an incidence of 8.5% - almost exactly that reported by Gudbjerg and Christensen (1961) in their total retrograde series - 8.6%.

Treleaven and Copestake conclude their article - "In general it is now our opinion that Seldinger catheterisation is not the procedure of choice for visualisation of occlusive vascular disease distal to the lumbar aorta. The majority of difficulties we have experienced in femoral puncture have been in the group who have already suffered severe arterial damage. In this group we now more commonly perform direct puncture of the abdominal aorta, or bilateral femoral arteriography with puncture of both common femoral arteries."

Bell (1962), discussing the treatment of post-catheterisation injuries, reported on 49 patients on whom retrograde arterial catheterisation had been carried out. In 21 of these the route was transfemoral by the Seldinger method, the other 28 being by the brachial route, where catheterisation was carried out by open arteriotomy. Three major vascular injuries occurred in the transfemoral group. Two patients, both 41 year old men, developed thrombosis in their catheterised right common femoral arteries. A third man, aged 53 years, developed thrombosis of the right common femoral and external iliac arteries, and a large retroperitoneal haematoma from an arterial puncture opposite the origin of the internal iliac artery. He comments about this patient's examination "obstruction to the passage of the catheter was apparent upon several trials. Because of abdominal and pelvic pain, the procedure was terminated." In his discussion Bell says that "in selecting patients for retrograde arterial study it would seem desirable to avoid the femoral artery in diabetic, hypertensive or elderly individuals in whom there is clinical evidence of systemic arteriosclerotic disease." The numbers in Bell's series are small, and it may be that the experience of the catheteriser was limited, with a consequent increase in the risk of complication.

Waldhausen and Klatte (1962) discussing their "counter-current" method, quote Gudjberg and Christensen, and were sufficiently anxious about the hazards of aortic dissection at translumbar aortography to evolve their modification of the technique of aortography - a modification which was essentially a return to the method described by Castellanos and Pereiras (1940).

A letter from Lesser (1963), a few weeks after the publication of their paper, says that the writer "heartily agrees that their technic is simple and much safer than the use of a catheter in patients with atheromatous disease".

Mandelbaum and Shumacker (1963) report three patients in whom femoral artery thrombosis, and one in whom a false aneurysm of the femoral artery developed after Seldinger catheterisation of the femoral artery. They do not give the size of the series in which these complications occurred.

In 1963 Luke and McGraw reported their experience of complications following catheter angiography at 372 Seldinger examinations. They quote their ten year experience of 500 translumbar aortograms with two "complications of note", one a death from renal "shut-down" following the use of 70% sodium acetrizoate in a patient with a Leriche type of aortic occlusion, and the second, a non-fatal destruction of a kidney following the use of too concentrated a solution of the same contrast. During a period of four years they carried out 372 catheterisations by Seldinger's method

(364 transfemoral and 8 transbrachial) encountering five "major and serious complications". These five complications occurred in the patients examined by the transfemoral route. Two were iliac artery occlusions; one an iliac artery occlusion plus superficial femoral artery occlusion, necessitating amputation and the fourth, femoro-iliac artery thrombosis and cardiac arrest following a massive posterior myocardial infarct. In the fifth patient, death occurred following aortic dissection and total occlusion of both popliteal arteries by athero-sclerotic debris.

Luke and McGraw make it quite clear that they did not use Seldinger catheterisation in aortic and peripheral angiography when the patient was being investigated because of peripheral arterial disease, so that one is entitled to assume that the vessels which thrombosed following catheterisation in their series were unlikely to be as grossly diseased as those in patients with peripheral vascular disease.

Later in 1963, McGraw, reviewing his experience in arteriography, and discussing the complications, considers the same group of patients as did Luke and McGraw. Although he describes Seldinger's method (which, with Luke in the earlier paper, he had said they used) he writes "the femoral artery is punctured with a trocar through which a catheter is passed", and then later describes withdrawing the trocar and catheter together. It therefore appears that, rather than using the Seldinger technique, these workers were using a technique little different from that used by Peirce (1951) and by Greenwald, LeFevre, Root and Humphries (1955), substantially Farinas's (1941) method, but percutaneous. Both the reports agree that the technique is not used in the investigation of peripheral arterial disease. The needle used must have been of very wide bore to allow the passage through it of a yellow or a green Odman-Kifa catheter(1956), described in the earlier paper (Luke and McGraw 1963) as being used in these patients. McGraw also gives the time during which the catheter was in the femoral artery in three of the five patients who developed complications - 3 hours and 15 minutes, 3 hours, and 2 hours and 40 minutes. These times seem excessive.

In 1963, Gillanders reported one aortic dissection during 229 translumbar aortograms, and another during 140 retrograde aortograms using the Seldinger technique. The incident in the translumbar group occurred during translumbar aortography carried out after failed catheterisation from each femoral artery, the catheter sticking at 16 cms. on the right and at 20 cms. on the left. A test injection confirmed the correctness of the needle position, but aortic dissection occurred with the main injection, which was carried out with a Talley pump at a pressure of 40 lbs. per square inch. It is uncertain whether either of the failed catheterisations, the translumbar aortogram or the use of the pressure injector was separately responsible for the aortic injury. The dissection in the Seldinger catheterisation group occurred in a patient in whom there had been resistance to the passage of the yellow Odman catheter at 20 cms. Gillanders comments that he has largely abandoned the catheter method in favour of translumbar aortography in the investigation of atherosclerosis of the aorta and great vessels.

Lang (1963 a and b) surveyed the complications of percutaneous retrograde arteriography using the Seldinger technique. He collected details of 11,402 procedures during which seven deaths occurred:

2 - from aortic and/or renal artery thrombosis.

1 - from carotid artery thrombosis.

1 - during passage of the catheter through a coarctation

2 - in whom no cause for death was found.

This mortality rate of 0.06% compares well with McAffee's report (1957) of a 0.28% mortality in 13,207 abdominal aortograms, 12,832 of which were translumbar - the others being 141 by catheterisation of the exposed femoral artery, and 234 by percutaneous catheterisation.

81 serious complications are recorded by Lang:-

Arterial thrombosis (with secondary loss of the limb in 6)	47
Arterial embolism	9
Tip of guide wire or catheter broken	5
Perforation of major vessels with serious complications	13
Renal complications	2
Bowel ileus and necrosis	5

There were 325 minor complications:-

Perforation of a major vessel with sequelae	22
Intramural and subintimal "dye" injection without sequelae.	136
Local haematomata	167

Temporary arterial spasm and loss of pulse were observed in practically all minor complications.

The significance of haematoma depends very much on the criteria used, since minor haematoma formation is a common sequel of arterial puncture with a trocar or needle of the Seldinger size. However, even disregarding nine instances of arterial embolism, an incidence of 0.412% arterial thrombosis, and subsequent limb loss in 0.053% of all patients, and in 12.77% of those who developed arterial thrombosis, is disturbing as a complication of a diagnostic procedure, as is the incidence of major vessel perforation at 0.31%, with serious complications in 0.114% of all patients and 59.09% of those with perforation. The incidence of intramural and subintimal injections of contrast medium of 1.19% is strikingly lower than that reported by Gudjberg and Christensen (1961). In one of these reports (Lang 1963 a) he notes that patients with arterio-sclerotic disease in the advanced age group were particularly prone to complications such as intramural and subintimal injections, and perforation of their tortuous vessels.

Beall, Henly, Morris, Crawford, Cooley and Debakey (1963), discussing their experience with more than 3,000 translumbar aortograms say, "several complications are inherent in the use of retrograde catheter aortography, especially in the presence of aorto-iliac occlusive disease. Inpatients with complete occlusion of the aorto-iliac region retrograde aortography is contraindicated and in these with a partial occlusion there is always the danger of dislodging a plaque by passage of the catheter. A year later, Beall, Morris, Garrett, Henly, Hallman, Crawford, Cooley and DeBakey (1964) repeat this comment in a further review of 4,613 translumbar aortograms.

Kottke, Fairbairn and Davis (1964) discussing concurrent series of 80 translumbar aortograms and 195 percutaneous transfemoral (Seldinger) abdominal aortograms "almost all" for renal investigation, report 10 major complications in the former and 24 complications in the latter.

The complications in the translumbar group were:

Complication	Number
Allergic reaction to sodium acetrizoate	1
Back pain plus drop in blood pressure (? retroperitoneal haematoma)	2
Bilateral sciatic leg pain	1
Periaortic injection of test dose	3
Needle in renal artery	2
Severe abdominal pain without drop in blood pressure	1
TOTAL	10

i.e. 12.5% of 80

They say that only two of these complications were major - presumably they refer to the possible retroperitoneal haematomata - and none had a permanent result.

The complications in the retrograde catheterisation group were:-

Complications	Patients	
	Number	Required Operation
Arterial occlusion	11	-
Haematoma	3	1
False aneurysm	1	1
Loss of spring wire tip	1	1
Aortic perforation	1	-
Allergy to radio-opaque media	2	-
Miscellaneous	5	-
Intramural injection	2	
Hypotension and bradycardia	1	
Tender Quadriceps muscle	2	
Probably arterial occlusion	2	
TOTAL	24	3
	i.e. 12.3% of 195	i.e. 1.5% of 195

Note - they do not include the probable arterial occlusions in their total number of complications

Although the percentage incidence of complications in each group is the same, the retrograde catheterisation group contains a number of more serious ones e.g. arterial occlusion, and aortic perforation. In 10 out of the 13 patients in whom arterial occlusion (or probable occlusion) occurred, the thrombosis occurred at the puncture site, and in 3 it was distal to the popliteal artery. One is entitled to suspect that the peripheral thrombosis followed embolisation from atheromatous debris, or thrombi, loosened by the catheter, and swept peripherally by the blood stream to occlude the smaller leg arteries - the sequel of catheterisation mentioned by Leriche et al (1952).

More recently still, Strandness and Bell (1965)said "complications from retrograde femoral catheterisation would appear to be related to the extent of the atheromatous disease in the femoral artery and those vessels proximal to it."

- - - -

The technique of radiographic examination of peripheral vascular disease by translumbar aortography alone, or with femoral arteriography, or by translumbar aortography or direct femoral arteriography depending on the clinical picture, rather than by retrograde catheterisation is a widely accepted one. It seems reasonable to disregard many of the arteriographic reports before the early 1950's, up to which time few had been concerned with vascular disease but dealt mainly with application of aortography to the study of renal masses. This does not entitle one to disregard the early work of dos Santos, (1929 a and b 1931, 1932, 1949), followed by Osorio (1933), and others in the clinical applications of translumbar aortography, nor the reports of Brooks (1924), Singleton (1928), and Charbonnel and Masse (1929) on femoral arteriography. These reports are of course, of small numbers compared with some of the modern reports such as those from the DeBakey group in Houston, notably Beall, Morris, Crawford, Cooley and DeBakey (1961); Beall, Henly, Morris, Crawford, Cooley and DeBakey (1963); and Beall, Morris, Garrett, Henly, Hallman, Crawford, Cooley and DeBakey (1964).

Those who use translumbar aortography as the routine method of radiological investigation in all patients with occlusive vascular disease affecting the lower limbs, regardless of the site of claudication and of the state of the peripheral pulses in the lower limbs, have a very strong argument on their side. They hold that it is vital to know precisely the state of the aorta and iliac arteries - the "run-in" - before any decision is made about surgical treatment of occlusive disease distal to the inguinal ligament. Few of them, on the other hand, seem to feel it necessary to obtain as detailed knowledge of the leg arteries - the "run-off" - although most appear to follow the contrast medium into the leg arteries.

De Reus and Vink (1955) feel that femoral arteriography should be discarded and aortography used in all patients, in order not to miss aorto-iliac stenosis.

Wylie and Gardener (1955) reporting 62 thromboendarterectomies, used translumbar aortography for their 32 radiological examinations and obtained radiographs of the upper leg arteries. Three years later, in 1958, Wylie and Goldman reviewed the role of aortography in determining operability in lower limb arteriosclerosis. This report was based on the records of 500 patients, the increase of 368 since the earlier report, reflecting the swelling surgical activity at that time, in the investigation and treatment of these lesions. They demonstrated the arterial tree "from the level of the renal arteries to the distal popliteal bifurcation", the radiographs shown extending to the level of the junction of the middle and distal thirds of the leg. Undoubtedly they regard distal arteriosclerosis as being important, saying that intimal change increased in surgical significance the more distal it is.

Perhaps the most important group who use translumbar aortography in all their patients is the one at Houston from which Beall, Morris, Crawford, Cooley and DeBakey (1961) reviewed their experience of 2,400 examinations, saying that occlusive disease in the aorto-iliac region constitutes the major indication for this examination.

In the United Kingdom, Gillespie and Douglas (1961) say that there is much to be said for using aortography as a routine, although they admit that femoral arteriography gives better visualisation below the knee. They feel that femoral arteriography has a definite place in the examination of a patient with a critically nourished foot, and a palpable femoral pulse, who is unfit for aortography.

By 1963 Beall, Henly, Morris, Crawford, Cooley and DeBakey were able to review more than 3,000 translumbar aortograms. They held the widespread fear of translumbar aortography to be unjustified, especially with the newer, safer contrast media, provided a few simple precautions were taken. For example, they gave 500 to 1,000 ml. of 5% destrose in distilled water prior to aortography, believing that hyperhydration lessens the possibility of renal damage (Morris, Crawford, Couves, DeBakey and Moyer 1956). They did not use a second injection of contrast medium during any aortogram (Beall, Crawford, Couves, DeBakey and Moyer 1958). They took radiographs from the level of the nipple to "below the knees". Their reproductions do not extend distal to the upper leg.

Again in 1964, discussing the indications for translumbar aortography, Beall, Morris, Garrett, Henly, Hallman, Crawford, Cooley and DeBakey reiterate that obstructive lesions in the aorto-iliac region have been their main dication for translumbar aortography. They observe, from their experience of 4,613 examinations that there need no longer be fear of the complications, since these are not justified by their experience.

There is a considerable body of opinion which takes the view that the better demonstration of the lower limb vessels at direct femoral arteriography is advantageous, and that aortography should be reserved for those patients with clinical evidence of aorto-iliac occlusion (Sutton 1962).

Lindbom (1950), using femoral arteriography in the investigation of the lower limb arteries, used translumbar aortography in those in whom iliac artery occlusion was diagnosed clinically. This pattern of radiological investigation was reported by Milanes, Perez-Stable, Casanova, Bustamente and Hernandez (1963) and by Julian and Dye (1955). Similarly, Mavor, (1955-6) discussing lower limb occlusive disease, used femoral arteriography in the investigation of his patients. He does not say how his five patients with secondary aorto-iliac occlusion (one in the external iliac artery and four at the aortic bifurcation) were diagnosed radiologically, or if the diagnosis was purely clinical.

Edwards (1957) felt that "whenever a view of the femoral arteries will suffice, femoral arteriography is the preferable procedure, even if it needs to be performed on each side".

From Bristol, Horton and Ross (1957) wrote in a correspondence following a report by Gayliss and Laws (1956) vide infra, "having regard to the potential dangers, it is doubtful if aortography should be employed except in disease of the aorta or great intra-abdominal arteries of such a nature that direct surgery is contemplated and will be made easier by the addition of radiographic delineation of the disease."

Eiseman and Waggener (1957) discussing 134 patients of whom 101 had obliterative disease, the other 33 having an aneurysm used translumbar aortography and femoral arteriography.

Horwitz and Penneys (1957) made it clear that they tailored their radiological procedure to the physical findings, using aortography in the absence of one or both femoral pulses; femoral arteriography where the femoral pulse was palpable and the popliteal pulse absent, and no radiological investigation at all if there was a good popliteal pulse. In the last instance they felt that the occlusive lesion was distal to the knee and grafting was therefore impractical.

Eyler (1957) discussing 600 translumbar aortograms and arteriograms used separate injection of each femoral artery in order to get sufficient contrast and detail in the limbs. He pointed out that a single aortic injection can be used to demonstrate the vascular tree from the level of the renal arteries to the division of the popliteal artery.

Two years later de Takats (1959) indicated his preference for the use of femoral arteriography at the time of sympathectomy, saying that aortograms seemed unnecessary in most of the patients today, although he continued to use aortography in some of his patients.

Linton (1959) in a general review of peripheral vascular disease came down in favour of femoral arteriography as opposed to aortography because of the hazards of the latter.

Surprisingly Knox and Finby (1961), who used translumbar aortography as well as femoral arteriography, continued to use an open exposure of the femoral artery rather than percutaneous puncture.

In 1962 Szilagyi, Smith, Macksood and Eyler reviewed 1502 patients in whom 2399 abdominal aortograms and 887 femoral arteriograms had been carried out. Three years earlier Szilagyi (1959) had commented that he seldom carried out femoral arteriography, which he tended to use only in the poor risk patients. It seems unlikely that as many as 26.9% of his patients could be grouped in that category and is probable that his use of femoral arteriography had extended by 1962.

Linton and Darling (1962) continued to use femoral arteriography as their method of pre-operative investigation of femoro-popliteal occlusion. They regard it as an important investigation, placing a satisfactory femoro-popliteal arteriogram as the first of their nine requirements for saphenous vein bypass autografting.

A technique precisely the same as that used in the present series was advocated by Sutton in 1962, i.e. femoral arteriography in those with equal and palpable femoral pulses, and translumbar aortography in those in whom one or both femoral pulses are absent.

Discussing safe routine peripheral angiography, Domingo, Schaeffer, Fries, Sawyer and Wesolowski (1964) describe their use of both translumbar aortography and femoral arteriography, but do not detail their choice of method in relation to the patient's clinical picture.

Inada, Hayashi and Okatani (1964) reviewing their experience with chronic arterial occlusive disease in the limbs, examined a small group of patients by translumbar aortography, with the addition of femoral arteriography if the occlusion was below the level of the femoral artery.

Haimovici (1964) discussed his use of femoral arteriography but pointed out that a minimal aortic or iliac artery stenosis might be missed with this method. He used a retrograde injection of contrast into the femoral artery, if there was a systolic murmur in the groin to suggest such a lesion in order to obtain radiographs of the iliac arteries. Apparently this retrograde injection was not used in every patient, but restricted to those in whom there was clinical suspicion of aorto-iliac disease. Schobinger (1964) discussing translumbar aortography, writes that it was "appropriate to mention that the literature unnecessarily perpetuates statements pertaining to the dangers of the method. Translumbar puncture of the aorta should not be undertaken by the inexperienced, neither is it a field for those who cannot admit defeat." He added that the mortality rate in translumbar aortography must be revised downwards. He used translumbar aortography in those patients in whom one or both femoral pulses were absent and for the five years before the publication of his report had used bilateral femoral arteriography wherever possible.

In 1965, Knox, Finby and Moscarella said that "femoral arteriography has become the definitive diagnostic technique in evaluating occlusive arterial disease of the lower extremity." They had carried out 690 such examinations over twelve years, mostly at open exposure of the femoral artery.

Interesting, in view of their previous exclusive use of translumbar aortography, are two reports from Houston, Texas. One by Crawford, Garett, DeBakey and Howell (1966) and the other by Beall, Lewis, Weibel, Crawford and DeBakey (1966) make it apparent that they had begun to use translumbar aortography and subsequent femoral arteriography in order to demonstrate the arterial tree from the diaphragm to the toes.

- - - -

The level at which the aorta is punctured in translumbar aortography has given rise to differences in detail of technique in various units. Although many workers do not detail their puncture level, a number do, and they can be clearly divided into those who routinely puncture above the renal arteries, and those who puncture below these vessels where possible. This second group tends to restrict their suprarenal aortic puncture to those in whom there is clinical evidence of aortic occlusion, which can, of course extend to the level of the renal arteries. It is interesting historically that

Dos Santos, Lamas and Caldas (1931) described their use of two puncture sites - at the level of the 12th thoracic vertebra for mesenteric and renal studies, and at the 3rd lumbar body for examination of the pelvic arteries. Among those who routinely puncture at a high level are Eyler (1957), Eiseman and Waggener (1957), Foster and Killen (1959), Knox and West (1961) and the Houston group, Beall, Morris, Crawford, Cooley and DeBakey (1961); Beall, Henly, Morris, Crawford, Cooley and DeBakey (1963); Beall, Morris, Garrett, Henly, Hallman, Crawford, Cooley and DeBakey (1964); Beall, Lewis, Weibel, Crawford and DeBakey (1966).

Those who vary their puncture site depending on the clinical picture include Wagner and Price (1947), Lindgren (1953), Edwards (1957), Wylie and Goldman (1958), Linton (1959), Szilagyi (1959), Lowman (1960), Heringman and Greenstone (1960), Sutton (1962) and Szilagyi, Smith, Macksood and Eyler (1962). These puncture the aorta at an infrarenal level in those patients in whom there is clinical evidence of unilateral iliac artery occlusion, and at a suprarenal level in those in whom there is possible aortic occlusion.

In favour of the low puncture is the suggestion that complications are lessened with a low puncture, in particular those associated with a marked flooding of the coeliac axis, superior mesenteric artery of the renal arteries. It also avoids the so-called "paraplegia level" at the 12th thoracic to 2nd lumbar level. On the other hand, an infrarenal puncture entails entering the aorta at a part well known to be involved more severely by atherosclerosis than the suprarenal aorta, with possible risk of dissection or haemorrhage (Massell, Heringman and Greenstone, 1960 and Szilagyi, Smith, Macksood and Eyler 1962). It has been realised for many years (Lindgren, 1953) that low puncture "concentrates" the contrast medium in the arteries of the pelvis and avoids its dissipation in the large abdominal vessels.

We have not used scoline nor any similar relaxant in order to produce apnoea during the injection of contrast and radiography. The patients have been allowed to breathe normally during the series of exposures. Laws (1959) in a letter in the British Journal of Radiology following a report of inferior mesenteric artery occlusion as a complication of translumbar aortography, by McDowell and Thompson (1959) wrote that he felt that the occlusion was caused by a dissection of the aorta, and commented on the use of relaxants in translumbar aortography. He believes that they should not be used, feeling that the sudden relaxation in muscle tone, with a consequent increase in abdominal compression may cause the needle to move. The present writer feels that with adequate general anaesthesia no such sudden relaxation is obvious. His anxiety has been that the administration of relaxants is followed by muscle twitching, which can be quite marked. This, he believes, in association with active inflation of the patient's lungs, several times by the anaesthetist, may well cause movement of the needle tip in the aortic lumen and make the careful preliminary positioning of the needle, with test injections, unreliable.

It is widely agreed that site and accuracy of needle positioning in the aorta are of extreme importance in the prevention of renal, spinal and intestinal complications (Beall, Crawford, Couves, DeBakey 1963). A generally accepted method of demonstrating the position of the needle tip, before the main aortographic injection, is to use a "test" or "pilot" injection. A number of workers in this field have used this method - Sutton (1957 and 1962) Wolfman and Boblitt (1959), McDowell and Thompson (1959), Gillanders (1963), Domingo, Schaeffer, Fries, Sawyer and Wesolowski (1964) and Granger (1965). Many of those who have reported on aortography, but have not discussed their use of a test injection, may well have used it, but not felt that it warranted discussion.

Lindgren (1953) wrote "even if a trial injection of a small quantity of contrast medium shows it all to enter the lumen of the vessel some of the contrast nevertheless be injected paravascularly during the main injection". He advocated passing a slender stylette through the needle to determine the relation of the needle tip to the aortic wall. This should be, he believed, about 4 to 5 mms. from the wall opposite to the puncture site. If the stylette does not advance more than 1 mm. from the needle tip, the latter is very close to the aortic wall, while if it advances a centimetre or more, the needle is in a branch. He notes, none the less, that a test injection is still necessary to show the relation of the needle to an aortic branch.

Lindgren's criticisms of the absolute reliability of the test injection are borne out in practice. For example McDowell and Thompson (1959) undoubtedly dissected an aorta at their main injection (Laws 1959) although they had accepted their test injection as showing a satisfactory needle position.

- - - -

Mechanical injection of contrast medium into the aorta is the original method, Dos Santos describing a pump for this purpose in 1931. Other mechanical injectors have been described by Melick and Vitt (1948), Stirling (1957), Pattinson and Somerville (1958), and Sutton and Burkhead (1960). A number of workers have always preferred a manual injection - Goodwin, Scardino and Scott (1950), Lindgren (1953), Sutton (1957 and 1962), Massell, Heringman and Greenstone (1960), and Knox and West (1961). Sutton (1957) feels that the chances of dissection of the aorta are increased by the use of pressure injectors, holding that some of the dissections reported by Gayliss and Laws (1956) were due, in part, to this. He comments in his book (1962) "with hand injectors the experienced operator can often feel the increased resistance should the needle point slip out of the arterial lumen, and can stop the injection". While the writer believes that this may be possible with the relatively gentle injection into the femoral artery, he doubts if it can apply to the forced aortic injection.
McAfee (1957) notes in his review of the complications of

translumbar aortography that the incidence of renal complications seemed to be "unduly" high in those centres where a mechanical injector was used. Manual injection has been used throughout this series without any problems due to lack of adequate contrast content in the aorta.

- - - - -

In the femoral arteriogram series it seemed important, where possible, to carry out bilateral arteriography, regardless of the unilaterality of symptoms. A number of reports have been made referring to the value of bilateral examination. These are discussed briefly below, and on the basis of the four in the 1950's the policy of bilateral arteriography was followed.

Wessler and Schlesinger (1953) studied 72 amputated lower limbs, 66 of which had been amputated because of atherosclerotic gangrene. In 7 of these 66, both limbs were available for study. In these, extensive occlusive disease was present in each pair of extremities, and in only one was the extent of the disease markedly different on the two sides.

In 1954 Krahl, Pratt, Rousselot and Rusicka reported a clinical and arteriographic study of 50 patients with arterial insufficiency of the lower limbs as their main complaint. 13 patients (26%) had bilateral lesions radiologically.

A year later Greenwald, LeFebre, Root and Humphries (1955) reported 103 consecutive arteriograms on 76 patients, 27 being examined bilaterally and 49 unilaterally. A "symmetrical tendency" was clearly apparent in the distribution of the disease.

Dunlop and Santos (1957) discussing 41 femoral arteriograms, pointed out the value of performing angiography of the "uninvolved" leg. They felt that because of the bilateral nature of the disease several stages of the process might be illustrated in the same patient.

In 1960 Conley and Kennedy reviewing 100 consecutive lower limb arteriograms, 96 of which were for arteriosclerotic disease, said "Arteriosclerosis in the lower extremities tends towards bilateral involvement although not symmetrical as to the site and extent of involvement". They pointed out that symptoms are usually unilateral except when the aortic bifurcation is involved.

Singer and Rob (1960) discussed the fate of 359 patients with intermittent claudication. None had Buerger's disease. In 58 patients the disease was bilateral from the beginning of the period of observation - i.e. in 16.2%.

Warren, John, Shepherd and Villavicencio (1961) commented that they were struck by the "extraordinary symmetry" of the distribution of the obliterative disease in the arteries of opposite legs in some patients. They added that it was difficult to escape the conclusion that the occult aetiological factors, both systemic and local, which cause arteriosclerosis work together in an orderly rather than a haphazard fashion.

A year later in 1962, Edwards, discussing patterns of occlusion wrote that particularly in diffuse arterial disease there was evidence of rather symmetrical involvement.

Boyd (1962) speaking to the Royal Society of Medicine on the natural course of arteriosclerosis, on the basis of follow-up of 1476 patients with claudication, noted the bilateral nature of the disease. Nearly 25% of the femoral thrombosis and 12% of the popliteal thrombosis were bilateral when the patients were first seen. In the age group 35 to 44 years, 64.7% were bilaterally involved and in the 55 to 64 year group, 38.1% were.

Kohler and Viljanen (1964) examined the iliac arteries and the arteries of the lower limbs bilaterally in 138 patients. As a result of their experience they put forward a simple rule saying "it may be said that when there is occlusion in one leg, the other will also be seriously affected in 5 out of 6 cases."

Also in 1964, Oldham complained that few authors gave a clear account of the percentage of their patients with bilateral lesions when first seen. In his experience about a third of patients are aware that both legs are involved at the time of their first visit. A further third shows evidence, such as absent pulses or oscillometric change, indicating serious involvement of the second leg. Clinical examination of the remaining third suggests that the main vessels are still relatively unobstructed. This evidence of disease in the opposite limb is very close to Boyd's (1962) 64.7% incidence of bilateral occlusion in his 35 to 44 year old group.

Seldinger (1964) says that the arteries of the two lower limbs frequently show symmetrical changes, but gives no figures.

In 1966, Watt reported finding bilateral occlusion in 110 (60%) of 184 patients with unilateral claudication and symmetrical occlusion patterns in 7 patients - 2.7% of 264 patients examined by bilateral arteriography.

- - - -

While this series of patients was being collected two new methods of arteriographic examination of the aorta were described.

A technique of brachial artery catheterisation was described in 1962 by Samuel, who used a modified Riley needle and the standard 160 Seldinger guide wire. This technique, which he used in the investigation of the thoracic and descending aorta was, he felt, probably safer in the investigation of the bifurcation of the aorta than the direct translumbar puncture, with less risk of trauma to a damaged aortic wall, the puncture being away from the affected vessel and the injection at a distance from the obstruction. Of his 25 examinations only in 1 was catheterisation unsuccessful, but here the Seldinger 160 needle was used, not the modified Riley needle. In 4 the catheter could not be advanced beyond the vertebral artery.

Newton (1963) and Hanaffee (1963), followed by Roy (1965), each described a technique of Seldinger catheterisation of the axillary artery. By this method a catheter could be passed to any level in the aorta and used for contrast medium injectionin the study of occlusive vascular disease.

It was not felt desirable to alter the method of examination in the patients when an attempt was being made to collect a series. Hence neither of these methods has been used.

Conclusion

There is, it is felt, strong evidence against the use of retrograde percutaneous femoral artery catheterisation as the method of radiological examination of the distal aorta and lower limbs. A considerable body of support exists for the use of translumbar aortography, with a varying puncture level, and for femoral arteriography, depending on the clinical picture. It appears that both lower limbs should be examined rather than restrict the examination to symptomatic limbs alone. This routine was adopted in this series when possible.

None the less a view exists, the validity of which cannot lightly be dismissed, that the distal aorta and iliac arteries should be examined in all patients with ischaemic disease affecting the lower limbs regardless of the level at which the occlusion is thought to be on clinical grounds. It is felt that a study of the distal aorta and iliac arteries should be carried out in patients whose complaint is solely of leg claudication, and in whom no clinical evidence is found of aortoiliac occlusion.

The collection of this group of patients in this hospital is now in progress.

- - - -

DISCUSSION OF COMPLICATIONS

DISCUSSION OF COMPLICATIONS

The first patient's death from coronary occlusion may well be related to the fall in blood pressure occuring after the injection of contrast material (Amundsen, Amundsen and Muller, 1956), with the initial episode of coronary artery thrombosis occurring at this time. Certainly his restlessness and sweating suggest, in retrospect, that this is possible.

It is difficult to consider how one can avoid complications in patients with degenerative vascular disease when some degree of hypotension follows injection of contrast material. Sutton (1962) remarks that he had occasionally seen a pronounced fall in blood pressure after lumbar aortography, and adds that this can precipitate hemiplegia in patients with atheromatous carotid stenosis. Certainly the risks of death from coronary thrombosis are high in patients with peripheral vascular disease. McDonald (1953) found that 23 (29%) of his 79 patients with intermittent claudication had angina pectoris in addition, and of the 56 patients with claudication, but without angina pectoris 8 (14%) showed electrocardiographic evidence of ischaemic heart disease. Bloor (1960), reviewing 1476 patients seen between 1947 and mid 1953, found that by 1960, 673 were dead, 401 from cardiac disease. In other words, 27.2% of his patients died what he calls "cardiac death", and 15.1% had non-fatal coronary occlusions. Singer and Rob (1960) following up patients with claudication found that 22.1% had evidence of previous myocardial infarction. During the period of follow-up, 39 patients had fatal coronary occlusions, (i.e. 12.1% of the patients in the series) and a further 9.9% had non-fatal occlusions. Begg and Richards (1962) found a fatal myocardial infarction rate of 25.3% in their 198 patients 25.25% with intermittent claudication. Taylor and Calo (1962) noted a coronary occlusion death rate of about 8.5% in a follow-up study of 412 patients.

McAfee (1957) analysing the complications in 13,207 abdominal aortograms noted 3 coronary occlusions within two hours of recovery from general anaesthetic in translumbar aortography. Two were fatal. "A few" coronary occlusions were seen one or two days after aortography.

It seems from these figures, showing a high incidence of coronary occlusion in patients with peripheral vascular disease, that chance alone makes it inevitable that, in any series, a patient may have a coronary occlusion at or about the time of arteriography.

- - - -

In the second patient in whom the pathologist found little functional renal tissue remaining in the cystic kidneys, it seems reasonable to accept that the sudden load of radiographic contrast material was more than these grossly diseased kidneys could tolerate. This must be regarded as a death from renal failure, secondary to the effect of the contrast medium, on already severely damaged kidneys.

- - - -

Two massive reviews of the complications of translumbar aortography were made by McAfee and Willson (1956), and by McAfee (1957). The first is based on a "reasonably complete" review of the English literature, the available foreign literature and 150 aortograms performed in the John Hopkins Hospital. McAfee bases his review of the complications on an analysis of 12,832 translumbar aortograms performed in various centres in the United States. Crawford, Moyer, Beall and DeBakey (1957) reviewed their complications in a series of 300 aortograms and give a large bibliography.

It is clear from these reviews that the commonest complication is renal, either oliguria or anuria, each of which could be fatal. McAfee and Willson (1956), and McAfee (1957) believed that these complications were associated with injection of contrast material into, or at the origin of, a renal artery; with mechanical rather than manual injection; with the two needle technique of aortography long-favoured in the U.S.A. (Wylie and McGuiness (1953) Langsam and Wilensky (1954) Bruwer and Ellis (1958)); with doses of contrast material over 25 cc. and with aortic occlusion, where a large proportion of contrast material passed into the renal arteries.

Beall, Crawford, Couves, DeBakey and Moyer (1958), discussing renal complications, suggested that injection of contrast material into the aorta causes vasospasm in the kidneys. They advocated hyperhydration prior to aortography, giving 100 ml. 5% Dextrose in water, intravenously. (Morris, Crawford, Beall and Moyer 1956; Beall, Lewis, Weibel, Crawford and DeBakey 1946.) Wylie and Goldman (1958) noted 23 renal complications in 200 patients in whom a suprarenal aortic puncture was made but only in 2 of 210 patients in whom the puncture was infrarenal.

\- - - -

Paraplegia also occurs as a serious complication of aortography.

It was first reported by Antoni and Lindgren (1949) following translumbar aortography in a very emaciated patient, with a pillow under the abdomen in order to make the puncture easier. After a difficult anaesthetic induction, they had difficulty in puncturing the aorta, but eventually succeeded, injecting contrast medium mechanically. The aorta was filled with contrast medium down to the level of the upper part of the second lumbar vertebra, and no further. Some perivascular injection of contrast material occurred. Following the aortogram, the patient became paraplegic below the twelfth thoractic/first lumbar level. Antoni and Lindgren regarded this as an example of Steno's experiment in man, feeling that the abdominal aorta had been compressed by the pillow in their very thin patient. (Steno - Niels, Steenson, a Danish anatomist - noted in 1667, motor and sensory paraplegia of the lower part of the body in rabbits, following compression of the abdominal aorta.) They did not attribute the complication to the aortogram itself, although it appears from their illustration of the aortogram that there had been a subintimal injection of contrast material.

Boyarsky (1954) reported a patient in whom paraplegia below the eighth thoracic level followed aortography. It seems significant that he too had difficulty in puncturing the aorta. Abeshouse and Tiongson (1956) noted generalised convulsions, most marked in the lower limbs, for ten seconds following the injection of contrast in their patient who became paraplegic. Baurys (1956), reporting a patient who became paraplegic after translumbar aortography, says "the operator had some difficulty, and made several punctures before the needle was introduced into the aorta." The patient reported by McCormack (1956), who became paraplegic following aortography, was examined after direct anterior wall puncture of the abdominal aorta at sympathectomy and had two injections of contrast material. It is interesting that McCormack queries the possibility of aortic dissection, but tends to rule it out. McAfee (1957) recorded 29 spinal cord lesions in 13,207 abdominal aortograms - an incidence of 0.2%. Hare (1957) reported paraplegia in a woman of 59, after an easy translumbar puncture, and a double injection of contrast medium from a mechanical injector. Anthony (1958) reported paraplegia occurring once in 100 translumbar aortograms.

In Grossman and Kirtley's patient (1958) paraplegia followed translumbar aortography using a two needle technique. At the first injection some extravasation of contrast material occurred and the film changer jammed. A repeat injection was made after the needles had been withdrawn and re-introduced. At this examination complete aortic occlusion below the third lumbar vertebra was demonstrated.

38 examples of spinal cord injury related to abdominal aortography were collected by Killen and Foster (1960) from an inquiry sent to "all chiefs of Radiology and of Urology in the U.S.A.". A useful table of the previously reported examples is given by Efsen (1966) who

reported four instances of paraplegia after catheter aortography.

Puncture of the subarachnoid space, with death following injection of contrast material was reported by Doroshow, Yoon and Robbins (1962). They believed this to be the third report of this accident.

\- - - -

A fresh look was taken at the complications of translumbar aortography by Gayliss and Laws (1956). They described dissection of the wall of the aorta at translumbar aortography when some or all of the contrast material is injected into the media of the aorta. This they regarded as an important fact since its significance might not be appreciated, in that sequelae could occur as a result of dissection of the aortic wall might take place in spite of scrupulous technique. They believed this to be a not uncommon complication, one which could explain a number of the major disasters following aortography for which there had previously been no satisfactory explanation. They suggest that lumbar and intercostal artery origin may be torn by the dissection, causing ischaemia of the cord and paraplegia. Dissection with local occlusion involving a mesenteric artery can, they feel, cause stasis of the contrast medium in the involved vessel, and consequent infarction and gangrene of the gut. They suggest that the same mechanism may apply to many reported examples of renal failure. Hare (1957), in a correspondence following this article and in his report of his paraplegic patient (1957), felt that lumbar artery damage could occur from direct trauma by the needle, or by disturbance of an atheromatous plaque as well as by subintimal dissection.

Sutton (1957) in the same correspondence, felt the test injection to be essential, and was against mechanical injection of the contrast medium, adding that not more than 25 cc. of 70% sodium acetizoate should be used. He recommended a soft, rather than a rigid connecting tube between the needle and the injection syringe, since a rigid tube could cause displacement of the needle.

Samuel and Denny (1958), discussing a report by Conger, Reardon and Avery (1957), of fatal renal failure following translumbar aortography, re-emphasise the importance of aortic dissection as a cause of complications.

Boblitt, Figley and Wolfman (1959) noted intramural injection in 10.8% of 390 patients. There were three deaths, two from uraemia associated with a dissecting aneurysm at the renal artery origins, and one associated with a probable intramural injection at renal artery level. One of these three patients showed opecification of the rectal wall at aortography, and prior to death, had tenesmus and rectal necrosis - similar to those patients discussed below. Wolfman and Boblitt (1959) noted that most of the complications occurring in translumbar aortography are identical with those occuring in spontaneous dissecting aneurysm. They had four dissections in 302 translumbar aortograms, each being fatal.

In discussion they suggest that the first reported fatality in translumbar aortography (Wagner and Price 1950), previously regarded as a superior mesenteric thrombosis may have been due to dissection. Laws (1959) pointed out that the inferior mesenteric artery occlusion following translumbar aortography, reported by McDowell and Thomson (1959) appeared to be due to aortic dissection. Recovery following aortic resection and Teflon grafting in a patient who had an aortic dissection at translumbar aortography, and who developed an almost complete flaccid paralysis of the right leg, was reported by Takara, Peasley, McKeel and Wilkerson (1959). It seems from his figure 1, that the patient reported by Padhi (1960), with fatal infarction of the descending colon following translumbar aortography, had aortic dissection. In this patient the descending colon is shown heavily outlined with contrast medium. Guilfoil (1963), reviewing the ten similar examples traced in the literature reported a non-fatal inferior mesenteric artery syndrome after translumbar aortography. His films were "not technically satisfactory for reproduction", but he comments that there was no intramural injection of contrast medium. His observation that the patient showed a blue discolouration of the lower buttocks and upper thighs on injection of contrast medium suggests that some major vascular accident occurred at that time. He noted that there was contrast medium in the wall of the descending and sigmoid colons "outlining the bowel almost as well as though the x-ray film represented a barium enema." At least seven of the ten instances of inferior mesenteric artery damage at aortography, which he reviewed, showed this appearance.

McAfee (1957) in his massive survey of the complications of abdominal aortography, had reported three instances of superior mesenteric artery injection of contrast medium, with two deaths from gangrene of the gut, and two inferior mesenteric artery injections with gangrene of the left colon, one of which was fatal. He did not relate these complications to intramural injection but felt they were due to direct injection of contrast medium into the branch. In the 13,207 abdominal aortograms which he reviewed he recorded 136 intramural and subintimal "dye" injections without sequelae - i.e. 10.2%.

The cause of paraplegia following aortography, has been ascribed to spinal artery spasm with consequent ischaemia of the cord (Abeshouse and Tiongson, 1956) or to a direct toxic effect of the contrast medium on the spinal cord (McCormack, 1956, Margolis, Tarazi and Grimson 1956).

Sutton (1962) appears reluctant to accept Gayliss and Laws (1956) explanation of the mechanism of complications and notes seeing major subintimal injection of contrast medium only twice in over fifteen hundred lumbar aortograms. He feels that chemotoxicity of contrast material is a more convincing explanation. Similarly Hughes and Brownell (1965) feel a direct toxic effect of contrast medium to be the cause of their patient's paraplegia. Their patient was examined by transfemoral Seldinger catheterisation. Faure, Djindjian and

Lefebre (1966), reporting another two instances of paraplegia similarly felt that a toxic effect of the contrast material is responsible.

Other complications of translumbar aortography have been reported.

Retroperitoneal haemorrhage was apparently first reported by McAfee and Willson (1956) who felt that multiple punctures were dangerous. McAfee (1957) and Crawford, Beall, Moyer and DeBakey (1957) reported further instances of haemorrhage.

Perforation of a hollow viscus was reported by Trippel, Bernhard, Holf and Laufman (1957) and by Rob (1958).

Damage to the thoracic duct, with resulting chylothorax, was reported by Maluf and McCoy (1955), Crawford, Beall, Moyer and DeBakey (1957), Gasper and Secrest (1957), Schwarz (1960), and Cook, Flaherty, Willmarth and Langelier (1960). It is worth noting that in Schwartz's patient there was failure to puncture the aorta and in the patient reported by Cook et al there were three attempts to puncture.

Acute necrotising pancreatitis was reported by Robinson (1956), following direct injection of 20 ccs.

of 70% sodium acetrizoate into the coeliac axis, followed by the same dose into the aorta at a lower level.

Haemothorax was recorded by Szilagyi, Smith, Macksood and Eyler (1962).

Retroperitoneal sepsis and gangrene of the skin of the back were reported by McAfee (1957).

The example of gangrene of the large gut, left ovary, and right ovary with uterine tube reported by Fineberg, Schechter and Barrick (1958) was undoubtedly due to the massive aortic dissection and intramural injection of contrast material which the authors noted.

Sutton (1962) notes that pneumothorax and accidental cardiac puncture have been reported.

- - - -

Femoral Arteriography

The complications reported are less startling than those in translumbar aortography.

Segmental gangrene of a portion of the thigh following injection of 30 cc. 70% sodium acetizoate into the femoral artery, with some extravasation was reported by Klingenberg (1958).

Botseas and Lawrence (1959) reported two instances of skin necrosis following femoral arteriography performed by open arteriography and insertion of a polythene catheter - a modified method of Castellanos and Pereiras (1950).

Perforation of the caecum was noted by Knox and West (1961).

Trauma to atheromatous plaques with consequent haemorrhage was suggested as a possible hazard by Melick and Vitt (1948). Julian and Dye (1955) reported such trauma, with elevation of the plaque. Subintimal haemorrhage and eventual thrombosis of the main artery was reported by Julian and Dye (1955). Sutton (1962) feels this to be a theoretical, rather than a practical danger in view of the vast numbers of atheromatous arteries punctured without mishap.

In the 106 patients with pregangrene or established gangrene, examined by direct femoral arteriography, the writer is convinced, that, although no gross and dramatic change occurred during or immediately following arteriography, in about a quarter, a definite change occurred in the appearance of the foot, and in its temperature as judged crudely by palpation. The colour changed, becoming rather darker and bluer, and the foot became colder. This change did not occur within five minutes of the injection of contrast material, if the needle remained in the femoral artery. It did occur within one minute of withdrawing the needle and starting compression of the puncture site. This was noticed early in the examination of this series of patients and care has been taken that the degree of compression was as little as possible. This effect has not been a lasting one, the foot returning to its pre-arteriogram appearance within a few hours. It is obviously extremely difficult to assess any harmful effect of arteriography in these limbs in which the natural history of the pathological process, without treatment, is one of deterioration. Fortunately no gross change has occurred.

There has always been anxiety about carrying out arteriography in gangrenous limbs since Singleton (1928) reported deterioration in gangrenous lower limbs after femoral arteriography with 100% sodium iodide. Similarly dos Santos (1932) comments, "well tolerated in free circulation, the arterial injection becomes dangerous as soon as there is an obstruction or stasis (gangrene, aneurysm etc.). Twice we have seen aggravation of gangrene following arteriography with "abrodil"." Also in 1932, Allen and Camp described extension of gangrene as a complication of arteriography with sodium iodide. Kleinsasser (1947) likewise suggests that pre-existing gangrene may be aggravated by arteriography. It seems quite clear from the reports of Humphries, de Wolfe and Le Fevre (1957) and of Taylor (1962 and 1964) that surgery has more to offer the patient with severe lower limb ischaemia than a major amputation. With bypass grafting and sympathectomy limbs can be salvaged. Accurate demonstration of the sites of occlusion and of the patency of vessels suitable for the insertion of the graft is essential in the selection of the patients for surgery and planning the operation. It seems quite clear that in view of the possibility of saving a limb one must accept any possible hazard inherent in arteriography of these critically nourished limbs.

It seems worthwhile to undertake a study of the effect of arteriographic examination on the lower limb, both in patients with claudication and gangrene, using atraumatic thermocouples or thermography (Skversky, Herring and Barran (1964), Winsor and Bendezu (1964), Wallace (1967)). The development of a temperature fall could then be related to any particular episode during the examination and the length of time for return to the pre-arteriogram level demonstrated.

- - - -

How can one avoid complications?

There seems no doubt from the many reports of complications following repeated or attempted puncture of the aorta, that it is wiser to abandon an arteriogram rather than persist in the face of difficulty in puncturing a vessel, particularly the abdominal aorta. Although Szilagyi, Smith, Macksood and Eyler (1962) say that an examination can be regarded as safe if the probability of death is no greater than 1 in 1000, this seems too high to be generally acceptable in a diagnostic investigation. McAfee (1957) gave a death rate of 2.9 per 1000 in his collected series. It is worth remembering that Schobinger (1964) felt that the mortality rates in aortography require revision downwards. Writing elsewhere, in the same year, he states "certain, by nowclassic, papers are constantly quoted to emphasise over and over again specific danger points and the incidence of severe and fatal complications associated with some types of angiographic procedures. If some of these "classics" have undoubtedly fulfilled their mission either by justly cautioning against the indiscriminate use of certain procedures or by fostering the development of new and, at the time, better-tolerated methods, it is nevertheless necessary to re-evaluate their consequences and validity in the light of present-day knowledge. In this respect it is paramount to realise that the advent of the newer triiodinated contrast media has drastically changed the incidence and severity of a great number of untoward effects of some angiographic procedures; they have changed the effects in favour of the patient and the angiographer."

Some apparently minor points seem to the writer of importance in keeping complications to a minimum. The use of a newly re-sharpened needle, absolute refusal to allow any movement of the patient upon the table after the introduction of the needle, and above all the acceptance by the vascular surgeons that it is wiser to abandon the examination early if the artery (particularly the aorta) is not entered promptly, rather than to persist and possibly cause injury to the patient, all appear to be the valuable precautions.

The use in aortography of test injections, and of small volume of contrast medium both in the aorta and in the femoral arteries, are further easily taken precautions.

DISCUSSION - AORTO-ILIAC SERIES

How does the incidence of aorto-iliac disease and occlusion in the present series compare with previous reports?

TABLE 69

Authors	Total with Aorto-iliac Occl.	MALE No.	MALE % of Total	FEMALE No.	FEMALE % of Total
Present series - with occlusion	53	42	79.2	11	20.8
all patients	84	63	75.0	21	25.0
Burt, Learmonth & Richards (1952) (aortic occlusion only)	11	10	90.9	1	9.1
Milanes, Bustamente, Guerra, Nunez, Hermandez, Perez-Stable, McCook & Indigo (1952)	30	25	83.3	5	16.7
Edwards and Le May (1955)	37	33	89.2	4	10.8
Haimovici and Escher (1956)	13	10	76.9	3	23.1
Brown, Grant, Key, Wilson & Bigelow (1957)	30	27	90.0	3	10.0
Massareli & Estes (1957)	105	91	86.7	14	13.0
DeBakey, Crawford, Cooley & Morris (only 199 showed complete occl.)	448	408	91.1	40	8.9
Foster & Killen (1959)	117	110	94.0	7	6.0
Julian, Javid, Dye & Issa (1959) (aortography in 96)	126	101	80.2	25	19.8

TABLE 69 (continued)

Authors	Total with Aorto-iliac Occl.	MALE No.	MALE % of Total	FEMALE No.	FEMALE % of Total
Shepherd & Warren (1960) (50 with occlusive disease)	52	45	86.5	7	13.5
Singer & Rob (1960)	109	94	86.2	15	13.8
Friedman, Holling & Roberts (1964)	43	31	72.1	12	27.9
Hardin (1964)	134	113	84.3	21	15.7

If only the patients with complete occlusion in the aorto-iliac region are considered, the incidence of women in this series is higher than in all but two of the series reported (Haimovici and Escher 1956, and Friedman et al, 1964). These series, like the present one, are small, and it may be that the high female incidence is due to chance. None the less these series may, like the present one, be unselected and form an accurate picture of the disease in a community, with no loading, due to referral of patients from outside the area covered by its radiological and surgical services, because of special interest and skill in the hospital from which these reports come. It is worth noting that in two of the large series, DeBakey et al (1958) in the U.S.A., and Singer et al (1960) in London, the female incidence was 8.93% and 13.76% respectively. Neither of these two series can be regarded as representative of their communities or of the U.S.A., or England, since in the years preceeding these reports each unit had a large number of patients referred to it.

In view of these figures it is suggested that aorto-iliac disease is commoner than usually believed, in women, and that approximately one in five of all patients with aorto-iliac occlusion are women.

TABLE 70

Sites of occlusion in the aorto-iliac arteries.

Site	WOMEN Number	WOMEN %	MEN Number	MEN %
Aorta	4	26.1	4	7.4
Right common iliac artery	3	20.0	11	20.3
Left common iliac artery	4	26.7	13	24.1
Right external iliac artery	1	6.7	9	16.7
Left external iliac artery	3	20.0	17	31.5
TOTAL	15	100.1	54	100.00

(The totals are greater than the numbers of women and men showing complete occlusion since four women and eighteen men had multiple occlusions (Table 38 and 39).

The incidence of occlusions occurring in each artery in the total series in men and in women, is shown in Table 70 and in Table 20 of all occlusions

50 of the 61 (i.e. 82%) occlusions in the iliac arteries occur in men - the incidence being almost the same as the male proportion of the patients in the aorto-iliac group, i.e. 75%.

Half the aortic occlusions occurred in women, and formed 1.5% of all occlusions in women. Aortic occlusion accounted for only 0.4% of all occlusions in men. Its percentage incidence is thus 3.6 times higher in women than in men. The high proportion of aortic occlusion to other occlusions in the aorto-iliac group in women, compared with men is shown in the ratio of aortic occlusion: common iliac occlusion: external iliac occlusion. In women this ratio is 1 : 1.75 : 1.5, while in men it is 1 : 6 : 6.5.

How do the ratios of occluded arteries in the aorto-iliac group in the present series compare with the reported ratios?

TABLE 71

Author	Aorta	Common Iliac	External Iliac
Present series - all patients with occlusion	1	3.9	3.8
Present series - men with occlusion	1	6.0	6.5
Present series - women with occlusion	1	1.8	1.5
Heinzen, Dunbar & Parsons (1954)	1	2.2 ("iliacs")	
Krahl, Pratt, Rousselot & Ruzicka (1954)	1	1.8	1.0
De Wolfe, Le Febre, Humphries Shaw & Phalen (1954)	1	2.9	0.4
Edwards and Le May (1955)	1	4.2	1.3
Wylie & Gardner (1955)	1	2.6	0.3
Julian, Javid, Dye & Issa (1959)	1	1.8	not recorded
Lund, and Henrichsen (1960)	1	1.7	3.3
Shepherd & Warren (1960	1	3.9	not recorded
Thevenet and Vialla (1961)	1	2.8	2.0
Boyd (1962)	1	2.2	not recorded
Inada, Hayashi & Okatani (1964)	1	2.0	not recorded
Kohler & Viljanen (1964)	1	9.9 ("iliacs")	
Valdoni & Venturini (1964)	1	1.8	1.7

These figures show how in the reported series the aorta is the least commonly occluded artery, except in the series reported by Wylie and Gardner (1955) where external iliac artery occlusion is the least common, being only 0.25 as frequent as aortic occlusion. With the exception of the series reported by Lund and Henrichsen (1960) and the men in the present series, the common iliac artery is occluded more commonly than the external iliac, so much so that Julian, Javid, Dye and Issa (1959) say "the distribution of the occlusion indicates that the occlusive lesions are more frequently primary in the common iliac arteries than in any other part of the system". In the present series the difference in incidence of occlusion in the common and external iliac arteries is minimal, but external iliac artery occlusion is slightly more common than common iliac artery occlusion in men, and common iliac artery occlusion slightly more common than external iliac artery occlusion in women.

If we consider only the 11 women with aorto-iliac occlusion, 4 (36.4%) showed aortic occlusion, while of the 42 men with aorto-iliac occlusion, only 4 (or 9.5%) showed aortic occlusion.

Although the numbers are small it appears that in this series aortic occlusion is relatively commoner (about four times) in women than in men.

- - - -

Is there a similar difference in sex incidence in occlusion of the common and external iliac arteries?

TABLE 72

Artery	WOMEN			MEN		
	No. Occluded	% of the women in the aorto-iliac group (21)	% of the 11 women in this group with Occlusion	Number occluded	% of the 63 men in the aorto-iliac group	% of the 42 men in this group with Oclusion
Aorta	4	19.0	36.4	4	6.3	9.5
Common iliac	7	33.3	63.6	24	38.1	57.1
External iliac	6	28.6	54.5	26	41.3	61.9

This shows that in the women with occlusion in their aorto-iliac arteries, common iliac artery occlusion was minimally commoner than in men, while external iliac artery occlusion was minimally less common than in men.

Age of patients with aorto-iliac occlusion.

Present series	Number of Patients	Average age (Years)	Range of age (years)
Total	53	56.6	36-76
Male	42	56.9	40-76
Female	11	56.2	36-76
Male with claudication	34	56.5	42-76
Female with claudication	10	52.3	36-65
Male gangrene	6	62.5	40-72
Female gangrene	1	76	76
Male pregangrene	2	50.5	42 + 59
Female pregangrene	1	72	72

Previously reported series	Number of Patients	Average age (Years)	Range of age (Years)
Massarelli and Estes (1957)	105	55.3	34-70
DeBakey, Crawford, Cooley & Morris (1958)	199	Not given	23-80
	(Highest incidence in 5th. 6th. and 7th. decades)		
Shepherd and Warren (1960)	52	53.2	30-72
Singer and Rob (1960)	109	53	38-77
Begg and Richards (1962) (Claudication only)	198	55.4	21-76
Friedman, Holling & Roberts (1964)	43	49	Not given

Few reports of aorto-iliac disease give the age of the patients. Among those who do give the age are those in the table above. Although the difference in ages is minimal it does seem that the patients in the present series are slightly older than those in the reported series.

- - - -

<u>Age of patients in the aorto-iliac group compared with those in the femoro-popliteal tibial group</u>.

In the present series the average of the patients in the aorto-iliac group, with and without occlusion, is 57.1 years and in the femoro-popliteal group is 60. years. A detailed breakdown of the ages in women and in men is shown in Tables 78 and 77 for the aorto-iliac group, and in Tables 80 and 79 for the femoro-popliteal tibial group. These figures showing the patients in the aorto-iliac group to be younger than those in the femoro-popliteal group, are in keeping with previous reports. DeBakey, Creech and Cooley (1954) noted that their patients with aorto-iliac occlusive disease were approximately a year younger than those with femoro-popliteal occlusive disease. Similarly, Singer and Rob (1960) noted the mean age of

109 patients with aorto-iliac thrombosis as 53, and of 250 patients with femoro-popliteal thrombosis as 58. Shepherd and Warren (1960) found the mean age of their patients with aorto-iliac thrombosis to be 53.2, and in those with "ilio-femoro-popliteal" thrombosis to be 58.6. No age is given by Edwards (1962) but he says "patients with the aortic bifurcation process are apt to be young", nor by Darling and Linton (1964) whose patients in the aorto-iliac group were said to be younger than those in whom the lower limb was diseased. In the present series the aorto-iliac patients were almost three years younger than those in the femoro-popliteal group, and in the other series cited were one to five years younger than the patients in the femoro-popliteal group. The widest age difference was that reported by Friedman, Holling and Roberts (1964) whose patients in the aorto-iliac group were 49 years old (on average) and whose patients in the femoro-popliteal group were aged 61 on average.

\- - - -

AORTIC OCCLUSION

It is clear that there is a striking difference in the aortographic appearances of aortic occlusion, in this series, between men and women. Basically the difference is that the aortic bifurcation and entire common iliac arteries have been shown in three women and not at all in the men. The fourth woman and one man (Figures 27 and 35) showed refilling of their distal common iliac arteries. It seems unlikely to the writer that this difference can be accounted for by any technical factors. The number of films taken and the duration of the arteriographic series of films was constant, at one film per second for 6 seconds.

In the future the length of the radiographic series will be increased in the patients with clinical evidence of aortic occlusion in an attempt to detect very delayed iliac artery filling.

\- - - -

What is the generally accepted view of the pathogenesis of aortic occlusion?

Leriche (1923) in the original report of the syndrome known by his name reporting two patients with thrombosis of the distal aorta and obliteration of the origins of both iliac arteries, made no suggestion about the natural history of the lesion but felt it was due to an arteritis. In 1940 he commented "I have the impression that aortic obliteration with simultaneous iliac obliteration, probably secondary, is the usual case, while isolated double iliac occlusion with patency of the aorta is a rare example". With Morel (1948), he felt that the occlusion began in one common iliac artery, extended retrogradely into the aorta, hampering and eventually stopping blood flow into the opposite common iliac artery leading to a final stage of aortic bifurcation and bilateral iliac artery occlusion. They felt that less frequently the process began in the aorta and involved the iliac arteries secondarily. In 1951 Leriche restated this view of the natural history of aortic occlusion, but added that twice he had seen the lesion begin in the aorta itself.

It does appear that most workers accept the iliac origin of aortic occlusion as the usual method. Certainly the surgeons in the Vascular Unit in Houston, Texas, subscribe to this view "... the process seems to begin most frequently in the iliac arteries....", DeBakey and Cooley (1954); "when both common iliacs are occluded, complete occlusion of the distal aorta occurs", DeBakey, Crawford, Cooley and Morris (1958) and similarly Crawford, DeBakey, Cooley and Morris (1961).

Milanes, Stables and Lastra (1950) regarded primary obstruction of the aorta as rare, feeling, like Leriche that bilateral iliac artery thrombosis was the factor responsible for aortic thrombosis. This view was repeated two years later (Milanes, Bustamente, Guerra, Nunez, Hernandez, Perez-Stable, McCook and Inigo (1962)). Gould and Wilson (1954), Heinzen, Dunbar and Parsons (1954), Julian, Javid, Dye and Issa (1959), Shepherd and Warren (1960), and Thevenet and Vialla (1961) all restate this opinion.

Ortner and Griswold (1950) suggested that either an aortic or iliac occlusion preceeded aortic bifurcation occlusion. They obviously did not regard aortic origin of the process as rare. Similarly Beaconsfield and Kunlin (1953) reporting 35 patients from Leriche's unit felt that the thrombosis began either in a common iliac artery or in the aorta itself, below the origin of the inferior mesenteric artery. They believed an iliac origin of the thrombus to be three times as common as an aortic origin. In five patients in whom resection and homograft replacement for aortic occlusion was performed Oudot and Beaconsfield (1953) noted that both common iliac arteries were thrombosed in each patient.

Elkin and Cooper (1949) felt that the lesion started at the aortic bifurcation and spread from there. Theis (1952) also regarded disease of the abdominal aorta as the primary cause of aortic thrombosis.

Rian and Eyler (1967) noted that in aortic occlusion both iliac arteries were also thrombosed, but gave no views as to the origin of the lesion.

De Wolfe, Le Fevre, Humphries, Shaw and Phalen (1954) felt that if Leriche and the others who believed that iliac artery thrombosis was the first stage of pathogenesis of aortic thrombosis were correct, iliac artery thrombosis would be seen more frequently than or at least as frequently as thrombosis of the terminal aorta. They found common iliac artery occlusion in 16 of the 30 patients they discussed and do not mention the lower end of their seven aortic occlusion. They used a single film technique and it seems likely that filling of common iliac arteries may have been missed in patients with aortic occlusion.

A number of reports make no mention of the lower end of the occlusion - Holden (1946), Burt, Learmonth and Richards (1952) and Elliott and Peck (1952).

- - - -

Thepathology reports a bout the same times as Leriche's clinical report (1940), note iliac artery involvement in association with aortic occlusion. For example Gross and Philips (1940), discussing seven examples of aortic occlusion, note that in 5 patients there was bilateral iliac artery occlusion, and in one patient unilateral iliac artery occlusion. The state of the iliac arteries is not recorded in the seventh patient. Lueth (1940), reporting four patients, describes iliac artery thrombosis in two patients, a veryshort right common iliac artery occlusion in one, and does not mention the iliac arteries in the fourth. This patient, a man of 80, had an abdominal aneurysm and clot dislodged at operation impacted in the aortic bifurcation. This last patient is thus not an example of the generally accepted picture of the Leriche type of aortic occlusions. Lueth noted that aortic occlusion might occur in patients with mitral stenosis and auricular fibrillation - his youngest patient, a man of 45, fell into this group. (Twenty years later, in 1960, Starer and Sutton re-emphasised the association between mitral stenosis and aortic occlusion, reporting six instances in sixty patients with aortic thrombosis.) Greenfield (1943) reporting five patients with aortic occlusion described iliac artery thrombosis in three, one of whom had an abdominal aneurysm and did not detail the state of the iliac arteries in the other two. Coelho, Leeds and Freeman (1955), discussing twenty patients in whom there had been thrombo-endarterectomy because of occlusion of the terminal aorta, found patent common iliac arteries in only two.

Starer and Sutton (1958) reporting 32 patients with aortic occlusion say "in most of our cases the common iliac arteries were occluded, and flow could be seen to start about the iliac bifurcation" - this is the type of occlusion pattern seen in the first woman (Figure 27) and the fourth man (Figure 35). It is worth noting that in the diagram in this report (reproduced as Figure 83 in Sutton's book on arteriography in 1962) only one patient is shown to have patent common iliac arteries. Incidentally, Sutton (1962) remarks "stenosis of the abdominal aorta may precede thrombosis" does not expand this statement.

In considering previous reports of aortic occlusion it is of considerable interest and importance to quote Learmonth (1954). Discussing DeBakey and Cooley (1954) on "Surgical Considerations of Acquired Disease of the Aorta" at a meeting in the U.S.A., he said "I am quite sure that the disease originally described by

Leriche goes through an entirely different series of events in Scotland than it does in this country, or on the continent of Europe." - a remark of considerable significance, but strangely overlooked and forgotten.

It is suggested that the four men in the present series fall into the generally accepted pattern - aortic occlusion in association with iliac artery occlusion - either common, or common and external. With only one injection of contrast medium high in the abdominal aorta and radiography over a period of only 6 seconds it is possible that the duration of the exposure series was too short to show iliac artery filling, but the findings in the women suggest that the radiographic series was adequate in its time span.

In the women, contrast medium filling was shown in the common iliac arteries in all four patients with aortic occlusion. In three patients the entire common iliac artery on either side was shown, as was the aortic bifurcation. In the fourth, the common iliac arteries were shown only distally. A fifth woman is considered briefly. In this patient (not included in the series of aortic occlusions since this was not present at the initial examination), in whom bilateral common iliac artery occlusion was demonstrated, initially, a repeat translumbar aortogram ten months later showed that the occlusion had extended proximally up the abdominal aorta (Figures 59 and 60) - the generally accepted progression.

It therefore seems possible that aortic occlusion has a different natural history in men and in women. In men the appearance in this series fits with the generally accepted picture of aortic and bilateral iliac artery occlusion. In the women only one patient showed this pattern initially (although a second did on follow up of bilateral common iliac artery occlusion). Three showed aortic occlusion with normal aortic bifurcations and common iliac arteries. In addition, one woman showed incomplete aortic occlusion - gross atheroma with incomplete thrombosis throughout her infrarenal aorta, with normal common iliac arteries (Figure 61).

It is therefore suggested that while aortic occlusion in men and women is associated with common iliac artery occlusion, this association is less marked in women. Aortographic evidence is put forward to suggest that in women aortic occlusion may be due to primary aortic thrombosis more commonly than has previously been accepted.

In each of the patients in whom the common and external iliac arteries were occluded there was associated occlusion of the ipsilateral internal iliac artery. Local collateral channels and distant ones coming down from the lumbar arteries, were much more numerous in the patients with intermittent claudication than in those with pregangrene or gangrene.

- - - -

So far as the occlusion patterns in relation to the clinical presentation are concerned the numbers are too small for any analysis. Of the eleven patients in whom the common and external iliac arteries were occluded, four (i.e. 36.4%) had gangrene and one pregangrene.

It does seem then that common and external iliac artery occlusion is associated with severe ischaemic change in the lower limbs, particularly in elderly patients - two of those with gangrene were in the age group 61-70, and the remaining two in the 71-80 age group. The patient with pregangrene was 42. Clearly, these patients may well have had occlusive disease peripherally in the limbs, not demonstrated by the restricted examination carried out, in that arteriographic films were not obtained in the distal parts of the limbs. It was striking that in those patients with multiple occlusions there was a very different degree of collateral filling in those with claudication and those with gangrene. In all the patients with multiple occlusions the ipsilateral internal iliac artery was occluded. The patients with claudication showed a relatively profuse collateral circulation either from the lumbar arteries, or from the inferior mesenteric artery. On the other hand those with gangrene, or pregangrene, showed a sparse collateral network.

\- - - -

Because of the small numbers of patients involved, little can be suggested from the occlusion patterns in the aortic-iliac group. It does seem that in men occlusion of the right common iliac artery is the commonest solitary occlusion, while in women aortic occlusion is the commonest. Occlusion of the right common and external iliac arteries is the commonest multiple occlusion pattern seen in men. In women the four multiple occlusion patterns found were equal in incidence.

DISCUSSION OF FEMORO-POPLITEAL SERIES

Asymptomatic Limbs

Little attention seems to have been paid to the asymptomatic limb in patients presenting clinically with peripheral vascular disease. There have been some reports since Wessler and Schlesinger (1953) carried out injection studies on limbs amputated because of arterio-sclerotic gangrene. In seven patients both legs were available for study and extensive occlusive disease was found in each pair of extremities. It seems impossible that an asymptomatic limb was amputated, and hence although this paper is quoted as one reporting the disease process in asymptomatic limbs, this seems doubtful. Similarly, Krahl, Pratt, Rouselot and Ruzicka (1954) noted that 13 of their 50 patients had bilateral lesions but it appears from their report that they were referring to patients with bilateral disease rather than to those with lesions on the asymptomatic side. A "clearly apparent tendency" to symmetry of the disease process in the lower limb was noted in the 27 patients examined bilaterally by Greenwald, Le Fevre, Root and Humphries (1955) but again it seems that they were referring simply to the patients with bilateral symptoms. Dunlop and Santos (1957) were apparently the first to point out the value of carrying out

Asymptomatic Limbs

Little attention seems to have been paid to the asymptomatic limb in patients presenting clinically with peripheral vascular disease. There have been some reports since Wessler and Schlesinger (1953) carried out injection studies on limbs amputated because of arterio-sclerotic gangrene. In seven patients both legs were available for study and extensive occlusive disease was found in each pair of extremities. It seems impossible that an asymptomatic limb was amputated, and hence although this paper is quoted as one reporting the disease process in asymptomatic limbs, this seems doubtful. Similarly, Krahl, Pratt, Rouselot and Ruzicka (1954) noted that 13 of their 50 patients had bilateral lesions but it appears from their report that they were referring to patients with bilateral disease rather than to those with lesions on the asymptomatic side. A "clearly apparent tendency" to symmetry of the disease process in the lower limb was noted in the 27 patients examined bilaterally by Greenwald, Le Fevre, Root and Humphries (1955) but again it seems that they were referring simply to the patients with bilateral symptoms. Dunlop and Santos (1957) were apparently the first to point out the value of carrying out arteriography on the uninvolved leg because of the bilateral nature of the disease. Similarly, in 1960 Conley and Kennedy noted the tendency towards bilateral involvement but were not impressed as to the degree of symmetry of the lesion (Watt, 1966, reported symmetrical change in 7 patients, 2.7% of his series of 264). Singer and Robb (1960), discussing claudication recorded bilateral disease in 23.2% of their patients but appear to mean that 23.2% of their patients presented with bilateral claudication, rather than to be discussing the asymptomatic limb. Warren, John, Shepherd and Villavicencio (1961) commented on the "extraordinary symmetry" of the distribution of the obliterative process in the arteries of opposite legs in some of their patients. Edwards (1962) also found evidence of rather symmetrical involvement in the severest grades of ischaemia. Kohler and Viljanen (1964) commenting upon the lack of interest in examining the asymptomatic side suggested that if there was occlusion in one leg, the other would be "seriously affected" in 5 out of 6 cases. They do not specify the incidence of <u>occlusion</u> in the asymptomatic leg.

Pleading the case of conservatism in the management of claudication, Oldham (1964) reported that one third of his patients had bilateral symptoms, one third had signs of "serious involvement" of the asymptomatic leg and in the remainder the main vessels were relatively unobstructed.

Tables 73 and 74 show the numbers of occlusions on the symptomatic and asymptomatic sides in men and in women in the femoro-popliteal group.

- - - -

TABLE 73

No. of Limbs	COMMON FEMORAL	SUPERFICIAL FEMORAL	PROFUNDA FEMORIS	POPLITEAL	ANTERIOR TIBIAL	POSTERIOR TIBIAL	PERONEAL	NO. OCCLUSION
MALE CLAUDICATION								
Symptomatic Limbs								
368	4	195	17	97	85	83	39	88
% of 368	1.1	53.0	4.6	26.4	23.1	22.6	10.6	23.9
Asymptomatic limbs								
188	1	25	3	8	40	40	14	104
% of 188	0.5	13.3	1.6	4.3	21.3	21.3	7.4	55.3
MALE GANGRENE								
Symptomatic Limbs								
44	1	20	4	13	24	27	15	7
% of 44	2.3	45.5	9.1	29.5	54.5	61.4	34.1	15.9
Asymptomatic Limbs								
24	1	7	1	6	10	14	7	4
% of 24	4.2	29.2	4.2	25.0	41.7	58.3	29.2	16.7

TABLE 73 (continued)

NO. OF LIMBS	COMMON FEMORAL	SUPERFICIAL FEMORAL	PROFUNDA FEMORAL	POPLITEAL	ANTERIOR TIBIAL	POSTERIOR TIBIAL	PERONEAL	NO. OCCNS.
MALE PREGANGRENE								
Symptomatic Limbs								
30	3	10	3	15	10	20	9	2
% of 30	10.0	33.3	10	50	33.3	66.7	30	6.7
Asymptomatic Limbs								
16	-	4	2	3	2	9	6	4
% of 16	-	25	12.5	18.8	12.5	56.3	37.5	25
MALE ULCERATION								
Symptomatic Limbs								
5	-	2	-	3	3	2	1	1
% of 5	-	40	-	60	60	40	20	20
Asymptomatic Limbs								
3	-	-	-	1	2	1	-	1
% of 3	-	-	-	33.3	66.7	33.3	-	33.3

TABLE 73 (continued)

NO. OF LIMBS	COMMON FEMORAL	SUPERFICIAL FEMORAL	PROFUNDA FEMORAL	POPLITEAL	ANTERIOR TIBIAL	POSTERIOR TIBIAL	PERONEAL	NO. OCCNS.
MALE COLD FEET								
Symptomatic limbs								
6	-	-	-	-	-	1	1	5
% of 6	-	-	-	-	-	16.7	16.7	83.3
Asymptomatic Limbs								
2	-	-	-	-	1	-	-	1
% of 2	-	-	-	-	50	-	-	50

TABLE 774

NO. OF LIMBS	COMMON FEMORAL	SUPERFICIAL FEMORAL	PROFUNDA FEMORAL	POPLITEAL	ANTERIOR TIBIAL	POSTERIOR TIBIAL	PERONEAL	NO. OCCNS.
FEMALE CLAUDICATION								
Symptomatic Limbs								
72	-	33	1	15	15	20	9	20
% of 72	-	45.8	1.4	20.8	20.8	27.8	12.5	27.8
Asymptomatic Limbs								
29	-	4	-	2	3	11	4	14
% of 29	-	13.8	-	6.9	10.3	37.9	13.8	48.3
FEMALE GANGRENE								
Symptomatic Limbs								
21	2	7	5	7	7	8	7	5
% of 21	9.5	33.3	23.8	33.3	33.3	38.1	33.3	23.8
Asymptomatic Limbs								
12	-	-	-	-	2	6	1	6
% of 12	-	-	-	-	16.1	50	8.3	50

TABLE 74 (continued)

NO. OF LIMBS	COMMON FEMORAL	SUPERFICIAL FEMORAL	PROFUNDA FEMORAL	POPLITEAL	ANTERIOR TIBIAL	POSTERIOR TIBIAL	PERONEAL	NO. OCCNS.
FEMALE PREGANGRENE								
Symptomatic Limbs								
16	-	5	2	9	8	11	7	3
% of 16	-	31.3	12.5	56.3	50	68.8	43.8	18.8
Asymptomatic Limbs								
11	-	2	1	2	4	9	5	1
% of 11	-	18.2	9.1	18.2	36.4	81.8	45.5	9.1
FEMALE ULCERATION								
Symptomatic limbs								
6	-	1	-	1	2	5	-	1
% of 6	-	16.7	-	16.7	33.3	83.3	-	16.7
Asymptomatic Limbs								
3	-	-	-	-	-	2	-	1
% of 3	-	-	-	-	-	66.7	-	33.3

TABLE 74 (continued)

NO. OF LIMBS	COMMON FEMORAL	SUPERFICIAL FEMORAL	PROFUNDA FEMORAL	POPLITEAL	ANTERIOR TIBIAL	POSTERIOR TIBIAL	PERONEAL	NO. OCCNS.
FEMALE COLD FEET								
Symptomatic Limbs								
5		1	-	1	-	1	1	4
% of 5	-	20	-	20	-	20	20	80
Asymptomatic Limbs								
1	-	1	-	-	-	-	-	-
% of 1	-	100	-	-	-	-	-	-

MEN

Comparing the symptomatic and the asymptomatic side in intermittent claudication there is a very highly significant difference ($P < 0.001$) between the numbers of occlusions on the symptomatic and asymptomatic side in the superficial femoral artery. There is a similar very highly significant difference in the incidence of popliteal artery occlusion.

So far as the common femoral artery was concerned, there were not sufficient occlusions for the difference to be adequately tested. The difference in incidence of occlusion in the profunda femoris artery was not a significant one.

In the anterior tibial, posterior tibial and peroneal artery occlusions there was no significant difference between the symptomatic and the asymptomatic side.

In gangrene the difference between the numbers of occlusions in profunda femoris on the two sides was too small to be tested. No significant difference is shown in the incidence of superficial femoral, popliteal, anterior tibial, posterior tibial and peroneal arteries between the symptomatic and the asymptomatic sides.

In pregangrene there was no significant difference on the symptomatic and the asymptomatic sides in the numbers of occlusions in the superficial femoral popliteal, posterior tibial and peroneal arteries. The numbers of occlusions in the common femoral and profunda femoris arteries and in the anterior tibial artery were too small to be adequately tested.

- - - -

WOMEN

In intermittent claudication a very highly significant difference ($P < 0.001$) between the incidence of superficial femoral artery occlusions in the symptomatic and the asymptomatic limbs, but there is no significant difference between the incidence of occlusion in the popliteal, anterior tibial, posterior tibial and peroneal arteries in these two limbs.

In gangrene no significant difference was shown between the two types of limb in posterior tibial artery occlusion.

In gangrene no significant difference was found in the incidence of complete occlusion in the posterior tibial artery in the symptomatic and asymptomatic limbs. The figures for anterior tibial artery and peroneal artery occlusion are too small to be tested.

In pregangrene the numbers of occlusions in the superficial femoral profunda femoris and popliteal arteries are too small to be adequately tested but no significant difference is shown in the incidence of occlusion in either type of limb in the anterior tibial, posterior tibial, and peroneal arteries.

- - - -

These figures then show that in men in intermittent claudication the incidence of occlusion in the leg arteries is not significantly different between the symptomatic and asymptomatic limbs. This finding is also shown in women with claudication where there is also no significant difference statistically between the incidence of popliteal artery occlusion on either side. This similarity in incidence in leg artery occlusion in the symptomatic and asymptomatic limbs demonstrates that complete arterial occlusion frequently occurs in the leg in men before complete occlusion of the superficial femoral and of the popliteal arteries and in women that it occurs before occlusion of the superficial femoral artery.

- - - -

In men with gangrene, no significant difference is detected statistically but the simple percentage incidence of numbers of occlusions shows a very close similarity between the numbers of occlusion in the popliteal, posterior tibial and peroneal arteries.

- - - -

In women with gangrene, no significant difference in posterior tibial artery occlusion is shown. The numbers of occlusions in the anterior tibial and peroneal arteries are not subject to adequate test.

No significant difference is demonstrated in leg artery occlusion in women with pre-gangrene, nor in occlusion of the posterior tibial and peroneal arteries in pre-gangrene in men. Similarly in pre-gangrene in men there is no significant difference in the incidence of femoral and popliteal artery occlusions.

Whilst there is no statistical evidence in gangrene and in pre-gangrene, of a wide difference in the incidence of occlusions of the superficial and popliteal arteries as there is in men with claudication, it is felt that the large number of limbs examined in intermittent claudication in men make it clear that the incidence of leg artery occlusion is almost identical in the two groups of limbs, but that there is a wide difference in superficial femoral and popliteal artery occlusion.

- - - -

It seems reasonable to assume that leg artery occlusion may occur in the absence of symptoms and that symptoms may not arise until occlusion of the superficial femoral or popliteal artery supervenes. In women it is suggested that occlusion of the popliteal, anterior tibial, posterior tibial and peroneal artery may exist in the absence of symptoms until occlusion occurs in the superficial femoral artery.

TABLE 75

Incidence of complete occlusion in the 367 men examined by direct femoral arteriography - 453 examinations on the symptomatic side and 233 on the asymptomatic

SYMPTOMATIC LIMBS

Presenting Symptom	No. of limbs examined	Number with complete occlusion	% incidence in symptomatic limbs examined in patients with this symptom
Right Claudication	102	85	83.3
Left Claudication	104	84	80.8
Bilateral Claudication	162	111	68.5
Right gangrene	23	18	78.3
Left gangrene	15	15	100
Bilateral gangrene	6	4	66.7
Right pregangrene	18	17	94.4
Left pregangrene	12	11	91.7
Bilateral pregangrene	-	-	-
Right ulceration	2	2	100
Left ulceration	3	2	66.7
Bilateral ulceration	-	-	-
Right cold foot	2	0	-
Left cold foot	-	-	-
Bilateral cold feet	4	1	25
	453	87	77.3

TABLE 75 (continued)

ASYMPTOMATIC LIMBS

Presenting Symptom	Number of limbs examined	Number with complete occlusion	% incidence in asymptomatic limbs examined in patients with this symptom.
Right claudication	94	39	41.5
Left claudication	94	45	47.9
Bilateral claudication	-	-	-
Right gangrene	17	14	82.4
Left gangrene	7	7	100
Bilateral gangrene	-	-	-
Right pregangrene	9	7	77.8
Left pregangrene	7	5	71.4
Bilateral pregangrene	-	-	-
Right ulceration	1	1	100
Left ulceration	2	1	50
Bilateral ulceration	-	-	-
Right cold foot	2	1	50.0
Left cold foot	-	-	-
Bilateral cold feet	-	-	-
	233	120	51.5

TABLE 76

Incidence of complete occlusion in the 95 women examined by direct femoral arteriography - 120 examinations on the symptomatic side and 56 on the asymptomatic side

SYMPTOMATIC LIMBS

Presenting symptom	Number of limbs examined	Number with complete occlusion	% incidence in symptomatic limbs examined in patients with this symptom.
Right claudication	15	13	86.7
Left claudication	17	13	76.5
Bilateral claudication	40	26	65
Right gangrene	9	7	77.8
Left gangrene	10	7	70
Bilateral gangrene	2	2	100
Right pregangrene	6	5	83.3
Left pregangrene	8	8	100
Bilateral pregangrene	2	-	-
Right ulceration	2	1	50
Left ulceration	2	2	100
Bilateral ulceration	2	2	100
Right cold feet	1	1	100
Left cold foot	-	-	-
Bilateral cold feet	4	-	-
	120	87	72.5

TABLE 76 (continued)

ASYMPTOMATIC LIMBS

Presenting Symptom	Number of limbs examined	Number with complete occlusion	% incidence in asymptomatic limbs examined in patients with this symptom
Right claudication	14	8	57.1
Left claudication	15	7	46.7
Bilateral claudication	-	-	-
Right gangrene	4	3	75
Left gangrene	8	3	37.5
Bilateral gangrene	-	-	-
Right pregangrene	5	4	80
Left pregangrene	6	6	100
Bilateral pregangrene	-	-	-
Right ulceration	1	-	-
Left ulceration	2	2	100
Bilateral ulceration	-	-	-
Right cold feet	1	1	100
Left cold foot	-	-	-
Bilateral cold feet	-	-	-
	56	34	60.7

Tables 75 and 76 show the incidence of occlusion in men and in women in the symptomatic and asymptomatic limbs in the femoro-popliteal group. The incidence of occlusion in the symptomatic limbs in men with claudication is seen to be over 80% in those patients who have unilateral symptoms, but to be only 68.5% in the limbs of the patients with bilateral claudication. Similarly, in the limbs with gangrene, the incidence of occlusion is higher at 78.3% and 100% in patients with unilateral gangrene, than in the limbs examined in patients with bilateral gangrene where only 66.7% of the limbs show complete occlusion. These figures have been examined statistically and there is strong evidence ($p < 0.01$) that this difference in the incidence of occlusion is significant.

In women with claudication where the number of limbs available for study was so much smaller, the same trend is shown - that the bilaterally involved limbs show a smaller incidence of occlusion than do the limbs in patients with unilateral symptoms - but numbers here are so small that this difference does not reach significance. In the women with gangrene where only 21 limbs were available, the opposite finding occurs, the bilaterally symptomatic limbs being more frequently occluded than unilaterally symptomatic limbs, but the numbers here are so small, particularly in bilateral gangrene that no real reliance can be placed on them. The findings in the limbs of women with claudication show the same trend as in the men with claudication and the men with gangrene.

It is therefore suggested that the limbs in men in intermittent claudication and in gangrene show a significant difference in that the incidence of occlusion is smaller in the limbs in patients with bilateral disease than in those unilaterally affected

In women with intermittent claudication the numbers are smaller and are not in the significant range but the same trend is shown. These trend is also shown in women with pregangrene. The opposite finding - that the bilaterally affected limbs are more frequently occluded than those with unilateral symptoms - is found in women with gangrene but here the numbers are small. This finding is out of line with the trend shown in the other clinical presentations.

It is therefore suggested that there is evidence from this survey that the disease process differs between the patients with unilateral disease with those with bilateral disease, with a greater tendency towards complete occlusion in the limbs of patients with unilateral symptoms. There are 2 possible alternatives here -

(1) That there is a more generalised athero-sclerotic narrowing throughout the arterial tree in the patients with bilateral disease, and

(2) That the occlusion in patients with bilateral symptoms is outwith the area shown on the films.

1. The first possibility appears the more likely one, that the patients with bilateral clinical presentation have a more widespread athero-sclerotic process throughout their arterial tree, while in the patients with the unilateral symptoms the disease is less diffuse. One of the difficulties in attempting to classify and score the degree of atheromatous narrowing of an artery radiologically, is that, at the moment, this has to be done subjectively rather than objectively - a criticism that cannot be levelled so readily at a consideration confined to the length of complete occlusion. Haimovici, Shapiro and Jacobson (1960) used a method of classifying athero-sclerotic disease but their method is a subjective one, as is the modification used by Hoar, Wheelock, Kellett, Koch and Guggenheim (1966).

It appears that the accepted scorings for the degree of athero-sclerosis used by pathologists are of little value when applied to angiograms. Gore and Tejada (1957) used weighting method, based on the diameter of residual lumen regarded as a fraction of the "normal". They comment that because atheroma is irregular and patchy, multiple foci of narrowing are the rule, and they consider for scoring purposes the five most severely stenosed areas. From their figures calculated from the degree of reduction in diameter of the lumen, they calculate an "index of narrowing". This unfortunately is not applicable to the study of arteriograms, since the diameter of the original normal lumen cannot be assessed radiologically.

The second method used by pathologists is that described by the World Health Organisation in 1958, In the coronary and cerebral arteries the stenosis is classed as moderate where more than half the diameter of the normal lumen remains and as severe where less than half remains. It is pointed out that it should be stated whether the stenosis is diffuse, localised, solitary or multiple. In the aorta the report suggests that the percentage area of a specified aortic segment involved by disease should be estimated but this method is a pure post-mortem one, and cannot be applied to angiography.

Experimental work has been performed for many years to study the effects of a decrease in the arterial lumen. Mann, Herrick, Essex and Baldes (1938), working with the canine carotid artery, found a reduction in the internal diameter of 70% possible before blood flow was reduced by 50% and they noted that the area of the lumen needed to be reduced by 90% before a 50% reduction in blood flow occurred.

Haimovici (1954) and Haimovici and Escher (1956) suggested from dog experiments that a stenosis of 60-70% reduction of the diameter was necessary to cause a severe degree of arterial insufficiency. No consistent reduction in blood flow until the degree of stenosis reached 80% was reported by May, DeWeese and Rob (1963) using the aorto-iliac segment in dogs.

In clinical reports Wylie and McGuiness (1953) suggest that the lumen of a major artery must be reduced by at least 90% before ischaemic symptoms are caused. Eiseman and Waggener (1957) quoted a 70% reduction in diameter as the level below which a decrease in blood flow occurs.

Fiddian Byar and Edwards (1964) considering flow through stenosed vessels note that an increase in stenosis length produces a disproportionately small further decrease in flow, and report that a ten-fold increase in stenosis length only halves the flow at worst.

It seems that none of these reports is applicable to the arteriographic study of athero-sclerosis the diameter of th e original lumen is unknown and cannot be demonstrated radiologically, where the stenosing process is diffuse, involving arteries of steadily decreasing lumen with scattered areas of more severe narrowing superimposed upon a general reduction in arterial lumen.

It is of interest, in this context, that Lindbom (1950) says that he measured the degree of intimal thickening in only a few cases and that "the degree was generally estimated".

2. So far as occlusion not being shown on the film series is concerned, there is no clinical doubt that complete occlusion was not overlooked in the aorto-iliac region, in the patients examined by direct femoral arteriography. Undoubtedly occlusions may have been present in the feet, but not demonstrated by the radiographic technique employed in this series, but it seems doubtful if occlusions in the foot itself could be the cause of intermittent claudication, although this criticism is a very valid one in gangrene of the foot, where occlusions in the pedal arteries may occur.

Age and Occlusion

Little note has been taken of the ages of the patients presenting clinically with peripheral vascular disease and who show complete occlusion or no complete occlusion arteriographically. DeBakey, Creech and Cooley (1954), discussing 22 patients with obliterative disease in the abdominal aorta noted that the patients in this group were approximately a decade younger than those with peripheral athero-sclerotic occlusion and that in this group patients with aorto-iliac disease, the patients with complete occlusion were on average a decade younger than those with incomplete occlusion. Starer and Sutton (1958) called this observation "paradoxical".

It is therefore of interest to look at the ages of the patients, both men and women, with and without complete arterial occlusion in both the aorto-iliac and femoro-popliteal groups.

- - - -

TABLE 77

MEN

1. Average age of the 63 patients in the aorto-iliac group = 58 years (range 40 to 76 years)

2. Average age of the 42 patients in the aorto-iliac group with occlusion = 57.4 years (range 40 to 72 years)

3. Average age of the 21 patients in the aorto-iliac group without occlusion = 59.2 years (range 43 to 74 years)

Symptom	With or Without Occlusion	Number	Average age (years)	Range of age (years)
Claudication	with	34	56.5	42 to 76
	without	19	59.3	43.to 74
Gangrene	with	6	62.5	40 to 72
	without	2	66	65 & 67
Pregangrene	with	2	50.5	42 & 59
	without	–	–	–

TABLE 78

WOMEN

1. Average age of the 21 patients in the aorto-iliac group = 54.4 years (range 26 to 76 years)

2. Average age of the 11 patients in the aorto-iliac group with occlusion = 54.5 years (range 36 to 76 years)

3. Average age of the 9 patients in the aorto-iliac group without occlusion = 52.3 years (range 41 to 73 years)

(Aortography was abandoned in the patient with pregangrene)

Symptom	With or without occlusion	Number	Average age (years)	Range of age (years)
Claudication	with	10	52.3	36 to 65
	without	9	52.3	41 to 73
Gangrene	with	1	76	76
	without	-	-	-
Pregangrene	with	-	-	-
	without	-	-	-

Aorto-Iliac Group

Tables 77 and 78 show the ages of the men and women patients in this group.

Firstly it is shown in men that the average age of the patients with gangrene is higher than of those with intermittent claudication. The average age of the two patients with pregangrene is considerably below the average age of those with intermittent claudication.

Secondly, in men the average age of the patients in the aorto-iliac group with intermittent claudication and complete occlusion is 2.8 years lower than in those with intermittent claudication, without occlusion. Similarly in the patients with gangrene - those with complete occlusion are, on average, 3.5 years younger than those without. In pregangrene, the two patients in the series were both completely occluded, no patients occurring in this group without occlusion.

In women in the aorto-iliac group, the average age of the patients with intermittent claudication and with complete occlusion is identical with the age of the patients without complete occlusion. The single patient with gangrene had completely occluded. There were no patients with pre-gangrene.

- - - -

TABLE 79

MEN

1. Average age of the 367 men in the femoro-popliteal group = 59.9 years (range 27 - 87 years)

2. Average age of the 305 men in the femoro-popliteal group with occlusion = 60.8 years (range 38 - 87 years)

Here occlusion on the symptomatic side or occlusion in one of the symptomatic limbs in those with bilateral symptoms have been counted.

3. Average age of the 62 men in the femoro-popliteal group without occlusion = 55.3 years (range 27 - 35 years)

Symptom	With or Without Occlusion	Number	Average age (years)	Range in years
Claudication	with	235	59	41 - 80
	without	52	54.3	27 - 67
Gangrene	with	36	68.2	38 - 87
	without	5	61.8	42 - 75
Pregangrene	with	28	64.2	49 - 77
	without	2	61.5	40 & 63
Ulceration	with	4	79.3	66 - 87
	without	1	72	72
Cold Feet	with	2	54.5	53 & 56
	without	2	61.5	60 & 63

TABLE 80

WOMEN

1. Average age of the 95 women in the femoro-popliteal group = 60.3 years (26 to 85 years)

2. Average age of the 75 women in the femoro-popliteal group with occlusion = 61.8 years (32 to 85 years)

Here, occlusion at the symptomatic side, or occlusion in one side of the symptomatic limbs in those with bilateral symptoms, have been counted.

3. Average age of the 20 women in the femoro-popliteal group without occlusion = 54.5 years (26 to 70 years)

Symptom	With ot Without Occlusion	Number	Average age (years)	Range in years
Claudication	with	42	57.9	42 - 72
	without	10	54.1	26 - 67
Gangrene	with	15	63.4	32 - 79
	without	5	53	34 - 70
Pregangrene	with	13	70.3	61 - 85
	without	2	57	53 & 61
Ulceration	with	4	67	56 - 78
	without	1	59	59
Cold feet	with	1	72	72
	without	2	55	47 & 63

In the femoro-popliteal group the numbers available are larger. Here the finding in the aorto-iliac group in men patients with complete occlusion are younger than those without complete occlusion is reversed. Both in men and in women patients with complete occlusion are older than those without complete occlusion, the men being 5.5 years older and the women 7.3 years older. The detailed age difference in men and in women are shown in Tables 79 and 80. The men with complete occlusion in claudication are 4.7 years older than those with incomplete occlusion, whilst in women with claudication those with complete occlusion are 3.8 years older than those without complete occlusion. Similarly, in gangrene the men with complete occlusion are 6.4 years older than those without occlusion, while in women the difference is 10.4 years. In pre-gangrene men with complete occlusion are 2.7 years older than those without complete occlusion and the women with complete occlusion 13.3 years older than those without. A similar age difference between the patients with and without complete occlusion is shown, both in men and in women presenting with ulceration. In men those with complete occlusion are 7.3 years older, and in women 8 years older, than those with incomplete occlusion. In women with cold feet, the single patient with complete occlusion is 17 years older than the average age of the two without complete occlusion. In men, where there are two patients with cold feet who showed complete occlusion and two with no complete occlusion, the patients without complete occlusion are 7 years younger than those without complete occlusion. This is the only example in the femoro-popliteal series where the patients without occlusion were older than those with occlusion.

These figures have been analysed statistically.

In the aorto-iliac group, in men, the age differences between the patients showing complete occlusion and those not completely occluded are not within the significant range. In the aorto-iliac group in women where the numbers are very small the average age of the patient with claudication is identical with those without complete occlusion.

In the femoro-popliteal group in men there was a highly significant ($p < 0.001$) difference betwenn the ages of those patients with intermittent claudication with and without occlusion. A significant ($p < 0.05$) difference was found between the ages of the men with pregangrene with and without complete occlusion. So far as the men with gangrene are concerned the age difference is not a significant one but the trend is in the same direction as in the patients with intermittent claudication and pregangrene. In women, in the femoro-popliteal group a level of significance in the age difference is reached only in those with pregangrene. The trend that those with complete occlusion are younger than those with complete occlusion is shown in patients with gangrene and inclaudication.

These findings show -

1. That the patients in the present series who fall clinically into the aorto-iliac group and who show complete occlusion at some level in the aorta or iliac arteries tend to be younger than the patients falling into the femoro-popliteal group and who also show complete occlusion. The age difference between the patients in the aorto-iliac group and those in the femoro-popliteal group is not the decade quoted by DeBakey et al (1954) but only 3.4 years in the men and 7.3 years in the women.

2. In the aorto-iliac group in men the age difference between the patients with and without complete occlusion does not fall statistically within a significant range, but the average age of the patients with complete occlusion in claudication and in gangrene is noted to be lower than the average age in the patients without complete occlusion.

3. In the femoro-popliteal group in men, in intermittent claudication and in pre-gangrene the patients with complete occlusion are older than those without complete occlusion. This finding is statistically significant.

4. In the men with gangrene in the femoro-popliteal group the ages do not fall within a significant range but none the less the same trend is shown.

5. In women in the femoro-popliteal group the patients with complete occlusion presenting with pre-gangrene are older than those without complete occlusion. This finding is statistically significant.

6. The women with intermittent claudication and with gangrene in the femoro-popliteal group do not fall into a significant range, but the same trend - that the completely occluded are older than the non-occluded - is again shown.

7. It is difficult to reconcile the finding that the patients with femoro-popliteal disease with complete occlusion are older than those without complete occlusion, with Duguid's (1946, 1948, 1955 and 1960) thrombogenic hypothesis of the origin of atheroma where thrombosis is regarded as an earlier stages in degenerative vascular disease than is atheroma. It may be that his theory which applies to mural thrombi

in the aorta, resulting in intimal thickening (1948), does not apply to the massive thrombus of complete occlusion, in the lower limb.

DISTRIBUTION OF OCCLUSION IN THE LOWER LIMB

The order of frequency of occlusion in the limbs in the different clinical conditions is shown in the following table.

TABLE 81

Order of frequency of occlusion with percentage incidence in theoccluded limbs

1. Symptomatic limbs in men with intermittent claudication (368 limbs).	
Superficial femoral	69.6
Popliteal	34.6
Anterior tibial	30.4
Posterior tibial	29.6
Peroneal	13.9
Profunda femoris	6.1
Common femoral	1.4
2. Symptomatic limbs in men with gangrene (44 limbs)	
Posterior tibial	73.0
Anterior tibial	64.9
Superficial femoral	54.1
Peroneal	40.5
Popliteal	35.1
Profunda femoris	10.8
Common femoral	2.7

TABLE 81 (continued)

3. Symptomatic limbs in men with pregangrene (30 limbs)

Posterior tibial		71.4
Popliteal		53.6
Superficial femoral	equal in number	35.7
Anterior tibial	equal in number	35.7
Peroneal		32.1
Common femoral	equal in number	10.7
Profunda femoris	equal in number	10.7

4. Symptomatic limbs in women with claudication (72 limbs)

Superficial femoral		63.5
Posterior tibial		38.5
Popliteal	equal in number	28.8
Anterior tibial	equal in number	28.8
Peroneal		17.3
Profunda femoris		1.9
Common femoral		-

5. Symptomatic limbs in women with gangrene (21 limbs)

Posterior tibial		50.0
Superficial femoral	equal in number	43.8
Popliteal	equal in number	43.8
Anterior tibial	equal in number	43.8
Peroneal	equal in number	43.8
Profunda femoris		31.3
Common femoral		12.5

6. Symptomatic limbs in women with pregangrene (16 limbs)

Posterior tibial		84.6
popliteal		69.2
Anterior tibial		61.5
Peroneal		53.8
Superficial femoral		38.5
Profunda		15.4
Common femoral		-

- - - -

7. Asymptomatic limbs in men with intermittent claudfation (188 limbs)

Posterior tibial	equal in number	47.6
Anterior tibial		47.6
Superficial femoral		29.8
Peroneal		16.7
Popliteal		9.5
Profunda femoris		3.6
Common femoral		1.2

8. Asymptomatic limbs in men with gangrene (24 limbs)

Posterior tibial		70.0
Anterior tibial		50.0
Superficial femoral	equal in number	35.0
Peroneal		35.0
Popliteal		30.0
Profunda femoris	equal in number	5.0
common femoral		5.0

9. Asymptomatic limbs in men with pregangrene (16 limbs)

Posterior tibial		75.0
Peroneal		50.0
Superficial femoral		33.3
Popliteal		25.0
Anterior tibial	equal in number	16.7
Profunda femoris		16.7
Common femoral		-

10. Asymptomatic limbs in qomen with intermittent claudication (29 limbs)

Posterior tibial		73.3
Superficial femoral	equal in number	26.7
Peroneal		26.7
Anterior tibial		20.0
Popliteal		13.3
Common femoral		-
Profunda femoris		-

11. Asymptomatic limbs in women with gangrene (12 limbs)

Posterior tibial	100.0
Anterior tibial	33.3
Peroneal	16.7

12. Asymptomatic limbs in women with pregangrene (11 limbs)

Posterior tibial		90.0
Peroneal		50.0
Anterior tibial		40.0
Superficial femoral	equal in number	20.0
Popliteal		20.0
Profunda femoris		10.0
Common femoral		-

It is shown that in the symptomatic limbs of men and of women with intermittent claudication, occlusion of the superficial femoral artery is the most frequent. In men the second commonest occlusion in these limbs is in the popliteal artery, with in third and fourth place, with virtually identical numbers occlusion in the anterior and posterior tibial artery. In women, occlusion of the posterior tibial artery is the second most common, being relatively slightly more common in those limbs than popliteal artery occlusion is in men. The popliteal and anterior tibial arteries are occluded equally as commonly, almost as frequently as anterior tibial occlusion in the men. In the symptomatic limbs of men and of women with gangrene and pregangrene occlusion of the posterior tibial artery alone is the commonest. This findings are comparable with those reported by Wessler and Schlesinger (1953) who, from a study of limbs amputated because of ischaemia noted that the posterior tibial artery was "truly the artery of occlusion" in the leg, being the most frequently and most extensively occluded, and the first to be completely obstructed in these limbs.

The examination of the asymptomatic limbs has shown that the posterior tibial artery in intermittent claudication, gangrene and pregangrene, both in men and in women, is the commonest artery to be occluded in these limbs. The number of limbs examined is (except in the asymptomatic limbs in intermittent claudication in men), so small that it seems unwise to attempt to conclude too much from them. In the asymptomatic limbs in men with intermittent claudication the incidence of anterior tibial artery occlusion is identical with posterior tibial artery occlusion, being present in almost 50% of the occluded limbs. Superficial femoral artery occlusion was present in less than a third of the occluded limbs.

LEG ARTERY OCCLUSION

Patterns of leg artery occlusion

The patterns of leg artery ocdusion are considered in Table 82 and 83 for the symptomatic and asymptomatic limbs in men and in women. Unfortunately there is little previously reported material with which this can be compared. Lindbom (1950) found the posterior tibial artery to be the most frequently occluded followed by the anterior tibial and then by the peroneal artery which was the least frequently occluded. He noted that the peroneal artery might be the only patent artery in the leg in elderly patients - the "peroneal leg" described in amputation material (Dible, 1956).

Kennedy Watt (1966), considering the arteriographic appearances in bilateral arteriography in 264 men with intermittent claudication, found posterior tibial artery occlusion alone to be the commonest leg artery occlusion, followed by anterior tibial artery occlusion alone with occlusion of the anterior and posterior tibial arteries together in third place. He, it will be remembered, considered both the symptomatic and the asymptomatic limbs together. In the present series the commonest leg artery occlusion in the symptomatic limbs of men with claudication was occlusion of the anterior tibial artery alone. Second most frequent was occlusion of the posterior tibial artery alone, and in third place (only half as common) was occlusion of the anterior with the posterior tibial artery. This was the largest group of limbs examined in the present series - 368 - the other groups of limbs examined on the symptomatic side being much smaller, only one, the 72 symptomatic limbs in women with claudication, being larger than 50. In these limbs the commonest pattern of leg artery occlusion was occlusion of the posterior tibial artery alone, followed closely by occlusion of the anterior tibial artery alone and thirdly by occlusion of all three leg arteries together. In the symptomatic limbs of men with gangrene occlusion of all three leg arteries together was the commonest finding, accounting for almost one-third of the limbs in which leg artery occlusion was found. In the symptomatic limbs of women with gangrene, anterior tibial artery occlusion on its own was the commonest finding but only 13 limbs showing leg artery occlusion were available in women with gangrene. These figures are too small to be reliable, as are those in symptomatic limbs of women with pregangrene, where occlusion of all three leg arteries together was the commonest finding.

In the asymptomatic limbs in men with claudication the anterior tibial artery is shown to be the most frequently occluded followed, as in the symptomatic limbs, by the posterior tibial artery alone, and by the anterior tibial together with the posterior tibial artery.

In the asymptomatic limbs of men with gangrene posterior tibial artery occlusion is the commonest.

In men with pregangrene occlusion of the posterior tibial with the peroneal artery is the commonest. In the small numbers of asymptomatic limbs examined in women the posterior tibial artery was the most frequently occluded in claudication, gangrene and pregangrene.

The figures show that in the symptomatic limbs of men with claudication occlusion of a single leg artery alone is present in almost 60%, with a similar incidence in the symptomatic limbs of women with claudication. In the symptomatic limbs of men with gangrene, occlusion of a single leg artery alone was found in less than 40% of the limbs with leg artery occlusion. In the symptomatic limbs of women with gangrene just over 50% of the limbs showing leg artery occlusion, showed occlusion in a single artery.

It is therefore shown that in the asymptomatic limbs in intermittent claudication the tendency is for only one leg artery to be occluded in those limbs in which there is leg artery occlusion, while in gangrene multiple leg artery occlusion is the commonest finding.

In the asymptomatic limbs in both men andwomen with intermittent claudication occlusion of a single leg artery is commoner than occlusion of multiple leg arteries. In the asymptomatic limbs of men with gangrene multiple artery occlusion is the commonest finding and similarly in the asymptomatic limbs in men with pregangrene. In the asymptomatic limbs of women with gangrene and pregangrene the incidence of single and multiple leg artery occlusion is identical.

- - - -

TABLE 82

PATTERNS OF LEG ARTERY OCCLUSION

	Number	% of Total
1. Symptomatic Limbs in Men		
a) Intermittent claudication		
Anterior tibial alone	43	31.6
Posterior tibial alone	31	22.8
Peroneal alone	6	4.4
Anterior and posterior tibial	23	16.9
Anterior tibial and peroneal	4	2.9
Posterior tibial and peroneal	14	10.3
Anterior and posterior tibial plus peroneal	15	11.0
TOTAL	136	99.9
b) Gangrene		
Anterior tibial alone	6	17.6
Posterior tibial alone	6	17.6
Peroneal alone	1	2.9
Anterior tibial and peroneal	-	-
Anterior and posterior tibial	7	20.6
Posterior tibial and peroneal	3	8.8
Anterior and posterior tibial plus peroneal	11	32.4
TOTAL	34	99.9

	Number	% of Total
c) Pregangrene		
Anterior tibial alone	3	12
Posterior tibial alone	10	40
Peroneal alone	1	4
Anterior tibial and posterior tibial	3	12
Anterior tibial and peroneal	1	4
Posterior tibial and peroneal	4	16
Anterior and posterior tibial with peroneal	3	12
TOTAL	25	100

2. Symptomatic limbs in Women

	Number	% of Total
a) Intermittent Claudication		
Anterior tibial alone	7	25
Posterior tibial alone	9	32.1
Peroneal alone	1	3.8
Anterior tibial and posterior tibial	3	10.7
Anterior tibial and peroneal	-	-
Posterior tibial and peroneal	3	10.7
Anterior and posterior tibial and peroneal	5	17.9
TOTAL	28	100.2

	Number	% of Total
b) Gangrene		
Anterior tibial alone	4	30.8
Posterior tibial alone	2	15.4
Peroneal alone	1	7.7
Anterior tibial and posterior tibial	-	-
Anterior tibial and peroneal	-	-
Posterior tibial and peroneal	3	23.1
Anterior and posterior tibial with peroneal	3	23.1
TOTAL	13	100.1

	Number	% of Total
c) Pregangrene		
Anterior tibial alone	-	-
Posterior tibial alone	2	16.7
Peroneal alone	-	-
Anterior tibial and posterior tibial	3	25
Anterior tibial and peroneal	1	8.3
Posterior tibial and peroneal	2	16.7
Anterior and posterior tibial with peroneal	4	33.3
TOTAL	12	100.0

TABLE 83

PATTERN OF LEG ARTERY OCCLUSION

	Number	% of Total
1. Asymptomatic limbs in men		
a) Intermittent claudication		
Anterior tibial	20	30.3
Posterior tibial	18	27.3
Peroneal	4	6.1
Anterior tibial and posterior tibial	14	21.2
Anterior tibial and peroneal	2	3.0
Posterior tibial and peroneal	4	6.1
Anterior and posterior tibial with peroneal	4	6.1
TOTAL	66	100.1
b) Gangrene		
Anterior tibial	1	5.9
Posterior tibial	5	29.4
Peroneal	1	5.9
Anterior tibial and posterior tibial	4	23.5
Anterior tibial and peroneal	1	5.9
Posterior tibial and peroneal	1	5.9
Anterior and posterior tibial with peroneal	4	23.5
TOTAL	17	100.0

c) Pregangrene

	Number	% of Total
Anterior tibial	-	-
Posterior tibial	3	30
Peroneal	1	10
Anterior tibial and posterior tibial	1	10
Anterior tibial and peroneal	-	-
Posterior tibial and peroneal	4	40
Anterior and posterior tibial with peroneal	1	10
TOTAL	10	100

2. Asymptomatic limbs in Women

a) Intermittent claudication

	Number	% of Total
Anterior tibial	1	8.3
Posterior tibial	6	50
Peroneal	-	-
Anterior tibial and posterior tibial	1	8.3
Anterior tibial and peroneal	-	-
Posterior tibial and peroneal	3	25
Anterior tibial and posterior tibial with peroneal	1	8.3
TOTAL	12	99.9

	Number	% of Total
b) Gangrene		
Anterior tibial	-	-
Posterior tibial	3	50
Peroneal	-	-
Anterior tibial and posterior tibial	2	33.3
Anterior tibial and peroneal	-	-
Posterior tibial and peroneal	1	16.7
Anterior and posterior tibial with peroneal	-	-
TOTAL	6	100

	Number	% of Total
c) Pregangrene		
Anterior tibial	-	-
Posterior tibial	3	30
Peroneal	1	10
Anterior tibial and posterior tibial	2	20
Anterior tibial and peroneal	0	-
Posterior tibial and peroneal	2	20
Anterior and posterior tibial with peroneal	2	20
TOTAL	10	100

SUMMARY OF INCIDENCE OF

OCCLUSION

Summary of the incidence of occlusion in the men and the women in the femoro-popliteal group is shown for the symptomatic side in Table 84 and the asymptomatic side in Table 85 .

TABLE 84

SYMPTOMATIC

Type of Limb	Number of limbs examined	Number of limbs with occlusion	Number with this type of occlusion	% incidence of this type of occl. in symptomatic limbs	% incidence of this type of occ. in occl sym. limbs
All leg artery occlusions					
Men - claudication	368	280	136	37	48.6
gangrene	44	37	34	77.3	91.9
pregangrene	30	28	25	83.3	89.3
Total	442	345	195	44.1	56.5
Women - claudication	72	52	28	38.9	53.8
gangrene	21	16	13	61.2	81.3
pregangrene	16	13	12	75	92.3
Total	109	81	53	48.6	65.4
Leg artery occlusion alone.					
Men - claudication	368	280	24	6.5	8.6
gangrene	44	37	14	31.8	37.8
pregangrene	30	28	8	26.7	28.6
Total	442	345	46	10.4	13.3

TABLE 84 (continued)

Type of Limb	Number of limbs examined	Number of limbs with Occlusion	Number with this type of Occlusion	% incidence of this type of occlusion in symptomatic limbs	% incidence of this type of occlusion in occluded symptomatic limbs.
Women - claudication	72	52	12	16.7	23.1
gangrene	21	16	5	23.8	31.3
pregangrene	16	13	3	18.8	23.1
Total	109	81	20	18.3	24.7
Leg artery and main femoro-popliteal occlusion					
Men - claudication	368	280	112	30.4	40
gangrene	44	37	20	45.5	54.1
pregangrene	30	28	17	56.7	60.7
Total	442	345	149	33.7	43.2
Women - claudication	72	52	16	22.2	30.8
gangrene	21	16	8	38.1	50
pregangrene	16	13	9	56.3	69.2
Total	109	81	33	30.3	40.7

TABLE 84 (continued)

Type of Limb	Number of limbs examined	Number of limbs with occlusion	Number with this type of ocdusion	% incidence of this type of occlusion in symptomatic limbs	% incidence of this type of occlusion in occluded symptomatic limbs
Proximal artery alone.					
Men - claudication	368	280	144	39.1	51.4
gangrene	44	37	3	6.8	8.1
pregangrene	30	28	3	10	10.7
Total	442	345	150	33.9	43.5
Women - claudication	72	52	24	33.3	46.2
gangrene	21	16	3	14.3	18.8
pregangrene	16	13	1	6.3	7.7
Total	109	81	28	25.7	34.6

TABLE 85

ASYMPTOMATIC

Type of limbs	Number of limbs examined	Number of limbs with occlusion	Number with this type of occlusion	% incidence of this type of occlusion in all asym-tomatic limbs	% incidence of this type of occlusion in occluded asymptomatic limbs
All leg artery occlusions					
Men - claudication	188	84	66	35.1	78.6
gangrene	24	20	17	70.8	85
pregangrene	16	12	10	62.5	83.3.
Total	228	116	93	40.8	80.2
Women - claudication	29	15	12	41.4	80
gangrene	12	6	6	50	100
pregangrene	11	10	10	90.9	100
Total	52	31	28	53.8	90.3

TABLE 85 (continued)

Type of Limbs.	Number of limbs examined	Number of limbs with occlusion	Number with this type of occlusion	% incidence of this type of occlusion in all asymptomatic limbs	% incidence of this type of occlusion in occluded asymptomatic limbs
Leg occlusions alone					
Men - claudication	188	84	52	27.7	61.9
gangrene	24	20	12	50	60
pregangrene	16	12	5	31.3	41.7
Total	228	116	69	30.3	59.5
Women - claudication	29	15	9	31	60
gangrene	12	6	6	50	100
pregangrene	11	10	5	45.5	50
Total	52	31	20	38.5	64.5

TABLE 85 (continued)

Type of limb	Number of limbs examined	Number of limbs with occlusion	Number with this type of Occlusion	% incidence of this type of occlusion in all asymptomatic limbs	% incidence of this type of occlusion in occluded asymptomatic limbs
Leg artery and main femoro-popliteal occlusion					
Men - claudication	188	84	14	7.4	16.7
gangrene	24	20	5	20.8	25
pregangrene	16	12	5	31.3	41.7
Total	228	116	24	10.5	20.7
Women - claudication	29	15	3	10.3	20
gangrene	12	6	-	-	-
pregangrene	11	10	5	45.5	50
Total	52	31	8	15.4	25.8

TABLE 85 (continued)

Type of limb	Number of limbs examined	Number of limbs with Occlusion	Number with this type of occlusion	% incidence of this type of occlusion in all asymptomatic limbs	% incidence of this type of occlusion in occluded asymptomatic limbs
Proximal artery alone					
Men - claudication	188	84	18	9.6	21.4
gangrene	24	20	3	12.5	15
pregangrene	16	12	2	12.5	16.7
Total	228	116	23	10.1	19.8
Women - claudication	29	15	3	10.3	20
gangrene	12	6	-	-	-
pregangrene	11	10	-	-	-
Total	52	31	3	5.8	9.7

Symptomatic side.

It is shown that 50% of the completely occluded symptomatic limbs in patients with intermittent claudication have occlusion only in their proximal arteries, that is to say in the common femoral, superficial femoral, popliteal or profunda femoris. In gangrene and pregangrene in men and in pregangrene in women only 10% or less of the occluded limbs show pure proximal artery occlusion. In women with gangrene almost 20% of the occluded limbs show proximal artery occlusion alone.

Leg artery occlusion alone occurred in the occluded symptomatic limb in between a quarter to one-third in women with claudication, and in men and women with gangrene and pregangrene, but in only 1 in 12 of the occluded limbs in men with intermittent claudication.

Proximal plus leg artery occlusion occurred in 40% or less of the occluded limbs inintermittent claudication but in oer half those limbs in gangrene and in pregangrene.

It appears then, that proximal artery occlusion alone is relatively benign so far as severe ischaemic change endangering the survival of the limb is concerned in that it is seen in almost half the completely occluded limbs in intermittent claudication but in only 1 in 10 of the occluded limbs with gangrene and pregangrene. Its incidence is higher than this (almost 1 in 5) in the occluded limbs in women with gangrene but the numbers involved are so small that little reliance can be placed upon this figure.

Leg artery occlusion alone so far as men are concerned is not commonly associated with intermittent claudication but is seen in more than a quarter of the limbs in gangrene and pregangrene. The discovery of leg artery occlusion alone in men must be regarded as having a serious prognosis for the survival of the limb. On the other hand in women the incidence of leg artery occlusion is almost identical in intermittent claudication, in gangrene and in pregangrene and it appears then that in women leg artery occlusion on its own does not have the same association with severe ischaemic disease as it does in men.

Proximal artery oclusion in association with leg artery occlusion is found in 40% of the occluded limbs in men with claudication and in 30% in women with claudication. It is found in between 50%

and 70% of the occluded limbs in patients with gangrene and pregangrene. It appears then to be more frequently associated with severe ischaemic disease than with the more benign intermittent claudication.

Since no less than 30% of the occluded claudicating limbs in women, and 40% in men show this association of proximal and leg artery occlusion, shown also in 50% of the occluded gangrenous limbs in women, and in 54% in men, and in 69% of the occluded pregangrenous limbs in women and in 60% in men, it is felt that the statement that occlusion is commonly localised to one segment does not apply to the present unselected series.

- - - -

Asymptomatic limbs.

60% of the occluded asymptomatic limbs in men and women with claudication show leg artery occlusion alone. A similar incidence is shown in both sexes in gangrene and in pregangrene where the numbers of asymptomatic limbs examined were much smaller than in intermittent claudication.

Proximal artery occlusion alone occurred in approximately 20% of the occluded asymptomatic limbs in men and women, with claudication. (No asymptomatic limbs in women with gangrene or pregangrene showed this occlusion pattern). Proximal and leg artery occlusion occurs in about 1 in 5 of the occluded asymptomatic limbs in intermittent claudication and in almost half the few occluded asymptomatic limbs in pregangrene. A quarter of the occluded asymptomatic limbs in men with gangrene showed this pattern.

It appears then that leg artery occlusion on its own occurs more commonly in the asymptomatic limb than in the symptomatic limb. Proximal artery occlusion plus leg artery occlusion is shown to be more common in the symptomatic limbs than in the asymptomatic limbs. This finding supports de Takats's (1959) comment that occlusion in the leg arteries was often asymptomatic until a higher occlusion supervened

How do these findings compare with the reported series?

A problem in examining the reported series is that, as Boyd (1960) pointed out, the mass of papers reports small surgical series, and there is often difficulty in being sure whether the writers refer to "patients" or "limbs".

The incidence of occlusion has been considered from three points of view -

(1) in the amputated limb

(2) in series of patients subjected to vascular surgery

(3) in radiological series.

- - - -

(1) Amputated limbs

Wessler and Schlesinger (1953) found leg artery occlusion in 28.8% of 66 limbs amputated because of ischaemic change. In each limb there was at least one point of complete occlusion in the major arteries proximally. These results are different from the present clinical series in that we have found leg artery occlusion in 77% of the gangrenous limbs in men and 92% in women and have seen main artery occlusion in only 52.3% of the male limbs with gangrene and in 52.4% of the female limbs with gangrene. Their examination of the amputated limbs has possibly been at a later stage in the natural history of the lesion than was the arteriographic examination in the present series, and this may in itself account for the lower incidence of main vessel occlusion in the present series. It cannot account for the difference in the incidence of leg artery occlusion which in Wessler and Schlesinger's group is smaller even than the incidence in the symptomatic limbs in patients with claudication in the present series.

On the other hand Dible (1966) also examined limbs amputated because of gangrene or incipient gangrene, found complete or major partial obliteration in 60% of the femoral arteries and in 64% of the popliteal arteries in these limbs. Since he includes partial occlusion his incidence is higher than that in the present series - 52.3% but is similar. He found leg artery occlusion in 76.7% of the amputated limbs an incidence very similar to that in the present series, in symptomatic gangrenous and pregangrenous limbs.

Living patients

The majority of the series quoting the incidence of occlusion in the different arteries in the lower leg are small.

(2) Surgical series.

Cannon, Barker & Kawakami (1958) found calf vessel occlusion in 69.5% of their patients. Since no less than 36.6% of the patients with leg artery occlusion came to amputation it seems reasonable to regard them as being severely ischaemic and comparable to the patients of the present series with gangrene and pregangrene where the incidence of leg artery occlusion is considerably higher - between 81 and 92%. Hanson (1960) suggested that leg artery occlusion is more frequently associated with severe intermittent claudication or with rest pain and that the milder symptoms such as claudication are due to isolated main vessel occlusion. This contention is not really borne out by the patients in the present series where 37-39% of the symptomatic limbs in patients with claudication show leg artery occlusion. Unfortunately the presence of leg artery occlusion in the present series could not be related to the severity of the symptoms in patients with claudication since the patient's assessment of his claudication distance is unreliable. It seems desirable to relate the occlusion pattern, particularly in the leg arteries, to the claudication distance. It is felt that the arteriograms in a series of patients in whom the claudication distance has been assessed on a tread-mill (Bloor 1961) have to be examined to see if leg artery occlusion is related to a short claudication distance. Lund and Henrichsen (1960) felt that leg artery occlusion was usually associated with "fairly severe" arterial insufficiency. Their incidence of leg artery occlusion is very similar to that in the present group. Stokes and Butcher (1960) found leg artery occlusion in a third of their patients with femoral popliteal occlusion. In the present series this is higher, being 44% in men with claudication and 40% in women. 87% of the proximal artery occlusions in symptomatic limbs in men with gangrene were associated with leg artery occlusion, as were 72.7% of those in women. In pregangrene 85% of the proximal occlusions in the symptomatic limbs in men had associated leg artery occlusion, as did 90% of those in women.

Szilagyi, Smith and Esfahani (1961) considering severe ischaemia in 108 patients, (excluding those whose main complaint was claudication) found the most common occlusion pattern to be occlusion of the superficial femoral with one or more of the leg arteries. This is different from the present series where leg artery occlusion was the commonest individual pattern found in gangrene. In pregangrene in men, popliteal and posterior tibial artery occlusion was the commonest pattern and similarly in women. This shows the appearances in the present series in this severely ischaemic limb to be of more distal occlusion than that reported by Szilagyi et al. The numbers are comparable, being 111 in the present series, but since the American series was selected in that the patients were treated by angioplasty it is possible that patients with leg artery occlusion alone, in whom angioplasty cannot be carried out, may have been excluded.

Crawford, DeBakey, Cooley and Morris (1961) also suggest that involvement of the proximal and distal arteries is associated with severe ischaemia but this does not appear to apply in the present series where 1 in 3 of the men with intermittent claudication have proximal artery plus leg artery occlusion as do 1 in 5 of the women. A similar suggestion relating distal disease to severe ischaemia was made in 1962 by E.A. Edwards.

Liston and Darling (1962) considering 76 limbs in whom vein grafts had been performed found calf artery occlusion in 47%, an incidence higher than in the present series of intermittent claudication but considerably lower than in gangrene and pregangrene. One third of their patients had severe ischaemia. This seems a low incidence of leg artery occlusion for such a series. Similarly in 1962, Morris, DeBakey, Wheeler, Crawford and Cooley discussing impending and overt gangrene found distal popliteal and leg artery occlusion in 38.9% almost exactly the same as the incidence in the present series in claudication but considerably lower than the present figures for gangrenous and pregangrenous limbs. Again it seems likely that selection of patients has excluded many with surgically untreatable leg artery occlusion.

In 1962, Taylor, discussing the treatment of gangrene, found leg artery occlusion in 63% of his patients an incidence similar to the present one.

Valdoni and Venturini (1964) in a series of 600 patients found leg artery occlusion in only 17%, but their patients were examined by high translumbar aortography, and it may be that this low incidence of leg artery occlusion represents incomplete demonstration of the arteries below the knee.

(3) Arteriographic Series.

Milanes, Perez-Stable, Casanova, Bustamente and Hernandez (1953) in a selected series of arteriograms found leg artery occlusion in 46.8% In the present series 45% of the symptomatic limbs show leg artery occlusion. A similar incidence of leg artery occlusion (38%) was noted by Krahl et al (1954). In 1955 Sutton, considering femoral arteriography, held that leg artery occlusion was found particularly in the advanced stages of vascular disease.

Margulis, Nice and Murphy (1955) discussing 84 femoral arteriograms, considered collateral patterns in great detail, an effort which Seldinger (1964) felt unjustified regarding a general evaluation of the capacity of the collateral bed as more valuable from the point of view of therapeutics.

Perhaps the most important series from the point of view of comparison with the present one is that reported in 1963 by Singer. His series of 320 patients with 364 affected lower limbs was examined by the same method as the present one. His Table I considers the most severely affected vessel in these limbs. If one assumes that in the limbs where the leg arteries were the "most severely affected" that this means they were completely occluded, this accounts for the occlusion pattern in only 9 limbs i.e. in 2.5% of the affected limbs. In the present series occlusion of the leg arteries alone accounts for the occlusion pattern in 12% of the limbs examined - this percentage is brought lower by the 6.5% incidence of leg artery occlusion only, in the symptomatic limbs of men with claudication - by far the largest group in the series - but the incidence of leg artery occlusion alone is between 16 and 31% in the other clinical groups in the symptomatic limbs. It is possible that Singer's low incidence of leg artery occlusion is accounted for by the patients being almost all claudicators and that few had presented with gangrene (this series was examined before Taylor's report in 1962 on the treatment of gangrene). None the less Singer's incidence of leg vessel occlusion (assuming this is what he meant by "most severely affected") in his series of 364 limbs is 2.5%. In the present series of 368 male limbs with claudication the incidence is 6.5% i.e. 2.6 times that in Singer's group. In the other clinical groups in the present series the incidence of leg occlusion on its own is between 6.7 and 12.7 times that in Singer's series. This clearly indicates that in the present unselected series the incidence of leg artery occlusion is considerably higher than that reported by Singer.

Kohler and Viljanen (1964) found the most proximal occlusion in 272 limbs to be in the leg arteries in 5.1%. 93% of his patients were men and 60% of the limbs were examined for claudication, but the incidence of leg artery occlusion does seem to be smaller than in the present series. The series reported by Haimovici, Shapiro and Jacobson, in 1960, of 102 arterriograms, is a curious one in that only one third of the patients had intermittent claudication, 28% had gangrene and 40% rest pain. Their incidence of leg artery occlusion alone is 15.1% somewhat higher than the incidence in the total series of symptomatic limbs in the present group at 12% (but this figure is considerably reduced by the large number of symptomatic limbs in men with claudication, where the incidence of leg artery occlusion is low - 6.5%.) 81.4% of their arteriograms showed proximal plus leg artery occlusion - a very much higher incidence than noted in the present series where it is 33%.

Kennedy Watt (1956) considered the bilateral arteriograms on 264 men with intermittent claudication. He obviously takes both the symptomatic and the asymptomatic limbs and gives his results from the appearances in the total examination series. It is therefore unfortunately not strictly comparable with the present one where the symptomatic and asymptomatic limbs are considered separately. Similarly, Kennedy Watt has considered as a positive finding, severe arterial narrowing which was disregarded in the present series where only unequivacal complete occlusion was considered. This means that Kennedy Watt's figures contain both complete occlusion and gross narrowing, while in the present series the figures only comprise complete occlusion. In his series 40.3% of the arteriograms showed femoro-popliteal occlusion (or gross narrowing of the femoro-popliteal segment) without lower leg occlusion in 40.3%, the incidence of complete proximal leg artery occlusion without distal.artery occlusion in the present series being 29.1%. 31.6% of Kennedy Watt's arteriograms showed femoro-popliteal occlusion (or severe narrowing) with associated lower leg occlusion. In the present series 22.7% showed complete occlusion of a proximal artery with a leg artery. The most comparable figure is that for leg artery occlusion alone. Here Kennedy Watt does not include stenosis. 14% of his arteriograms showed lower limb occlusion, a figure identical with the present series where 13.7% of the arteriograms showed leg artery occlusion alone.

- - - -

Symptomatic limbs

It seems clear therefore that the present unselected series shows that the incidence of leg artery occlusion is generally higher than is usually stated, and that proximal artery occlusion (i.e. occlusion in the common and superficial femoral, and popliteal arteries) with a patent lumen distally is found in only 43.5% of the occluded limbs in men, and in 34.6% of the occluded limbs in women.

Proximal artery occlusion without associated leg artery occlusion is the commonest pattern in the occluded limbs of patients with intermittent claudication, where it occurs in 51.4% of the occluded limbs in men, and in 46.2% of those in women.

In patients with gangrene or pregangrene, proximal artery occlusion with associated leg artery occlusion is the commonest occlusion pattern, occurring in between 50 and 70% of the occluded limbs.

13.3% of the occluded limbs in men and 24.7% of those in women show complete occlusion only in the leg arteries.

- - - -

Asymptomatic limbs

Here the commonest finding is of leg artery occlusion alone, in 60% of the occluded asymptomatic limbs. Main proximal artery occlusion with associated leg artery occlusion was found in a fifth of the asymptomatic limbs in men and in a quarter of those in women.

Proximal artery occlusion alone was found in 20% of the occluded asymptomatic limbs in men, and in only 10% of those in women.

- - - -

DISCUSSION OF HISTOGRAMS

DISCUSSION OF HISTOGRAM APPEARANCES

It seems from the available literature that no workers in the field of occlusive arterial disease in the lower limb, other than Kennedy Watt (1965), have followed Lindbom (1950) in constructing histograms of occlusions. There is therefore little previous material with which the histograms in the present series can be compared.

Lindbom's material was of two types. Firstly, the arteriograms in 295 limbs in 205 patients, and secondly, post-mortem arteriography in 356 limbs, usually in elderly individuals with a slight selection in favour of aortic arteriosclerosis. In the clinical material the arteriograms of 81 limbs of 66 patients came from hospitals other than the Karolinska Sjukhuset, and are called "extraneous". His histogram (reproduced as Figure 89) shows the occlusion numbers at different levels between the origin of profunda femoris and the origin of the anterior tibial artery in 141 limbs with thrombi of all lengths, excluding the extraneous cases with thrombi of more than 51 millimetres in length. The method of measurement of the lengths of occluded segments of the artery was different from that used in the present series. Lindbom used a drawing 45 cms. in length (approximately half-life size) of the "average" extremity. He filled in the occlusion on these drawings, making a reduction to the size of the average limb. In other words, to a considerable extent, he related his occlusions to a standard limb length. He then measured the occlusions on the drawings to the nearest millimetre and used these measurements in the construction of the histograms. No comment was made about the clinical presentation of his patients.

Kennedy Watt (1965) examined the bilateral arteriograms in a group of 264 men with intermittent claudication, and constructed a histogram of the 295 femoral popliteal occlusions found in the 528 arteriograms performed. This histogram is reproduced as Figure 90. He took as his base line the knee joint mid-way between the femoral and tibial condyle only millimetres different from that used by Lindbom and in the present series where the proximal tip of the intercondyloid eminence was taken as the base line.

Kennedy Watt adopted 40 cms. the distance of the origin of profunda femoris artery from the base line on the grounds that since the upper part of the superficial femoral artery is usually either wholly occluded or patent there is only a minor variation in the upper 10 cms. of histograms which allow for individual variation in the level of origin of profunda femoris artery. As in the present series a calculated level of the popliteal bifurcation was used in the patients where there was occlusion at this level and where accurate measurements were therefore not possible. In his series Kennedy Watt used -5cms. as the level of the popliteal bifurcation while in the present series -6 cms. was used for the left bifurcation in men, -6.1 cms. for the right and -5.6 cms. and -5.7 cms. for the left and right bifurcation respectively in women.

How do the histograms compare with each other?

It seems reasonable to compare Lindbom's histogram (bearing in mind that the "extraneous cases" with thrombi greater than 51 millimetres in length were omitted) with the histogram of all occlusions in the present series (Figure 18). The summit line of Lindbom's histogram proximal to the peak level of incidence is concave, while in the present series this segment of the histogram is convex. This suggests that in the present series the occlusions above the "adductor peak" tended to be longer than Lindbom's. It is possible that the exclusion of thrombi more than 51 millimetres in length in the extraneous arteriogram may partially account for this.
The difference in appearances may be accounted for by there being a longer interval, in the present series, between the

development of complete arterial occlusion in the femoral popliteal segment and arteriography, than there was with Lindbom's material. It is accepted that occlusions begin distally in Hunter's canal and progress proximally (Lindbom 1950; Palma, 1952; Sutton, 1955; Mavor, 1956; Dunlop and Santos, 1957) with a less frequent distal extension.

Unfortunately, we have found it virtually impossible for our patients accurately to date the onset of symptoms, although MacPherson (1964) finds that in at least 25% of his patients with diseased leg arteries, the onset of symptoms are so sudden that the patient could state the exact time and place that they began.

From examination of the two histograms, Lindbom's (Figure 89) and the present one (Figure 18) the incidence of occlusion in the popliteal artery is almost identical in the two series. In view of this, it would appear unjustifiable to suggest that the type of disease is markedly different in the two series.

Kennedy Watt's histogram (Figure 90) illustrates the occlusions both in the symptomatic and asymptomatic limbs in men with claudication. His histogram is strikingly similar to that of Lindbom with its concave summit line above the adductor peak. Below the adductor peak the summit line is also concave indicating a steadily decreasing number of occlusions throughout the extreme distal femoral artery and the popliteal artery. This is different from the appearances in Lindbom's histogram and in that in the present series, in that these both show a slight convexity mid-way between the adductor peak and the base line indicating a small increase in the instances of occlusion in the upper popliteal artery, an increase not shown in Kennedy Watt's series. Kennedy Watt's histogram can more accurately be compared with that of the occlusions in the limbs of men with intermittent claudication in the present series (Figure 85). Here, although the appearances above the adductor peak are now more similar in the two groups, the upper part of the histogram in the present series still lacks the concavity of Kennedy Watt's. The appearances below the adductor peak are very similar. The slight difference at the -5 cm. level is due to the different points being used in the construction of the histogram, where the popliteal bifurcation was occluded. The striking difference between Kennedy Watt's histogram and the present one is that there is a greater tendency in the present series for the occlusions to be longer in the upper part of the artery.

In view of the difference in the histogram appearances which show the occlusions in the present series to be at variance with

Lindbom's and Kennedy Watt's particularly in the femoral canal above the opening in the tendon of adductor magnus, it seems reasonable to suggest that this may be accounted for simply by the occlusions being demonstrated arteriographically at a more advanced stage in their natural history in the present series than in either of the two other series.

It is also shown that in women (Figure 81) the peak incidence of occlusion is at a greater distance from the knee joint than men, lying about 5 cms. more proximally, above the level of the adductor peak in men.

No difference, either in men or women, has been shown between the right and left limb (Figure 82).

In the limbs where there is no associated leg artery occlusion, the histogram (Figure 83) shows the occlusion lengths to be generally short with a definite peak at the adductor canal. On the other hand, in the femoro-popliteal segment in the limbs with associated leg artery occlusion the increase in convexity of the summit curve above the adductor peak shows the occlusions to involve the mid and upper portions of the superficial femoral artery, almost as frequently as the distal femoral artery at the adductor peak. It is difficult to explain this satisfactorily. If, as it appears from the examination of the asymptomatic limbs, that the process of complete occlusion frequently starts in the leg arteries, it seems curious that the patients did not come to arteriography until the femoral artery shows an occlusion of a greater length, than in the limbs where the leg arteries are patent. In other words the patients with leg artery occlusions do not appear to present for angiography until the disease is further advanced in the superficial femoral artery than in those limbs where there is not leg artery occlusion. This finding is a paradoxical one.

The histogram (Figure 84) shows the appearances of femoro-popliteal occlusion in association with the varying combinations of leg artery occlusions -

1. With anterior tibial occlusion.

   Here the occlusions are generally distributed throughout the superficial femoral artery with a reduction to about half in the number in the upper popliteal artery.

2. With posterior tibial artery occlusion.

   The occlusions are widespread throughout the superficial femoral artery. The incidence of occlusion in the upper popliteal artery is almost as high as in the superficial femoral artery.

3. With peroneal artery occlusion.

   Here the numbers are very small. The distribution appears to be general.

4. With anterior and posterior tibial artery occlusion.

   The numbers of occlusions increases steadily from the origin of the superficial femoral artery to the upper popliteal artery and the frequency of involvement of the popliteal artery is almost the same as in the superficial femoral artery.

5. With posterior tibial and peroneal artery occlusion.

   Here again there is a general distribution of occlusion throughout the superficial femoral artery and an identical incidence of occlusion in the upper popliteal artery. In contrast to the appearances in association with anterior and posterior tibial artery occlusion there is a decrease in the number of occlusions distally in the popliteal artery.

6. With anterior tibial and peroneal artery occlusion.

   The numbers here are tiny and are most frequent below the adductor opening.

7. With occlusion of all three leg arteries.

   A steady rise in the number of occlusions is shown supero-inferiorly throughout the femoro-popliteal segment with a rapid rise in the numbers of occlusions in the upper popliteal artery, a rise which increases to a peak in the distal popliteal artery, where the maximum incidence of occlusion occurs in this group of limbs.

Where the arteries in the leg are concerned Lindbom (1950) remarks that for the study of occlusions in these arteries, use was made chiefly of autopsy material, as in the living patient these arteries could often not be judged in detail. The post-mortem group of arteriograms is composed of "selection of elderly individuals, and, to a slighter extent, a selection of cases with severe aortic arterio-sclerosis". Certainly, it does appear that there was not necessarily a history of peripheral vascular disease in the autopsy group examined and the histograms in Lindbom's monograph, of leg artery occlusion cannot therefore be regarded as truly demonstrating the appearances in occlusive vascular disease. He does note that, in the posterior tibial artery, the incidence of occlusion increased in the distal direction, and that in arterial tibial artery occlusion there was and "accumulation" proximally of the ankle joint. He noted "no significant variation in the incidence in the peroneal artery".

Kennedy Watt (1966) does not show any histograms of occlusion in the leg arteries.

Bearing in mind that Lindbom's histograms were based on autopsy material, and that in the present series the entire course of the leg was not demonstrated in almost half the limbs the findings are very similar. In the present series, in the anterior tibial artery (Figure 19) the greatest incidence of occlusion is seen to be between the 20 and the 25 cms. below the base line, in other words proximal to the ankle joint, but the appearance of the histogram suggests that the highest incidence of occlusion is about the mid leg. In the posterior tibial artery (Figure 20) the incidence of occlusion is seen to rise with increasing distance from the knee joint. The appearances in the peroneal artery (Figure 21) show the maximum increase of occlusion at the origin of the artery with a steadily decreasing incidence distally.

Summary of the histogram appearances of occlusion in the symptomatic and asymptomatic limbs.

1. Femoro-popliteal artery

Symptomatic limbs

In men with intermittent claudication a high peak incidence of occlusion is shown at the distal end of the adductor canal, the number of occlusions increasing steadily from the origin of the superficial femoral artery to this site of maximum incidence. Below this peak the number of occlusions falls rapidly throughout the popliteal artery. In women the occlusions are more generally scattered throughout the femoro-popliteal artery without the high peak distally in the adductor canal seen in men. There is some decrease in the number of occlusions distally in the popliteal artery but the appearances suggest that in women there is a tendency for the popliteal artery to be involved relatively more frequently than in men with claudication.

In gangrene in men, the histographic appearances are those of a generalised distribution of occlusion throughout the femoro-popliteal artery with a relatively high incidence of popliteal artery occlusion. In women with gangrene, the numbers available were small but there is a general distribution of occlusion throughout the femoro-popliteal segment with a slightly increased incidence distally in Hunter's canal.

In pre-gangrene in men the maximum incidence of occlusion is seen to be distally in the adductor canal and in the entire length of the popliteal artery. The numbers of occlusions in the upper and lower popliteal arteries are very similar.

In women with pregangrene there appears from the small number of limbs available to be a general distribution of occlusion throughout the femoro-popliteal segment.

Asymptomatic limbs

In men the histographic appearances are those of occlusions scattered throughout the femoro-popliteal segment, the site of maximum incidence being about 4 cms. more proximally in the adductor canal than in the symptomatic limbs. There is a tendency for the popliteal artery, particularly distally, to be spared.

There were so few femoro-popliteal occlusions in the asymptomatic limb in women with claudication that little can be deduced from these appearances.

In the asymptomatic limbs in men with gangrene a generalised distribution of occlusion is shown.

No femoro-popliteal occlusions were seen in the asymptomatic limbs of women with gangrene.

In pre-gangrene, both in men and in women, few occlusions on the asymptomatic side were found and no conclusions can be drawn.

2. Anterior tibial artery.

Symptomatic Limbs.

In men with intermittent claudication the number of occlusions is seen to increase steadily distally with the maximum incidence in the middle third. In women the occlusions are seen to be well scattered throughout the anterior tibial artery but to have their greatest incidence proximally.

In men with gangrene the maximum incidence is shown to be in the distal half of the artery. In women with gangrene the occlusions are scattered but particularly involve the mid part of the artery.

In pre-gangrene in men the occlusions are shown to be scattered generally throughout the entire course of the artery and a similar appearance is found in the women.

Asymptomatic Limbs.

There is seen to be little difference in the general trend of distribution of occlusion in the anterior tibial artery between the symptomatic and the asymptomatic limb.

In the asymptomatic limbs in men with claudication there is a general distribution of occlusion throughout the artery. There were few occlusions in the asymptomatic limbs in women and these are general in distribution with a slight preponderance proximally.

A generalised distribution of occlusion is shown in the asymptomtic limbs of men and women with gangrene and with pregangrene.

3. Posterior tibial artery.

Symptomatic limbs.

In men with claudication the maximum incidence of occlusion is distally in the posterior tibial artery while in women there is a tendency for the occlusions to be scattered throughout the artery.

In men and women with gangrene the occlusions are generally scattered throughout the artery with slight increase in incidence distally.

This also applies in men and women with pregangrene.

Asymptomatic Limbs

The distribution of occlusion in the asymptomatic limbs in men with intermittent claudication is identical with that in the symptomatic side.

In women, the asymptomatic limb shows an increased incidence of occlusion distally.

In gangrene and pregangrene there is a general distribution of occlusion throughout the posterior tibial artery in men and in women.

3. Peroneal artery

Symptomatic limb

In men with claudication, the occlusions are shown to be generally scattered throughout the artery. Similarly, in women the distribution is general. In gangrene and in pre-gangrene where the numbers of occlusions are small the occlusions are shown to be scattered generally throughout the artery.

Asymptomatic Limbs.

The numbers of occlusions here are extremely small and it seems that they are scattered generally throughout the artery.

ACKNOWLEDGEMENTS

ACKNOWLEDGEMENTS

I have to thank the following -

The Physicians and Surgeons in Dundee, particularly, Professor Donald Douglas, under whose care so many of these patients were, for allowing me to examine their patients.

Professor Alan Lendrum for permission to quote the post-mortem report.

Dr. Donald Emslie-Smith for reporting the electrocardiograms.

Dr. Elizabeth Sweet and Dr. Pullar Smith, who as Senior Registrars in the Radio-Diagnostic Department, carried out a number of these examinations between 1960 and 1963.

The Anaesthetists in Dundee Royal Infirmary for their help.

The nursing and radiographic staff of the Radio-Diagnostic Department for their assistance over the years.

Mr. L.A. McKenzie, the Regional Physicist, for making available to me a calculating machine and a trans-illuminated drawing board.

Dr. Peter Sprent, of the Department of Mathematics, University of Dundee, for his advice on the statistical aspects.

Mr. Murray Ettles for the photography.

Mrs. Phyllis King for typing the draft.

Mrs. Anne Gallacher for the final typing.

- - - -