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Surgical treatment of renovascular hypertension in children and adolescents

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Renovascular disorders are rather rare in children and adolescents but have severe consequences due to complicating hypertension. Six cases successfully treated by surgery are described. The importance of early diagnosis and vascular correction is stressed; normalization of blood pressure has been achieved in every case.

The most frequent cause of "surgical" hypertension in childhood and adolescence is the typical form of coarctation of the isthmic section of the aorta. The next in rank are vascular abnormalities of the kidney or those leading to impaired renal circulation. The latter comprise atypical coarctation of the descending or abdominal aorta and disorders leading to stenosis of the renal artery.

Patients

Six patients with renovascular hypertension have been operated on during the last six years. Three of them were younger than 14 years while the others were adolescents between 14 and 18 years of age.

Table I summarizes the principal preoperative data.

Case 1. A girl of 14 years was found by screening in the school to have a blood pressure of 180/120 mm Hg. She was admitted for evaluation of this condition. At admission she had a normal appearance and was normally developed. Arterial pulsation was weak all over both lower limbs, over the abdominal aorta a holosystolic murmur could be heard. The murmur could be followed over both iliac arteries. Laboratory tests revealed only slight hypokalaemia. All renal functions were normal, the size of kidneys was also normal.

Catheter angiography and direct blood pressure measurements were carried out. The angiography revealed multiple arterial supply of both kidneys. The artery supplying the upper pole of the left kidney was occluded on a proximal section of about 15 mm. The abdominal aorta showed a funnel-shaped stenosis at the level of the renal arteries, the minimum diameter being 6 mm. The pelvic arteries below the bifurcation were of normal size (Figure 1). There was a blood pressure difference of 40 mm Hg between the suprastenotic and infrastenotic parts.

Since the lower extremities showed unimpaired arterial supply even during loading, we desisted from surgical treatment of the aortic abnormality. After infracolic approach indirect reimplantation of the left upper polar artery was carried out by help of a graft taken from the left saphenous vein. The patient's hypertension normalized during the early

TABLE I

Serial number of patient	Age, years	Gender	RR (mm Hg)	Diagnosis
1	14	F	180/120	Coarctation of abdominal aorta. Aorta angusta. Bilateral multiple renal arteries. Occlusion of left superior renal polar artery.
2	12	M	190/120	Bilateral multiple renal arteries. Stenosis of right renal arteries.
3	13	M	180/110	Stenosis of right renal artery. Hypoplasia of left kidney. Hydroureter and pyelonephritis on left side.
4	16	F	170/110	Stenosis of left renal artery. Occlusion of left subclavian artery. Takayashu's disease.
5	16	M	200/140	Occlusion of left renal artery. Double right renal artery. Hyperbilirubinaemia.
6	17	M	190/130	Stenosis and ventroposition of right renal artery. Multiple renal arteries on left side.

postoperative period. The surgical wounds exhibited primary healing, and the patient was discharged on the eighth day after surgery. She has been checked regularly during the past five years, and she has been free of complaints.

Case 2. A 12 years old boy, his hypertension was detected by school screening. He had been complaining of frequent headaches and irritability. He was admitted to our department. Protracted excretion of the radioopaque material by the right kidney and slight parenchymal loss in the same kidney suggested renovascular origin of the hypertension. Arteriography revealed each three renal arteries on both sides arising in ventroposition. All three arteries of the right kidney exhibited initial stenosis

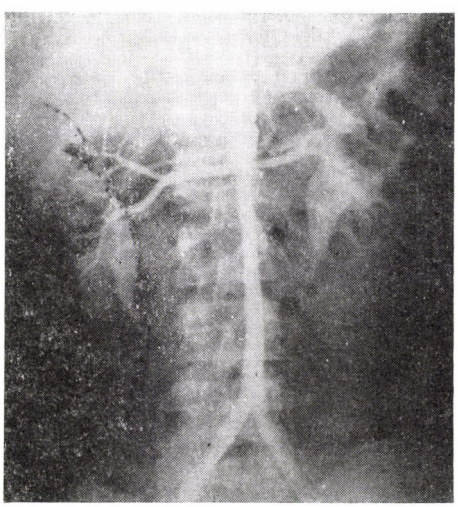

FIG. 1. Case 1. Aorta angusta and multiple renal arteries. Occlusion in a length of 15 mm of the artery supplying the upper pole of the left kidney

with poststenotic dilatation. Isotope nephrography showed a 30% functional share of the right kidney. Total kidney functions were unaffected. Slight secondary hypokalaemia was present. We decided to perform surgical reconstruction.

The arteries of the right kidney were approached supracolically after mobilization of the duodenum. All three arteries were ligated at the stenotic orificial level and indirect antecaval reimplantation was carried out using an autologous saphena graft shaping a new tripartite hilus. Some hours after surgery the patient's blood pressure stabilized at a value of 120/70 mm Hg. The postoperative period was uneventful. He has been followed for two years; he is free of complaints and is engaged in sports. Isotope renography showed reequalization of the function of the two kidneys.

Case 3. This 13 years old boy had been treated for urinary tract infection and hypertension in another hospital. The pyuria having been cured, urography and renovasography were carried out. These revealed hypoplasia of the left kidney which was supplied by a double renal artery. Excretion was unimpaired. The dilated left ureter was tortuous and at the vesicoureteral junction stenosed. The orificial section of the right renal artery exhibited a 80% narrowing. Percutaneous transluminal angioplasty was performed which resulted in a transitory moderation of the hypertension of 180/130 mm Hg. When the blood pressure had returned to the previous high values, angiography was again carried out and this showed persistence of the stenosis seen previously on the right renal artery. The patient was referred to us for surgery.

Since the functional isotope tests showed a 40% share of the left kidney within the total function, we decided to retain the left kidney. The right renal artery was exposed infracolically. After mobilization of the inferior vena cava and the left renal vein, aortorenal arteriotomy and dilatatory plastics using a Gore-tex patch were performed. After surgery the patient's blood pressure decreased only moderately; this was explained first by parenchymal damage of the left kidney. Control by Angiotron angiography, however, unequivocally demonstrated a stenosis of the reconstructed blood vessel section (Figure 2). Two weeks later surgery was repeated. The right renal artery was approached supracolically from the right side. Indirect

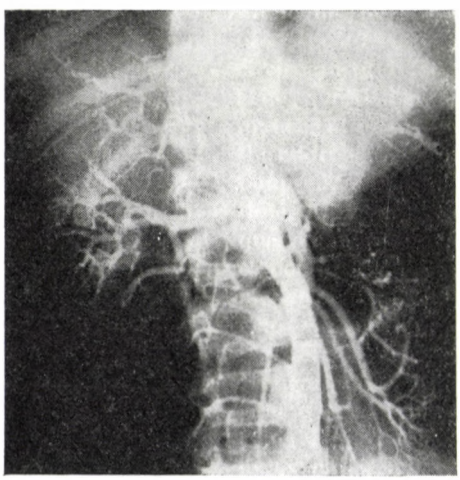

FIG. 2. Case 3. Abdominal summation aortography. Stenosis of right renal artery and hypoplasia of left kidney

reimplantation was carried out utilizing an arterial graft taken from the infrarenal part (internal iliac artery) of the aorta. This was followed by normalization of the blood pressure, only minimal doses of antihypertensive drugs were necessary. The surgical wounds exhibited healing by first intention. A control isotope renography performed two months later showed a 25% increase in the perfusion of the right kidney. Angiotron angiography confirmed ideal anatomical conditions (Figure 3). The patient's blood pressure could be kept normal with 0.5 mg prazosine twice daily. Now, cessation of antihypertensive treatment is being weighed and an ureteroplasty is planned.

Case 4. A girl of 16 years was admitted because of hardly palpable arterial pulsation on the left arm and a blood pressure of 170/110 mm Hg on the right arm. She was normally developed, had slight hirsutism, and a systolic murmur could be heard above the left supraclavicular fossa and the abdominal aorta. Endocrine hypertension was excluded by detailed laboratory studies. Angiography was indicated, the characteristic localization of the vascular malformations suggested Takayashu's disease. The left subclavian artery was found to be occluded as far as its second third; its distal section was supplied via the thyreocervical trunk (Figure 4). The remaining supraaortic trunks showed normal anatomy. A mild, sand-glass shaped stenosis was observed on the abdominal aorta at the level of the renal arteries. A stenosis exceeding 60% was demonstrated after the orifice of the left renal artery in a length of 10 mm (Figure 5). Since there was no functional or nutritive damage on the left upper extremity, surgical treatment of the renal artery stenosis, which had maintained the hypertension, was decided. During surgery under total heparinization "axillary" aorto-arteriotomy was carried out, after local endarteriectomy free circulation to the orifice of the renal artery was secured by using dilatatory plastics with a Gore-tex patch which was applied so as to correct the stenosis of the aorta as well.

The postoperative course was uneventful, the patient's blood pressure returned to normal values on the first postoperative day. Histology revealed vascular changes characteristic of Takayashu's disease. One year later the patient had a normal blood pressure. Now she has been free of complaints for four years, there has been no

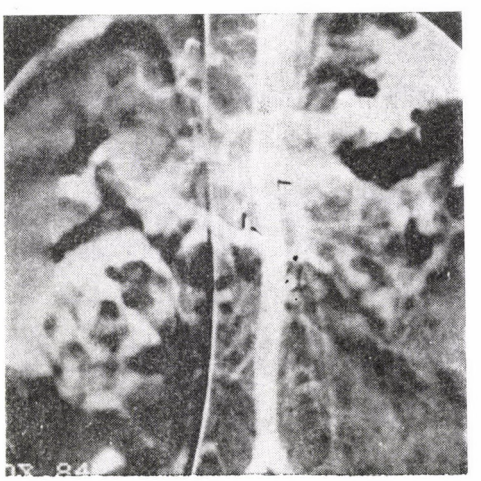

FIG. 3. Case 3. Postoperative angiogram demonstrates arterial autograft of good function on right side. Photograph made by subtraction technique

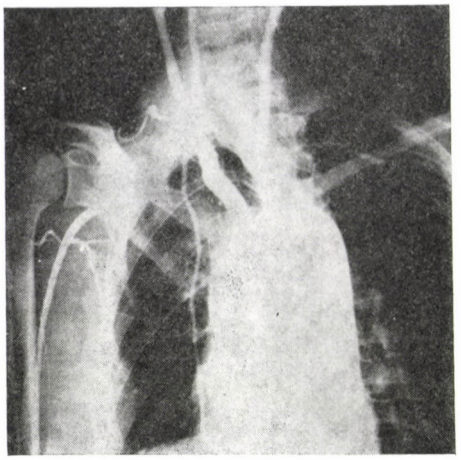

FIG. 4. Case 4. Takayashu's arteriitis occludes the intrathoracal section of the left subclavian artery, the other supraaortic arteries are unaffected

progress in her supraaortic condition, her blood pressure is now 130/80 mm Hg.

Case 5. A boy of 16 years had been found to have a blood pressure of 200/140 mm Hg. Conservative treatment had been attempted, this had resulted in a slight decrease in his hypertension. He had been admitted for further evaluation to another hospital. At admission he had had pronounced hypokalaemia and slightly elevated serum bilirubin. The latter had been explained as a result of mild congenital enzymopathy. By urography, bilateral excretion had been demonstrated but transport of the contrast material was protracted on the left side. There had been no difference in renal size. Aortography had revealed postorificial occlusion of the left renal artery in a length of 10 mm, the normal distal part was supplied through

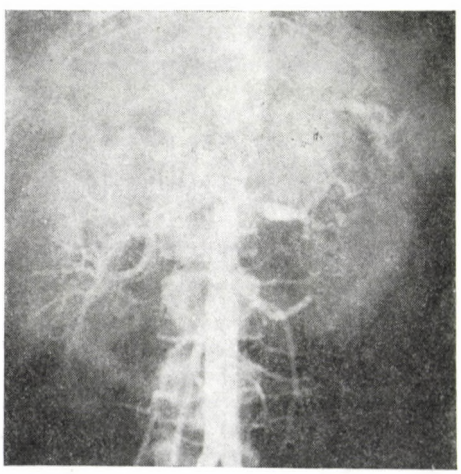

FIG. 5. Case 4. Takayashu's arteriitis. Abdominal aortogram shows the stenotic orifice of the renal artery and the slight, sand-glass shaped stenosis of the abdominal aorta

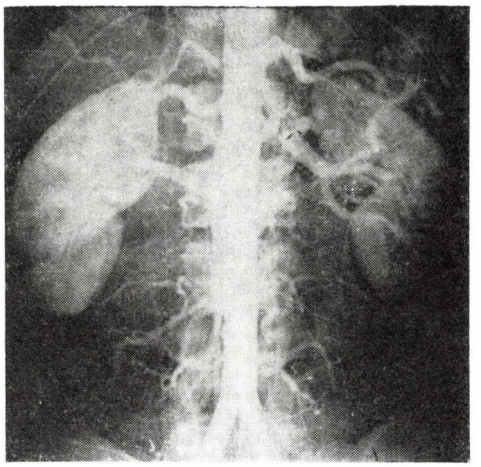

FIG. 6. Case 5. Occlusion of left renal artery, refilling of the poststenotic section through the rich collateral network

a rich arterial collateral plexus around the pelvis. There was a double right renal artery (Figure 6).

The patient was transferred to our department for surgical correction. Our findings were in full agreement with those obtained earlier. By upper-median laparotomy the left renal artery was prepared infracolically and direct aortorenal reimplantation was carried out. The patient's blood pressure returned to normal values within a few hours. His postoperative course was uneventful. He now has been free of symptoms and complaints for one and a half years.

Case 6. In a 17 years old male patient hypertension had been detected at a routine school examination one and a half years earlier. Urography, radiorenography, plasma renin activity of selected renal vein

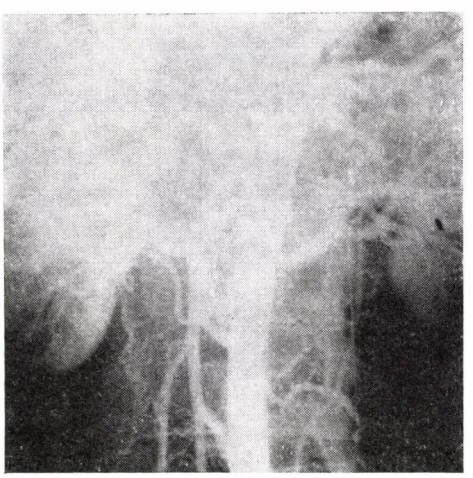

FIG. 7. Case 6. Renovasogram showing paraaortic stenosis of right renal artery

blood and aortography unequivocally pointed to hypoperfusion of the right kidney. There was a 90% stenosis on the right renal artery in ventroposition, at 1 cm after the orifice the stenotic blood-vessel divided into two arteries, crossing each other and exhibiting slight post-stenotic dilatation. The left kidney was supplied by multiple renal arteries. The kidneys were about the same size, but their functional share was 30% and 70%, respectively (Figure 7).

At surgery, the right renal artery was approached supracolically. After ligation of the stenotic common trunk antecaval indirect reimplantation was carried out, utilizing an autologous saphena graft. End-to-end anastomosis was made with the upper pole artery and side-to-end anastomosis with the artery supplying the lower pole. The patient's blood pressure returned to normal values within a few hours. After an uneventful postoperative period he was discharged on the eighth postoperative day. Now he has been in excellent health for one year, he is normotensive and capable of continuing his original studies. There is no functional difference between his two kidneys.

Table II sums up further data of our patients.

Discussion

Renovascular disease is rare in childhood and adolescence but it is a severe condition because of the high risk of hypertensive damage [2, 6]. Its exact incidence in these age groups is difficult to estimate because systematic screening has only been established in recent years [7, 17, 19, 21]. Within the highly selected renovascular material of our Department the share of paediatric cases is 4%.

There are some differences in pathology between childhood and adult cases. In children affected by renovascular hypertension 50—60% of the abnormalities are of congenital origin [4]. Atypical coarctation, multiplicity of the renal artery, ventroposition of its orifice are often accompanied by stenosis [13]. In the material of Stanley and Fry [29] orificial stenosis makes up 50% of all cases. In some of their cases the abnormality was accompanied by

Table II

Serial number of patient	Renin quotient	Type of surgery	Postoperative blood-pressure, mm Hg	Duration of follow-up
1	—	Left indirect aortorenal reimplantation, venous graft	130/70	5 years
2	—	Right antecaval aortorenal indirect reimplantation, hilar microreconstruction	120/70	2 years
3	1.43	I. Right orificial Gore-tex patch plastics II. Right antecaval indirect reimplantation, autologous arterial graft	160/100 120/80	3 months
4	1.3	Aortorenal Gore-tex patch plastics	120/70	4 years
5	—	Left direct reimplantation	120/70	1 year
6	1.8	Right indirect reimplantation, hilar microreconstruction	120/80	1.5 years

neurofibromatosis or abdominal coarctation of the aorta.

Inflammatory vascular changes occur much less frequently. In our material one patient was affected by Takayashu's arteritis. In the largest paediatric material there were three cases, one of them of grave outcome [31]. Even less frequently can fibromuscular hypertension be observed, although alterations affecting distal sections of the renal artery and attributed to a local weakness of the vascular wall may exhibit similar histology. Stenosis of sclerotic origin does not occur in these age groups.

It seems that hypoperfusion causes less parenchymal damage in children and adolescents, therefore 0.5—1.0 cm reductions in renal length should be considered pathological. The diagnostic value of urography is rather restricted since functional deficits can only be shown in advanced cases. In our cases renal arterial occlusion did not lead to appreciable changes in size or function. Isotope studies — perfusion and scintigraphy — allow a more refined approach.

Plasma renin activity was determined in half of our cases since only positive results are of diagnostic value. There is no close relationship between the renin quotient and the success of surgical treatment [16, 23].

The most decisive method is angiography, also in children. Indication for surgical treatment should be based on clinical data and angiography [3]. For visualising a short, orificial stenosis, oblique projections may be indispensable. Demonstration of a collateral plexus may be a valuable indirect sign, its visualisation may be facilitated by pharmacoangiography.

In respect of surgical techniques there are no basic differences between operations on children and adults [12, 15, 20, 22]. Surgery is performed under complete heparinisation. Indirect or direct reimplantation of the renal artery is the most suitable method, by-pass techniques and autotransplantation are less commonly used [11, 14, 25]. Similarly, segment resection, endarteriectomy and patchplastics are not often applied. In case of multiple renal arteries and small size, microsurgery is indicated. In our material in situ solutions were preferred. Some authors favour ex situ methods [32].

For reconstruction of the renal artery we usually apply reimplantation and saphena grafting but in small children autografts taken from the internal iliac artery can best be used. The small dimensions may necessitate knot technique; this is favourable also for the growing tissue [25, 27].

In children and adolescents the otherwise widely used transluminal angioplasty is less suitable because of anatomical variations and localisations. The intense tissue reaction of the young organism is a further discouraging factor [5, 9, 31].

In centres with angiosurgical experience the results are good. Reconstruction gradually extrudes nephrectomy [29], the rate of complete recovery is above 90%. In our own

material blood pressure normalised in all cases soon after surgery. In one case a relapse of hypertension occurred; repeated angiography proved to be helpful in early recorrection [10, 24].

Isotope diagnostics seems to be most suitable for follow-up. Late angiography can be used for checking the condition of the implant and may reveal subclinical alterations.

Early diagnosis and adequate treatment of renovascular hypertension of children and adolescents are based on well-organised screening programme and an efficient surgical background.

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