baby has been lost from eclampsia during the past four years. The perinatal mortality associated with hypertension (140/90 mm. Hg or over) in booked patients has been reduced to 3.6%, and that associated with all cases of toxæmia, booked and non-booked, to 5%.

The Cranbrook Report suggests that 70% of confinements should take place in hospital and that the normal stay should be 10 days. A further 70 lying-in beds would be required in Bradford alone to implement this suggestion, and the capital expenditure necessary throughout the Midlands and North of England would not be small. Neither would it be easy to obtain the necessary nursing staff.

Early discharge of patients has made it possible to improve antenatal care in Bradford and prevent toxæmia. It is not fraught with danger, could be economical, savours of common sense, and may indicate the future pattern of obstetrics. It will involve reorientation of obstetric and paediatric thought and the further development of the home-help service, possibly on a local and part-time basis.

Summary

The staff of St. Luke's Maternity Hospital, Bradford, became convinced that all primigravidae, together with those multigravidae who had shown abnormalities in previous pregnancies, should be seen weekly from the 24th week of pregnancy onwards. The underlying philosophy of this step was that whereas it is impossible to affect the number of patients with hypertension it is possible to delay its onset, to lessen its severity, and usually to prevent it from becoming associated with proteinuria. The most important time to detect these changes and to prevent them from becoming irreversible is between the 24th and 34th weeks of pregnancy.

It soon became evident that there was little use in detecting indications for admitting patients into the antenatal ward if no beds were available. As the total number of beds could not be increased it was obvious that the number of antenatal beds could only be increased by decreasing the number of lying-in beds. After prolonged negotiations it was agreed to increase the antenatal beds from 25 to 40, thus cutting down the number of lying-in beds to 51. This step involved either decreasing the number of hospital confinements or sending home a certain number of patients on the second day of the puerperium, and the latter alternative was accepted by all concerned.

During the first full year of the operation of this scheme, 2,898 women were delivered of 2,969 babies; and 741* (26%) of these women were sent home within 48 hours to the care of their own general practitioners and to be visited by the domiciliary midwives. None of these 741 babies was lost during the first 14 days of life and only four were admitted to the paediatric wards. Only three of these mothers were readmitted to hospital—two because of secondary post-partum haemorrhage and one to the fever hospital because of pyrexia.

It is relevant to report that there has been only one maternal death in Bradford during the past seven years which was in any way related to toxæmia and that

*Up to the end of September, 1959 (when the scheme had been in operation for 18 months), 1,381 mothers with their babies had been sent home within 48 hours of delivery, and only one baby had died during the first 14 days of life. That was a mature infant, delivered spontaneously, which died from cerebral haemorrhage. Those competent to judge state that this baby could not have been saved even if the mother had been kept in for 10 days.

neither mother nor baby has been lost from eclampsia during the past four years. It may be concluded that the combined maternity scheme agreed between hospital staff, local health authorities, and general practitioners has made it possible to improve antenatal care and almost to eliminate severe pregnancy toxæmia from the city. It is not fraught with danger to either mother or child, prevents the baby from becoming a culture medium for the hospital staphylococcus, could be economical, savours of common sense, and may indicate the future pattern of obstetrics. It will involve reorientation of obstetric and paediatric thought, and the further development of the home-help service, possibly on a local and part-time basis.

MALIGNANT HYPERTENSION AND HYPOKALAEMIA: CURED BY NEPHRECTOMY

BY

C. T. DOLLERY, M.B., B.Sc., M.R.C.P.

R. SHACKMAN, F.R.C.S.

AND

JOHN SHILLINGFORD, M.D., M.R.C.P.

*From the Departments of Medicine and Surgery,
Hammersmith Hospital and Postgraduate Medical
School of London*

The association of hypokalaemia and hypertension has attracted much attention since Conn (1955a, 1955b) described primary hyperaldosteronism and successfully predicted that some cases of potassium-losing renal disease would prove to have the same aetiology (Milne, 1955). The early patients were found to have an adrenal adenoma as the source of the increased aldosterone production, but there have been subsequent reports of patients with hyperaldosteronism and severe hypertension who proved to have adrenal enlargement but no tumour (Holten and Petersen, 1956). The interpretation of the aetiological importance of the enlarged adrenals in these cases is difficult in view of the known association of adrenal hypertrophy with severe hypertension (Dawson, 1956). Primary renal disease may be responsible for potassium loss, but this is usually associated with acidosis (Milne *et al.*, 1952), and not with alkalosis as occurs with uncomplicated potassium deficiency. Renal damage and pyelonephritis may indeed follow prolonged potassium depletion (Milne *et al.*, 1957). Prunty (1957) felt that there was no good evidence that hypokalaemia and alkalosis could be caused by renal disease alone.

The present paper concerns two patients with malignant hypertension and severe hypokalaemia who, after excision of a kidney with a narrowed artery, both recovered the ability to conserve potassium.

Case 1

The patient, a male newspaper correspondent aged 54, had enjoyed good health until three months before he was admitted to hospital. His first complaint was of headaches, which were particularly severe on waking. One week later, on account of an increase in their severity, he consulted his general practitioner, who found a blood-pressure of 240/140 mm. Hg and noted a retinal haemorrhage in the right

eye. Treatment was begun with mecamlamine, at first 20 mg. daily and later 30 mg. daily. The blood-pressure fell to 170/100 mm. Hg on treatment, but his clinical condition did not improve. He developed thirst, frequency of micturition, and nocturia. He had been a very active man, and he noticed marked lassitude and loss of appetite—he lost 17 lb. (7.7 kg.) in weight. His exercise tolerance declined, though he was still able to undertake normal activity without dyspnoea. One week before admission he became nauseated and had several small vomits; he felt

weak and could stand only with difficulty. There had been no change in his vision. There was no family history of hypertension or renal disease.

On examination he looked ill and showed signs of recent loss of weight. The blood-pressure was 260/180 mm. Hg and the pulse rate 100, with regular rhythm. The venous pressure was not raised. The heart was slightly enlarged, and the apex beat lay in the fifth intercostal space 5 in. (12.5 cm.) from the midline. The impulse was of left ventricular type. At the apex there could be heard a soft ejection murmur in early systole and a loud atrial sound. There was no oedema, and the liver was not enlarged. The retinae showed bilateral papilloedema, soft exudates, and many flame-shaped haemorrhages. Examination of the lungs revealed no abnormality. Neither kidney was palpable, and there was no tenderness in the renal areas. Rectal examination revealed nothing abnormal. There was loss of muscle power in the limbs and trunk. The grip was weak. No abnormal-

FIG. 1.—Case 1. Left kidney with capsule stripped, showing normal upper pole and shrinkage below it.

FIG. 2.—Case 1. Kidney sliced to show normal cortex and medulla in upper pole and marked shrinkage of both layers in remainder.

ities were detected on examination of the cranial nerves or the sensory system. Reflexes were all present but sluggish.

Investigations.—Haemoglobin, 17.3 g./100 ml.; white cells, 10,000/c.mm.; E.S.R. 12 mm. in first hour. Serum sodium 127, potassium 2.0, chloride 79, and bicarbonate 31 mEq/l. Blood urea 40 mg./100 ml. Serum albumin 2.2 g./100 ml., globulin 4.6 g./100 ml. On an unrestricted fluid intake and the ordinary ward diet he passed 5,270 ml. of urine in 24 hours, which contained 15.2 g. of protein and 84 mEq of potassium. After 10 hours of fluid deprivation the urine specific gravity was 1008. During the 10 hours he passed 2,475 ml. of urine, and the test was ended because of thirst. Urine culture was sterile. The chest x-ray examination showed slight cardiac enlargement, mainly left ventricular. The electrocardiogram had evidence of left ventricular hypertrophy, and there were "u" waves

suggestive of hypokalaemia. On the plain radiograph of the abdomen the right kidney measured 14 by 6 cm. and the left 9 by 4.5 cm. Excretion pyelography showed that both kidneys concentrated the radio-opaque contrast medium satisfactorily, and on the right the cortex measured 28 mm. in thickness and on the left 13 mm. The right renal outline was smooth and the left lobulated.

Treatment.—The blood-pressure was controlled initially by subcutaneous injections of pentolinium and later by oral pempidine, 30 mg. daily, but despite some reduction of

FIG. 3.—Case 1. Main left renal artery with lumen reduced to a slit by fibrous tissue and thrombus. ($\times 17$.)

FIG. 4.—Case 1. Glomeruli, which appear normal, are crowded together but the tubules are shrunken and evenly separated by fibrous tissue. ($\times 120$.)

pressure the retinitis progressed and papilloedema increased. The dietary intake was supplemented with 200 mEq of potassium daily for eight days. During this period the serum potassium rose to 4.6 mEq/l. and the serum sodium to 137 mEq/l.; the urine output decreased to under 2 litres daily.

Operation under General Anaesthesia.—On October 23, 1958, the patient was explored through a Morris muscle-cutting incision. A contracted densely adherent left kidney was exposed and removed without undue difficulty. The renal artery was very atheromatous at the line of section. There was no evidence of tumour in the left adrenal.

Pathological Report

Macroscopic (Figs. 1 and 2).—The specimen was a kidney 85 mm. long and weighing 80 g. The upper pole was

supplied by an aberrant renal artery and appeared normal for 1.5 cm. Below this the kidney showed considerable shrinkage, with thinning of the cortex and medulla (cortex 4 mm., normal 10 mm.; medulla 9 mm., normal 22 mm.). The capsule stripped easily. The renal artery supplying the shrunken area was greatly narrowed by a grossly thickened intima of fibrous tissue and reduplicated elastic fibres (Fig. 3).

Microscopic.—In the upper pole the tubules and glomeruli were normal in appearance. The only abnormality was reduplication of the external elastic lamina of the arcuate arteries. There was no change in the interlobular arteries. In the shrunken part of the kidney (Fig. 4) the glomeruli showed occasional fibrosis but were mostly within normal limits. There was no thickening of the Bowman capsules. The convoluted tubules, however, were shrunken and evenly separated by an increased fibrous stroma. The lumina were patent. An occasional focus of lymphocytes was found. The interlobular arteries followed a wavy course due to cortical shrinkage; the internal elastic lamina thus appeared slightly reduplicated. The larger arteries showed similar elastic reduplication to those in the upper pole but appeared reduced in diameter. **Conclusion:** Arteriosclerosis of the main renal artery with incomplete infarction.

Post-operative Course

The patient's blood-pressure fell to normal next day (Fig. 5), and has remained normal.

FIG. 5.—Case 1. Average daily blood-pressure, showing the dramatic reduction to normal after nephrectomy.

femoral on that side. He was treated with phenindione, 150 mg. daily, and his exercise tolerance has improved. He feels well and has returned to full work, which includes visits abroad.

Case 2

The patient, a 56-year-old wharf-manager, had a long medical history. He had been known to have bilateral apical pulmonary tuberculosis for 17 years, and had received several periods of treatment. He had suffered claudication for 10 years and bilateral gluteal claudication for a year. He had remained under close supervision, and his blood-pressure had been noted to rise from 130/80 mm. Hg in 1948 to 190/95 mm. Hg in 1958, three months before his admission. In December, 1958, he suffered several small haemoptyses, and was found to have a small cavity in the upper lobe of the left lung. He was admitted to Hammersmith Hospital in January, 1959, for a further period of antituberculosis chemotherapy. On admission he complained of morning headaches for the preceding four days but otherwise had felt well. He had been at work, and had no loss of strength. There was no family history of hypertension or renal disease.

On examination he was a well-built fit-looking man. His blood-pressure was 270/120 mm. Hg and the pulse rate 72, with regular rhythm. The venous pressure was not raised. The heart was slightly enlarged, with the apex in the fifth intercostal space 5½ in. (14 cm.) from the midline. The apex beat was left ventricular in type. The first and second sounds were normal, with a soft atrial sound at the apex. The aorta could be felt to pulsate to the level of the umbilicus, but pulses were not palpable in the legs. A systolic bruit was heard over the left femoral artery. There was no oedema, and the liver was not enlarged. The retinae showed arterial narrowing and arteriovenous nipping, but no haemorrhages or exudates. The margin of the left disk was slightly blurred.

The chest movements were restricted, and increased conduction of breath sounds with whispering pectoriloquy was present over both apices. The feet were warm despite the absent pulses, and there was no trophic change in the skin. Examination of the abdomen disclosed no abnormality, and rectal examination was normal. Muscle power was good, and all the tendon reflexes were normal. There were no sensory abnormalities. Examination of the urine disclosed heavy proteinuria but no pus cells.

Treatment of the pulmonary tuberculosis was begun at once with streptomycin, 1 g. daily intramuscularly, and para-aminosalicylic acid, 12 g., and isoniazid, 200 mg. daily orally. Next day he had a small epistaxis, and complained of thirst and polyuria. During the following week he noticed progressive worsening of his headaches and loss of strength, which was confined to the trunk and limb muscles. He found it difficult to stand out of bed unaided. The retinae showed haemorrhages, exudates, and bilateral papilloedema. There was no Rombergism, ataxia, or nystagmus.

Investigations

Haemoglobin, 11.2 g./100 ml.; packed cell volume, 33.5%; E.S.R. 25 mm. in the first hour. Serum sodium 137, potassium 2.3, chloride 87, bicarbonate 33, magnesium 1.7 mEq/l. Urea 44, uric acid 5.0, fasting blood sugar 72 mg./100 ml. Serum cholesterol 465 mg./100 ml. Salivary sodium concentration 20, potassium 12 mEq/l. Serum proteins: albumin 2.2 g./100 ml., globulin 5.1 g./100 ml. Urine culture was sterile. The volume of a 24-hour urine specimen was 2.4 litres, containing 22 g. of protein and 97 mEq of potassium. At the time of collection the serum potassium was 2.2 mEq/l. and the dietary potassium intake small because of nausea and anorexia. Wassermann reaction and Kahn test were negative. On the plain radiograph of the abdomen the right kidney measured 15 by 6.5 cm. and the left 12 by 5 cm. Excretion pyelography showed poor concentration of the radio-opaque contrast medium on the right and none on the left side.

In view of the patient's severe headaches and progressive retinitis treatment was begun at once with pentolinium, 2.5 mg. six-hourly by injection. He was transferred to a metabolic ward and put on a diet containing 80 mEq of potassium and 73 mEq of sodium daily. After six days on this diet a 24-hour urine specimen contained 8.4 µg. of aldosterone (normal 4.6 to 23.5 µg. daily).

FIG. 6.—Case 2. Potassium balance, showing a strongly positive balance on the high intake and parallel rise in serum potassium concentration.

A retrograde pyelogram showed a normal caliceal system on both sides. The cortex on the left measured 11 mm. and on the right 24 mm. in thickness; the renal outlines were smooth.

Divided renal-function studies with diiodone labelled with ^{131}I , and surface counting, demonstrated a reduced clearance from the right side and none from the left.

After the renal-function studies the total potassium intake was increased to 300 mEq daily. During the next six days the patient retained 900 mEq of potassium (Fig. 6), and the serum potassium rose from 2.2 to 4.4 mEq/l.

Operation.—On February 26, under general anaesthesia, the left kidney was approached by a Morris muscle-cutting incision. It was found to be adherent, but was freed without difficulty. There was pulsation in the aorta but none in the left renal artery, which appeared completely thrombosed at the line of section; the vein was patent.

FIG. 7.—Case 2. Left kidney with capsule stripped to show patchy fine granularity of surface and a few coarse scars.

FIG. 8.—Case 2. Kidney sliced to show increased pelvic fat and shrunken cortex.

Sections of the main renal artery showed replacement of the lumen by (a) a crescent of long-standing fibrosis with recanalization, and (b) occlusion of the remaining lumen by organized thrombus (Fig. 9). The renal vein was normal.

The glomeruli were crowded together; many appeared normal except for thickening of Bowman's capsule; others were totally hyalinized (Fig. 10). The tubules were mostly shrunken and separated by fibrous tissue infiltrated by lymphocytes. The lining cells had survived. The arteries of the kidney were shrunken and the internal elastic lamina thereby reduplicated. In addition there was intimal fibrous endarteritis. The intensity of the renal shrinkage varied, and in a few areas the nephrons appeared to be comparatively healthy. Maximal shrinkage was seen in the outermost subcortical layers.

Conclusion: The picture was one of incomplete infarction of the whole kidney due to obstruction of the main renal artery.

Post-operative Course

The blood-pressure fell after operation but not to normal levels (Fig. 11). In view of the severe retinitis, 14 days after operation treatment was begun with pempidine, 2.5 mg. six-hourly, but this dose had to be halved because it caused severe postural hypotension. Subsequently the blood-pressure has remained at about 190/90 mm. Hg without hypotensive drugs. There has been resolution of the retinitis apart from hard exudates, and the disks have returned to

FIG. 9.—Case 2. Main renal artery, showing a crescent of fibrous tissue with recanalization and occlusion of remaining lumen by organized thrombus. (The semicircular slit is a fixation artifact.) ($\times 10$.)

FIG. 10.—Case 2. Glomeruli are crowded and appear normal, but the tubules are shrunken and separated by fibrous tissue infiltrated by lymphocytes. ($\times 120$.)

normal. The proteinuria fell from 20 g. daily before operation to 6 g. daily after it. The serum potassium concentration has remained in the normal range without supplements. The patient is regaining strength, and has been discharged home.

Discussion

The association of hypertension and hypokalaemia is of considerable importance because of the diagnostic difficulties to which it may give rise (Aird *et al.*, 1956). In these two cases the simultaneous and abrupt onset of the two conditions suggested that they were related, and the demonstration of unilateral renal disease offered

the hope of surgical cure of the hypertension. Before operation the precise renal pathology was in doubt, though renal shrinkage with a normal pelvis favoured ischaemia. The renal potassium loss with a low serum level suggested a diagnosis of primary hyperaldosteronism, but the presence of renal disease supported an alternative possibility that this disease was the primary cause of the failure to conserve potassium. The prompt reversal of the potassium-losing tendency after nephrectomy favoured the latter explanation.

There are three possible mechanisms whereby unilateral renal ischaemia might give rise to hypokalaemia. One of these is loss from the damaged tubules of the ischaemic kidney, and the prompt improvement after surgery would support this view. However, loss from the contralateral kidney, due either to the nephrosclerosis of malignant hypertension or to a humoral factor such as secondary hyperaldosteronism, cannot be excluded. Divided renal-function studies with ureteric catheters were attempted to resolve this point, but technical difficulties rendered these studies inconclusive. Whatever the explanation may be, both patients have maintained a normal serum potassium since nephrectomy, which rules out a diagnosis of primary hyperaldosteronism. The aldosterone output was normal in the second case but was not determined in the first. It is of interest that the aldosterone output was high in two similar cases, one described by Wrong (1957) and the other by FitzGerald *et al.* (1957).

Wrong's patient was cured of both hypertension and hypokalaemia after subtotal adrenalectomy and resection of an ischaemic kidney. In the case reported by FitzGerald *et al.* cure of the potassium-losing tendency followed unilateral adrenalectomy, but the blood-pressure remained high and the patient died in uraemia. These cases may be examples of secondary hyperaldosteronism, and this explanation was proposed by both authors. The case of Holten and Petersen (1956) could be interpreted in a similar way. It is possible that Wrong's case may have been similar to our own, because the adrenal tissue was found to be normal and the kidney proved to have an obstructed artery. Our cases do not resemble the others reported in important respects, notably in the apparently rapid onset, the heavy proteinuria, and cure without adrenalectomy. Both the resected kidneys showed the incomplete infarction (*Teilinfarzierung*) described by Fahr (1934): crowded glomeruli separated by shrunken tubules. There can be no doubt that the kidney lesions were the result of ischaemia. Doubt remains about the mechanism of the potassium loss, but, in our second case at least, it is unlikely that aldosterone played any part.

The possibility of similar cases deserves to be considered whenever malignant hypertension and severe hypokalaemia occur together, because of the dramatic cure that may follow nephrectomy.

Summary

Two patients have been studied who presented with malignant hypertension and hypokalaemia of rapid onset. They were found to have a continuing renal potassium loss despite a low serum level. Both proved to have unilateral obstruction of the renal artery, and hypertension was cured in one by nephrectomy, though in the other there was only slight reduction of pressure. The serum potassium level in both has remained normal since operation without supplements. The possible causes of the potassium loss have been discussed.

We should like to thank the Department of Pathology of the Postgraduate Medical School for the pathological reports and the photomicrographs; and Dr. A. H. Gowenlock, senior lecturer in chemical pathology at Manchester University, who kindly determined the aldosterone output in Case 2.

REFERENCES

- Aird, I., Milne, M. D., and Muehrcke, R. C. (1956). *Brit. med. J.*, **1**, 1042.
 Conn, J. W. (1955a). *J. Lab. clin. Med.*, **45**, 6.
 — (1955b). *Ibid.*, **45**, 661.
 Dawson, I. M. P. (1956). *J. Path. Bact.*, **72**, 393.
 Fahr, T. (1934). In F. Henke and O. Lubarsch's *Handbuch der speziellen pathologischen Anatomie und Histologie*, vol. 6, part. 2. Springer, Berlin.
 FitzGerald, M. G., Fourman, P., James, A. H., and Scarborough, H. (1957). *Scot. med. J.*, **2**, 473.
 Holten, C., and Petersen, V. P. (1956). *Lancet*, **2**, 918.
 Milne, M. D. (1955). *Proc. roy. Soc. Med.*, **48**, 780.
 — Muehrcke, R. C., and Heard, B. E. (1957). *Brit. med. Bull.*, **13**, 15.
 — Stanbury, S. W., and Thomson, A. E. (1952). *Quart. J. Med.*, **21**, 61.
 Prunty, F. T. G. (1957). *Ibid.*, **26**, 586.
 Wrong, O. (1957). *Ibid.*, **26**, 586.

NEPHRECTOMY IN CASES OF HYPERTENSION

BY

J. G. YATES-BELL, F.R.C.S.

Urological Surgeon, King's College Hospital, London

The possibility that hypertension might be related to unilateral renal disease was first suggested by Ask-Upmark (1929). The first case in which hypertension was relieved by removal of a kidney, diseased in this case by chronic pyelonephritis, was published by Butler (1937), without apparent knowledge of Ask-Upmark's earlier paper.

Braasch (1942) claimed that hypertension had been relieved permanently in 65 (33%) of the 198 patients in his series, and gave as the criterion of a cure a minimum period of two years' reduction of blood-pressure following nephrectomy. Heritage (1943) presented a very thorough survey of the problem of hypertension and listed among the causes of the condition urinary obstruction and renal vascular disease. He concluded that investigation of a case of unexplained hypertension demands "a complete urological search" before such procedures as splachnicectomy are undertaken.

The ensuing 15 years produced many papers in the world literature, and certain important points of common accord became apparent. First, the incidence of unilateral renal disease as a cause for hypertension is low. Braasch (1942) gives the figure of 4% and Ratliff *et al.* (1947) 5.5%. Secondly, only a fraction of these patients will prove suitable for surgery. Thirdly,