

The Influence of Postural Changes on the Glomerular Filtration Rate in Nephroptosis¹

V. T. ANDRIOLE,² M. BONADIO AND C. BIANCHI

Department of Internal Medicine, Yale University School of Medicine, New Haven, Connecticut, and the 2nd Medical Clinic, C. N. R. Clinical Physiology Laboratory, University of Pisa, Italy

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The influence of postural changes on renal function was determined in 13 patients with nephroptosis and in 5 normal subjects by measuring GFR in the erect and supine positions. The results indicate that GFR was reduced in the erect position in 10 of 13 patients with either unilateral or bilateral nephroptosis whereas GFR was increased in the erect position in 4 of 5 patients without renal disease. One patient with bilateral nephroptosis and renovascular hypertension was studied before and after surgical correction of his disease. These observations indicate that patients with nephroptosis may have significant reductions in renal function when they assume an upright position, and suggest that GFR measurements in the supine and erect position in patients with nephroptosis can be helpful in evaluating this disease.

Abnormal renal mobility or "nephroptosis" has been observed to occur in about 20% of women in the third to the fifth decade of life, and in only 2% of men (1). The right kidney is involved in 70%, the left in 10%, and both kidneys in 20% of cases. However, only 20 per cent of patients with this abnormality complain of urinary symptoms and the rest are either asymptomatic or have symptoms unrelated to the kidney (2, 3). For these reasons, the role of nephroptosis in the pathogenesis of disease has undergone considerable debate. At one time some physicians considered this condition to be highly significant clinically, whereas others regarded it as an unimportant anomaly (2, 3). However, renal ptosis is at times treated by nephropexy without considering the real influence of this condition on renal function. In fact, while there are many contributions concerning the influence of postural changes on renal function in normal subjects, and in patients with different parenchymal renal diseases (4-11), little data is available on renal function in patients with nephroptosis.

The present research, therefore, was undertaken to determine whether the anatomical anomaly of nephroptosis was also associated with pathophysiological altera-

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tions in renal function. In an attempt to better understand the importance of this condition, glomerular filtration rate (GFR) was measured in the recumbent and erect positions in patients with either unilateral or bilateral nephroptosis, and in subjects without renal disease. The results indicate that the GFR is significantly decreased in the erect as compared to the supine position in patients with nephroptosis. These observations suggest that nephroptosis is a disease instead of a simple anomaly.

MATERIALS AND METHODS

Eighteen patients, 1 male and 17 females, ranging in age from 17–48 years and who had been admitted to the University of Pisa hospitals, were studied. A history, physical examination, serial blood pressure readings, urinalysis, blood urea nitrogen, serum creatinine, creatinine clearance, and intravenous pyelography in the upright and supine positions were determined in all patients prior to inclusion in the study.

Patients were considered to have nephroptosis when intravenous pyelography demonstrated that either the right, left, or both kidneys moved by at least more than one vertebral body in the upright as compared to their respective locations in the supine position, and when the nephroptotic kidney was palpable. Patients were considered to be without renal disease when blood pressure, 3 separate urinalyses, blood urea nitrogen, serum creatinine, creatinine clearance, and intravenous pyelography in the two positions were within normal limits. The studied population, according to these criteria, consisted of 13 patients with either unilateral or bilateral nephroptosis and 5 patients without renal disease. One patient, with bilateral nephroptosis and renovascular hypertension, was studied before and after surgical correction for renovascular hypertension and severe nephroptosis. The remaining patients were normotensive and were studied once. Another patient, also normotensive, had unilateral nephroptosis and renal ectopia.

GFR was first measured in the upright, and shortly thereafter in the supine position in each patient on the same day. Hypaque (sodium diatrizoate) labelled with iodine-131 was employed as a tracer to measure GFR. In fact, its renal clearance equals that of inulin and hyposulphite and does not change in a wide range of plasma concentration of non-labelled Hypaque, or by greatly changing the urine flow (12–16). In each patient a dose of about 0.9 $\mu\text{Ci}/\text{kg}$ of body weight was employed for the first measurement in the erect position, while for the second measurement in recumbency the dose was doubled to minimize the influence on the clearance value of any free iodine-131 which may remain in the blood after the first administration of the tracer.

GFR was determined with ^{131}I -Hypaque by an external counting method previously described in detail (17). A scintillation counter provided with a suitable collimator placed over the bladder was used to measure the amount of the radioiodinated tracer eliminated into the urine during the clearance period. Besides avoiding bladder catheterization, this method allows the measurement of GFR after a single injection of the tracer, and thereby also avoids constant venous infusion. A series of preliminary studies to compare the results of this new method with conventional standard clearance of inulin plus a large clinical experience of more than 11,000 GFR measurements have demonstrated its reliability.

External vesical counting was begun after an equilibrium period of 90 min following intravenous injection of the tracer. Since the method requires emptying the

bladder by urination, hydration was conveniently accomplished by giving patients 500 ml of water to drink during the first 45 min after receiving the intravenous tracer. Patients emptied their bladders approximately 60 min after receiving the tracer, and were then maintained in the same position in which they were to be examined for the last 30 min of the 90 min equilibration period. The clearance period lasted 25–30 min. At the middle of the clearance period a venous blood sample was taken using a heparinized syringe. At the completion of the initial clearance period in the upright position, the patient received a second intravenous injection of the tracer, and the clearance was repeated except that the patient remained in the supine position for 30 min prior to beginning external counting over the bladder. Serial measurements of blood pressure and pulse rate were obtained at various intervals throughout both clearance periods.

RESULTS

The influence of posture on the GFR rate was determined in 5 patients with unilateral ptosis of the right kidney, 6 patients with bilateral nephroptosis, one patient with bilateral nephroptosis and renovascular hypertension, one patient with right renal ptosis and renal ectopia, and in 5 subjects without renal disease. These results are shown in Table 1 and Figs. 1 and 2.

In Fig. 1, each point represents the values obtained in one patient for the GFR in both the erect position, plotted along the ordinate, and the supine position, plotted along the abscissa. It is apparent that the GFR was decreased, sometimes markedly, in the erect as compared to the supine position in almost all patients with nephroptosis. In only two instances did the GFR in the erect position closely approximate the GFR in the supine position. In contrast, the GFR was higher in the erect as compared to the supine position in 4 of the 5 subjects without renal disease.

In an attempt to determine whether the degree of ptosis, that is, unilateral or bilateral, influenced the GFR, the results obtained were divided into three groups as shown in Fig. 2. The first column represents those patients without renal disease; the second, those with unilateral nephroptosis; and the third, those with bilateral renal ptosis. The results are plotted as the percent difference in the GFR in the erect and supine position ($\text{GFR erect} - \text{GFR supine} / \text{GFR supine} \times 100$), for each patient studied. Positive values indicate an increase, and negative values a decrease in the GFR in the erect as compared to the supine position. The horizontal broken line in each column represents the mean for each group. When these groups are compared it is apparent that a change in posture produced significant effects on the GFR in those patients who had either unilateral (mean = -15.65% , $P = <0.05$) or bilateral (mean = -21.69% , $P = <0.01$) nephroptosis as compared to those who had no renal disease (mean = $+8.85\%$, $P = 0.30$). In the second column there is one point, represented by a square, which has not been included in the calculation of the mean value for those patients with unilateral nephroptosis, because this patient had renal ectopia combined with a minimal degree of ptosis of the right kidney. In this one case a marked increase in GFR in the erect as compared to the supine position was observed. We have no apparent explanation for this observation. Similarly, in the third column, there are two points represented by triangles which also have not been included in the calculation of the mean value for those patients with bilateral ptosis. These two points represent the variation in GFR observed before (∇) and after (Δ) surgery in one patient

TABLE I
INFLUENCE OF POSTURE ON GFR IN RENAL PTOSIS

Group	Age ^a	Sex	Mean blood pressure		GFR ^b		Percent difference
			Erect	Supine	Erect	Supine	
<i>Ptosis unilateral</i>							
L. B.	48	F	125/100	105/70	46.94	72.47	-35.23
M. P.	36	F	115/95	120/80	55.76	69.18	-19.40
D. N.	18	F	110/80	100/65	86.37	85.33	+1.22
S. M.	23	F	120/90	120/80	85.13	99.18	-14.17
F. D'A.	36	F	120/80	120/80	85.48	95.67	-10.65
						Mean	-15.65
<i>Ptosis bilateral</i>							
A. P.	24	F	120/90	120/80	74.50	82.45	-9.64
A. M.	27	F	120/80	115/80	60.49	79.89	-24.28
M. GZ.	40	F	110/80	110/80	93.89	96.63	-2.83
M. N.	34	F	100/80	100/85	61.82	89.49	-30.92
C. M.	34	F	130/90	120/80	57.15	84.04	-32.00
D. B.	17	F	120/90	120/90	51.56	74.15	-30.47
						Mean	-21.69
<i>Other</i>							
Bilateral ptosis and hypertension							
E. S.	43	M	155/120	155/120	a) 9.92 ^c	46.73	-78.74
			120/100	125/90	b) 25.73 ^d	107.11	-75.98
Unilateral ptosis and ectopia							
A. C.	46	F	120/80	115/70	101.69	65.52	+55.20
<i>No renal disease</i>							
A. O.	48	F	130/90	130/90	78.21	72.34	+8.11
D. M.	24	F	120/90	120/90	101.97	95.79	+6.45
L. C.	32	F	135/90	125/80	117.01	96.65	+21.06
M. G.	17	F	120/80	115/80	78.99	94.50	-16.41
A. P.	26	F	115/80	110/70	122.02	97.57	+25.06
						Mean	+8.85

^a Age (years).

^b GFR = (ml/min) corrected for body surface area

$$\text{Percent difference} = \frac{\text{GFR erect minus GFR supine}}{\text{GFR supine}} \times 100.$$

^c Values obtained (a) before surgery, and (b) after surgery.

^d X-rays of the kidneys in the erect position were not done.

with bilateral renal ptosis and renal vascular hypertension. This case is of sufficient interest to warrant a brief description.

Case Report

S. E., a 43-year-old male, was admitted to the hospital in April, 1973. Four months before a blood pressure of 175/110 was casually discovered. On admission to the hospital the blood pressure was 230/130 in the supine and erect position. Auscultation of the abdomen revealed a mild systolic murmur in the right periumbilical area. The heart was not enlarged. There were no significant electrocardiographic alterations. Urinalysis showed occasional trace of protein and few red blood cells in the sediment. The urine culture was sterile. Blood urea nitrogen was 30

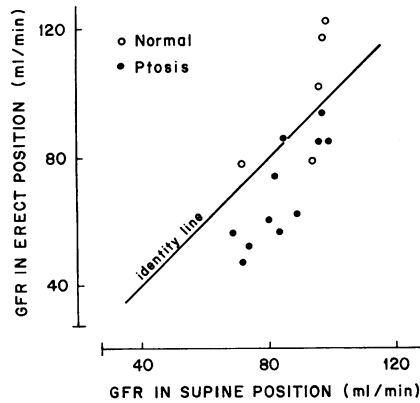


FIG. 1. GFR values in the supine (abscissa) and erect (ordinate) positions in patients with nephroptosis and controls.

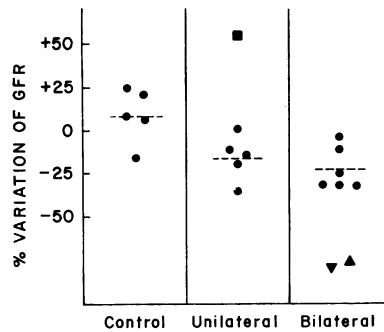


FIG. 2. Variation of GFR in the erect position in controls and patients with unilateral or bilateral nephroptosis.

mg% and serum creatinine 1.34 mg%. A rapid sequence intravenous pyelogram showed a delay in the appearance and excretion of the contrast medium on the right side and a greater concentration on the same side. The two kidneys did not differ in size. In the upright position the right kidney descended more than two vertebral bodies and the left about 1.5 vertebral bodies. The renogram (^{131}I -hippuran) and the renal scan (^{197}Hg -chlormerodrin) showed no evidence of renal function on the right side, while on the left side they were normal. The rapid sequence renal scan (^{131}I -hippuran) showed a very reduced uptake of the tracer on the right side, which remained unchanged in the kidney for over 1 hr, whereas the left renal scan was normal. This picture is typical of right renal ischemia. A retrograde femoral arteriogram showed a severe stenosis in the proximal portion of the right renal artery with poststenotic dilatation.

Two months later the patient underwent surgery in the Clinica Chirurgica of the University of Pisa. A thrombotic stenosis of the first portion of the right renal artery was demonstrated. This thrombus was removed and a side-to-side anastomosis between the aorta and right renal artery, as well as nephropexy were performed. On the second post-operative day the blood pressure was 160/100 and on the 10th day it was 125/70.

The GFR in supine and erect position before and after surgery are shown in Table 1 and in Fig. 2.

The decrease in GFR observed in the erect position occurred in the absence of major changes in blood pressure in patients with renal ptosis (Table 1). Only 3 of 12 normotensive patients with nephroptosis had blood pressure increases greater than 10 mm Hg in the erect position. The remaining patients, including those without renal disease, showed only insignificant blood pressure changes when they assumed the erect position.

DISCUSSION

The influence of postural changes on renal function has been studied previously by a number of workers (4–11). However, it is difficult to carefully compare the results of these studies because of the different techniques and varied experimental conditions employed by these workers. Most of these studies have been carried out in patients with a variety of renal parenchymal diseases, and in supposedly normal subjects. Little information is available concerning the effect of postural changes in patients with nephroptosis. McCann and Romansky (4) studied 5 selected patients with nephroptosis and hypertension and observed that effective renal plasma flow was markedly reduced in the erect position in these subjects, whereas the GFR, measured by inulin clearance, was not significantly changed (mean decrease of 0.58%). These results seem to be in contrast with those obtained more recently by other workers using isotope renography (18, 19). These workers observed definite alterations in the renographic curve of the ptotic as compared to the opposite kidney (18, 19). However, renography represents a semiquantitative measure of renal function and cannot be easily compared with clearance values.

GFR has also been measured, by means of inulin clearances, in patients with parenchymal renal disease in both the supine and erect positions (7–9). A mean decrease in GFR of 18 and 28% in erect lordosis has been observed in patients with orthostatic proteinuria by King and Baldwin (7) and Robinson and colleagues (9) respectively. Furthermore, creatinine clearance has also been found to decrease markedly in the erect position in a series of patients with different parenchymal renal diseases (10), and in hypertensive patients during upright tilting (11).

The influence of postural changes on the GFR of supposedly normal subjects has also been determined (4–7, 11). However, the results have not been uniform. While McCann and Romansky (4) observed no decrease in GFR in control subjects in the erect position, Brun and colleagues (5) reported a mean decrease of 20%, with important variations among different control subjects in a passive erect posture. In addition, King and Baldwin (7) observed a mean decrease of about 29% in control subjects in erect lordosis, a value surprisingly higher than the 18% decrease obtained by the same workers in patients with renal parenchymal disease. On the other hand, Goodyer and Seldin (6) observed no differences in the GFR, determined in the supine position and during quiet standing, in normal subjects undergoing a solute diuresis. The different results obtained by these various workers may be explained, in part, by the different techniques employed. Some experiments were performed in normal subjects by tilting, while others were carried out in the active upright position. Furthermore, the duration of the upright position varied in different experiments. Although differences in technique and duration of the erect

position may account for some of the variation in GFR observed in normal subjects, it would be interesting to know the results of intravenous pyelography in the erect and supine positions in these supposedly normal subjects. This information has not been reported by other workers, except for the few patients studied by McCann and Romansky (4). Since the incidence of nephroptosis is rather high, it is possible that this condition was present in some of these supposedly normal subjects. This seems to be the most likely explanation for the variation in the results reported.

In the present study, the minimal variation in GFR in the two positions, observed in our normal subjects, closely agrees with the results obtained by McCann and Romansky (4). However, our results are in contrast with those observed by other workers who may not have screened their supposedly normal subjects for the presence of nephroptosis (5, 7, 11). Our observations in nephroptotic patients can be compared to the only available renal functional data of McCann and Romansky (4) who observed no significant variations of GFR in the erect position. In contrast, our results demonstrate an unquestionable decrease in GFR in the erect position in patients with either unilateral or bilateral renal ptosis. This difference cannot be easily explained. However, the renographic studies, previously reported by others (18, 19) have demonstrated an important frequency of functional alterations in ptotic as compared to normal kidneys. Furthermore, the external counting method used in the present study does not require continuous intravenous infusion and bladder catheterization, and allows the measurement of GFR during conditions which are more physiological for the patient than the conditions required to measure inulin clearance. Another important difference between our series of nephroptotic patients and those of McCann and Romansky (4) is that their patients were hypertensive, whereas ours, with one exception, were not.

The coexistence of renal ptosis and hypertension was first described in 1938, by Schroeder and Steel (20). Two years later McCann and Romansky (4) introduced the concept of "orthostatic hypertension." Since then a number of cases of abnormal renal mobility and hypertension have been reported (3, 21, 22), and the importance of using upright aortography to study these patients has been stressed (23, 24).

The coexistence of nephroptosis and hypertension occurs most frequently in women. Our case of nephroptosis and hypertension is one of the few which occurred in males. In this patient, as in other reported cases, the causal relationship between nephroptosis and hypertension has not been demonstrated. However, our case does emphasize the importance of measuring GFR in the supine and erect position, before and after surgery. In fact, after revascularization and nephropexy of the right kidney, the blood pressure, in our patient, fell to normal values, and the GFR doubled to a normal value in the supine position. In contrast, in the erect position the GFR, which was markedly reduced before surgery, improved only slightly. This result might be due to the fact that this patient had bilateral nephroptosis and that nephropexy was only partially effective. Nevertheless, the measurement of GFR, before and after surgery, is clearly important and helpful in evaluating the success of corrective surgical procedures.

Our results suggest that nephroptosis is a real renal disease rather than a simple anomaly and that patients with this abnormality should be followed closely to determine whether renal function will be further compromised. The measurement of GFR in the supine and erect position in patients with nephroptosis can be important in evaluating the seriousness of this disease, and may provide some guidelines for

the selection of those patients who should be treated surgically. Furthermore, since the reliability of nephropexy is still controversial, GFR measurements in the two positions before and after surgery could be helpful in clarifying the effectiveness of this procedure.

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