Origin of Femoro-popliteal Occlusions

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In 1950 Lindbom published the results of a radiological survey of atherosclerotic lesions in 356 legs of 185 cadavers and in 295 arteriograms of 205 patients with arterial insufficiency. He identified two principal sites of origin for femoro-popliteal occlusions, the main one being in the adductor region and the subsidiary in the popliteal artery above the level of the knee-joint.

In this survey a similar though simpler and more graphic method has been used to analyse the bilateral femoral arteriograms of a comprehensive group of 264 male patients suffering from intermittent claudication. The information obtained suggests that there are three principal sites of origin of femoro-popliteal occlusions, and the relative incidence of occlusion at these sites has been assessed.

Material

Femoral arteriography, unlike aortography, is a simple and safe procedure and has been employed routinely in the Unit in all suitable patients, except the very old and unfit. The arterial tree from the groin to lower calf or ankle is readily visualized with 60% Urografin on unscreened films placed in a 3-tray cassette tunnel operated manually.

From the middle of 1957, when the Unit opened, to the end of 1960 over 300 male patients with intermittent claudication due to femoro-popliteal or tibial lesions were examined, and the majority were investigated by bilateral femoral arteriography. When the arteriograms of those whose claudication appeared to be due to cardiac insufficiency (six cases) or anaemia (one case) were excluded, together with arteriograms technically unsatisfactory in either leg, there remained 528 arteriograms in 264 patients—approximately 85% of the original number seen in the out-patient department.

Method

As the technique of arteriography was standard throughout the series, the films obtained in different patients could be compared, and occlusions have been measured on film and

expressed in centimetre distances from the level of the knee-joint (midway between the femoral and tibial condyles). At a constant tube distance of 50 in. (127 cm.) some distortion of the vessel image is present, and magnification was found to be 4% in the lower part of the thigh, increasing to 8% at the groin. The latter error is relatively unimportant, as the upper half of the superficial femoral artery is usually occluded throughout or patent. The vessels in the thigh are normally seen on the first and second films, and, as the trays of the cassette tunnel are shallow, no major error (less than 1%) is introduced when either film is used for measurement.

This method does not apply any correction for varying length of limb, but gives a more vivid impression of the level of occlusion than the method of Lindbom (1950), who equated occlusions to a standard limb-length.

To construct a histogram (Fig. 1) a scale is required, and 40 cm. has been adopted as the distance of the common femoral junction from the knee-joint. This junction is sometimes not evident on the arteriogram owing to occlusion, to lack of x-ray penetration of the groin, or to superimposition of the superficial and deep arteries; but when exact measurement was possible the mean distance from knee-joint level to common femoral junction was found to be 40.034 cm. (standard deviation 1.5 cm).

Individual variations in the total length of the femoral and popliteal arteries do not affect the choice of 40 cm. as the "standard" level of the common femoral junction, because the upper segment of the superficial femoral artery is usually either wholly occluded or patent, and consequently there is minimal variation in the top 10 cm. of the histogram.

The adoption of a standard level for the popliteal bifurcation is more difficult, as anatomical variations occur and the bifurcation may sometimes be situated at or above knee-joint level. There were six arteriograms in which a high popliteal bifurcation was present, but all these arteries were patent and the recording of occlusions was therefore not affected. In the remainder the mean distance from knee-joint level to popliteal bifurcation was 5.08 cm. (standard deviation 0.9 cm), and 5 cm. has been used in the scale as the level of the popliteal bifurcation. Where the lowest portion of the popliteal artery and the bifurcation was occluded, the bifurcation has been assumed to lie at -5 cm.

Fig. 1 illustrates the method of construction of a histogram for the right leg of 42 patients who had bilateral claudication. The occlusions are measured from the knee-joint and drawn vertically on graph paper against the scale of 40 to -5 cm. By counting horizontally the number of vessels occluded at each level horizontal lines can be drawn against a similar scale to obtain the frequency-distribution curve of occlusion at each level.

Results

Both sides of Fig. 1 give complementary information. The chart of occlusions on graph paper shows that long occlusions usually extend up to

FIG. 1.—Illustrating construction of histogram on femoro-popliteal occlusions—right leg in bilateral claudication (42 patients).

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the common femoral junction, and short occlusions occur principally at the middle and lower parts of the scale. The histogram shows that the maximum incidence of occlusion lies near the middle of the scale, which corresponds to the adductor region (Lindborn, 1950). This peak can be seen (Fig. 1) to be produced by occlusions which have their upper or lower limits within the segment and to the short occlusions lying wholly within this region.

The absence of variation in the 30/40-cm. segment indicates that this portion of the artery is either patent or occluded throughout in these 42 arteriograms. The frequency of total occlusion of this segment is presumably due to the absence of large collaterals arising from it, thrombosis tending to obliterate the small muscular branches of this region.

The lowest part of the curve between 13 and -5 cm. corresponds to the popliteal artery, whose rate of occlusion is lower than that of the adductor region, and the curve is smooth in this small group of arteriograms.

Fig. 2 is the histogram of the 295 femoro-popliteal occlusions found in the 528 arteriograms. Twenty-two arteriograms showed a double occlusion and 273 (51.7%) of the limbs examined had evidence of femoro-popliteal occlusion. The curve obtained resembles that of Fig. 1, the adductor peak lying

FIG. 2.—Histogram of 295 femoro-popliteal occlusions.

between 14 and 27 cm. and being maximal at 18 cm. In this figure there is some variation in the 30/40-cm. segment, indicating that occlusion is occasionally limited by collaterals at this level.

There were 94 occlusions measuring 20 cm. or longer (31.9% of 295), and, of these, 86 extended up to the common femoral junction and are responsible for the broadening of the histogram at the upper end.

The popliteal part of the curve is not as smooth as in Fig. 1 and appears to have two steps (from 13 to 4 cm. and from 2 to -5 cm.).

Short Occlusions

The site of origin of an occlusion must lie within the occluded segment, and the shorter the occlusions charted the more closely related to the sites of origin should the curve become. Increasing selectivity, however, diminishes the number of observations, and occlusions measuring 2 cm. or less (25) are insufficient to yield a satisfactory curve.

The selection of occlusions measuring 5 cm. or less gives sufficient data, and the histogram of the 88 occlusions found (Fig. 3) yields a curve in which three peaks are visible. The largest peak lies in the adductor region and extends from 14 to 21 cm., is maximal at 18 cm., and contains 61 (69.3%) of the 88 occlusions. The second peak at 5-10 cm. occurs in the popliteal artery above knee-joint level and contains 11 occlu-

sions (12.5%). The lowest peak lies between 2 and -5 cm. in the lowest part of the popliteal artery and also contains 11 occlusions. The remaining five occlusions occupy intermediate positions.

FIG. 3.—Histogram of 88 occlusions, 5 cm. or less.

Occlusions of 3 cm. or less numbered 46, and this histogram yields a curve (Fig. 4) similar in pattern to the previous one. The adductor peak again lies between 14 and 21 cm., is maximal at 17 cm., and contains 32 (69.6%) of the 46 occlusions. The upper popliteal peak from 5 to 10 cm. contains five occlusions, and the lower popliteal peak from 1 to -5 cm. contains six occlusions, the remainder (three) occupying intermediate sites. The lowest peak in this figure can be seen to rise as it approaches the popliteal bifurcation.

FIG. 4.—Histogram of 46 occlusions, 3 cm. or less.

This distribution pattern of short occlusions suggests that occlusions of the femoral and popliteal arteries commonly develop at one of three specific sites: (1) the adductor region; (2) in the popliteal artery above the level of the knee-joint; and (3) in the popliteal artery below knee-joint level.

Distribution of "Incipient" Occlusions

In many arteriograms severe narrowing of the arterial lumen is evident where a large atherosclerotic plaque has formed. This may be a cause of symptoms owing to the reduced blood-flow through the stenosed area and may be expected to favour the deposition of thrombus, leading ultimately to occlusion. When the diameter of the lumen is reduced by half it seems possible to describe the lesion as an "incipient" occlusion, and the distribution of such lesions might be expected to be related to the sites of origin of occlusions.

Fig. 5 illustrates the frequency-distribution curve of the 167 "incipient" occlusions found in the 528 arteriograms. The segment from 14 to 24 cm. contains over 60% of the plaques, has a maximum incidence at 19 cm., and corresponds closely to the adductor peak for occlusions. The lesions in the popliteal artery (13 to -5 cm.) are more scattered, but there is an

aggregation of observations at 5 to 8 cm. which might correspond to the middle peaks of Figs. 3 and 4. Lesions below knee-joint level are few except at the popliteal bifurcation.

FIG. 5.—Histogram of sites of 167 atherosclerotic plaques.

The relative absence of plaque formation in this segment does not accord with the "occlusion peak" found previously (Figs. 3 and 4), but the rise in the lowest peak of Fig. 4 and the high incidence of narrowing at the popliteal bifurcation (Fig. 5) suggest that the lowest group of occlusions may arise from lesions developed at the popliteal bifurcation.

A study of popliteal-bifurcation lesions in arteriograms indicates that the narrowing produced by a plaque varies in site. There may be narrowing of the popliteal artery itself or constriction of the origin of one or both tibial arteries, and subsequent thrombosis could therefore produce either a popliteal or a tibial occlusion. Upward spread of thrombus from the bifurcation would be arrested by the first adequate collateral (usually one of the sural arteries), and in a few cases a collateral arising below the level of the knee-joint would give a short occlusion as in the lower popliteal peaks of Figs. 3 and 4.

Distribution of Large Collateral Vessels

When thrombosis develops it spreads both proximally and distally until halted by a large collateral vessel whose rate of flow is high enough to maintain patency. During this process minor branches are frequently overwhelmed and occluded. Each occlusion, therefore, is bounded above and below by a collateral developed from one of the larger branches of the femoral and popliteal arteries.

In Fig. 6 the upper and lower levels of each of the 295 femoro-popliteal occlusions have been plotted, and this, by

FIG. 6.—Composite histogram of upper and lower levels of 295 occlusions of the femoral and popliteal arteries.

inference, is the histogram of the large collaterals developed in response to occlusion. It is the frequency-distribution curve of the "limiting collateral" above the occlusion and of the "re-entrant collateral," but it is not the distribution curve of all the collaterals developed by each patient. Fig. 6 shows that large collateral vessels capable of limiting occlusion seem to be absent in the upper part of the superficial femoral artery, and are few in number in the popliteal artery between the knee-joint and the popliteal bifurcation.

Discussion

Although arterial occlusion at any level from the aorta downwards can produce intermittent claudication, the femoral and popliteal arteries are the vessels most commonly affected and the adductor region is the commonest site of occlusion (Leriche and Bertrand, 1946). The evidence presented in this paper suggests that femoro-popliteal occlusions originate at three principal sites: in the adductor region, in the popliteal artery above the level of the knee-joint, and at the popliteal bifurcation.

Adductor Region

Estimates of the frequency of occlusion in the adductor region vary. Mavor (1958) believed that it was the primary site of thrombosis in 83% of 223 cases (including aorto-iliac occlusions), and Dunlop and Santos (1957) found an incidence of 76% in 41 arteriograms. Singer (1963) analysed arteriograms performed at St. Mary's Hospital and found that 64% of femoral arteries were thrombosed in the adductor region, cases of aorto-iliac occlusion being excluded.

In the present series the maximum incidence of occlusion was found at 18 cm. (Fig. 2), where 60.5% of the 273 occluded arteries were thrombosed. This relates to only one point in the arterial tree, however, and does not give an estimate of the number of occlusions located or arising in the adductor region. Further evidence concerning incidence can be obtained from Figs. 3 and 4, where the percentage of adductor occlusions was 69.3 and 69.6 respectively, and in Fig. 5 62.3% of the atherosclerotic plaques were found in the adductor region. These figures are more closely allied to Singer's figures than those given by Mavor or by Dunlop and Santos, and it seems reasonable to assume that the adductor region is the site of origin of between 60 and 70% of femoro-popliteal occlusions in intermittent claudication.

The commonly accepted theory of the cause of occlusion at this level is the repeated trauma experienced by the pulsatile artery where it lies in intimate contact with the tendon of adductor magnus (Dunlop and Santos, 1957; Palma, 1959). This could produce intimal haemorrhage, which Lindbom (1950) has shown to be common in the adductor region and which Winternitz, Thomas, and LeCompte (1938) regard as the most important factor in the increase in size of atherosclerotic plaques.

On the other hand, Texon, Imparato, and Lord (1960) implanted an autograft of carotid artery into the femoral artery of a dog and found that the autograft became S-shaped and developed atherosclerotic changes on the concavity of the graft. This observation may be significant, as the femoral artery in the adductor region has a natural S-shaped curve.

The distribution of observations in Fig. 6 suggests another possible factor. Robertson (1960) found that intimal cushions develop at the origin of branches in the femoral and popliteal arteries in early foetal life, and that in adult life they become nodular with increasing age, and vascularization and the eventual deposition of lipid completes their transformation into atherosclerotic plaques. Fig. 6 shows that large branches are most numerous in the adductor region and in the popliteal artery above the level of the knee-joint, sites at which occlusion is commonest (Figs. 3 and 4). There is also a negative corre-

lation between the distribution of branches and plaque formation in that intimal thickening (Lindbom, 1950) and plaque development (Fig. 5) are uncommon in the regions where branches are few—that is, in the upper part of the superficial femoral artery and in the popliteal artery below the level of the knee-joint. Occlusion rarely originates at these sites (Fig. 5).

It is therefore possible that several factors contribute to the high incidence of occlusion in the adductor region, and that plaque formation at the origin of lateral branches may play a part in the development of occlusion.

Popliteal Artery

Mavor (1958) regarded the development of thrombosis at a site other than the adductor region as uncommon, and he implicated the popliteal artery as the primary site of thrombosis in only 10% of cases, whereas Haimovici, Shapiro, and Jacobson (1960) found an incidence of popliteal occlusion of 32.7%.

This apparent discrepancy may be due to the different types of material surveyed, as popliteal occlusion is commoner in patients with gangrene than in those with intermittent claudication.

Figs. 3 and 4 suggest that popliteal occlusions arise above the level of the knee-joint in 12% of cases of intermittent claudication and that a further 12% arise at the popliteal bifurcation.

The cause of occlusion in the popliteal artery above the level of the knee-joint has never been adequately explained. Haimovici *et al.* (1960) suggest that the popliteal artery above the knee-joint is subject to trauma during bending and stretching of the knee, but do not explain why lesions should arise mainly above the knee-joint.

The popliteal artery in this region is surrounded by adipose tissue, which allows it to move easily during flexion, and it is not confined by a fixed anatomical structure comparable to the

adductor tendon. Fig. 7 shows that when the knee is flexed the atherosclerotic artery develops a large primary and smaller secondary curves owing to the arterial elongation which occurs in atherosclerosis. In this figure branches leave the main artery at the ends of the major curve, and it is possible that the artery is tethered to contracting muscle at these points and is free to develop a curve only between these branches. If this is so, and the sural and genicular branches determine the curve pattern of the tortuous atherosclerotic popliteal artery, the curve pattern will vary according to the levels at which branches arise.

Lindbom (1950) suggested that the site of greatest stress occurred on the summit of the convexity of the curve of the popliteal artery and predisposed to calcification on the convexity, whereas Texon *et al.* (1960) suggested that atherosclerotic changes were most severe on the concavity of the curve. If plaque-formation does occur at the summit of the curve the variable curve pattern of the popliteal artery would explain the scattered distribution of plaques between 0 and 10 cm. (Fig. 5).

It is also possible that the development of intimal thickening at the origin of branches plays a part in the production of lesions. If there is an association between the development of intimal cushions and plaque-formation (Robertson, 1960) the distribution of large branches in the popliteal artery (Fig. 6) would explain the incidence of popliteal occlusion above the level of the knee-joint (Figs. 3 and 4).

Mavor (1958) stated that the popliteal artery below the level of the knee-joint was usually healthy and free of branches, but did not associate the two. It is possible that the development of occlusion in the popliteal artery above the knee-joint is related to the large number of branches at this level (Fig. 6) and that the relative absence of lesions below the knee-joint (Fig. 5) and the known freedom from occlusion of this segment (Martin, 1958) are due to the relative absence of branches arising at this level.

Occlusion in the popliteal artery may therefore be related to the large branches arising from it, either through development of plaques at the origin of these branches or by the development of lesions at the summit of the popliteal curves determined by the sites of origin of the branches.

Summary

Comparative measurements of 295 femoro-popliteal occlusions in the bilateral femoral arteriograms of 264 male patients with intermittent claudication have been undertaken.

Femoro-popliteal occlusions appear to originate at three principal sites: In the adductor region in 70% of cases; in the popliteal artery above the level of the knee-joint—12%; and at the popliteal bifurcation—12%.

Plaque-formation is common at these sites and is uncommon in the proximal part of the superficial femoral artery and in the popliteal artery below the level of the knee-joint.

The distribution of large collateral branches is similar to the distribution curve for occlusions, and it is believed that there is a causal relationship between the sites of branching and the development of plaques and occlusions.

In the adductor region occlusion may be determined by the adductor tendon, by the S-shaped configuration of the artery in this region, and by the large number of branches at this level.

The distribution of lesions in the popliteal artery above the level of the knee-joint is diffuse and may be due to the development of lesions at the summit of the popliteal curves or to the development of lesions at the origin of large branches.

FIG. 7.—Lateral view of femoral arteriogram taken with the knee flexed. The popliteal artery is atherosclerotic and shows "secondary" curves. The large sural vessel arising just above knee-joint level appears to tether the artery and influence the curves above and below it.

The excellent arteriograms on which this paper is based were produced by the teamwork of the Unit as a whole, and I must

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Pseudolipoma of the Breast: a Mask for Cancer

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A swelling which has the clinical features of a diffuse subcutaneous lipoma is not infrequently found in the breast, and it commonly indicates underlying cancer. A true lipoma of the breast is rare. This subcutaneous swelling differs from a lipoma, which is a localized excess of adipose tissue, because the fat is normal in amount but under increased tension in the spaces between the fibrous septa which run from the superficial surface of the breast tissue to the skin. The increased pressure in the interseptal compartments produces a tumour with multiple points of attachment to the skin, a definite edge, and the consistency of fat. The word "pseudolipoma" would seem appropriate for this lesion.

One lipoma and 21 pseudolipomas were observed in a series of 480 breast conditions, 147 of them infiltrating cancers. Cancer was found in association with 18 of the pseudolipomas and duct ectasia with three. A pseudolipoma was present in 12% of the breast cancers.

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Pseudolipoma is a signal finding, for it is likely that there will be a cancer beneath it and the cancer itself may not be palpable.

The purpose of this paper is to emphasize the significance of the pseudolipoma and to explain its formation.

Clinical Features

Pseudolipomas have been found in patients aged 36 to 81 years, but most have occurred in post-menopausal women (see Table). The diameter has varied from 1 to 8 cm., a variation depending on the type and number of cancers or whether the cause was duct ectasia.

No swelling under the pseudolipoma could be felt in three patients, an indefinite swelling was palpable in four, and a definite swelling in 11 in whom a cancer was subsequently found. A definite swelling was felt in one of the patients with the underlying lesion of duct ectasia.

Details of Cases

Case No.	Age	Meno-pause	Length of History	Clinical Features					Pathological Features				
				Pseudo-lipoma Alone	Underlying Swelling		Firm Adherence to Skin	Lymph-nodes Palpable	Lymph-nodes Invaded	Type of Lesion	No. of Tumours	Diameter of Tumours	Diameter of Pseudolipoma
					Indefinite	Definite							
1	61	Post	38 yrs. lump, enlarging 2 mths.	-	-	+	-	++	-	Scirrhus cancer (contracted)	1	1.5 cm.	2.5 cm.
2	75	"	3 weeks	+	-	-	-	-	-	" " "	1	1.5 cm.	4.0 cm.
3	67	"	8 months	+	-	-	-	±	-	" " "	1	1.5 cm.	8.0 cm.
4	55	"	1 month	-	-	+	+	-	+	" " "	1	2.0 cm.	2.5 cm.
5	56	"	1 year	-	-	+	-	++	+	" " "	1	2.5 cm.	3.5 cm.
6	71	"	5 years	-	-	+	-	-	+	Scirrhus and diffuse cancer	1	Scirrhus 2 cm. Diffuse 6 cm.	6 x 7 cm.
7	69	Post	3 months	-	+	-	-	-	-	Cancerous plaque (contracted)	1	1.0 x 0.5 cm.	1.5 cm.
8	41	Pre	3 months	-	-	+	-	-	-	" "	1	5.0 x 1.5 cm.	6.0 cm.
9	59	Post	2 months	-	+	-	-	-	-	Plaques	2	2.5 x 0.5 cm. 1.5 x 0.5 cm.	5.0 cm.
10	36	Pre	1 year	-	+	-	-	-	+	"	2	2.0 x 0.5 cm. 2.0 x 0.5 cm.	5.0 cm.
11	50	Post	1 year	-	-	+	+	-	+	Multiple scirrhus (contracted)	2		3.0 cm.
12	42	Pre	6 months	-	-	+	-	-	-	" "	3		4.0 cm.
13	44	"	6 years	+	-	-	-	-	+	" "	3		8.0 cm.
14	58	Post	1 year	-	+	-	-	++	+	" "	4		4.0 cm.
15	50	"	1 month	-	-	+	+	-	+	" "	7		6.0 cm.
16	81	Post	2 months	-	-	+	-	±	-	Inflamed expanded cancer	1	2.0 cm.	3.5 cm.
17	59	"	7 months	-	-	+	-	-	-	" "	1	6.0 cm.	1.0 cm.
18	64	"	3 months	-	-	+	-	±	+	" "		4.0, 0.5 cm.	1.0 cm.
19	40	Pre	3 months	+	-	-	-	-	-	Duct ectasia			6.0 cm.
20	62	Post	37 years	-	-	+	-	++	-	" "			5.0 cm.
21	54	"	1 year	+	-	-	-	-	-	" "			3.0 cm.