

INTERRELATIONSHIP BETWEEN HYDRATION, URINE FLOW, RENAL BLOOD FLOW AND THE RADIOHIPPURAN RENOGRAM

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Soon after the introduction of radioisotope renography, it became evident that the shape of the tracing obtained varied with the state of hydration of the subject examined. Nevertheless, there has been no overall agreement about the preferred state of hydration under which to perform the renogram. Some workers believe that hydration gives better distinction between normal and abnormal (1,2), whereas others claim better separation when renography is performed after an overnight fast (3-6). The present work was done in an attempt to solve this problem and to find out whether there are any interrelationships between the states of hydration and variations in the renal blood flow on the renogram contour.

MATERIALS AND METHODS

This study was performed on 15 normal males aged 19-35 years. They were divided into two unequal groups of 10 and five subjects, respectively. In each case the renal blood flow was estimated twice by external monitoring of radiohippuran disappearance from the circulation using a collimated scintillation detector placed over the manubrium sterni at the level of the second ribs (7,8).

In the group comprising 10 normals, the first measurement was carried out with the subject under normal fluid balance. In the second determination the test was repeated after the patient had drunk 600-1,000 ml of water over a period of 1 hr. This process resulted in diuresis with a urine flow ranging from 2.9 to 21.0 ml/min.

The effects of hydration on both the radiohippuran renogram and renal blood flow were studied in the second group of five normal subjects. The test was performed in the sitting position, using a pair of well-matched scintillation detectors centered over both kidneys; the sites of the kidneys were determined with a small dose of ^{197}Hg . A third detector was placed over the manubrium sterni for the simultaneous determination of the renal blood flow. The collimators used had straight bores with 1½-in.-wide apertures; the crystal was recessed 3 in. from the

surface. The counting rate from each detector was recorded by an integrating printing scaler activated at 15-sec intervals over a period of 30 min. To start with, the study was performed after an overnight fast; then it was repeated following the intake of the water load. In the second determination the dose of radiohippuran was doubled.

At the end of the study, each subject was given 10 drops of concentrated potassium iodide to minimize the uptake of ^{131}I by the thyroid gland.

RESULTS

Under normal fluid balance, the 10 normal individuals studied had renal blood flows that ranged from 990 to 1,250 ml/min, or 915 to 1,299 ml/min/1.73 m² surface area, the average being $1,097 \pm 127$ ml/min/1.73 m² (mean ± 1 s.d.). With hydration, the renal blood flow did not change significantly in seven cases, the effect being a change of less than 5% from the previous estimation. In the remaining three subjects the renal blood flow increased in two and decreased in one individual (Table 1). The mean value for the renal blood flow after overhydration amounted to $1,101 \pm 195$ ml/min/1.73 m².

The effect of water diuresis on the renal blood flow after an overnight fast was not different. Out of the five normals studied, three did not show any significant change, one had a minor increase and one had slightly decreased renal blood flow (Table 2).

Furthermore, there was no noticeable relationship between the rate of urine flow and the type or magnitude of response of the renal blood flow to the water load used (Tables 1 and 2).

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TABLE 1. EFFECT OF WATER DIURESIS ON RENAL BLOOD FLOW

Number	Age (yr)	Surface area (m ²)	Renal blood flow			Rate of urine flow after water load (ml/min)
			Normal fluid balance (ml/min)	Hydrated (ml/min)	Change (%)	
1	32	1.65	1,235	1,208	-2.2	20.0
2	26	2.03	1,162	1,282	+10.3	11.6
3	25	1.52	990	951	-3.9	2.5
4	30	1.86	1,030	1,048	+1.7	9.5
5	30	2.08	1,100	1,060	-3.6	13.7
6	27	1.83	1,076	1,040	-3.3	6.7
7	28	1.93	1,160	1,115	-3.9	15.0
8	33	1.68	1,250	1,510	+20.8	21.0
9	32	1.88	1,230	1,280	+4.1	15.6
10	29	1.58	1,035	910	-12.0	4.7
Mean	29.2	1.80	1,127	1,140	6.6	12.0
±1 s.d.	2.7	0.18	94	181	6.1	6.2

TABLE 2. RADIOHIPPURAN RENOGRAM OF NORMAL SUBJECTS BEFORE AND AFTER HYDRATION

		Time for initial rise (min)		Peak time (min)		Ratio between left and right		Renal blood flow (ml/min)	Rate of urine flow (ml/min)
No.	State of hydration	Left	Right	Left	Right	Peak value	Slope of ascending limb		
1	Fasting	0.70	0.75	6.00	5.00	1.65:1	38:62	1,450	0.5
	Hydrated	0.85	0.95	3.50	3.00	1.20:1	41:59	1,148	2.9
2	Fasting	0.95	0.75	4.50	4.50	0.75:1	47:53	1,356	1.4
	Hydrated	0.85	0.80	2.75	2.75	0.97:1	31:69	1,369	10.3
3	Fasting	0.70	0.80	3.50	4.50	1.54:1	35:65	730	0.5
	Hydrated	0.75	0.85	3.00	3.25	1.03:1	39:61	712	7.9
4	Fasting	0.85	0.80	6.00	5.75	0.65:1	52:48	1,038	0.2
	Hydrated	0.75	0.70	2.75	2.75	0.82:1	57:43	1,041	3.2
5	Fasting	0.65	0.75	3.00	3.50	0.87:1	45:55	890	1.1
	Hydrated	0.80	0.80	3.25	3.00	1.06:1	43:57	1,005	2.6

The radiohippuran renogram is usually described by an initial abrupt rise in radioactivity (initial rise or initial deflection), followed by a slower increase to reach a peak (ascending limb) and ending with decreasing radioactivity (descending limb or excretory phase).

Hydration had no constant effect on the time required for occurrence of the initial rise as can be seen from the results obtained in the five normals studied (Table 2). However, with hydration the point of intersection of the ascending limb with the initial deflection was identifiable even in the cases in which it was not distinct in the hydropenic state due to the multiphasic character of the ascending limb (Fig. 1). The slope of the ascending limb became steeper, reaching peak value in a shorter time interval (Table 2). In addition, the ratio between the peak counting rates attained by both kidneys approached unity (Table 2 and Fig. 2). Regarding the descending limb, with hydration it became steeper

and freer from the stepwise descent that is sometimes encountered in subjects examined after an overnight fast (Fig. 2). However, the final portion of this limb became flatter after hydration (Fig. 2).

DISCUSSION

The results of the present study indicate that there is no consistent significant change in the total renal blood flow with hydration. This confirms the results of previous workers in this field using other techniques to measure the renal blood flow in human beings (9-11). Therefore any alteration in the shape of the radioisotope renogram under the effect of water load cannot be explained by a concomitant change in the total renal blood flow. However, this does not exclude the possibility of an intrarenal redistribution of blood flow as suggested by Thurau *et al* (12). This group of workers showed that with water diuresis the glomerular filtration rate, total renal blood flow and mean transit time through the

cortex did not change. But there was a definite decrease in the transit time through the medulla, suggesting an increase in the medullary blood flow.

In the present work it was observed that with hydration the slope of the ascending limb of the

renogram became steeper and radioactivity reached peak value earlier. These findings were also reported by previous workers (6,13) who explained them as being due to more rapid transit of radioactivity through the kidneys. In view of the change observed in the actual slope of this segment (Figs. 1 and 2) as well as the variation in ratio between the slopes of both sides after hydration (Table 2) without constant change in the renal blood flow, the slope of the ascending limb as such cannot readily be used for calculation of the relative renal blood flow to each kidney. This has been suggested by previous workers (4,5), but would not be considered valid until it is shown that even in normal subjects the relative blood flow to each kidney varies with the degree of hydration of the person examined. Moreover, using this method of calculation as suggested by the workers mentioned above, the relative blood flow to one kidney was $1\frac{1}{2}$ times or more than that going to the other kidney in five out of the 10 examples calculated and cited in Table 2.

Regarding the descending limb of the radiohippuran renogram, previous investigators reported that it was less steep with dehydration (14) which also

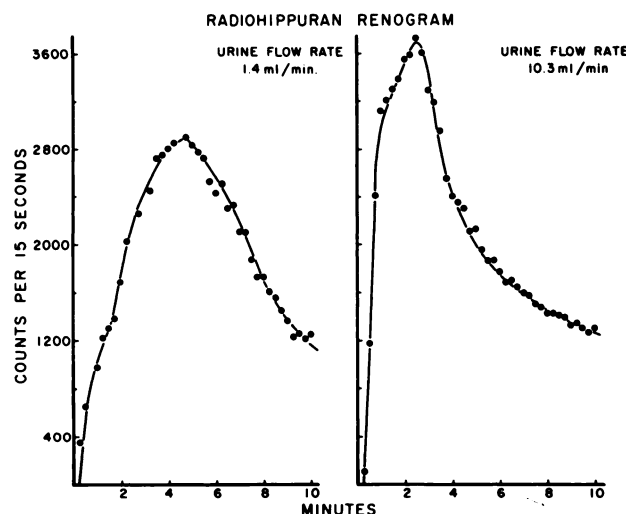


FIG. 1. Radiohippuran renogram of right kidney in normal individual before and after hydration to show better distinction between initial rise and ascending limb after hydration.

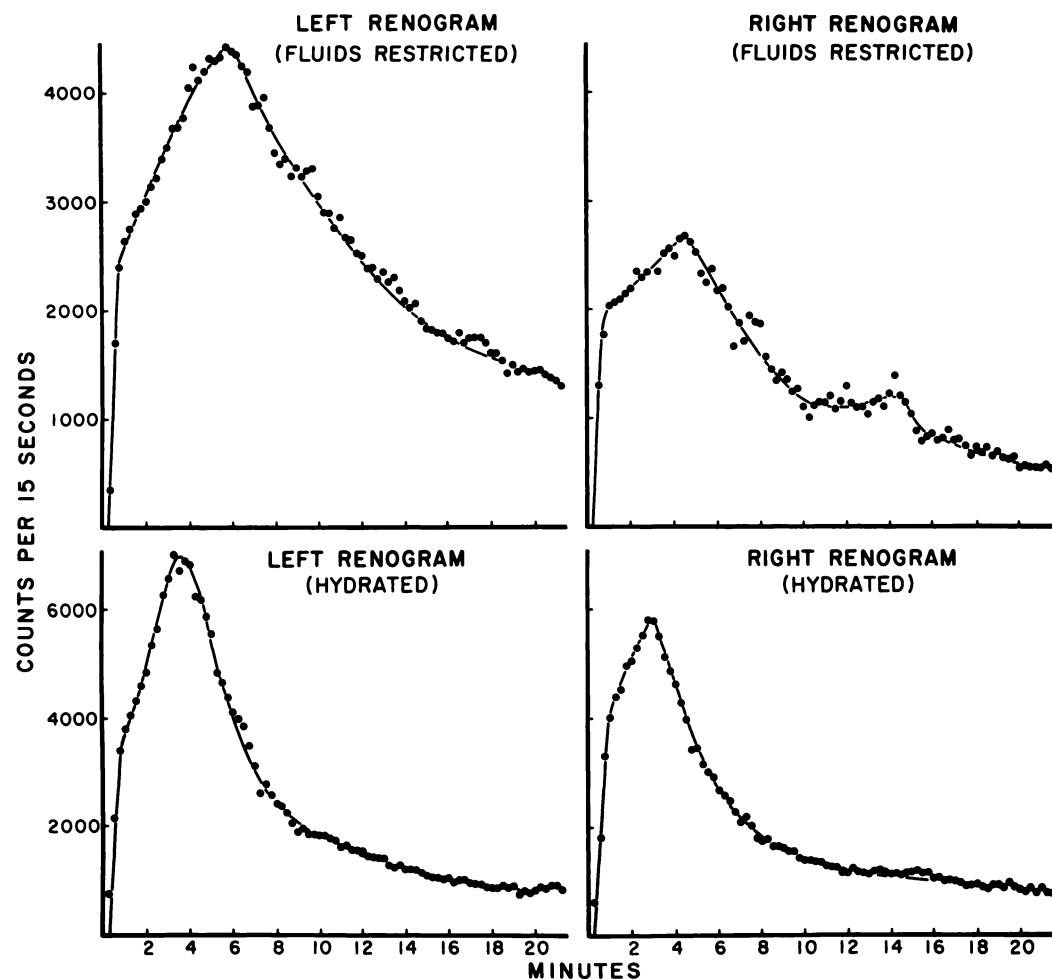


FIG. 2. Radiohippuran renogram of normal subject before and after hydration to illustrate effect of water diuresis on peak:peak ratio and descending limb.

means that it was steeper following hydration as stated by others (6). In this respect, the present work revealed that after hydration the early portion of the descending limb became steeper, whereas the final segment became flatter. The change in the earlier portion can be explained by a more rapid transit of radioactivity from the kidneys to the urinary bladder where it accumulates and in turn affects the latter part of the descending limb. This concept of the effect of bladder radioactivity on the counting rate recorded by the renal detectors is supported by the observation that there was a significant drop in the level of radioactivity measured by the renal detectors following evacuation of the urinary bladder. The magnitude of the effect of bladder evacuation on the counting rate recorded by the renal detectors at 25 min post-dose amounted to $33.4\% \pm 8.1$, with a range of 18.6–45.4%. This effect becomes easily appreciated when it is recalled that the field of view of a detector becomes progressively larger the farther we go away from this detector. Consequently, the urinary bladder which lies considerably anterior to the kidneys can come easily in the field of a detector placed behind the kidney, especially when the bladder is full.

The easier identification of the point of intersection of the initial rise in radioactivity with the ascending limb, together with the smoothness of the descending limb noticed after a water load, would favor performance of the radiohippuran renogram under hydration. This is further supported by the better equalization of the counting rate recorded over both renal areas at the time of peak activity after hydration, in contrast to the inequality frequently encountered when renography is performed after an overnight fast.

SUMMARY

Hydration had no consistent effect on the time required for the occurrence of the initial rise of radioactivity recorded during radioisotope renography. In contradistinction, the slope of the ascending limb became steeper and radioactivity reached peak value at an earlier time. The early portion of the descending limb became steeper, whereas the final part became flatter.

These changes cannot be explained by alteration in the renal blood flow since hydration did not cause any constant effect on the total renal blood flow. Furthermore, the slope of the ascending limb of the renogram cannot be used to calculate the relative blood flow to each kidney.

The advantages of recording the radiohippuran renogram under hydration consist of better equalization of the counting rates over the renal areas at the

time of peak activity and elimination of the stepwise descent in radioactivity. In addition, there can be a more readily identified point of intersection of the initial rise of radioactivity and the succeeding ascending limb of the renogram.

Lastly, the effect of bladder radioactivity on the counting rates recorded by the renal detectors is shown.

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