

Clinical Paper

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Pre- and Post-Nephrectomy Kidney Enlargement in Patients with Contralateral Renal Cancer

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Key Words

Renal growth, compensatory
Computed tomography
Cancer, renal
Nephrectomy

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Abstract

Pre- and post-nephrectomy kidney growth was studied by computed tomography (CT) in 32 patients with contralateral renal cancer. Kidney enlargement was assessed by comparing the size of the unaffected kidney, in 32 pre- and 61 post-nephrectomy CT examinations, with the corresponding normal size, determined from 120 CT examinations of binephric individuals with no renal disease. The unaffected kidney was found to be 36% larger 1 month before nephrectomy and 54, 62 and 47% in the 1st, 2nd, and 3rd postoperative year, respectively. Compensatory renal growth was influenced both by contralateral cancer and nephrectomy and did not depend on the patient's age or sex.
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Introduction

Studies on patients who have undergone nephrectomy for renal cancer have shown that the remaining kidney was larger than before the operation [1-3]. In fact, those reports assessed the effect of nephrectomy on the remaining kidney by comparing its size on urograms before and after contralateral kidney removal. However, there are no studies on the effect that the partial destruction of renal parenchyma, due to cancer, may have on the size of the unaffected kidney before nephrectomy. When assessing the overall hypertrophy of the remaining kidney in patients with renal cancer, both the preoperative change in size and the postoperative increase in size due to nephrectomy should be taken into account.

Previous studies on compensatory renal hypertrophy in patients with renal cancer assessed the size of the remaining kidney only from its length [2] or length and width [1] in intravenous urography. Computed tomogra-

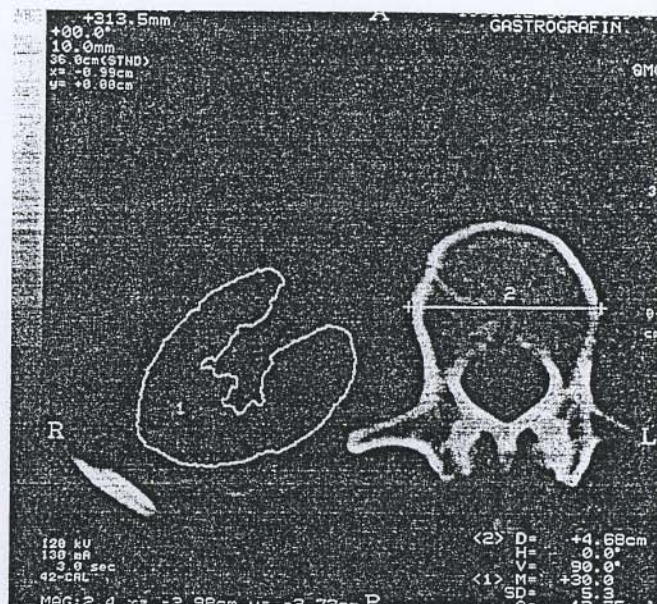
phy (CT), however, is a reliable means for measuring the amount of renal parenchyma [4] and, thus, for assessing kidney size accurately.

The purpose of this study was to determine, in patients with renal cancer, whether the unaffected kidney increases in size before nephrectomy and to estimate by CT the overall enlargement of the remaining kidney after contralateral kidney removal.

Material and Methods

This study consisted of 93 CT abdominal examinations performed on 32 patients with renal cancer (20 males and 12 females, 42-77 years old). Each patient had 1 CT examination 1 month before kidney removal and at least 1 postoperative examination in 34 months after nephrectomy. Seven patients had one, 21 had two, and 4 had three CT examinations after the operation. Thirty-one examinations were performed in the 1st, 16 in the 2nd, and 14 in the 3rd postoperative year. Additionally, CT abdominal examinations of

Fig. 1. CT scan through the pelvis of the right kidney. Boundary outline and area computation of renal parenchyma (1) and measurement of vertebral body transverse diameter (2).



120 binephric patients (40–80 years old) with no history of renal disease were used to obtain a representative size of the normal kidney for each decade, 15 men and 15 women per age group. Patients with congenital anomalies of the kidney, hypertension, chronic use of potentially toxic drugs, renal cysts or any other cause that may alter kidney morphology were excluded from this study.

Kidney size was assessed from three 10 mm CT scans of the non-contrast enhanced examination; two through the upper and lower calyceal levels and one at the level of the renal pelvis. In each CT section the area occupied by the renal parenchyma was computed by means of the CT software (fig. 1). The transverse diameter of the first lumbar vertebra was also measured to take into account the patient's body format [4, 5].

Data were analyzed with a computer program on a PC/AT computer. Kidney size was assessed by renal parenchymal measurements (equation 1):

$$\text{Normalized kidney size} = \frac{\text{PU} + \text{PL} + \text{PM}}{D^2} \quad (1)$$

where PU, PL and PM are the renal parenchymal area in square centimeters through the levels of the upper and lower calyces and the renal pelvis, respectively, and D is the diameter of the first lumbar vertebra in centimeters.

The percentage change in size of the remaining kidney was computed by equation 2:

$$\text{Percentage change in kidney size} = \frac{\text{RKS} - \text{NKS}}{\text{NKS}} \times 100 \quad (2)$$

where RKS is the remaining kidney size and NKS is the corresponding normal kidney size in binephric individuals, both estimated by employing equation 1 with regard to adults of the same sex and age group.

Table 1. Normalized kidney sizes in binephric individuals (mean \pm SD)

Age group years	Right kidney cm ²	Left kidney cm ²
40–49	2.74 \pm 0.37	2.66 \pm 0.42
50–59	2.55 \pm 0.33	2.42 \pm 0.35
60–69	2.37 \pm 0.38	2.21 \pm 0.37
70–79	2.18 \pm 0.41	2.05 \pm 0.40

Results

The normalized kidney sizes of binephric individuals per decade are presented in table 1. Renal size was found to decrease by about 7% per decade in adults over 40. There were no significant differences in kidney size between sexes ($p > 0.10$) since the body habitus was taken into account.

The normalized sizes of the unaffected kidneys before and after nephrectomy are tabulated in table 2. Results showed that the size of the healthy kidney in patients with renal cancer was 36% larger than the corresponding normal kidney in binephric individuals 1 month before nephrectomy. After kidney removal, the remaining kidney was 46% larger in the first month and 54, 62 and 47% during the 1st, 2nd and 3rd postoperative year, respectively, an overall hypertrophy of about 53%.

Table 2. Normalized kidney sizes in nephrectomized patients (mean \pm SD)

Age group years	Before nephrectomy		After nephrectomy	
	CT examinations	size, cm ²	CT examinations	size, cm ²
40-49	7	3.78 \pm 0.68	14	4.27 \pm 0.93
50-59	11	3.41 \pm 0.54	19	3.85 \pm 0.77
60-69	9	3.24 \pm 0.48	21	3.67 \pm 0.66
70-79	5	2.89 \pm 0.57	7	3.20 \pm 0.67

The percent increase in the size of the remaining kidney was found to be significantly different between the 1st and 2nd ($p < 0.05$), and 2nd and 3rd ($p < 0.025$) year after nephrectomy. The percentage change in size of the unaffected kidney was not found to differ significantly ($p > 0.10$) between men and women and between patients younger and older than 60 years either before or after nephrectomy, using the Student's *t* test.

Discussion

It is known that after nephrectomy the remaining kidney increases in size and overfunctions [3]. Both hyperfiltration and anatomic hypertrophy develop in parallel [3, 6]. Previous studies have assessed the compensatory hypertrophy of the remaining kidney in patients with contralateral renal cancer from the difference in size before and after kidney removal [1-3]. However, to our knowledge, no reports have been published that estimate the increase in size of the unaffected kidney in patients with renal cancer before nephrectomy and assess the overall renal hypertrophy, by comparing the size of the unaffected kidney with the normal kidney size of binephric individuals.

Reports based on autopsy material [7, 8] have revealed that the weight of the normal kidney depends on the adult's age, sex, and body habitus. For the purposes of this study, those factors were eliminated in the comparison of normal and remaining kidneys of adults of the same sex and age group. The influence of body habitus was eliminated by referring renal parenchymal measurements to the transverse diameter of the first lumbar vertebra. This diameter is related to the adult's body habitus and it has been previously employed for assessing the size of the

normal pancreas [5] and kidney [4]. We have also employed CT because it provides a reliable and accurate means to estimate the amount of renal parenchyma.

According to our results, the unaffected kidney in patients with renal cancer was found to be 36% larger than the corresponding normal kidney in binephric individuals 1 month before nephrectomy. This pre-operative growth might be the compensatory reaction of the unaffected kidney to the progressive destruction of functional parenchyma in the diseased kidney. All previous studies on compensatory hypertrophy have not taken into account this pre-operative renal growth. Thus, by comparing the size of the unaffected kidney before and after nephrectomy, they have substantially underestimated the overall compensatory hypertrophy. This can be easily seen from our findings if the pre-operative increase in kidney size (36%) is subtracted from the overall hypertrophy (53%) to give 17% renal growth, obviously caused by nephrectomy. Therefore, there is a considerable underestimation (36%) in the actual hypertrophic ability of the unaffected kidney in patients with contralateral renal cancer. Nevertheless, if our results were to be seen in this aspect, 17% of renal growth due to nephrectomy is close to the 18% obtained by Ekelund and Gothlin [1] from comparative measurements on pre- and postoperative urograms.

In the month following nephrectomy the remaining kidney was found to be 46% larger than the corresponding normal kidney. Studies on animals [3] found a 40-50% increase in kidney weight and function in relation to binephric animals during the same time period. Our findings suggest that most of the post-nephrectomy compensatory renal growth is attained shortly after kidney removal. This might be of value since some drugs have an effect on the rate of compensatory renal growth in animals [3] in the immediate post-nephrectomy period.

The results of this study showed that the remaining kidney was 54, 62 and 47% larger than the corresponding normal during the 1st, 2nd and 3rd postoperative year, respectively, suggesting that the size of the remaining kidney varied with post-nephrectomy time. This finding is in disagreement with previous studies [9, 10] that no correlation exists between kidney size and postoperative time. However, those studies assessed renal size only from its length on urograms.

The percentage increase in kidney size did not differ significantly between patients over and under 60. This result is in agreement with Boner et al. [9] and Ekelund and Gothlin [1], who found no correlation between renal hypertrophy and patient age.

In conclusion, this study showed that even before nephrectomy the unaffected kidney undergoes considerable enlargement in patients with contralateral renal cancer. The overall compensatory renal hypertrophy is influenced both by renal cancer and nephrectomy, and it is not related to either the patient's age or sex.

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