Preliminary Step towards Renal Nomogram in Malaysian Adult Population
ADEELA AROOJ, YEOH JING WUI, EKO SUPRIYANTO
Advanced Diagnostics and Progressive Human Care Research Group
Research Alliance Biotechnology
Faculty of Health Science and Biomedical Engineering
Universiti Teknologi Malaysia
UTM Johor Bahru, 81310 Johor
MALAYSIA
eko@biomedical.utm.my http://www.biomedical.utm.my

Abstract—Renal ultrasonography is a relatively inexpensive, fast, non-invasive and radiation-free imaging modality to diagnose a range of kidney diseases. Variation in kidney sizes can be associated with different kidney diseases. Commonly, measurements of renal size of any age are compared with the measurements that are predicted by standard nomograms. However, the current nomograms which are widely used locally are derived from studies based on western population of relatively small sample sizes. Therefore, there is an urge in developing our own Malaysian population nomogram to provide a better accuracy of renal measurements in terms of making a proper medical diagnosis. This study analysed 200 kidney samples after taking ultrasonic images from normal adult Malaysian population. The renal parameters analysed were length, width, thickness and volume which were plotted against height, weight and gender of the respondent. Results showed there is a significant direct positive correlation between renal size and body weight. There is not much difference genderwise. The relationship between body weight and height to kidney size also corresponds to other studies that the higher the body weight, the bigger the kidney is.

Key words – ultrasonography, nomogram, renal volume

1 Introduction

Medical imaging has played an important role in helping physicians to make a medical diagnosis. One such safe and easily available technique in Malaysia is ultrasound imaging. Ultrasound imaging or also known as ultrasound scanning or sonography is a relatively inexpensive, fast, non-invasive and radiation-free imaging modality. Ultrasound is excellent in making diagnosis of various diseases or conditions including renal disease.

Evaluation of renal measurements using ultrasound imaging such as length, width and thickness is an important parameter in the diagnosis and also management in many renal disorders as it is known that there is a close relationship between renal size and its function (1). Many studies have shown that the renal size and measurements is influenced by many factors such as age, ethnicity, gender, weight and height (2-4). It is also known that the left kidney is larger than the right kidney, independent of gender (6-8). Many studies also concluded that renal measurements variations occur in nephropathies due to hypertrophic process and/or atrophy (6, 9). Study done by Mazzotta et al. (2002) found that the most important measurement of renal size is longitudinal length in subjects with normal renal function whereas renal parenchymal volume is, the more exact sonographic parameter in end stage renal disease with failure (1). Thus, it is imperative to establish the pattern of renal measurements for a more accurate diagnosis.

In common practice, measurements of renal size of any age are compared with the measurements that are predicted by standard nomograms. However, to our best knowledge, the current nomograms which are widely used locally were derived from studies based on western
population of relatively small sample sizes (5). Therefore, there is an urge to develop our own Malaysian population nomogram to provide a better accuracy of renal measurements in terms of making a proper medical diagnosis and also during monitoring the disease progress. Thus, this research is conducted as a small step in order to formulate a nomogram of renal measurements for Malaysian adult population.

2 Materials and Methods

We analyzed 200 ultrasound images of both left and right kidneys from 100 Universiti Teknologi Malaysia (UTM) Skudai students who took part in this research. There were 50 female students and 50 male students. The data will then analyze using Microsoft Excel software.

Parameters of measurement

Longitudinal length: the maximal longitudinal axes should be evaluated from the ventral side (normal value in an adult, 9-12 cm).

Width: From the ventral ultrasonographic section of the kidney, we can also obtain the width that is almost perpendicular to the longitudinal length.

Thickness: The thickness is measured from the cross section.

From these 3 parameters that can be obtained from the ultrasound images, we can formulate the volume of the kidney by using the following formula:

\[ \text{Volume} = \frac{\text{Thickness} \times \text{Width} \times \text{Length}}{2} \]

This formula is the approximation of the ellipsoid formula. However, the value will be a bit smaller as the normal kidney is bean-shaped and not in real ellipsoid shape. The volume can also be more accurately calculated if we use the average of depth in longitudinal and transverse section as follow:

\[ \text{Kidney volume} = L \times W \times \left\{ \frac{(D1 + D2)}{2} \right\} \times 0.523 \]

3 Results and Analysis

Data that were collected are analyzed and the results are as follow:

![Chart 1: Gender vs. Length (cm)](image1)

![Chart 2: Gender vs. Width (cm)](image2)
Based on Chart 1 to Chart 4, we can see that there is not much difference in the parameters of both genders, even though we can say that renal size in male population is relatively bigger than female population. However, we can conclude that the left kidney is larger than the right kidney independent of gender. The results that we obtained were comparable with the results from the study done by Mario et al. in 2002.

Table 1: Relationship between gender and renal dimensions in individual

<table>
<thead>
<tr>
<th>Renal Dimensions</th>
<th>Male (n=376)</th>
<th>Female (n=249)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Kidney Length (cm)</td>
<td>12.01</td>
<td>11.90</td>
</tr>
<tr>
<td>Right Kidney Width (cm)</td>
<td>11.56</td>
<td>11.59</td>
</tr>
<tr>
<td>Left Kidney Length (cm)</td>
<td>12.67</td>
<td>12.67</td>
</tr>
<tr>
<td>Left Kidney Width (cm)</td>
<td>12.59</td>
<td>12.67</td>
</tr>
</tbody>
</table>

Table 2: Renal dimensions according to body weight

<table>
<thead>
<tr>
<th>Body Weight (kg)</th>
<th>Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right*</td>
</tr>
<tr>
<td>&lt;60: n=216</td>
<td>11.6±0.7</td>
</tr>
<tr>
<td>60-69: n=331</td>
<td>11.9±0.7</td>
</tr>
<tr>
<td>70-79: n=236</td>
<td>12.1±0.7</td>
</tr>
<tr>
<td>&gt;80: n=121</td>
<td>12.5±0.8</td>
</tr>
</tbody>
</table>

Table 3: Renal dimensions according to patient’s height

<table>
<thead>
<tr>
<th>Patient’s Height (m)</th>
<th>Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right*</td>
</tr>
<tr>
<td>&lt;1.55: n=194</td>
<td>11.4±0.6</td>
</tr>
<tr>
<td>1.56-1.65: n=290</td>
<td>11.7±0.6</td>
</tr>
<tr>
<td>1.66-1.75: n=332</td>
<td>12.3±0.7</td>
</tr>
<tr>
<td>1.76-1.85: n=88</td>
<td>12.6±0.5</td>
</tr>
</tbody>
</table>

*p<0.001 according to analysis of variance

Based on Chart 5, we can see that, there is a significant direct positive correlation between renal size and body weight. It shows that the heavier the individual is, the bigger the size of the kidney will be. Similar findings were also reported on several separate studies such as a study done by Mario et al. in 2002 for Brazilian population as shown in Figure 1 to Figure 3. The same goes with the individual’s height (1, 6).
normal size for normal kidney is 10 to 13cm for length of right kidney and 11 to 14cm for length of left kidney. For width, the range is about 6 to 7cm and the thickness is about 3cm.

4 Discussions

Normal renal measurements are an important factor in studying renal function and its disorders. It is also important in making a primary diagnosis as well as during the subsequent follow-up of patients with renal diseases, in order to monitor the diseases’ progress (5). Ultrasound imaging has been a method of choice to evaluate these measurements due to its availability throughout the country. Although, there are some limitations such as variations in terms of observers’ skills and interpretation, variability in patients’ cooperation, position and hydration status, it is still widely used due to its non-invasiveness, reproducibility and accessibility (5).

In the present study, we analyzed renal size in terms of length, width, and thickness which are simple, reproducible, reliable and objective measurements (6). Data that was obtained for both left and right kidney from all the participants of this research agreed with previous studies done that left kidney is larger than the right (6-8). One possible explanation is, due to the size of spleen which is smaller than the liver, thus the left kidney has more space for its growth. Another possible explanation is that because of the left renal artery is shorter and straighter than the right one; this causes increased blood flow in the left artery which may result in relatively increased in volume (12, 13).

The relation between body weight and height to kidney size also equals to other studies that the higher the body weight, the bigger the kidney is. This is independent of gender. The same goes to the height (6, 13). Thus, heavier and taller individuals have longer, wider and thicker kidneys than their lighter counterparts (1). This is most likely due to; the kidneys develop at the same rate as the whole body develops. From the data obtained, we can also conclude that renal size in female population is relatively smaller compared to male population. However, the differences in renal measurements found in this study are quite minimal. As a conclusion, study done by Mario et al. in 2002 and one other study done in Pakistan (10) highlights the necessity of investigating renal dimensions for each population, strengthening that European and American populations’ data cannot be used as universal patterns (6) as it is known that the Westerners are taller and bigger compared to other ethnicities such as Asians. Thus, more studies on this issue should be conducted for each different population so that, in the near future there will be more accurate reference depending on each particular ethnic race.

5 Conclusions

Renal dimension are different for different populations and should be adjusted to weight and height of the individuals. Basically, 2000 images are required to plot the kidney nomogram. Preliminary results have been presented here. The present data shows that weight and height of a person is directly proportional to the all parameters of the kidney measurements. In order to get accurate Malaysian nomogram, it is highly recommended to complete the study on 2000 kidney samples.

6 Acknowledgements

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