

## Correlation between anthropometric parameters and volume, weight and size of normal pancreas, spleen and kidney in adult's autopsies

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### Abstract

**Introduction:** Knowledge about the normal morphometric measurements helps the physician in identifying if the organ is normal or unusual while performing an autopsy. However, the weight of organs probably can be influenced by anthropometric measurements of the individual. The study aims to determine the volume, weight and size of normal pancreas, spleen and kidney and its correlation with anthropometric parameters.

**Materials and Methods:** The study was a retrospective study conducted in the department of anatomy and forensic, Rajiv Gandhi Institute of medical sciences, Ongole, a tertiary care teaching hospital.

**Results:** There was correlation between all the anthropometric measurements and organ morphometric measurements in spleen and pancreas ( $p < 0.05$ ). The volume, weight, length and depth were positively correlated with body weight, BMI, and BSA ( $p < 0.05$ ). The width was positively correlated with weight, height, BSA. ( $p = < 0.05$ ) in Kidney.

**Conclusion:** The anthropometric measurements can be a good proxy for the organ measurements.

**Keywords:** Anthropometry, Organ measurements, Spleen, Kidney, Pancreas.

### Introduction

Abdominal organ weight and its morphometric parameters bear potential significance in detecting the possible organ defects or diseases.<sup>1</sup> Any infection, hematologic or metabolic condition may alter the volume, size and weight of the organ.<sup>2</sup> Different population belonging to different geographic area have varied organ weights.<sup>3</sup> This can be explained by the fact that the genetic constitution of different population varies. Moreover, the dietary habits, daily water intake, climatic condition and customs varies according to population.<sup>4</sup>

Many studies in the past have evaluated the normal range of organ parameters, such as organ size, weight, and volume, in different ethnic groups all over the world. However, only very few studies have evaluated the morphometric sizes of internal body organs. Therefore, it is necessary to know the normal organ size of population and its association with the anthropometric parameters. Hence, this prospective study was undertaken to assess the organ volume, weight and size of disease free pancreas, spleen and kidney and to correlate it with anthropometric parameters.

### Objectives

1. To estimate the volume, weight and size of normal pancreas, spleen and kidney in adults autopsies
2. To assess the correlation between the anthropometric parameters and autopsy findings among the study population

### Materials and Methods

The study was a retrospective study of 90 cadavers, which were autopsied in the department of forensic, Rajiv Gandhi Institute of medical Sciences (RIMS) Ongole, between July

2017 to June 2018, for a period of 1 year. The study population included were cadaveric specimens of adults above 18 years of age of either gender, who underwent autopsy within 6 hours of death in the study setting, during the study period. The autopsy was conducted as per the Ghon's protocol, followed in our institution. As per the protocol, all cadaver's height and weight was measured before performing autopsy. Weight was measured using a manual cadaveric weighing machine, with an ability to record weight to the closest 100 grams. The height was measured as distance between heel and the upper part of the head. All the removed organs were measured by electronic weighing scale with an ability to record weight to the closest 1 gram. Archimedes principle was used to measure the volume by submerging the organs in a scaled measuring bowl filled with water. The average measurements were used for organ measurement. A foldable metal inch tape was used to measure length and width on a surface after marking the farthest points in corresponding direction. BMI was calculated using the formula:  $BMI = W/H^2$ , where W = weight in kilograms (kg) and H = height in meters (m). BSA was calculated using the Mosteller formula:<sup>5</sup>

$$BSA (m^2) = \left[ \frac{\text{height(cm)} \times \text{weight(Kg)}}{3600} \right]^{1/2} \text{ should be expressed as an exponential number.}$$

### Statistical Methods

Pancreas (volume, weight), Spleen measurements (volume, weight, length, width, depth), kidney measurements (volume, weight, length, width, depth) and anthropometric parameters (Height, weight, BMI, BSA) were considered as primary explanatory variables

All the quantitative parameters will be checked for the normal distribution within each category. A Shapiro-Wilk's test ( $p > 0.05$ ) and a visual inspection of their histograms, normal Q-Q plots and box plots showed that the pancreas, spleen, kidney measurements and anthropometric parameters were non-normally distributed.

Descriptive analysis of quantitative variables was carried out by mean and standard deviation for normally distributed variables. For non-normally distributed variables median and inter quartile range were used. Categorical variables were summarized by frequency and proportion.

Spearman's rank correlation coefficient ( $r_s$ ) was used to assess the association between quantitative explanatory and outcome variable. Linear regression analysis was done. Regression coefficient, along with its 95% CI and  $p$  values are presented.

$P$  value  $< 0.05$  was considered statistically significant. IBM SPSS version 22 was used for statistical analysis.<sup>6</sup>

## Results

Autopsy was done on ninety cadavers to assess the organ volume, weight and size of disease-free pancreas, spleen and kidney in the current study.

**Table 1:** Descriptive analysis of baseline parameters in the study population (N= 90)

Parameter	Summary
Age (in years) Median (IQR)	43.50 (35 to 57.75)
<b>Gender</b>	
Male	51 (56.70%)
Female	39(43.30%)
<b>Anthropometric Parameters</b>	
Height (in cm), Median (IQR)	172 (162.25 to 181)
Weight (in kg), Median (IQR)	73.75 (58.97 to 91.17)
BMI (kg/m <sup>2</sup> ), Median (IQR)	25.47 (19.60 to 33.26)
BSA (m <sup>2</sup> ), Median (IQR)	1.85(1.65 to 2.06)

The median age was 43.50 years, range between 35 to 57.75 years. Among the study population male participants were 51 (56.70%) remaining 39 (43.30%) were female. The median height was 172 cm, ranging from 162.50 to 181 cm. The median weight was 73.75 kg, range between 58.97 to 91.17 kg. The median BMI was 25.47 (kg/m<sup>2</sup>), range between 19.60 to 33.26 kg/m<sup>2</sup>. The median value of body surface area (BSA) was 1.85 m<sup>2</sup>, range between 1.65 to 2.06 m<sup>2</sup>. (Table 1)

The measurement such as weight, volume and size of all the organs are represented in median and IQR (Table 3). The median value of the volume of pancreas was 89.5 mL (IQR 65.75 to 106.50) and the weight was 85.50g (IQR 69 to 97.25). The spleen weighed 187.50g (132.75 to 242.75); the length was 11.60 cm (9.75 to 13.57); depth was 3.65cm (IQR 2.40 to 4.7); width was 8 (IQR 7 to 9.20) and the volume was 168mL(IQR: 102.75 to 255). The volume of kidney was 104(91.25 to 167.75); it weighed 112.50g (82 to 188.25); the length was 11cm (9 to 13); depth was 3 cm (IQR 2.75 to 5); width was 5.6 (IQR 5.17 to 6.80)

**Table 2:** Descriptive analysis for organs measurements in the study population (N= 90)

Organs measurements	Median	Inter Quartile Range (IQR)
Pancreas volume (mL)	89.50	65.75 to 106.50
weight (g)	85.50	69 to 97.25
Spleen volume (mL)	168	102.75 to 255
Weight (g)	187.50	132.75 to 242.75
Length (cm)	11.60	9.75 to 13.57
Depth (cm)	3.65	2.40 to 4.7
Width (cm)	8	7 to 9.20
Kidney volume (mL)	104	91.25 to 167.75
weight (g)	112.50	82 to 188.25
Length (cm)	11	9 to 13
Depth (cm)	3	2.75 to 5
Width (cm)	5.6	5.17 to 6.80

**Table 3:** Correlation between Pancreas measurements and anthropometric parameters (N= 90)

Measurements	Weight (kg)	Height (cm)	BMI (kg/m <sup>2</sup> )	BSA (cm <sup>2</sup> )
<b>Pancreas volume (mL)</b>				
Spearman rank correlation coefficient ( $r_s$ )	0.502	0.221	0.363	0.508
P value	<0.001	0.037	<0.001	<0.001
<b>Weight (g)</b>				
Spearman rank correlation coefficient ( $r_s$ )	0.577	0.112	0.468	0.574
P value	<0.001	0.293	<0.001	<0.001

Both pancreatic volume and weight were highly positively correlated with body weight ( $r_s=0.502$ ), BMI ( $r_s=0.363$ ), and BSA ( $r_s=0.568$ ) ( $p < 0.001$ ). A weak positive correlation was found between body height and pancreatic volume ( $r_s=0.221$ ,  $p < 0.05$ ). This suggests that pancreatic weight and volume increases with an increase in one's weight, BMI and BSA.

The Spearman correlations ( $r_s$  values) suggested that a positive correlation exists between volume, weight, length and depth with body weight, BMI, and BSA ( $p < 0.05$ ) (Table 4). A positive correlation was found between width of the kidney with weight, height and body surface area. ( $r_s=0.339$ ,  $r_s=0.303$ ,  $r_s=0.374$  respectively;  $p < 0.05$ )

**Table 4:** Correlation between kidney measurements and anthropometric parameters (N= 90)

Kidney measurements	Weight (kg)	Height (cm)	BMI (kg/m <sup>2</sup> )	BSA (cm <sup>2</sup> )
<b>Kidney volume (mL)</b>				
Spearman rank correlation coefficient (r <sub>s</sub> )	0.510	0.124	0.423	0.488
P value	<0.001	0.245	<0.001	<0.001
<b>Kidney weight (g)</b>				
Spearman rank correlation coefficient (r <sub>s</sub> )	0.609	0.165	0.493	0.608
P value	<0.001	0.121	<0.001	<0.001
<b>Kidney length (cm)</b>				
Spearman rank correlation coefficient (r <sub>s</sub> )	0.321	0.177	0.208	0.345
P value	0.002	0.096	0.04	0.001
<b>Kidney depth (cm)</b>				
Spearman rank correlation coefficient (r <sub>s</sub> )	0.603	0.134	0.505	0.585
P value	<0.001	0.207	<0.001	<0.001
<b>Kidney width (cm)</b>				
Spearman rank correlation coefficient (r <sub>s</sub> )	0.339	0.303	0.157	0.374
P value	0.001	0.004	0.139	<0.001

**Table 5:** Correlation between Spleen measurements and anthropometric parameters (N= 90)

Spleen measurements	Weight (kg)	Height (cm)	BMI (kg/m <sup>2</sup> )	BSA (cm <sup>2</sup> )
<b>Spleen volume (mL)</b>				
Spearman rank correlation coefficient (r <sub>s</sub> )	0.483	0.294	0.320	0.512
P value	<0.001	0.005	0.002	<0.001
<b>Spleen weight (g)</b>				
Spearman rank correlation coefficient (r <sub>s</sub> )	0.470	0.277	0.313	0.493
P value	<0.001	0.008	0.003	<0.001
<b>Spleen length (cm)</b>				
Spearman rank correlation coefficient (r <sub>s</sub> )	0.263	0.330	0.097	0.308
P value	0.012	0.001	0.364	0.003
<b>Spleen depth (cm)</b>				
Spearman rank correlation coefficient (r <sub>s</sub> )	0.368	0.238	0.243	0.395
P value	<0.001	0.024	0.021	<0.001
<b>Spleen width (cm)</b>				
Spearman rank correlation coefficient (r <sub>s</sub> )	0.424	0.222	0.311	0.433
P value	<0.001	0.035	0.003	<0.001

In spleen, there was correlation between all the anthropometric measurements and organ morphometric measurements ( $p < 0.05$ ) except for the length of spleen and BMI.

## Discussion

The volume, weight and thereby size of the organ varies with the disease present at death. The organs differ in size or volume due to these underlying pathological factors.<sup>7</sup> The organs also show racial as well as individual variations.<sup>8</sup> The use of charts from a different population, race or ethnic background is not very definitive in judgment of the pathological or non-pathological organ features. This necessitates us to update the existing reference tables from time to time with the help of appropriate autopsy materials. It is important to have standard reference charts for different organs with regard to the volume, weight, and size of for different populations.<sup>2</sup>

Organ weight may vary based on the anthropometric measurements and may vary from person to person. Therefore, percent body weight should be used to assess organ weight the anthropometric measurements are influenced by various factors. Few to be mentioned are

dietary, environmental, hereditary factors. So, there is also variation in the range of normal organ weight.<sup>9</sup>

In the current study, the median anthropometric measurement was measured. The height was 172 cm; weight was 73.75 kg; BMI was 25.47 kg/m<sup>2</sup> and body surface area was 1.85 m<sup>2</sup>. In a population based study by Shukla H et al<sup>10</sup> (2002) among Indian men, the mean height was 161.0 (SD 6.7) cm, weight was 56.7 (SD 11.0) kg, and BMI was 21.8 (SD 3.8) kg/m<sup>2</sup>. Among women, the mean height was 148.0 (SD 6.2) cm, weight was 49.8 (SD 11.2) kg, and BMI was 22.7 (SD 4.7) kg/m<sup>2</sup>.<sup>10</sup>

## Pancreas

In the present study the median value of the volume of pancreas was 89.5 mL and the weight was 85.50g. This was in accordance to the a study done by Caglar V et al<sup>2</sup> (2014) where the mean volume of pancreas was found to be 88.6 ± 31.5mL and weight was 87.3 ± 30.6 grams. A positive correlation was found between volume and weight of pancreas with body weight, height, volume, BMI, and body

surface area ( $p < 0.05$ ) in the present study. This can be interpreted as pancreatic volume and weight increases in accordance with increase in body weight, BMI and BSA. Similarly, Caglar V et al<sup>2</sup> (2014) reported that the body height, weight, body mass index, and body surface area was positively correlated with pancreatic volume and weight values. Our study finding was also in accordance to Saisho Y et al<sup>11</sup> (2007).

### Spleen

In the present study the spleen of cadavers weighed 187.50g. The volume was 168ml, with length 11.60 cm; depth 3.65cm and width 8 cm. Mubbunu L et al<sup>6</sup> (2018) conducted a study among 114 forensic autopsies from normal Adult Zambians. The spleen weighed weight  $169.9 \pm 107.2$  g and  $161.7 \pm 93.4$  g in males and females respectively. A positive correlation ( $p < 0.05$ ) was found between all the anthropometric measurements with splenic organ morphometric measurements in the current study. However, there was no correlation between length of spleen with body mass index.

The mean spleen length and volume were respectively, 201.3 mL and 209 g in the study by Caglar V et al<sup>12</sup> (2014). Also a positive correlation was reported between splenic organ morphometric measurements (volume and weight) with body height, weight, body mass index and body surface area. Chow KU et al<sup>12</sup> (2015) reported a significant association between splenic length and volume with gender, body height and weight. Spleen volume and weight was positively correlated with body height, weight, BMI, and BSA.

### Kidney

In the current study median weight and volume of the kidney was 112.50g and 104g respectively. The length, depth and width were 11cm, 3 cm and 5.6 cm respectively. A positive correlation was found between body mass index, body surface area, and weight with the volume, weight, length and depth ( $p < 0.05$ ). Similarly, a positive correlation was found between kidney width with cadaver's weight, height and body surface area ( $p = < 0.05$ ). In the study done by Prakash C et al<sup>13</sup> (2013) the mean kidney weight was  $136.65 \pm 62.24$  (R) and  $132.42 \pm 42.67$  (L) grams for males and  $111.91 \pm 32.29$  (R) and  $104.24 \pm 33.79$  (L) grams for females. For both the genders, a positive correlation was found between body weight and kidney weight. In a study by Caglar V et al<sup>2</sup> (2014) kidney volume was  $149.7 \pm 48.1$ , weight was  $150.7 \pm 45.4$ , length was  $11.3 \pm 1.1$ , and depth was  $3.8 \pm 1$  and width was  $6 \pm 0.8$ . The body surface area was better correlated with length and width of kidney. However, depth of the kidney correlated better with body weight.

### Conclusion

The current study established relationship between the morphometric parameters and anthropometric

measurements. Hence, the relationship must be taken into consideration during autopsy.

**Conflict of Interest:** None.

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