ARTERIOGRAPHY AND RENAL ARTERY STENOSIS

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IT IS now well recognised that renal ischaemia is an important cause of hypertension. There are several renal vascular lesions which may cause, or may be associated with, renal ischaemia. These include:

1. Renal artery stenosis and thrombosis.
2. Renal artery aneurysm.
3. Angiomatous malformation of the renal artery.
4. Arterio-venous fistula involving the renal arteries.
5. Embolus of the renal artery or its branches.

Of the lesions listed, *renal artery stenosis* is much the most frequent and important.

This condition is now generally accepted as a significant and important cause for hypertension of renal origin. Various pathological lesions have been cited as causes of renal artery stenosis. These and the number of cases encountered in our material are:

1. Atheroma, of which we have seen 135 examples.
2. Fibromuscular hyperplasia, and the possibly allied condition of fibrous hyperplasia, of which we have seen 43 cases.
3. External pressure, of which we have seen 2 examples.
4. Congenital hypoplasia of the renal artery origin—3 examples.

Numerically atheroma is clearly the most important cause of renal artery stenosis.

The clinical aspect of atheromatous renal artery stenosis have been discussed in detail in a previous paper from St. Mary's Hospital (Brown, Owen, Peart, Robertson and Sutton, 1960), and we have also reviewed the radiological aspects. (Sutton, Starer and Brunton, 1961; Sutton, Brunton, Foot and Guthrie, 1963.) I propose here to bring up to date the radiological analysis of our material, and the opinions previously expressed.

We have now examined over 700 known hypertensives with the deliberate object of confirming or excluding renal artery stenosis, or of demonstrating other vascular lesions causing, or

associated with, the hypertension. We have also examined about 2,500 patients with aorto-iliac disease by aortography. Amongst these we have seen 69 cases of renal artery stenosis mostly associated with hypertension. However, the true incidence amongst patients with aorto-iliac atheroma is not reflected in this figure since the majority of the patients investigated were normo-tensive and had low aortic punctures, i.e. below the level of the renal arteries.

TABLE 1		
RENAL ARTERY STENOSIS		Total
1. Arteriography for aorto-iliac disease		
Cases investigated—2,500	Stenosis 69	135
2. Arteriography for Hypertension		
Case investigated—700		
	(a) Stenoses 66	
	(b) Fibromuscular Hyperplasia 43	
	(c) Other lesions 10	

Our hypertensive cases were largely unselected and the procedure was carried out on most of the hypertensive patients admitted to the Medical Unit under Professor Peart at St. Mary's Hospital, and on some hypertensives admitted to other units. Among these 700 cases we have discovered 65 cases of simple renal artery stenosis, i.e. renal artery stenosis of the straightforward atheromatous stricture type. (Fig. 1).

We have previously described the changes observed at IVP in cases of renal artery stenosis, and which we regard as diagnostic or suggestive of renal artery stenosis (Sutton and others, 1961). We have now extended our experience in this field and have examined the pyelograms in about 100 cases of proven renal artery stenosis. The following changes are regarded by us as virtually pathognomonic of functional renal artery stenosis. (Fig. 2).

1. The affected kidney is smaller than the non-affected kidney.
2. The kidney contour is smooth, in contrast to the irregular contour of the small kidney in chronic pyelonephritis.

FIG. 1.—Severe atheromatous stenosis at the origin of the left renal artery.

3. Contrast values are denser on the affected side.
4. The calyces appear “spastic” though, as we have previously pointed out, this is not due to true spasm but to underfilling of the calyces associated with a reduced

urine flow. This of course is secondary to the reduced blood pressure distal to the stenosis, and to relatively increased water resorption.

These changes are to be expected on physiological grounds. This is because there is a reduced volume of glomerular filtrate, but the tubular resorption of water remains excellent. The final urine therefore is of low volume but has a high concentration of contrast medium, on the side of the stenosis. This may be well brought out in a water-diuresis pyelogram.

While we now regard the pyelogram syndrome I have described as diagnostic of renal artery stenosis there are several qualifications that must be made.

First, the full pyelogram syndrome of renal artery stenosis will only be seen in a proportion of cases where arteriography demonstrates a stenosis. In our material it has been present in over one-third of 100 cases where adequate pyelograms were available for examination, and in these cases it provides strong evidence, if not absolute proof, of the presence of a functional renal artery stenosis. In some cases only part of the syndrome has been present. Here also the diagnosis can be correctly suggested in particular if there is increased con-

FIG. 2.—IVP in a case of right renal artery stenosis. The affected kidney is smaller, with “spastic” calyces but there is denser contrast in the small pelvis.

trast concentration on one side.

More difficult to assess are the cases where there was no IVP function on the side of the stenosis and this happened in some cases; or the cases where function on the two sides at IVP appear equal—this was so in 40 of our cases. In some cases there may be severe ischaemic damage to the kidney or there may be a co-incidental lesion such as hydronephrosis or pyelonephritis. Again, where a branch artery or an accessory artery only is involved then only a part of the kidney is affected by the stenosis and the remainder will function exactly as does the non-affected kidney.

Finally, stenosis does not necessarily mean significant ischaemia of the kidney or significant interference with function. Before accepting a stenosis as functional we require confirmation by divided function studies and other investigations.

We have attempted to correlate the degree of stenosis as measured at arteriography with the pyelogram changes. We did this by arbitrarily grading the degree of encroachment on the renal artery lumen. Whilst aware of the theoretical objections to arbitrary gradings of this type the exercise was useful in demonstrating a significant relationship between the degree of stenosis and the pyelogram changes. Thus, although less than half our cases showed increased concentration of the medium, most of these cases were among the severer grades of stenosis.

We have strong evidence therefore that there is a close relationship between the degree of stenosis and the pyelographic change in the kidney, unless the picture is complicated by other features. We have in conjunction with the Medical Unit used various refinements of the IVP as tests of differential function of the two kidneys. These have included the water load test; IVP after administration of Pitressin; studies with and without abdominal compression, and serial films at rapid and different intervals after IVP.

Early films taken within 60 seconds of injection may be useful in showing differences in contrast at IVP as pointed out by Siggers (1961) but our own impression is that differences of contrast density in the pyelogram are best appreciated in the later stages of an IVP and are best seen in the films at 15 to 20 minutes.

Clearly, functional studies by modification of the normal pyelogram investigation can be carried out in many different ways. On the basis of our present experience however an IVP carried out with standard technique

seems the most practical mode of routine investigations, because of the many complex factors involved.

As regards *kidney size*, measurements of both kidney lengths were possible in about 100 cases. In 80% of these the kidney on the stenotic side was smaller, and in about two-thirds of these the difference in size was more than 1 cm. In ten cases the kidneys were equal in size and in eight cases the kidney on the side of the stenosis was larger. In all these eight cases the difference in size was minimal and it was the left kidney which was affected. It should be remembered that the left kidney can normally be a little larger than the right.

Fibromuscular Hyperplasia and Fibrous

Hyperplasia

We have now encountered 43 cases where there was a diffuse lesion involving a large segment of a renal artery, or one of its major branches. It has been claimed that this type of abnormality represents a specific entity which Wylie and Wellington (1960) have termed "fibromuscular hyperplasia" of the renal arteries. Hunt, Harrison, Kincaid, Bernatz and Davies (1962) also include the condition of fibrous hyperplasia in this group of cases.

The evidence for regarding fibromuscular hyperplasia of the renal artery as a specific entity is both pathological and radiological. It is claimed that the histology in these cases is quite different from that observed in cases of atheroma. The picture is said to be one of irregular muscular hypertrophy and quite unlike the histological picture seen in atheroma. Further atheroma tends to involve the origin of the renal artery but fibromuscular hyperplasia involves the middle third of the artery, and may extend over its whole course and into branch arteries. Fibromuscular hyperplasia is bilateral and diffuse in the majority of cases, though it can be unilateral. It may be associated with saccular aneurysm formation. Atheromatous stenosis on the other hand affects only the origin of the renal artery, and in most examples encountered is unilateral or primarily so.

The radiological appearances of fibromuscular hyperplasia are also quite different from those of atheroma and reflect the differences in pathology. In atheroma the lesion is only a few mm. in length and nearly always affects the origin of the main renal artery.

In fibromuscular hyperplasia, the lesion usually affects a long segment of the artery and is maximal in the middle one third of the renal artery. (Fig. 3.) It may also involve branch arteries.

FIG. 3.—Fibromuscular hyperplasia affecting the distal half of the main right renal artery. There is also a cyst in the lower pole of the kidney.

There are also clinical features in which fibromuscular hyperplasia differs from atheroma of the renal arteries. Atheroma of the renal artery, like atheroma elsewhere in the body has a predominantly male sex incidence. In our material the number of male cases has outnumbered the female cases by over two to one. Fibromuscular hyperplasia on the other hand has a predominantly female sex incidence. The series of 11 cases reported by Falubinska and Wylle were all female cases. Our own figures confirm this female sex incidence, but it is important that we have encountered a few male cases. Our 43 patients consisted of 37 females and 6 males.

It is also suggested in the literature that fibromuscular hyperplasia is predominantly a disease of young patients and is unusual in the elderly. Our own material however does not support this contention. The age distribution in our cases did not differ appreciably from that of the atheromatous stenosis cases at the time of diagnosis. There were 8 cases aged over 60, 13 cases aged 50-60, 11 aged 40-50 and 11 under 40. It should be remembered however that we have no evidence as to the length of time for which the disease was present before hypertension was diagnosed. This is a fascinating condition and considerable further work needs to be done for its elucidation. Unfortunately, relatively few cases have been operated on because of the bilateral or extensive nature of the arterial disease.

In some of the cases operated on an improvement in the hypertension has been obtained where the disease was predominantly

unilateral. In the original communication of Wylle and Wellington it was thought possible that there might be a relationship between this condition and toxæmia of pregnancy, because the hypertension in their first three patients was first noted during pregnancies. This interesting speculation was not supported by their further experience and it could hardly be relevant to our own male cases, or to the reported cases in children. However, it is a point which requires further investigation.

It is of interest that a few of our female cases suffered from hypertension which was first noticed during pregnancy. It is also interesting that many of our cases of fibromuscular hyperplasia showed clinically features suggestive of renal artery stenosis. Thus in some cases there was a loud bruit over the abdomen, and some of the predominantly unilateral cases showed typical IVP changes.

It is thus clear that fibromuscular hyperplasia can simulate simple atheromatous stenosis in its presentation both clinically and at pyelography if one artery is dominantly affected. This is not surprising as the condition does in fact produce a stenosis of the renal artery. However, differences between the kidneys on plain x-ray and pyelography will only be apparent if the lesion is more marked on one side. As the disease is commonly bilateral, this is the exception rather than the rule.

Fibrous Hyperplasia

Cases have been described where stenosis of the renal artery has been due to a fibrous stenosis which was (a) perimuscular, or (b) intimal. Hunt and others (1962) classified this condition as a variant of fibromuscular hyperplasia, despite the very different histology.

We have seen two verified cases but, radiologically we were unable to differentiate them from fibromuscular hyperplasia. The diagnosis would thus appear to be largely pathological.

Some of the cases of fibromuscular stenosis reported in the literature occurred in children. We have seen three such cases of renal artery stenosis in children and we think they do not really fall into the same category though they might be classified as "fibrous hyperplasia".

In one verified case our pathologist considered the lesions to represent areas of mal-development, i.e. to be congenital hypoplasia with some secondary intimal fibrosis rather than belonging to the fibromuscular or fibrous hyperplasias.

Extrinsic Pressure Bands

We have seen two examples of this very rare condition where the renal artery is compressed by a fibrous or fibromuscular band (D'Abreu and Strickland, 1962). In both our cases the band was found to contain lumbar sympathetic fibres and ganglion cells (Sutton and others, 1963), suggesting that it was part of the lumbar sympathetic chain.

Summary

Renal artery stenosis is an important cause of hypertension. One hundred and eighty eight cases have been diagnosed by angiography at St. Marys' Hospital in the past ten years. One hundred and nineteen of the cases were found among 700 hypertensive patients. The major cause was atheroma, but fibromuscular hyperplasia (43 cases) was also an important cause, particularly among the female patients. Other causes are fibrous hyperplasia, extrinsic pressure bands, and congenital arterial hypoplasia, but these are rare.

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