KIDNEY DEPTH AND ISOTOPE RENOGRAPHY

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In order to enhance the quantitative aspects of the isotope renogram, information is needed about the estimation of kidney depth. Preliminary data have suggested that kidney depth, determined at the time of renal biopsy, could be expressed as a function of the body surface area (*1*). It has also been shown that various parameters of the normal isotope renogram correlate with parameters of surface area (*2*). The purpose of this paper is to present a more comprehensive series of estimates of kidney depth and to relate them to the isotope renogram.

METHODS

Selection of subjects. The 76 patients (36 females and 40 males) chosen for the study had various renal diseases, and all were sent for needle biopsy of the kidney. Their ages ranged from 4 to 76 years with a mean of 19.7 years.

Kidney localization. Three measurements were made from an excretory urogram: (1) the distance from the midline (spine) to the lower pole of the right kidney, (2) the distance from the last rib to the lower pole of the right kidney and (3) the distance from the iliac crest to the lower pole of the kidney. These measurements were then transferred to the patient, and the site for biopsy was indicated with gentian violet.

Biopsy technique. The technique of Muehrcke and associates (*3*) with the Franklin modification of the Vim-Silverman biopsy needle was used.

Technique of depth estimation. After infiltration with 1% procaine at the site of the proposed biopsy, a No. 22 spinal needle was inserted until the renal capsule was encountered. Occasionally this could be felt, but usually the operator relied on the sensation of entering firm kidney tissue compared with the lesser resistance of fat or muscle. The fingers were placed on the needle at the skin, and the needle was withdrawn; the position of the fingers on the needle therefore indicated the depth of insertion. An applicator stick was broken off at the equivalent distance to serve as a depth gage.

Kidney depth was correlated by a stepwise regression program with height, weight, age and surface area (DuBois formula) for each sex separately and for both together. Some of the data which dealt with pediatric age groups were handled separately.

RESULTS

The mean height of all males (both adults and children) was 151 ± 23 cm (1 s.d.), of all females, 149 ± 17 cm, and of the whole group, 150 ± 21 cm. The average weight of males was 50.5 ± 21.9 kg, of females, 47.3 ± 16.8 kg, and of the whole group, 49.0 ± 19.6 kg. The mean surface (DuBois) area of males was 1.43 ± 0.42 m^2, of females, 1.39 ± 0.30 m^2, and of the whole group, 1.41 ± 0.37 m^2.

Mean kidney depth for males was 47 ± 13 mm, for females, 44 ± 10 mm, and for the entire group, 46 ± 12 mm. Values for the regression equations with standard errors of estimate are presented in Table 1.

The best predictions—standard error of estimate of 5.5 mm—were found in the group of females based on a regression equation involving height, weight and age. No appreciable improvement was ever found when surface area derived from height-weight nomograms was considered. In the males the best estimate of kidney depth was obtained from a height and weight regression equation. No improvement was obtained by using the surface-area calculation or age. In the entire group best fits required use of height, weight and age although the improve-

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TABLE 1. REGRESSION EQUATIONS FOR PREDICTION OF KIDNEY DEPTH*

Group (number)	Number of predictor variables (from among wt, ht, age, surface area)	Regression equations	Standard error of estimate (mm)
Males (40)	Best one	K.D. = 23.65 + 0.47 ht	8.8
	Best two	K.D. = 66.08 + 0.85 wt — 0.41 ht	7.7
	> two	No significant improvement	—
Females (36)	Best one	K.D. = 23.36 + 0.43 wt	6.5
	Best two	K.D. = 53.80 + 0.67 wt — 0.28 ht	6.0
	Best three	K.D. = 57.72 + 0.90 wt — 0.34 ht — 0.27 age	5.5
Both (76)	Best one	K.D. = 23.04 + 0.46 wt	7.8
	Best two	K.D. = 60.71 + 0.79 wt — 0.36 ht	7.0
	Best three	K.D. = 61.08 + 0.82 wt — 0.36 ht — 0.06 age	6.9
Pediatric (44)	Best one	K.D. = 30.51 + 0.30 wt	6.7
	Best two	K.D. = 53.12 + 0.56 wt — 0.23 ht	6.4
	> two	No significant improvement	—

* K.D. = kidney depth (mm). Units of measure are: for ht, cm; for wt, kg; for age, yr.

ment in estimate afforded by the age was minimal. Considering the pediatric group separately resulted in an improvement in estimate of only 0.5 mm.

DISCUSSION

Our data indicate that by using the general formula, kidney depth = 0.82 wt (kg) — 0.36 ht (cm) — 0.06 age (yr) + 61.08 (mm), one can estimate the depth of the kidney in the prone position within a standard error of estimate of 6.9 mm.

Because the error of most renographic equipment obeys the inverse-square law, it is evident that at the mean kidney depth of 47.3 mm a 16% error would be expected through two standard errors of estimate (14 mm) when a skin-to-crystal distance of 10 cm is used. Using a 20-cm-long collimator reduces the error to approximately 10%. In our system in which a crystal-to-skin distance of 22 cm is used, an error of 9% may be expected at the average crystal-to-kidney distance of 26.7 cm (Fig. 1).

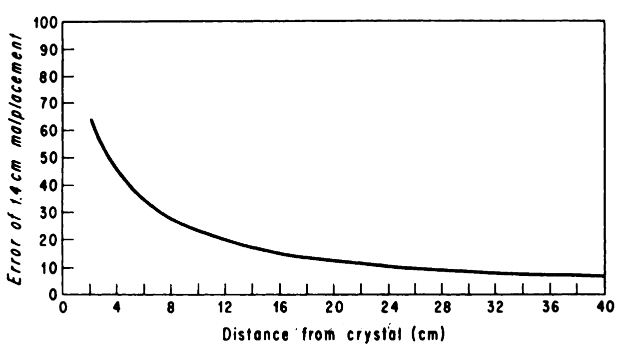

FIG. 1. Plot of theoretical percentage counting-rate changes (based on inverse-square law) of 1.4 cm at various distances from scintillation crystal to counting surface.

It should be noted that the kidney depths reported here relate only to those estimated in the prone position. When isotope renograms are made with the subject in the sitting position, these regression equations are not expected to apply precisely. It is likely that data from isotope renograms performed with the patient in the prone position can be made much more quantitative by correcting variation in kidney depth.

SUMMARY

Kidney depths were estimated from patients at the time of renal biopsy and related to the isotope renogram. Regression equations developed by a stepwise regression analysis were evaluated.

The smallest standard error of estimate was obtained when data were plotted as a regression of height, weight and age. Our data indicate that the distance from the scintillation crystal to the probe counting surface must be at least 22 cm to achieve errors less than 10%, based on variability of the kidney in normal subjects due to inverse-square-law effects.

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