Original Article

The evaluation and comparison of kidney length obtained from axial cuts in spiral CT scan with its true length

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Abstract

Background: Increased size of kidney is the main symptom of pyelonephritis and renal ischemia in children. Ultrasound and computed tomography (CT) scan methods are the imaging methods for evaluating the urogenital system. The aim of this study is to compare the kidney length obtained from spiral CT scan with the true length obtained from multi-slice CT.

Materials and Methods: From 100 patients 200 kidneys were examined in Alzahra Hospital in 2012. Multi-slice CT was used to obtain coronal and sagittal cuts to find the length of kidneys.

Results: The mean values of true size of axial sections of the right and left kidneys were 108.37 ± 12.3 mm and 109.74 ± 13.6 mm, respectively. The mean difference of axial sections' lengths in the right and left kidneys was 1.37 ± 1.22 mm. The mean values of length in the spiral CT scan of the right and left kidneys were 98.61 ± 15.8 mm and 103.11 ± 15.9 mm, respectively. The difference in the estimated size by multi-slice CT scan in oblique and axial images was significant (9.77 ± 1.19 mm and 6.63 ± 0.8 mm for the right and left kidneys, respectively ($P < 0.001$).

Conclusion: The average size of both kidneys determined in axial images was smaller than the actual size. The estimation of kidney size in axial images is not reliable, and to obtain the actual size, it is required to have the coronal and sagittal cuts with proper quality, which could be achieved by multi-slice method.

Key Words: Computed tomography scan, kidney, renal length

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INTRODUCTION

One of the main methods in urinary tract investigations is by the use of imaging such as ultrasound and computed tomography (CT) scan, and one of the important factors in the evaluation of urogenital system is its size.

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Renal length measurement has a special place in the diagnosis and treatment of renal diseases. Studies conducted have shown that in various diseases, the kidney size changes, which is probably due to inflammation resulting from infections or by the concentration of water and minerals. Diabetes can also increase the size of kidney and chronic diseases can decrease the size of kidney.[1]

In many cases, the main symptom of chronic renal failure is increase in kidney size; also, in patients

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with diabetes, the first sign of diabetic nephropathy is the change in kidney size.[2] Timely diagnosis and treatment can prevent the progression toward end-stage renal disease and kidney transplantation.[3]

One of the main symptoms of pyelonephritis which is the most common cause of kidney failure in children is increase in kidney size. Furthermore, a kidney which has a double collecting system is usually 1-2 cm longer than any kidney which has a single calyx-pelvis system.[4,5] Renal ischemia also causes unilateral size change.[6] In systemic renal diseases also, kidney size reduction can be seen.[5]

Therefore, controlling the size of kidneys and comparing them can be a major criterion in detection of renal damages.[4]

Today, CT scan devices are extensively used for diagnosing and evaluating kidney problems such as stones, renal artery stenosis, renal anatomy, staging of renal carcinoma, etc., and considering this point, CT scan is used for many patients for various reasons. One of the parameters which is measured and evaluated in CT scan reports is the kidney length. So, it is important to know the correct calculated length.[2]

In the conventional method of measuring by CT scan that coronal and sagittal and oblique cuts are not easily available and don't have enough quality, the kidney length is measured in axial cuts (the distance between the highest and lowest levels of kidney) in CT scan axial cuts. But kidney size is different in different directions because the kidneys are not upright in the body and the upper pole is anterior and posterior relative to the lower pole. Thus, the length obtained by this method is not equal to its actual length.[7,8]

In 2007, Kang *et al.* examined the size of kidney in kidney transplant donors and suggested the kidney size as a selection criterion in transplantation.[9] In another research conducted in 2009, Goldny *et al.* introduced the size of kidney as a criterion for the health of adult kidneys.[10] But the evaluation of correctness of kidney length obtained by the CT scan through conventional method and comparing it with the true length of kidney has not been performed yet, and it is not clear whether the obtained measurement with the mentioned method and its difference with the true length of kidney is meaningful.[11] Also, it is not clear whether this obtained size can be a suitable criterion for judging and can be reliable.

Therefore, the kidney size can be suggested as a criterion for kidney health. So, obtaining the true length of kidney can be helpful in various diagnoses, and one of the main methods for finding the kidney size is through CT scan.

This study was performed in Alzahra Hospital (Isfahan, Iran) in 2012-2013 and the estimated values by CT were compared with the actual size of kidney.

MATERIALS AND METHODS

This study is a descriptive–analytic research on the type of correlation, which was conducted in Alzahra Hospital in 2012.

The study population consisted of patients who referred to the hospital CT scan department for abdominopelvic CT during 2012 and patients whose both kidneys were investigable and had been studied. Multi-slice CT was used in this research because by the obtained coronal and sagittal cuts, the actual length of kidney can be obtained easily.

In this study, the information related to patient's CT scan was recorded and evaluated. At first the kidneys' lengths were measured by the conventional method based on the distance between the upper and lower poles of kidneys in axial cuts in the CT scan. Then the distance between the upper and lower points of kidneys based on geographic coordinates (X, Y, Z) was measured by using multi-slice CT devices, and with the help of these coordinates, the distance of these two points which is indeed the kidney length was measured and the actual kidney length was obtained in this way.

The obtained data including the demographic characteristics of patients were analyzed by using the SPSS software (version 20), and *t*-test and Pearson correlation test.

RESULTS

In this study, 200 kidneys of 100 patients were examined. Mean age of the patients was 16.8 ± 49.1 years with a range of 19-90 years.

Sexual distribution showed 46 (46%) men and 54 (54%) women. Mean ages of men and women were 53.6 ± 17.3 years and 45.7 ± 15.8 years, respectively. The *t*-test showed that there was a significant difference in sex between the studied groups ($P = 0.024$). In Table 1, the mean and standard deviation are listed based on sex.

The true size of axial sections in multi-slice CT

Mean true sizes of axial sections of the right and left kidneys were 108.37 ± 12.3 mm and

109.74 ± 13.6 mm, respectively, in the population under study. Also, based on paired *t*-test, significant difference was not observed between the lengths of axial sections in the two kidneys (Rt and Lt) (P = 0.26). The mean difference of lengths of axial sections in the right and left kidneys was 1.37 ± 1.22 mm. In Figure 1, the median range and percentile 25% and 75% of the axial sections' lengths of the two kidneys are shown.

Sections' length in spiral CT scan

Mean axial sections' lengths of right and left kidneys in the CT scan were 98.61 ± 15.8 mm and 103.11 ± 15.9 mm, respectively. Also, based on paired *t*-test, significant difference was observed between the lengths of axial sections in the two kidneys (P = 0.012). The mean difference of axial sections' lengths in the right and left kidneys was 4.5 ± 1.75 mm. In Figure 2, the median, range, and percentile 25% and 75% axial sections' lengths of the two kidneys are shown.

Table 1: Mean and standard deviation based on sex

Sex	Frequency	Mean age	SD	*P* value
Man	46	6.53	3.17	0.024
Woman	54	7.45	8.15	
Total	100	1.49	8.16	

SD: Standard deviation

Table 2: Mean and SD of axial sections' lengths of kidneys based on true size and CT scan

Side	Method				*P* value
	Estimated size in spiral CT		True size in multi-slice CT		
	Mean	SD	Mean	SD	
Right	98.61	15.8	108.37	12.3	<0.001
Left	103.11	15.93	109.74	13.6	<0.001

SD: Standard deviation, CT: Confidence interval

Comparison between true axial lengths in multi-slice CT scan

In Table 2, the mean and SD of axial sections' lengths are shown for both kidneys based on true size and the size obtained from CT scan. As seen in the table, the mean estimated size in CT scan was less than the true size of both kidneys. Results from paired *t*-test also showed that the mean axial sections' length in the CT scan was significantly different from the true size (P < 0.001). Mean differences between the true size and the estimated size were 9.77 ± 1.19 mm and 6.63 ± 0.8 mm, respectively, for the right and left kidneys.

DISCUSSION

Since the size of kidneys is one of the most important investigable and reliable factors in examining the urinary system, knowing the actual and correct values plays an important role in physician's judgment.[12]

For example, in diabetic patients, kidney size reduction is the first sign of diabetic nephropathy. In pyelonephritis (the most common cause of kidney failure in children), one of the signs of renal failure is increase in kidney size.[13]

Therefore, knowing the true measured values of kidney size has special importance in different methods of medical imaging.

The overall aim of this study is to compare the kidney size obtained from CT axial cuts by the conventional method with its actual length (measured by multi-slice CT), because measuring the length by the conventional methods (which is obtained by measuring the distance between the lower and upper poles in CT axial cuts) is not equal to the actual length with respect to the placement of kidneys in the body. In this issue, the

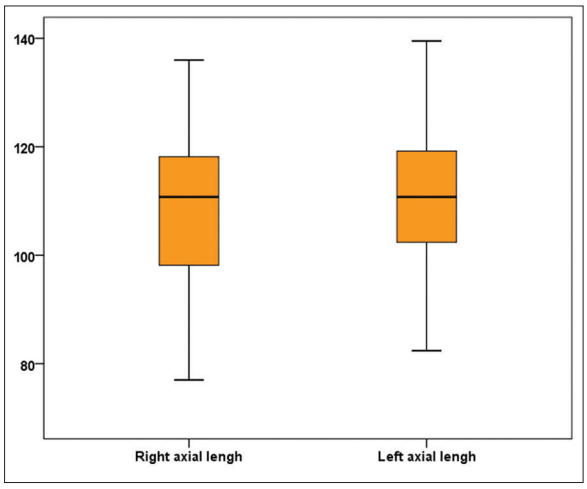

Figure 1: Median, range, and percentile 25% and 75% axial sections' lengths of right and left kidneys

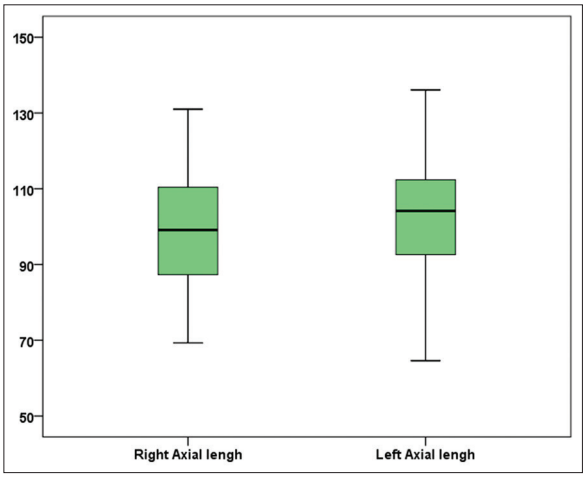

Figure 2: Median, range, and percentile 25% and 75% axial sections' lengths of right and left kidneys in CT scan

different values were significant, and therefore, it needs to be investigated because by knowing the actual values of kidney size, the changes can be evaluated in disease conditions and can be compared in different methods of imaging such as CT scan or ultrasound.

According to the results obtained from our study, the average estimated size of both kidneys was smaller in conventional CT than the actual size. The estimated size in CT scan was 9.77 ± 1.19 mm in the right kidney and 4.63 ± 0.8 mm in the left kidney.

Also, paired *t*-test of the data showed that the average of axial cuts' length in CT scan had a significant difference with the actual size ($P < 0.001$). With regard to renal investigations, kidney length is one of the most important indicators that is measured in different methods of imaging like ultrasound and CT scan,[14] and as stated earlier, the size of kidney can be an important indicator for diagnosing the various diseases of this organ. Also, it is a very good marker for patients' follow-up. The lack of consistency between the values obtained from the respective method and the true sizes of the kidney has led to deviation from standard values. The reason can be the non-existence of the coronal and sagittal cuts in spiral CT scan, and since spiral CT scan in routinely used in many centers for imaging, the mentioned method has to be used for measuring the kidney size (as well as other internal organs).

Therefore, it can be concluded from this study that the estimation of kidney size in spiral CT and conventional method (and using its cuts) is not reliable, and to obtain the actual size, it requires coronal and sagittal cuts of proper quality.

For other important internal organs including heart, liver, and spleen, further study needs to be done.

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