THE RENAL PARENCHYMAL FACTOR

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The pyelographic assessment of functioning renal tissue has been investigated by numerous workers. Braasch and Merricks[3] (1938), Kleeberg and Dreyfuss[10] (1946) and Billing[2] (1954) all commented upon the roentgenographic parameters of renal length and breadth. Moëll[11] (1956), in addition to investigating the size of the kidney on the X-ray, assessed the renal area both planimetrically and by applying the geometrical formula for the area of an ellipse. He found the two values to correspond. Besse, Lieberman and Lusted[1] (1958) found a direct relationship

between the kidney area as seen on the film and the kidney mass as found at autopsy. This was confirmed by Moëll[12] (1961).

The thickness of the renal parenchyma has been studied or mentioned by several authors. Pendergrass[11] (1943) mentioned the relative proportion of cortex to medulla. He proposed a line to be drawn through the tips of the renal calyces to demarcate the collecting system from the parenchyma. Burns, Drew and Dean[4] (1953) discussed the thickness of the parenchyma; so also did Olsson[13] (1954) and Hodson[9] (1960). In 1959 Hodson[8] described an interpapillary line drawn through the tips of the outer renal papillae. He found that this line bore a constant relationship to the surface outline, and that the thickness of the renal substance could be measured as the distance between this line and the surface of the kidney.

Vuorinen, Pyykönen and Anttila[15] (1960) appear to be the first to attach absolute values to the amount of functioning renal tissue and described their 'renal cortical index' relating the size of the collecting system to the total renal size. In 1962 Vuorinen, Anttila, Wegelius, Kauppila and Koivisto[16] mentioned that in the assessment of renal pathology not only did the renal cortical index rise under pathological conditions but that the difference, where present, between the indices for the two kidneys was an even better index of renal pathology. Vuorinen and his colleagues pointed out that in kidneys with an irregular shape their simplified method for obtaining the renal cortical index must lead to results that deviate from the results obtained in kidneys with regular outlines. However, they quoted Hodson[8] as mentioning that a change in the shape of the kidney may cause deformity of the calyces and also Frimann-Dahl,[6] who in 1961 reported that a deviation from the 'normal' form of the left kidney was often accompanied by changes in the calyces.

Vuorinen *et al.*[16] also admitted that their index presupposed that the form of the collecting system was identical, or almost identical, with the outline of the whole kidney. This is not always true, because the thickness of renal substance is greater at the pole of a kidney than in its lateral parts,[8] and also because when pathological changes occur they are not evenly distributed.[5,8]

For these reasons the author tried to devise a more accurate index of functioning renal tissue by measuring the apparent thickness of the renal parenchyma directly on the X-ray and correlating this value with the sum of the length and breadth of the collecting system. At the outset it must be mentioned that the values obtained are still only approximations, because the following factors have been ignored in this study: the effect of rotation of the kidney about its various axes,[7,8] geometric enlargement of the kidney, and the fact that when the patient is supine the caudal pole of the kidney is at a greater distance from the table top than the cranial pole.[12] However, as stated above,[1,12] there is a direct relationship between the observed roentgenographic kidney area and the actual kidney mass; the values are therefore considered to be valid.

In order to avoid confusion with the renal cortical index, and as the segment of kidney tissue assessed included both cortex and medulla, the term 'renal parenchymal factor' was coined. A scheme was devised whereby for each kidney 9 arbitrary measurements of renal parenchymal thickness were assessed, summated, and correlated with the sum of the length and breadth of the renal collecting system. A rigid scheme of renal measurement was adhered to. The measurements were only taken on radiologically normal intravenous pyelograms (IVPs). The film on which the whole of the renal circumference and the dye-filled collecting system was completely seen was used. If there was any doubt about the precise position of a point of reference the film was discarded. This was necessary in about one-third of the IVPs examined. Where possible, both kidneys were measured on the one film; it was possible in 25% of the cases only. The following points were marked on the film (Fig. 1):

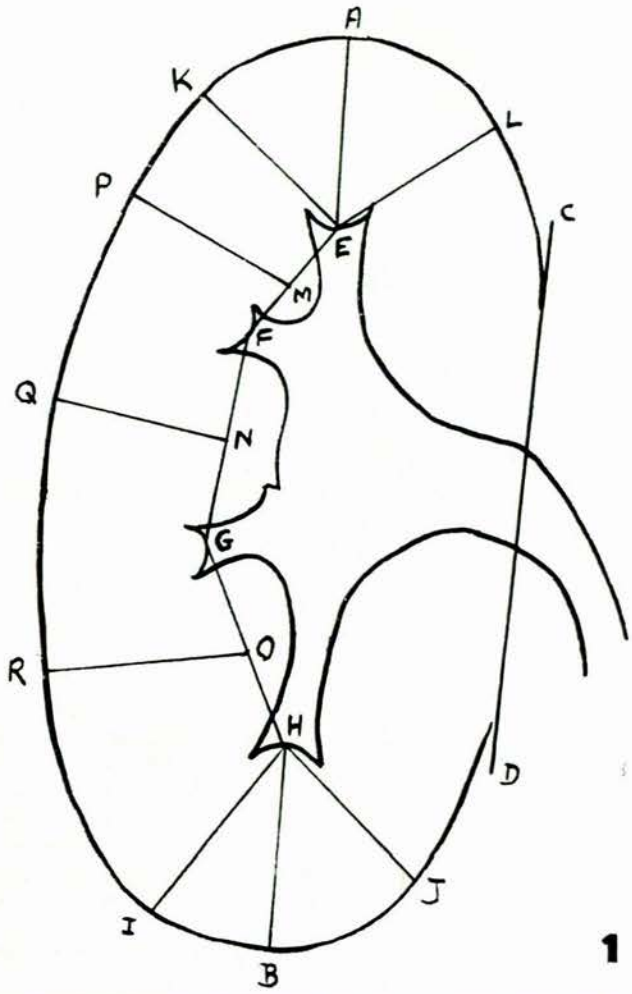

Fig. 1. Diagram of kidney marked to show points of reference (see text). If, because of variations in the calyceal pattern, lines MP, NQ or OR were difficult or impossible to obtain, three equivalent lines at equidistant intervals from each other perpendicular to tangents on the renal surface were marked from points along the interpapillary line EFGH.

(*a*) Points A and B marking the points of maximum distance between the outline of the cranial and caudal poles of the kidney.

(*b*) Line CD marking the innermost border of the renal margin.
(*c*) Points E, F, G and H marking the tips of the renal papillae.
(*d*) Points I, J, K and L such that the lines HI, HJ, EK and EL are perpendicular to tangents on the renal surface.
(*e*) Points M, N and O marking the midpoints of EF, FG and GH.
(*f*) Points P, Q and R such that the lines MP, NQ and OR are perpendicular to tangents on the renal circumference.

From the above indices the sum of the renal parenchymal measurements, namely EL+EA+EK+MP+NQ+OR+HI+HB+HJ, was obtained; and the breadth of the collecting system was considered to be the maximum distance between CD and the outermost renal papilla at right-angles to the length of the system. The renal parenchymal factor was considered to be the ratio between the length plus breadth of the collecting system and the sum of the parenchymal measurements, i.e.

$$\text{renal parenchymal factor} = \frac{EH + \text{breadth of collecting system}}{EL+EA+EK+MP+NQ+OR+HI+HB+HJ}$$

Material and Results

101 IVPs were arbitrarily chosen in accordance with the criteria described above, from patients at the King Edward VIII Hospital during the years 1962-63. 58 were from male patients and 43 female. No distinction was made between African and Indian patients. 50 left kidneys and 51 right kidneys were chosen. In the subsequent ratio studies no distinction was made between male and female patients, but a distinction was made between the left and the right kidney.

The values for the renal parenchymal factor for both kidneys varied between ·32 and ·64. The factor for the left kidney varied between ·32 and ·62 and the factor for the right kidney varied between ·32 and ·64. Table I re-

TABLE I. THE RENAL PARENCHYMAL FACTOR OF THE TOTAL SERIES WITH COMPARISON BETWEEN THE LEFT AND RIGHT KIDNEY

	Left	*Right*	*Total*
·30 — ·34	3	3	6
·35 — ·39	8	5	13
·40 — ·44	11	16	27
·45 — ·49	10	16	26
·50 — ·54	8	5	13
·55 — ·59	7	5	12
·60 — ·64	3	1	4
Number of cases	50	51	101
Mean renal parenchymal factor	·47	·45	·46
Standard deviation	·095	·053	·079
Standard error of mean	·012	·007	·008

presents the spectrum of results obtained, and Figs. 2, 3 and 4 the same in histogram form. The mean renal parenchymal factor for the total series was ·46. For the left kidney it was ·47 and for the right kidney ·45.

Comparison between the histograms for the two kidneys

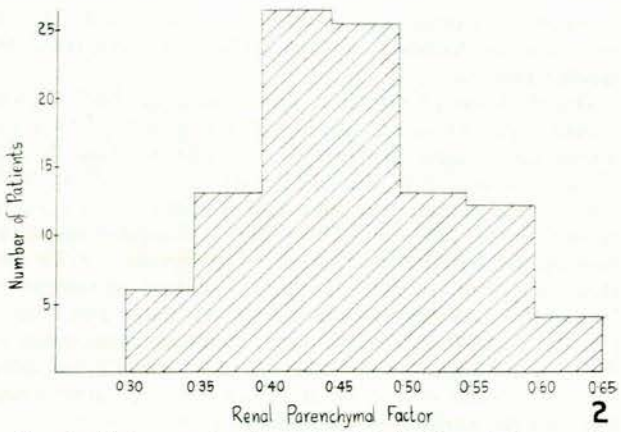

Fig. 2. Histogram to show the distribution of the renal parenchymal factor for the total series (101 cases).

(Figs. 3 and 4) reveals a more even range of distribution of the renal parenchymal factor on the left side than on the right. As mentioned above, it was only possible in 25 out of the 101 cases to assess the renal parenchymal factor on both sides on the same film. An analysis of this small series showed that in 15 out of the 25 cases the renal parenchymal factor on the left side was larger than

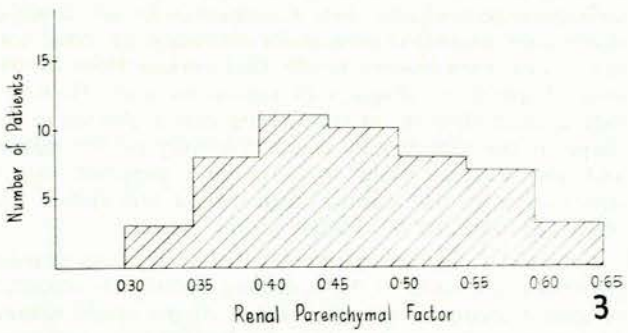

Fig. 3. Histogram to show the distribution of the renal parenchymal factor for the left kidney (50 cases).

on the right. The differences of values ranged from ·01 to ·13. In 10 out of the 25 cases the renal parenchymal factor on the right side was larger than on the left. Here the differences ranged from ·02 to ·08. It is felt that the series is too small to allow any conclusion to be arrived at, but

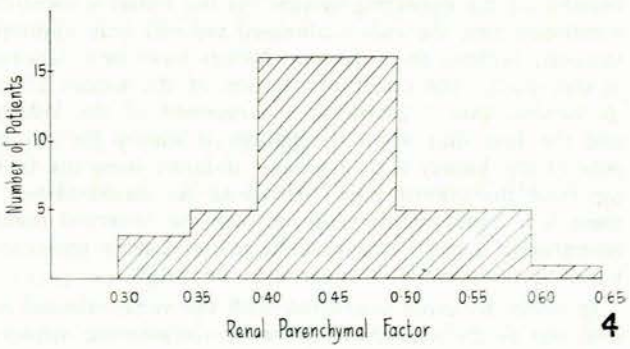

Fig. 4. Histogram to show the distribution of the renal parenchymal factor for the right kidney (51 cases).

it is interesting to note that Vuorinen *et al.*[16] found in their investigation into the renal cortical index that that index was larger in the left kidney than in the right.

Clinical Application of the Renal Parenchymal Factor

The main application of the renal parenchymal factor is intended to be in the diagnosis of the renal changes of chronic pyelonephritis, where, as Hodson[9] points out, characteristically there are in the kidney areas of coarse scarring with marked contraction of the renal substance which, if large enough, are associated with atrophy or fibrosis of the renal papillae. It is expected that the renal parenchymal factor will be elevated under these circumstances. An investigation into this matter will form the subject of a further paper.

SUMMARY

A method for measuring the renal parenchymal factor, which is an index of the amount of functioning renal tissue, is described. It differs from previous methods in that it assesses the amount of renal parenchyma more accurately.

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