

## EXTRA RENAL FUNCTION IN PATIENTS WITH DUPLICATION ANOMALY: OBLIGATORY AND COMPENSATORY RENAL GROWTH

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When one kidney is removed or destroyed the opposite one hypertrophies and increases its blood flow and function by 70 to 90 per cent.<sup>1, 2</sup> This increase is a process of true growth.<sup>3</sup> Hypertrophic renal growth is reversible when the removed kidney is replaced. However, when normal extra kidneys are transplanted into the same animal there is no decrease in size, blood flow or function of any of the kidneys.<sup>4, 5</sup> The animals merely retain extra renal function.

These facts lead to some important conclusions about the nature of renal growth. The process of normal renal growth is not reversed by an excess of kidneys, whereas compensatory hypertrophic growth is reversed. Thus, the kidney in a child normally grows with the child, unregulated by functional need. This growth process is obligatory as opposed to compensatory.

In humans there is some support for this notion in cases of transplantation between adults and children.<sup>6</sup> Kidneys from small children, when transplanted into adults, grow quite rapidly in the first month (hypertrophy) but then level off at a size no greater than that of a single kidney from a child transplanted into another child. Adult kidneys, when transplanted into children, neither increase nor decrease in size or function.

Evidence for obligatory renal growth in humans is more readily available through analysis of renal function in otherwise normal adults with renal duplication anomaly (bilateral or unilateral). Duplication of the renal collecting system is found in 1 to 10 per cent of routine adult excretory urograms (IVPs). It can be quite innocent in adults and often

appears to be associated with an increase in renal size.<sup>7</sup> If these people were born with an extra endowment of nephrons, accounting for the increased renal size, and if our concepts of renal growth are correct, such people should have extra renal function.

### METHOD

Seventeen adults with duplication anomaly discovered on routine IVP in the past year were retrospectively studied with regard to renal size and serum creatinine values. Renal size of each kidney was the greatest longitudinal axis (in centimeters) measured on anteroposterior views of the IVP. In only 1 case was the anomaly bilateral. In the other 16 cases the normal kidney served as a size control for the duplicated one (see figure).

Serum creatinine was determined by the standard Jaffe reaction on 3 separate samples and the average was determined. Control serum creatinine value was that obtained from 50 normal adult patients and determined during the same period in the same laboratory. There was an equal distribution of male and female patients in the group with duplication anomaly as well as in the control group of patients.

### RESULTS

**Size.** The duplicated kidneys measured 14.4 plus or minus 0.8 cm. standard deviation, while the normal controls were only 13.0 plus or minus 0.5 cm. standard deviation. The mean difference in size was 1.4 cm. The *t* test for paired data revealed this difference to be highly significant (*p* less than 0.001). The estimated increase in renal mass on the duplicated side (proportional to the axis<sup>3</sup>) is 36 per cent.

**Function.** The serum creatinine of control patients was 1.12 plus or minus 0.15 (1 standard deviation) mg. per cent. The serum creatinine of patients with duplication anomaly was 0.79 plus or minus 0.13 (1 standard deviation). The *t* test for raw data revealed this difference also to be highly significant (*p* less than 0.001), representing a decrease in serum creatinine in patients with duplication anomaly of 30 per cent.

### DISCUSSION AND SUMMARY

It is clear that kidneys with double collecting

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<sup>1</sup> Flanagan, W. J., Burns, R. O., Takacs, F. J. and Merrill, J. P.: Serial studies of glomerular filtration rate and renal plasma flow in kidney transplant donors, identical twins, and allograft recipients. *Amer. J. Surg.*, **116**: 788, 1968.

<sup>2</sup> Katz, A. I. and Epstein, F. H.: Relation of glomerular filtration rate and sodium reabsorption to kidney size in compensatory renal hypertrophy. *Yale J. Biol. Med.*, **40**: 222, 1967.

<sup>3</sup> Malt, R. A.: Compensatory growth of the kidney. *New Engl. J. Med.*, **280**: 1446, 1969.

<sup>4</sup> Silber, S. J. and Malvin, R. L.: Compensatory and obligatory renal growth in rats. *Amer. J. Physiol.*, **226**: 114, 1974.

<sup>5</sup> Silber, S. J. and Crudup, J.: The three-kidney rat model. *Invest. Urol.*, **11**: 466, 1974.

<sup>6</sup> Silber, S. J.: Renal transplantation between adults and children: differences in renal growth. *J.A.M.A.*, **228**: 1143, 1974.



Typical duplication anomaly on left side in otherwise normal adult. Larger endowment of renal mass is associated with increased renal function.

systems are significantly larger than normal kidneys (36 per cent). It also appears from accumulated data on serum creatinine from patients with such kidneys that they have an extra measure of renal function. Therefore, it is likely that people with double renal collecting systems are endowed from birth with extra nephrons and that the normal growth and function of these nephrons are not suppressed by their overabundance.

This dissociation of renal growth from need may also explain clinical phenomena of a more disturbing nature. Often marginal renal function is noted to deteriorate in children during a growth spurt in early adolescence and transplantation is necessitated. However, no persisting cause can be detected for the renal deterioration.

Serum creatinine values in infants and young children are normally much lower than in adults. The kidney in children is also considerably greater in proportion to the rest of their body than a kidney in adults. For example kidneys in a neonatal

child average 6.5 cm. in longitudinal axis, even though such infants weigh only 10 pounds.<sup>8, 9</sup> The kidney in a normal man weighing about 150 pounds averages 13.0 cm. longitudinal axis. Therefore, there is approximately an 8-fold increase in renal volume with a 15-fold increase in body size that occurs with growth. This differentially slower renal growth rate as opposed to total body growth rate explains the decreased serum creatinine in children compared to adults. A kidney functioning marginally in childhood (for example from an antecedent problem which had been fully corrected or from a congenital deficiency) may thus appear to deteriorate during a child's growing period, only because of this decreased obligatory growth of the kidney relative to the body.

Previously, interpretation of renal function in infants and children was confused by comparing the child's measured glomerular filtration to the normal adult surface area of 1.73 square meters rather than to weight or volume.<sup>10</sup> The smaller the child the greater the ratio of surface area to volume compared to the adult. Therefore, the smaller the child the lower the glomerular filtration will figure when compared to surface area rather than volume. This has led to the erroneous and widespread myth that kidneys in infants and babies are immature and do not function as well as kidneys in adults despite the decreased level of serum creatinine in children. However, exactly the opposite is true, namely babies have more renal mass and function relatively than adults. Kidneys merely grow and develop less rapidly than the rest of the body.

These new concepts of renal growth have strong support in experimental rat kidney transplantation and are valuable in explaining confusing clinical events in the growing child with renal disease.

<sup>8</sup> Hodson, C. J., Drewe, J. A., Karn, M. N. and King, A.: Renal size in normal children. A radiographic study during life. *Arch. Dis. Child.*, **37**: 616, 1962.

<sup>9</sup> Gatewood, O. M., Glasser, R. J. and Vanhoutte, J. J.: Roentgen evaluation of the renal size in pediatric age groups. *Amer. J. Dis. Child.*, **110**: 162, 1965.

<sup>10</sup> Barnett, H. L. and Vesterdal, J.: The physiologic and clinical significance of immaturity of kidney function in young infants. *J. Pediat.*, **42**: 99, 1953.