RADIOLOGY IN THE INVESTIGATION AND MANAGEMENT OF HYPERTENSION

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Radiology is often of value in the investigation and management of patients with hypertensive vascular disease. When the hypertension is secondary to renal or adrenal disease, radiology will frequently demonstrate the cause. This is particularly important when surgical cure is possible, as in certain unilateral renal lesions and disease of the adrenals. Table 1 gives a classification of the causes of hypertension and indicates the conditions in which radiology helps in the diagnosis.

Many of these conditions are not amenable to surgical treatment, but in certain cases unilateral nephrectomy or adrenalectomy may be of value. A recent review of nephrectomies for hypertension has shown that of 575 reported cases operated on between 1937-56 only approximately 26 per cent. were successful in reducing the blood pressure to 140/90 or less for longer than one year (Smith, 1956). The author points out that successful cases are reported more frequently than unsuccessful, so that it is likely that considerably less than one in four of the nephrectomies for hypertension are successful. The kidney is more often the victim rather than the cause of the hypertension. Examination of the resected kidneys in the successful cases showed that pyelonephritis, hydronephrosis and pyonephrosis and atrophy of the kidney were the commonest pathological conditions, accounting for approximately 70 per cent. of the successful nephrectomies. Nephrectomy for vascular lesions of the kidney accounted for a further 12 per cent. of the successful cases. Tumours and cysts of the kidney are rarely the cause of hypertension and accounted for only 4 per cent. of successful cases.

Radiological Investigation of the Kidneys and Adrenals

Straight Radiograph of Renal Tract

This examination should be carried out on all patients with hypertensive vascular disease in order to assess the size, shape and position of the kidneys and to demonstrate any abnormal calcification. Small kidneys with an irregular outline suggest

TABLE 1
CAUSES OF HYPERTENSION

1. Essential Hypertension
2. Secondary Hypertension
 1. *Diseases of Renal Tract*
 - (a) Type I nephritis
 - (b) Type II nephritis in late stage
 - x (c) Chronic pyelonephritis—unilateral
bilateral
 - x (d) Polycystic kidney
 - x (e) Renal stone or other obstructive lesion
 - x (f) Vascular lesions of the kidney
 - (g) Amyloid contracted kidney
 - (h) Radiation nephritis
 2. *Adrenal Disease*
 - x (a) Medulla—Pheochromocytoma
 - x (b) Cortex—Cushing's Syndrome
Primary Aldosteronism
 3. *Miscellaneous*
 - x (a) Coarctation
 - x (b) Polyarteritis
 - (c) Eclampsia

TABLE 2
INVESTIGATION OF HYPERTENSION

- Straight X-ray Renal Tract (all cases)*
For size and position of kidneys
For evidence of opaque calculi
- Excretion Pyelogram (all cases requiring treatment)*
For evidence of unilateral disease—pathology
function
- Retrograde Pyelogram*
To confirm unilateral disease
For divided renal function tests
- Aortography*
(Where indicated—see text)
Arteriogram—narrowing of major vessels
abnormal arterial tree
Nephrogram—distortion of renal outlines
ischaemic areas
- Renal Biopsy*
For evidence of pyelonephritis
- Presacral Gas-insufflation*
Little use in pyelonephritis
The method of choice in Adrenal Disease.

hypoplasia, atrophy or pyelonephritis with scarring. One large kidney may suggest hydronephrosis or the presence of a renal tumour or cyst. If both kidneys are large, polycystic kidneys are a likely cause. Although the kidneys may vary in position in normal patients, rotation or downward displacement of one kidney should not be ignored, since

it may be due to the presence of a suprarenal tumour, the outline or calcification of which may occasionally be seen on a plain film. Opaque calculi may be demonstrated. They are rarely the cause of hypertension, but their removal may be indicated on surgical grounds and may result in improvement of renal function.

Excretion Pyelogram

This examination is indicated in all patients with hypertension of sufficient severity to require treatment, and in all young patients with severe hypertension not due to nephritis or coarctation (Pickering and Heptinstall, 1953). Information may be obtained about renal *pathology and function*.

Pathology. In examining the pyelogram particular attention should be paid to the pattern of the calyces and to the thickness of cortex beyond the calyces. In pyelonephritis the calyces may be distorted or blunted, particularly opposite a contracted and scarred part of the kidney, where the depth of the cortex will be seen to be thin. This scarring may be localized or may involve the whole of one or both kidneys. In hydronephrosis the calyces are distended and the normal cupping is lost. A thin rim of cortex may be seen distal to the calyces, indicating the remnant of functioning renal tissue. Polycystic kidneys typically show large lobulated renal outlines with calyces deformed by multiple crescentic filling defects, so that they become narrow and elongated. In cases of suprarenal tumour the upper calyx may be deformed and depressed.

Function. The pyelogram is not a reliable test of renal function and minor differences between the concentration of contrast medium by the two kidneys should be ignored. If one kidney is seen to concentrate less well than the other, it is wise to repeat the examination before accepting the difference as evidence of diminished renal function on one side. A completely non-functioning kidney is less likely to cause hypertension than one with some function, even though the function may be much diminished (Rosenheim, 1954, 1956).

Retrograde Pyelogram

This examination may be used to confirm the findings of the excretion pyelogram and to examine the collecting system of a non-functioning or poorly functioning kidney. The examination may be combined with divided renal function studies, by which the function of the kidneys separately can be assessed. It has been shown that kidneys which appear to function satisfactorily on excretion pyelography may show significantly reduced function when clearance tests are carried out on each kidney separately through ureteric

catheters (Chasis, Redish, Goldring, Ranges and Smith, 1945; Graber and Shackman, 1956).

Aortography in Hypertension TECHNIQUE

A detailed discussion of the technique of renal angiography is beyond the scope of this paper and the reader is referred to papers by Riches and Whiteside (1956) and Murray and Tresidder (1957). The relative merits of the different techniques may be summarized as follows:

Translumbar Aortography. The percutaneous translumbar technique introduced by dos Santos *et al.* (1929) is frequently used and has the merit of being quick and in most cases gives very good diagnostic information. Serious complications, including paraplegia and renal failure, have followed aortography by this means. Some complications have been due to the injection of too great a quantity of contrast medium or to faulty positioning of the needle, resulting in the injection of the whole of the contrast into one of the major branches of the aorta. Other complications have occurred from intramural injection of contrast medium, causing a condition analogous to a dissecting aortic aneurysm (Gaylis and Laws, 1956).

Retrograde Aortography. This method, introduced by Seldinger (1953), aims at the introduction of a polythene tube into the aorta following percutaneous catheterization of one femoral artery at the level of the inguinal ligament. This technique allows accurate positioning of the contrast within the aorta and avoids some of the complications of the translumbar method. The tip of the catheter allows accurate positioning of the complications of the translumbar method. The tip of the catheter may be adjusted to lie near the origin of the renal arteries, so that, when the injection is made, the contrast passes a short way up the aorta and mixes with blood before passing into the renal arteries. This ensures an even distribution of the contrast. Since the patient is examined supine, the kidneys are nearer the film than when the translumbar method is used and consequently there is less distortion of the renal shadows on the film. This technique is the one of choice in renal angiography, except for certain specific cases when catheterization of the individual renal arteries may be preferable.

Selective Renal Angiography: Catheterization of Individual Renal Arteries. Tillander (1956) and Ödman (1956) developed a method of catheterization of the individual renal arteries after percutaneous puncture of a femoral artery. Injection of contrast then allowed the demonstration of the vascular system of each kidney separately without the confusion caused by the superimposition of shadows of the mesenteric artery and other

branches of the aorta. Although this method is capable of giving excellent results, it has certain disadvantages. The origin of the renal arteries, which may be the site of narrowing or partial thrombosis, is not shown and aberrant renal arteries may not be demonstrated. In addition, since it is necessary to examine both kidneys, each renal artery must be catheterized in turn.

VALUE OF AORTOGRAPHY

Demonstration of Main Renal Artery. During the arterial phase of the aortogram the renal arteries and their main branches should be clearly demonstrated. Narrowing of a renal artery near its origin may be responsible for hypertension. The usual cause is an atherosclerotic plaque, although other causes, such as internal proliferation, partial thrombosis, embolus and stenosis due to fibrosis have been occasionally incriminated. There may be post-stenotic dilatation. Cases of this type have been described in increasing numbers in recent years and treatment by nephrectomy (Thompson and Smithwick, 1952), thrombectomy (Freeman *et al.*, 1954) and arterial grafting (Poutasse *et al.*, 1956; Poutasse and Dustan, 1957) has frequently resulted in relief of the hypertension.

Normal kidneys are strikingly symmetrical both in size and calyceal pattern. A difference in kidney length of as little as 1 to 2 cm. may be indicative of renal artery occlusive disease (Hodson, 1957; Poutasse and Dustan, 1957). In these cases the excretion pyelogram may show delayed or diminished function on the smaller side, but the pyelogram may be entirely normal. Occasionally when there is occlusion of the main renal artery there will be no function from the kidney on excretion pyelography, but a retrograde examination may show a normal calyceal pattern.

Demonstration of Renal Arterial Tree. The arterial tree normally divides in a regular manner, the small branches tapering smoothly, forming a pattern which has been likened to an ash tree. In pyelonephritis and contracted senile kidney the arteries become tortuous, irregular in outline and contracted peripherally, forming an oak-tree pattern (Hodson, 1957). Although these arterial patterns have been well demonstrated by post-mortem injection, it is not always possible to demonstrate them satisfactorily by means of aortography. Since they indicate generalized renal artery disease, their demonstration is of little value.

Demonstration of Renal Substance. During the nephrographic stage the renal substance and the outline of the kidney can be seen clearly. Any scarring or irregularity of outline should be seen. Large ischaemic areas may be demonstrated by this method. Although the demonstration of ischaemic areas has proved of value in planning partial

nephrectomy for tuberculosis, its value in the investigation of hypertension is, as yet, uncertain. It may provide useful confirmatory evidence of diminished blood flow when a main renal artery or major branch is stenosed.

Demonstration of Adrenal Tumours. Although many suprarenal tumours are vascular and may be demonstrated by aortography, this is not usually the examination of choice; presacral perirenal pneumography is preferable.

Aortography may precipitate a severe hypertensive attack in patients with pheochromocytoma and recently two deaths have been reported following aortography in this condition (Saltz *et al.*, 1956). In each case the tumour was vascular and was consequently well demonstrated on the resulting radiographs. However, severe uncontrollable hypertension resulted and the patients died within hours of pulmonary oedema. Although there is a risk of precipitating a hypertensive attack by any abdominal manipulation of a pheochromocytoma, including manual examination, severe attacks have not yet been reported following presacral pneumography. This is consequently the method of choice for demonstrating these tumours.

INDICATIONS FOR AORTOGRAPHY IN HYPERTENSION

The indications for aortography in the investigation of hypertensive disease are not yet established. This subject has been recently reviewed by Poutasse and Dustan (1957), who submitted 134 selected hypertensive patients to aortography. In 30 of these there was evidence of unilateral or bilateral obstructive lesions of the renal artery. Of these, 19 were submitted to nephrectomy or corrective arterial surgery with relief of the hypertension in the great majority, although the follow-up period has necessarily been short, in half the cases less than one year. There were two post-operative deaths, one from renal failure and one from haemorrhage.

In the light of their experience Poutasse and Dustan give as their indications for aortography in hypertension:

(i) Any hypertensive patient, regardless of his age or duration of the hypertension, who shows unexplained disparity of the size and function of the kidneys on excretion urography. A disparity of kidney length of 1 to 2 cm. may be significant.

(ii) Young patients who do not seem to have essential hypertension, since they lack a family history of hypertension, and do not have any other demonstrable cause for their hypertension.

(iii) Elderly hypertensives, over 55 years, who suddenly develop accelerated or malignant hypertension. Since malignant hypertension is a rare complication of essential hypertension in the elderly, a secondary cause should be suspected.

(iv) Patients of any age with long-standing hypertension which abruptly becomes more severe, especially if there is a change in the excretion urogram or a history of pain in the flank to suggest thrombosis of a renal artery with subtotal renal infarction.

Renal Biopsy

A discussion of the value of renal biopsy in hypertension is outside the scope of this paper. Accurate radiographic localization of the kidney, however, is necessary before an attempt at biopsy is made. It may be possible to choose the site of biopsy with some accuracy if the biopsy is performed during an excretion pyelogram and the position of the needle is directed by screen control with the aid of an image intensifier. The lower pole of the right kidney is usually chosen (Kark and Muehrcke, 1954).

Presacral Perirenal Pneumography

This examination is of little value in hypertension of renal origin, since in pyelonephritis the perirenal adhesions prevent passage of air around the kidney. It is chiefly of value in the investigation of suspected adrenal disease. The presence of a tumour or hyperplasia may be strongly suggested on clinical grounds, but radiology in these patients is essential in order to localize the lesion with accuracy.

The technique usually employed is similar to that described by Ruiz Rivas (1950). This has proved to be a safe procedure provided care is taken to avoid gas embolism at the time of injection.

FIG. 1.—Normal presacral perirenal gas insufflation showing the adrenal glands. Note that the glands have straight or slightly concave sides.

tion. There are varying opinions concerning the best gas to use. Air was used originally and is still

FIG. 2a.—Presacral perirenal gas insufflation in a patient with Cushing's syndrome showing bilateral hyperplasia.

FIG. 2b.—Tomography of the same patient, as Fig. 2a. Note that the normal shape of the adrenals is retained although the glands are clearly enlarged.

FIG. 3.—Presacral perirenal gas insufflation in a patient with Cushing's syndrome showing a right-sided adrenal tumour. Note the convex borders replacing the normal straight sides. A cortical adenoma was removed surgically.

frequently used. Pure oxygen has been advocated on the grounds that its greater solubility in serum makes the risk from inadvertent intravascular injection less serious. More recently Durant *et al.* (1957) have shown that pure carbon oxide, which is approximately 20 times more soluble in serum than is oxygen, may be injected intravenously in humans in amounts up to 100 ml. without serious effects, which almost eliminates the risk of fatal gas embolism. This quick absorption means that the procedure causes the patient discomfort for a short time only, since the whole examination, including the taking of all the films, must be completed in approximately 30 minutes. As it is usually advisable to supplement the film of the abdomen with tomograms, in order to distinguish between retro-peritoneal gas and air in the alimentary tract, the radiographic part of the examination must be carried out as rapidly as possible.

Normally the adrenal glands are seen as approximately triangular shadows lying above and slightly medial to the upper pole of the kidneys. The left lies more medially and is demonstrated less regularly than the right. Normal glands vary considerably in shape, some being approximately equilateral, others long and thin, so that it is difficult to give any useful range of normal measurements. Harrison and Doubleday (1956) have estimated the average projected area of normal adrenal

glands to be 2 sq. cm. (range 1 to 4 sq. cm.) for the right and 2.6 sq. cm. (range 1.4 to 8.2 sq. cm.) for the left. Variation from the normal shape is of more diagnostic value than absolute measurements. The sides are usually straight or slightly concave. The earliest sign of a small tumour may be the appearance of a convex margin on one side of the gland, while large tumours alter the outline of the gland completely. It should be stressed that, while perirenal gas insufflation may supply valuable information about the presence of a tumour or hyperplasia, the technique has severe limitations in that a normal examination does not exclude the presence of a functioning tumour. For example, a small tumour may not alter the contour of the gland and a malignant tumour may infiltrate surrounding tissues and prevent the free passage of retro-peritoneal gas. Because of the wide normal variation, it is difficult to assess minor degrees of hyperplasia. Since certain tumours, notably the pheochromocytoma, may be multiple and para-aortic rather than suprarenal in position, it is important to include the whole of the abdomen on at least one of the radiographs.

In *Cushing's syndrome* the presence of adrenal cortical over-secretion can often be proved by biochemical assay, but perirenal gas insufflation is usually necessary in order to distinguish between hyperplasia or a tumour. In adults hyperplasia is

about twice as common as a tumour, but in cases occurring before puberty the cause is most likely to be a malignant tumour. A skeletal survey may provide evidence of osteoporosis, possibly with the appearance of 'fish-tail' vertebrae with biconvex disc spaces or collapse of vertebral bodies in the lower dorsal or lumbar spine. Fractures may occur even in the absence of evident osteoporosis and may be asymptomatic (Strickland, 1954). For example, unsuspected fractures of the ribs may be seen on well-penetrated films of the chest or upper abdomen. Fractures of the pubic rami may occur without symptoms. A lateral view of the pituitary fossa should be taken. Rarely a similar clinical picture may be due to a basophil tumour of the pituitary, Cushing's disease. Only in the rarest circumstances, however, will a basophil tumour grow large enough to cause enlargement of the pituitary fossa.

Primary aldosteronism, first described by Conn and Louis in 1956, is usually due to a cortical adenoma (Milne, Muehrcke and Aird, 1957), but cases due to a carcinoma (Foye and Feichtmeir, 1955) and bilateral hyperplasia (Van Buchem, Doorenbos and Elings, 1956) have been described.

The prolonged potassium depletion of primary aldosteronism predisposes to chronic nephritis, which may be determined by pyelography, and for this reason it is important that an aldosterone-secreting tumour should be removed before irreparable renal damage has occurred. In the early stages of the disease the pyelogram is normal.

Although in a patient with *pheochromocytoma* it is not essential for the surgeon to know the precise site of the tumour, pre-operative radiographic demonstration of the size, number and location of these tumours is of great value. Approximately 10 per cent. of pheochromocytomata occur in retroperitoneal ganglionic tissue outside the adrenal gland and in 10 per cent. of cases there are multiple tumours (Cahill and Aranow, 1949). These tumours are well demonstrated by perirenal gas insufflation combined with tomography, which is a safe procedure provided excessive manipulation of the patient is avoided.

The Heart in Hypertension

The Aorta

In hypertension the aorta frequently becomes elongated and unfolds, when the ascending aorta becomes easily seen on the right border of the heart shadow and the aortic knuckle becomes more prominent. The aorta may become dilated. These changes are common and are present in some degree in all patients with long-standing hypertension. In certain cases, however, dissection of the aorta occurs in patients suffering from severe hypertension and may be the immediate cause of

death. Beaven and Murphy (1956) found that nine of 44 patients with hypertension died with a dissecting aortic aneurysm. They attributed this high incidence to the hypotensive therapy which had allowed the patients to live longer than before such treatment was available, to the wide variation in the blood pressure which may occur with this treatment and possibly to a direct toxic effect of

FIG. 4a.—Postero-anterior chest radiograph in a patient with organized pulmonary oedema (confirmed post-mortem). Heart considerably enlarged.

FIG. 4b.—Same patient showing widening of the superior mediastinum due to a dissecting aortic aneurysm from which the patient subsequently died.

the hypotensive drug on the media of the aorta. The most obvious radiological sign of dissection of the aorta is widening of the superior mediastinum. This is naturally more easily recognized when previous comparable films are available. In some cases over-penetrated views may show widening of the descending thoracic aorta and occasionally it may be seen that there is an excessive soft tissue shadow lateral to the calcified atheromatous plaque which is frequently seen in the aortic knuckle, indicating effusion of blood in the media. This sign is naturally more significant if previous films show that the calcareous plaque has recently changed its relationship to the left border of the aortic knuckle.

Left Ventricle

The heart silhouette may be quite normal in the presence of severe hypertension, even though there may be clear electrocardiographic evidence of left ventricular hypertrophy. The small increase in the thickness of the muscle of the left ventricle is not appreciable radiographically. However, left ventricular enlargement of a mild or moderate degree is frequently seen and is initially due to a combination of left ventricular hypertrophy and dilatation. On the posterior-anterior film of the chest the apex of the heart will extend outwards and

downwards more than normally and in the lateral or left anterior oblique view the left ventricular border will be seen to overlap the barium-filled oesophagus. When left ventricular failure occurs, the heart frequently dilates and this is seen as a relatively sudden increase in the size of the heart, particularly the left ventricle. The heart returns to its previous size within a few days if the failure is treated effectively.

Left Atrium

In failure the left atrium also may be enlarged (Cobbs, Shillingford and Steiner, 1957) and may be demonstrated radiographically by the typical double atrial contour on the right border of the heart in the well-penetrated postero-anterior film and backward displacement of the barium-filled oesophagus in the lateral or right anterior oblique view.

Coarctation of the Aorta

It is well known that coarctation of the aorta may be symptomless and be diagnosed because of hypertension, cardiac murmurs or the recognition of radiological abnormalities.

FIG. 5.—Lateral radiograph of chest after barium swallow in a patient with hypertension with heart failure, showing enlargement of the left auricle and left ventricle.

FIG. 6.—Postero-anterior radiograph of the chest in a patient with coarctation showing the 'treble' aortic knuckle on the left side due to an enlarged left subclavian artery, aortic arch and dilated post-stenotic segment of aorta. Note the rib notching.

Notching of the inferior aspects of the ribs, due to dilated tortuous intercostal arteries, is frequently seen. Notching is usually bilateral, but may be unilateral, particularly when the coarctation is proximal to or affects the origin of the left subclavian artery, when the notching may be confined to the right side. Dilated internal mammary arteries may occasionally be seen as comma-shaped opacities immediately behind the sternum on the lateral view.

The heart size may be normal, but there is usually some enlargement of the left ventricle in all but minimal cases. Great enlargement of the heart is uncommon and is found only in complicated coarctation, usually with gross aortic valve disease.

The ascending aorta is frequently dilated and may become aneurysmal. The arch may be small or enlarged. The aortic knuckle is frequently lower and less prominent than usual. A dilated subclavian artery above and a dilated post-stenotic segment below may cause a triple convex shadow on the left mediastinal border. This post-stenotic segment, together with the anterior kink of the aorta at the site of the coarctation, frequently causes an impression on the posterior aspect of the barium-filled oesophagus. This very useful sign

allows the site of the coarctation to be assessed by radiology without the aid of contrast examination in a high proportion of cases; 33 out of 52 in the series reported by Cleland *et al.* (1956). Occasionally there may be aneurysmal dilatation of this post-stenotic segment.

It is possible by venous angiocardigraphy to demonstrate the site of the coarctation and estimate the length of the narrow segment. The left subclavian artery can frequently be seen, as well as the distance from its origin to the proximal end of the coarctation. More exact anatomical detail can be demonstrated by retrograde thoracic aortography, following catheterization of a radial artery (Brodén *et al.*, 1948; Jönsson *et al.*, 1948). Contrast examination is indicated when exact pre-operative anatomical detail is essential (e.g. when grafts are not available) or when there are atypical features.

The Lungs in Systemic Hypertension

For the purposes of description it is convenient to classify the lung changes seen in left heart failure into acute, subacute and organized pulmonary oedema. The division is not clear-cut, however, and features of more than one type of oedema may be present at the same time.

Acute Pulmonary Oedema

The patient with acute left heart failure is very ill and dyspnoeic. The diagnosis is essentially a clinical one. Any chest radiographs are usually taken with a 'relatively low output' 'ward unit', which necessitates a relatively long exposure and is not capable of taking a satisfactory lateral view in a dyspnoeic patient. The intra-alveolar albuminous pulmonary oedema is seen on the chest radiograph as the familiar 'bat's wing' shadowing which has been described by Hodson (1950) and Jackson (1951). These shadows, which are usually very dense, are most marked near the hilum and spread outwards into the lung fields, sparing the apices and periphery of the lung in characteristic fashion. The oedema tends to form posteriorly. The changes are bilateral, but may be more marked on one side initially. In heart failure true unilateral oedema is rare. If the attack of left heart failure is mild and the treatment successful, the shadows may disappear completely within 24 to 48 hours.

Subacute Pulmonary Oedema

When the left heart fails more gradually, the lung changes are less striking but equally characteristic and may be present at a stage when there are few symptoms and little or no clinical evidence of heart failure (Short, 1956). Recognition of these signs of early left heart failure may allow early treatment and prevent the onset of acute pul-

FIG. 7.—Retrograde thoracic aortogram in the same patient as Fig. 6 showing the short coarctation, post-stenotic dilation and the large left subclavian artery.

FIG. 8a.—Postero-anterior radiograph of the chest in a hypertensive patient with acute pulmonary oedema.

FIG. 8b.—The same patient 3 days later. Lungs clear.

monary oedema. It has been shown that the pulmonary capillary pressure, catheter 'wedge pressure,' is closely related to the pressure in the pulmonary veins and left auricle (Lagerlöf and Werkö, 1949). When the pulmonary venous pressure, and hence the capillary pressure, rises to

FIG. 9a.—Postero-anterior chest radiograph of a hypertensive patient with heart failure. Note the left pleural effusion, congested hila and septal lines in the lower zones.

a level exceeding the plasma-osmotic pressure (normal 25 to 30 mm. Hg) there is transudation of fluid into the lymph spaces and interstitial oedema results. Thus, while the acute left heart failure causes intra-alveolar oedema, a more gradual failure results in interstitial pulmonary oedema. This is seen radiographically by the appearance of short horizontal peripheral 'septal lines' in the lower zones due to oedema of the interlobular septa. These lines may be seen as high as the hilum. It has been shown in mitral stenosis that these septal lines do not appear until the pulmonary venous pressure exceeds the plasma-osmotic pressure, the critical level being approximately 22 to 25 mm. Hg (Carmichael *et al.*, 1954; Grainger and Hearn, 1955). These appearances may be associated with enlargement of the left atrium. There may be distension of the pulmonary veins, particularly in the upper lobe, but this is difficult to recognize and is seldom definite enough to be helpful.

Pleural effusions may be present in one or both pleural cavities. These may be small and a lateral view or screening may reveal interlobar, lamellar or posterior effusions not visible on the standard postero-anterior radiographs.

There may, at the same time, be clouding of the

FIG. 9b.—Enlargement of a part of Fig. 8a showing the septal lines due to oedema of the interlobular septa.

hilar region, with veiling of the main pulmonary arteries and the lobar branches.

Organized Pulmonary Oedema

If the acute pulmonary oedema does not respond quickly to treatment the exudate changes from an albuminous to a fibrinous one. This fibrin may organize, causing a fibrosis of the lung, usually in the upper and mid zones which may simulate fibrous tuberculosis. These changes are most often seen in cases of left heart failure in which treatment has been inadequate and a minor degree of failure has persisted over a long time or in which recurring episodes of pulmonary oedema have occurred. Organized oedema was seen most frequently in the early days of hypotensive drug therapy and was described in association with hexamethonium treatment originally by Doniach, Morrison and Steiner (1954) and more recently by Perry, O'Neal and Thomas (1957).

Pulmonary Changes in Uraemia

The presence of uraemia need not, by itself, cause any lung change. For example, a patient with polycystic kidneys may have a very high blood urea and yet have clear lung fields. In

FIG. 10.—Postero-anterior chest radiograph showing organized oedema in a hypertensive patient who had recurrent episodes of pulmonary oedema during the course of several years.

uraemia associated with the late stages of hypertensive vascular disease, however, extensive bilateral lung shadows of the 'bat's wing' type frequently occur. A probable explanation is that the uraemia causes damage to the pulmonary capillaries and allows oedema to form with a less degree of heart failure than in the non-uraemic patient (Doniach, 1947).

Periarteritis Nodosa

Hypertension may be a prominent or presenting feature of periarteritis nodosa and should be considered in all cases of severe or rapidly developing hypertension associated with either constitutional illness or unexplained lesions in other systems. Twenty-one of 86 patients studied by Rose and Spencer (1957) had hypertension on the initial examination and 17 more developed hypertension while under observation. Seven of these 38 hypertensive patients showed lung involvement which varied from necrotic and caseous lesions closely resembling tuberculosis to fleeting areas of pulmonary consolidation and multiple small infarcts. Although chronic lesions with cavitation may occur in periarteritis nodosa, this is exceptional. The most characteristic feature is the appearance of transient areas of pulmonary consolidation, clearing after a few days or weeks, only for other similar lesions to appear elsewhere in the lung fields.

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body fat is broken down and resynthesized daily. More insulin is used in synthesizing fat from carbohydrate than glycogen from carbohydrate. Insulin injections may cause a local atrophy of fat around the site of injection. Similar areas of localized atrophy may occur in diabetics in places distant from the site of injection (Magee and Critchley, 1957).

Abnormalities of carbohydrate metabolism demonstrated in association with lipodystrophy progressiva are invariably insulin-resistant. As the tissues seem unable properly to utilize insulin in this function it seems unnecessary to postulate further deficiencies, but to assume that the lipodystrophy occurs because of a failure of the adipose tissue to utilize insulin to lay down fat.

Why the atrophy assumes the distribution which it does is unknown. Endocrine abnormalities are found too frequently for the association to be entirely by chance, but the variations are not of any constant pattern. Pregnancy after the onset of the disease is not common, but when it does occur appears to run a normal course, although of the three cases in which details are given two were induced before term, and in one a Caesarean section was carried out.

Summary

A case of lipodystrophy progressiva associated with pregnancy is described, and the literature reviewed.

Acknowledgments

I am grateful to Mr. N. K. B. Kimbell for permission to publish the case, and for his and Dr. G. F. Walker's criticism.

Addendum

Another patient with lipodystrophy progressiva involving the upper half of the body since the age of five has recently been seen. She had two abortions at 14 and 18 weeks, followed by a normal child, delivered by Caesarean section, which was carried out for foetal distress. This tends to confirm the impression that these patients require especial attention in pregnancy and labour.

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