Malnutrition, Kidney Size and Composition

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SUMMARY

Kidneys from 42 infants were analysed for protein, fat, water, DNA and RNA.

No significant differences in composition could be found between groups of children with different degrees of weight deficit.

However, in a larger series of 200, it was shown that increasing degrees of weight deficit were associated with a reduction in kidney size. In the older children with the greatest degree of weight deficit, the kidney formed a significantly higher percentage of the body weight.

The general conclusion is that in the most severely malnourished children kidneys are smaller than normal.

The effect of malnutrition on renal function in infants and adults has been well documented (1). The general concensus seems to be that the functional changes are reversible once the malnutrition has been corrected, and it has even been shown that functions like glomerular filtration rate may rise to supra normal values in children recovering from malnutrition (2). This might imply that malnutrition had no permanent effect on renal structure and composition. In the rat, different effects are observed in that severe malnutrition post partum may lead to alterations in kidney composition and size (3). The present study was intended to measure renal size and composition in children who had died of various causes including protein calorie malnutrition.

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METHODS

From a total of 42 autopsies of children up to the age of 21 months, certain data were taken prospectively by one observer. These were age of the child, height, weight, and weight of both kidneys. Premature births and still births were excluded from the study. The left kidney was taken for analysis. One quarter was used to determine water content by drying to constant weight at 110°C: one quarter was used for the estimation of protein (4). One quarter used to measure fat (5) and one quarter was used for DNA and RNA measurements (6).

From a further 200 protocols of autopsies of children under 2 years of age, the height, weight and age of the child and the combined weights of the kidneys were taken retrospectively.

The degree of malnutrition was assessed by expressing the child's weight as a percentage of the expected weight for a child of that height or age. The expected weight for height or age was taken as the 50th centile of the Boston standard.

RESULTS

The ages at death and the major clinical diagnoses for the 42 children are shown in Table 1. Table 2 shows the data on kidney composition in relation to the degree of malnutrition. There is no significant difference between the 3 groups. Even if the children were divided on the basis of weight for age, there is still no difference with increasing severity of weight deficit.

The total DNA in both kidneys is shown in Table 3. The same divisions were not used as in Table 2 in order to obtain groups large enough for statistical evaluation. DNA in kidneys increases with age but the differences between the children less than and those greater than 85% of the expected weight for height were not significant. The protein / DNA ratios showed no significant change.

Kidney weight is known to be closely related to body length and this is shown in Figure 1. The children who had the greatest weight deficit do not appear to form a separate group.

The kidney weights from the larger autopsy series are shown in Table 4. Kidney weight increases with age in all 3 groups of children but the kidney weights decrease with increasing degree of weight deficit, at least in the children in the groups 0 - 5 and 6 - 11 months, but the small decrement in those over the age of 12 monts was not significant. In this group of children over 12 months of age the kidney weight as a percentage of the body weight was significantly higher. If the children are divided on the basis of weight deficit for age, then it is striking that weight deficit is associated with smaller kidneys. (Table 5.)

TABLE 1

AGES OF ALL AND DIAGNOSES IN SOME OF THE 42 CHILDREN STUDIED

Ages	—	12+ months	7
		0— 5 months	17
		6—11 months	18
Diagonosis	—	Malnutrition	8
		Gastroenteritis	9
		Pneumonia	11

TABLE 2

KIDNEY COMPOSITION IN THE 42 CHILDREN STUDIED

	Weight as a percentage of expected for height		
	90+(19)	**80—90 (11)**	**less than 80 (12)**
Weight of kidneys (g)	17.7±2.1	20.1±2.8	22.6±2.4
Protein g/100 g	7.5±0.8	7.8±1.0	8.1±1.1
Fat g/100 g	2.0±0.2	1.8±0.3	1.8±0.3
Water g/100 g	83.8±1.00	84.2±1.3	82.6±1.1
Total DNA mg	59.6±8.6	61.8±8.2	66.2±5.2
Total RNA mg	29.6±2.6	25.0±2.6	34.0±3.2

The number of children is given in brackets.
All values are reported as means ± SEM.

TABLE III

TOTAL DNA (mg) AND PROTEIN/DNA RATIOS IN THE CHILDREN STUDIED

Ages (months)	Weight as a percentage expected weight for height > 85		< 85	
	Total DNA(mg)	Protein /DNA	Total DNA(mg)	Protein/DNA
0 - 5	45.7± 6.3	44.4± 3.9 (10)	52.±6.6	58.5±10.0 (7)
6 - 11	65.4± 7.9	46.6± 7.3 (10)	52.7±4.1	52.5± 8.9 (5)
12+	120.6±35.1	28.0±10.3 (3)	77.1±9.5	57.1± 9.4 (7)

The number of children in each group is in brackets.
Al values are reported as means ± SEM.

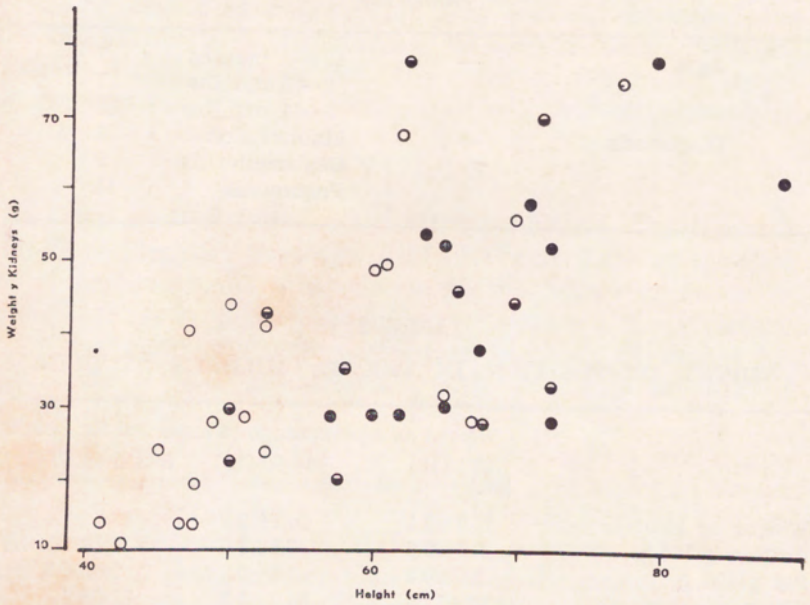

Figure 1. Kidney weights in relation to body length in the series of 42 cases.

- ● = Children less than 80% expected weight for height
- ◒ = Children less than 80-90% expected weight por height
- ◎ = Children less over 90% expected weight for height
- ⊙ = Children less over 90% expected weight for height

TABLE 4

KIDNEY WEIGHTS AND RELATION TO BODY WEIGHT IN THE SERIES OF 200

Body weight as porcentage of expected weight for height

Ages (months)	90+ Kidney weight		80 - 89 Kidney weight		Less than 80 Kidney weight	
	grams	as % Body wt	grams	as % Body wt	grams	as % Body wt
0 - 5	21.3±1.1	.53±.03 (49)	18.2±1.9	.47±.03 (9)	17.0±1.7*	.55±.07 (11)
6 - 11	28.7±1.1	.43±.03 (30)	26.5±2.6	.40±.03 (11)	22.7±1.6**	.45±.12 (23)
12+	35.3±3.8	.37±.03 (19)	34.5±3.0	.41±.03 (16)	30.4±1.6	.46±.02 (32)***

All values are means ± SEM.
The numbers in brackets refer to the number of children in that group

* $P < 0.05$ When compared with values for children 90+ expected weight for height.
** $P < 0.02$ When compared with values for children 90+ expected weight for height.

TABLE 5

KIDNEY WEIGHT (GRAMS) AND RELATION TO BODY WEIGHT IN THE SERIES OF 200

Ages (months)	Body weight as a percentage expected weight for age		
	> 80	60 - 79	< 60
0 - 5	21.1±1.2 (44)	19.2±1.3 (15)	17.6±2.0 (10)
6 - 11	31.0±1.9 (24)	27.2±1.8 (22)	18.4±0.9 (18)***
12+	40.8±3.2 (21)	30.4±1.4 (28)**	27.1±1.7 (18)***

All values are ± SEM.
The numbers in brackets refer to the number of children in that group.

*** Significantly different from the group > 80% $p < 0.001$
** Significantly different from the group > 80% $p < 0.01$

DISCUSSION

In a previous report (1) the clinical diagnosis was accepted as the sole criterion of malnutrition and it was shown that malnutrition led to a decrease of kidney weight. Here we have ignored the clinical diagnoses and divided the children according to the degree of weight deficit. In the group of 42, only 9 were diagnosed clinically as being malnourished and one of them had frank kwashiorkor. In the group of 200 only 9 were diagnosed clinically as suffering from kwashiorkor. The potential disadvantage of ignoring the clinical diagnosis is that the oedema of the kwashiorkor children may place them artificially in a less malnourished group.

The study shows that severe weight deficit is associated with a reduction in kidney size. However it would seem hat even those children who had no weight deficit had kidneys smaller than those of English children. Emery & Mithal (7) give figures for kidney weights for normal children, and these values are consistently higher than those observed here. They record mean kidney weights of 51 to 60 grams for children between the ages of 6 to 11 months, while in this age group the mean keight in this series is about 30 grams for the

children who were least malnourished. The cause for this is not apparent. We must note that 100% of our expected weight for height refers to children who were on the 50th centile of the Boston standard. To obtain a true comparison it will be necessary to have children with a wide range of weights including those who would be 100% of the American standard. Similarly the values for total DNA in the age group 0 - 5 months is considerably less than those given for normal newborns who died within the lst week of life (2). The same reasoning may apply.

The cause of the reduction in kidney weight with increasing weight deficit is not clear. There is no apparent difference in composition of the kidneys. Although there is a trend for total DNA to be less in the children over the ages of 6 months with the most severe weight deficit, these differences are not significant. Protein/DNA ratio shows no trend towards any reduction with increasing weight deficit. It is most probable that the series of 42 is too small to be divided into groups of a size large enough to show statistically significant differences. The significant increase in the fraction of the body weight contributed my the kidney may be interpreted to mean that with severe weight deficit the rest of the body is more wasted than the kidney.

The effect of malnutrition on the kidneys is much clearer in the rat where it has been shown that protein energy deficiency between 21 and 36 days post partum led to a reduction mainly in cell size, while energy deficiency during the first 21 days of life led to a reduction in cell number (3).

The impaired renal haemodynamics in malnorished children have been regarded as a function mainly of a poor cardiac output (2,9). The present results might indicate that loss of renal mass might be partially responsible for the impairment of function.

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RESUMEN

Composición, tamaño del riñón y malnutrición

Se analizó el contenido de proteína, grasa, agua, DNA y RNA en riñones provenientes de 42 infantes sin encontrarse diferencias significativas entre grupos con diferentes grados de deficiencia ponderal.

No obstante, en otra serie mayor de 200, se pudo demostrar que grados progresivos de deficiencia en peso estaban asociados con una reducción del tamaño del riñón. En niños de más edad que evidenciaron el más alto grado de deficiencia de peso, el riñón representaba un porcentaje significativamente mayor del peso corporal.

La conclusión general es que en niños más severamente desnutridos, los riñones poseen un tamaño menor que el normal.

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