EXPERIENCE WITH RADIOLOGY IN THE DIAGNOSIS OF RENAL HYPERTENSION

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SINCE the work of Goldblatt, Lynch, Hanzal and Summerville in 1934 on the production of persistent hypertension in dogs there has been sustained interest in investigating hypertensive patients from the point of view of demonstrating a renal lesion, the surgical treatment of which might lead to permanent relief of hypertension. Many lesions of the kidney have been found to be associated with hypertension and with wider use of renal arteriography, the importance of renal artery occlusive disease as an etiological factor in hypertension has been amply demonstrated. (Howard, Berthrong, Sloan and Yendt, 1953; Poutasse, Humphries, McCormack and Corcoran, 1956; De Camp and Birchall, 1958; Brown, Owen, Peart, Robertson and Sutton, 1962). Smith (1956) estimated that between $\frac{1}{2}$ to 2 per cent of all hypertensive patients have surgically correctable renal lesions, and recent estimates (Sutton, Brunton and Starer, 1960; Maxwell and Prozan, 1962) indicate that this figure may be as high as 10 per cent.

Essential hypertension and reno-vascular hypertension are often clinically indistinguishable (Maxwell, 1962; Wilson, Dustan, Page and Poutasse, 1963) but an underlying renal cause for hypertension may be suspected in the following circumstances:—

1. Hypertension of recent onset at any age, particularly if rapidly progressive.
2. Hypertension in a young patient with no family history of high blood pressure.
3. A sudden increase in the blood pressure in a patient known to have essential hypertension.
4. A previous history of abdominal or loin pain, of renal trauma or of peripheral arterial emboli.
5. When a bruit is heard on auscultation over the renal area.

Diagnostic studies that may be useful in

investigating patients selected by such criteria are:—

1. Excretory urography.
 2. Renal arteriography.
 3. Radio-active renal function studies.
 4. Individual renal function studies.
- and some authorities would include:—
5. Renal biopsy. (Vertes, Grauel and Goldblatt, 1964).
 6. Estimations of pressor substances in renal venous blood. (Grollman, 1964.)

This paper is concerned with the assessment of the value of the first two procedures, (a) in the detection of unilateral renal disease in hypertension and (b) in attempting to assess its functional significance.

Materials and Methods

During the period April 1962 to March 1965 two hundred and fifty-seven hypertensive patients were referred for radiological investigation in an attempt to demonstrate a renal cause of the hypertension. All patients had excretion urography carried out. Renal arteriography was performed in 46 patients.

Excretion urography was preceded by dehydration and adequate bowel preparation. Minute sequence radiographs were taken for four minutes before the application of compression to the ureters. If initial radiographs suggested the possibility of renal artery stenosis, a diuresis was induced by giving the patient 500 ml. of water by mouth and exposing further films twenty to thirty minutes later.

Arteriography was performed by percutaneous puncture of the femoral artery and retrograde catheterisation (Seldinger, 1953). In all cases a non-selective aortic injection was made. In some cases selective renal arteriography was carried out.

Results

The excretion urogram was considered to be abnormal in 62 of the 257 patients, i.e. 24 per cent. Table 1 shows the wide range of abnormalities found.

Eighteen of the 62 patients with abnormal excretion urograms were further examined by

TABLE 1.
RESULTS OF EXCRETION UROGRAPHY AND
ABNORMALITIES DETECTED

NORMAL	195
ABNORMAL	62
Calculi	10
Stenosis Renal Artery	11
Chronic focal pyelonephritis	10
Ureteric obstruction	7
Small kidney bilateral	5
Small kidney unilateral	6
Congenital abnormality:—	7
Ectopic kidney	1
Polycystic disease	1
Rotated kidney	3
Solitary kidney	1
Bil. pelvi-ureteric obstruction	1
Space occupying lesion	2
Others	4
Renal scar	
Renal operation	
Non-functioning kidney	
Calcified tuberculosis	

TABLE 2(a)
FURTHER INVESTIGATION OF PATIENTS WITH ABNORMAL
EXCRETION UROGRAMS

Abnormal Urograms	62
Arteriogram	18
Pathology confirmed	17
Pathology doubtful	1

TABLE 2(b)
SUSPECTED DIAGNOSIS (AFTER EXCRETORY UROGRAPHY)
IN EIGHTEEN PATIENTS UNDERGOING AORTOGRAPHY
FOR CONFIRMATION

Congenital abnormalities:—	5
Rotated kidneys	3
Pelvic kidney	1
Polycystic kidney	1
Non-functioning kidney	1
Small kidney bilateral	1
Small kidney unilateral	4
Chronic pyelonephritis (bilateral)	1
Renal scar	1
Renal artery stenosis (confirmed in 4)	5

TABLE 3
FURTHER INVESTIGATION OF PATIENTS WITH NORMAL
EXCRETION UROGRAMS

Normal urogram	195
Arteriogram	28
Normal	23
Abnormal:—	
Renal artery stenosis	3
Phaeochromocytoma	1
Aneurysm of left renal artery	1

renal arteriography. In 17 of these patients the renal arteriogram confirmed the findings of the excretion urograms; in the eighteenth case, a diagnosis of renal artery stenosis could not be confirmed since the origin of the renal artery was not well seen. Four patients in this group eventually proved to have unilateral renal artery

stenosis. In each case this diagnosis had been suggested on the basis of the excretion urogram. (Table 2 a, b.)

Of the 195 patients with normal excretion urograms, 28 had renal arteriography carried out. In five of these 28 cases an abnormality was demonstrated. Three patients were found to have unilateral renal artery stenosis, one patient had a phaeochromocytoma (Welch and Davidson, 1965) and one had a left renal artery aneurysm. (Table 3.)

Results of Surgery

Seven patients underwent surgery in an attempt to cure hypertension. Four had renal artery stenosis; one had a poorly functioning ectopic pelvic kidney; one had a functionless kidney; one had a unilateral small kidney. In none of the patients was there permanent alleviation of hypertension.

Case No. 1

A 41-year-old woman was known to be hypertensive for four months, with a blood pressure of about 240/140 mm. Hg. Renal function was normal. She was shown to have a stenosis of the right renal artery. A vascular repair was performed successfully but subsequently this was shown to be thrombosed and nephrectomy was performed. Her blood pressure fell to levels about 160/100 mm. Hg. for a year but then rose and hypotensive agents were exhibited.

Case No. 2

A 40-year-old woman had hypertension for 23 months (B.P. 215/130 mm. Hg.). Renal function was shown to be normal. She was found to have a lower polar artery stenosis. At operation the pressure over the stenosis was found to be reduced by 50 per cent. A partial nephrectomy was performed. The B.P. fell to 130/180 mm. Hg. for two months and then began to rise.

Case No. 3

A 47-year-old man had a preoperative blood pressure of 230/110 mm. Hg. He was shown to have a right renal artery stenosis. Renal function was normal. At operation the aortic pressure was 210/120 mm. Hg. and the pressure distal to the stenosis 80/60 mm. Hg. Nephrectomy was performed but the blood pressure subsequently showed no significant change from preoperative levels.

Case No. 4

A 40-year-old hypertensive female was shown to have a renal artery stenosis. At operation it was found technically impossible to reconstruct the artery but it was decided to spare the kidney.

Case No. 5

A 50-year-old male had a preoperative blood pressure of 190/110 mm. Hg. A functionless kidney was demonstrated and this was removed. There was no fall in blood pressure subsequently. The kidney contained numerous cysts and calculi and there was a degree of hydronephrosis.

Case No. 6

A 48-year-old male had a blood pressure of 190/110 mm. Hg. of about 24 months duration. He was found to have an ectopic kidney situated in the pelvis and this was removed. Post-operatively there was no change in blood pressure.

Case No. 7

A 45-year-old female had been hypertensive (B.P. 240/120 mm. Hg.) for about 18 months. A small kidney was demonstrated on one side and this was removed. It was scarred on the surface and microscopic examination revealed marked cortical scarring with sclerosis and narrowing of the vessels. There was evidence of chronic pyelonephritis. Post-operatively there was no change in blood pressure and hypotensive agents were required.

Discussion

The changes produced in an excretory urogram by renal artery stenosis are a result of diminished blood flow to the kidney and will be observed in a given case only if narrowing of an artery has a functional effect. The changes usually seen are diminution of the size of the affected kidney and other abnormalities which are due to disturbances of tubular function (Hodson, 1961). A difference of more than one-and-a-half centimetres in length between the two kidneys should be regarded as suspicious of renal artery stenosis, in the presence of a normal collecting system. In this respect it should be remembered that the normal left kidney is frequently up to one centimetre longer than the right so that a small left kidney should be regarded with greater suspicion. While such differences in size are a common manifestation of unilateral renal artery stenosis, they should by no means be regarded as essential to the diagnosis, since severe functional stenosis can be present without significant difference in size. In a recent unselected post mortem study Schwartz and White (1964) showed that the weight of the majority of kidneys associated with severe focal arterial stenosis is not reduced and concluded that the presence of kidneys of normal radiological dimensions does not preclude the possibility of severe renal arterial disease. In this connection it is of interest to note that of our eleven patients with small kidneys (Table 1) five were subjected to renal arteriography and none of these was found to have renal artery stenosis.

Decreased blood flow in a functional renal artery stenosis leads to a slower tubular urine flow rate with resultant increased reabsorption of sodium and water. Such changes may produce the following observed effects on the excretory urogram:

1. Delayed excretion of contrast on the

affected side. This can be demonstrated by exposing films of the kidneys at minute intervals after injection of the contrast medium, and before compression (Hodson, 1962) (Fig. 1).

2. Increased density of the pyelogram on the affected side. The contrast media used in excretory urography are excreted by glomerular filtration and because of increased water re-absorption a hyperconcentration of contrast medium in the urine of the stenosed kidney may be expected (Hodson, 1962). This effect may only be evident after hydration of the patient, (Amplatz, 1964) since a diuresis will occur on the normal side, so "washing out" the contrast medium. This has been described as a "radiological Howard test" (Fig. 2).

3. The small volume of urine produced on the affected side distends the pelvi-calyceal system poorly, producing a "low volume collecting system" (Whitely, Witcofski, Quinn and Meschan, 1962) (Fig. 2).

Other features suggestive of renal artery stenosis which may be seen on excretory urography include "ureteral scalloping" due to tortuous collateral vessels (Halpern and Evans, 1962) and localised contraction of renal substance, associated with normal calyces, which may indicate stenosis or thrombosis of a branch vessel.

It is well established that excretion urography may be essentially normal in patients who subsequently prove to have renal artery stenosis of functional significance. Using standard techniques and even with experienced observers interpreting the radiographs there may be no abnormality in 25 per cent or more cases of renal artery stenosis as compared with perhaps 10 per cent of false negatives in isotope renography (Howard and Connor, 1962; Morris and De Bakey, 1962). The routine use of minute sequence films for estimating excretion rate and urea infusion diuresis techniques may increase the diagnostic accuracy (Amplatz, 1964). While admittedly far from perfect, excretory urography is at present more widely available than isotope renography and when carefully carried out continues to be a useful screening procedure. At present it should be considered as complementary to the isotope renogram, and the two together can succeed in demonstrating the great majority of significant renal artery stenoses.

Renal arteriography is essential for confirmation of a diagnosis suspected by other techniques and also supplies anatomical information to the surgeon which may indicate the feasibility of a particular vascular reconstructive technique.

FIG. 1—Right renal artery stenosis. Delayed excretion from the right kidney.

FIG. 2—Right renal artery stenosis. Tomograph of I.V.P. after water load. Small right kidney; dense right pyelogram.

TABLE 4.
REASONS FOR PERFORMING ARTERIOGRAMS IN PATIENTS WHO HAD NORMAL EXCRETION UROGRAMS

Suspected phaeochromocytoma	1
Abdominal bruit	1
Under 50 years of age	21
Not clear	5
	<hr/> 28

The presence of post-stenotic dilatation or of differences in flow-rate and nephrogram density on the two sides indicate that an arterial narrowing is producing a functional effect on blood supply (Figs. 3, 4). Schwartz and White (1964) have shown that severe intrarenal stenosis is a

common accompaniment of extrarenal stenosis and they stress the need for adequate visualisation of the intrarenal arterial tree at angiography before embarking upon reconstructive arterial surgery. They also point out that severe extrarenal stenosis on one side implies that the opposite extrarenal arteries will be normal in only 9 to 18 per cent of cases. There is no doubt that selective renal arteriography is the method of choice for demonstrating the intrarenal arterial tree, and we now consider that both non-selective aortic injection and bilateral selective renal arterial injections should be carried out in cases of extrarenal stenosis.

FIG. 3—Non selective arteriogram. Right renal artery stenosis with post stenotic dilatation.

FIG. 4—Nephrogram phase. Poor nephrogram on the affected right side.

The reasons for performing arteriography in patients with normal excretion urograms are shown in Table 4. It will be seen that in one patient pheochromocytoma had been suspected on clinical grounds and arteriography was performed for localisation. The patient with the renal artery aneurysm had a definite bruit on auscultation of the abdomen. An isotope renogram carried out in this patient showed no evidence of a functional lesion due to the aneurysm. In 21 patients below the age of 50 arteriography was felt to be indicated despite a normal excretion urogram. No lesion was found at arteriography in any of these patients. In five patients over 50, although all three renal artery stenoses were found in this group, arteriography was probably not indicated, since it was evident for other reasons that a surgical approach to the treatment of hypertension was unlikely to be successful. There was no radiological evidence that the stenosis was producing a functional effect in any of these patients.

When a functional renal vascular lesion has been demonstrated there remains the problem of attempting to predict whether surgical cure is possible. We share the concern expressed by Chamberlain and Gleeson (1965) regarding the results of surgery and in our own series these results do not seem to be commensurate with the effort expended in investigation. Because medical management is today so successful in the control of both essential and renal hypertension the selection of those patients who should be submitted to surgery becomes even more important (Maxwell, 1962). It seems likely that the cause of failure of surgical treatment in many cases is the presence of irreversible pathology in the contra-lateral kidney. All methods of establishing the normality of that

kidney prior to surgery would therefore seem to be justified. For example it has been recommended that bilateral renal biopsy should be carried out in all cases being considered for surgery (Vertes, Grauel and Goldblatt, 1964). Bilateral selective renal arteriography should also be carried out in order to determine the presence of intrarenal arterial disease. Even where there is a diseased or non-functioning kidney which may be the causal factor, complete investigation of the apparently normal kidney is necessary. It is important that renal tissue should be preserved whenever possible by reconstructive operations in renal artery stenosis since the ischaemic kidney may be protected from the effects of prolonged high blood pressure by the stenosis.

Conclusions

The cure rate in patients subjected to surgery for renal hypertension is very variable and it seems likely that this is due to differences in selection. A large amount of time and money is spent in investigating these patients, in many of whom the hypertension can be adequately controlled by medical measures. Before initiating renal investigation in a hypertensive patient the physician should consider carefully whether a surgical approach would be possible if a remediable lesion were found. If so both excretion urography and isotope renography are indicated. Where these investigations show evidence of a functional renal lesion renal arteriography including bilateral selective studies should be carried out. In patients in whom both excretion urography and isotope renography

are normal arteriography should be performed only in the younger age groups or where clinical indications are very strong.

Prediction of surgical cure will be dependent on establishing the normality of the intrarenal arterial tree and of a normal renal histology.

Summary

Two hundred and fifty-seven hypertensive patients were investigated by excretion urography. Renal pathology was demonstrated in 62 patients. Renal arteriography was carried out in 46 patients.

Six patients had surgical treatment—either nephrectomy or an attempted vascular repair. In none of these patients was there a permanent return of blood pressure to normal levels.

The radiology of renal hypertension is discussed along with the indications for embarking upon detailed investigation.

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