Full Length Research Paper

Sonographic measurement of the antero-posterior diameter of the head of the pancreas in normal adult population in Port Harcourt, South-South Nigeria

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Normal values of the antero-posterior diameter of the head of the pancreas are of utmost value in radiological practice. With more than 60% of diseases and tumours of the pancreas occurring in its head, knowledge of its normal size is essential to the clinician. Computed tomography (CT) is the most effective technique for the diagnosis and staging of pancreatic carcinoma and magnetic resonance imaging (MRI) has been used to study the normal pancreas. However ultrasonography remains a reliable, reproducible, safe, and cheap imaging modality for assessing this organ. The aim of this study is to generate sonographic data for the antero-posterior diameter of the head of the pancreas in normal adult population in Port-Harcourt South-South Nigeria. In this study, the antero-posterior diameters of the head of the pancreas of four hundred normal adults were measured. The ultrasound machine used was Aloka 3500(Aloka Inc. Japan 2004), with a 3.5MHz curvilinear probe. For the participants' weight and height, a dual height and weight scale was used. Of the four hundred adult participants, two hundred and seventeen were females and one hundred and eighty three were males. The mean antero-posterior diameter of the head of the pancreas was 2.03 cm +/-0.33 cm. There was a poor linear correlation between the subjects' weight and the pancreatic head diameter(r=0.009), as well as between the height and pancreatic head diameter(r=0.005). Ultrasonography is an affordable, reliable and reproducible means of measuring the antero-posterior diameter of the head of the pancreas and the findings from this study can be used as a reference for disease detection and monitoring.

Keywords: Ultrasound, pancreas, south-south Nigeria.

INTRODUCTION

Accurate determination of the antero-posterior diameter of the head of the pancreas is of utmost significance, as most diseases of this organ occur in its head. Any change in the size of the head can be used to detect and monitor these disease processes. Some of the diseases include pancreatitis, pseudocyst, and neoplasms. Between sixty to seventy per cent of pancreatic tumours occur in the head (Janet Muffin, 2007).

Before 1970, imaging the pancreas was limited to the assessment of its surrounding structures or angiography. With the introduction of sonography in medicine, visualization of the pancreas itself became a reality. (Atri

and Finnegan, 2005)

Plain radiography plays a limited role in the investigation of diseases of the pancreas, except in cases of calcification from chronic pancreatitis.

Computed tomography (CT) with contrast enhancement is the most effective technique for the diagnosis and staging of pancreatic carcinoma (Muffin, 2007). But due to the hazards of radiation and cost, it is not suitable for population studies.

Magnetic resonance imaging (MRI) has also been used to study the normal pancreas. But differentiating bowel loops from pancreas was difficult in subjects with little retroperitoneal fat and also because of motion in the upper abdomen (Stark et al., 1984).

Upper gastrointestinal barium studies are mainly indirect means of detecting pancreatic diseases and not

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for direct assessment.

Ultrasonography is a cheap, non-invasive, non-ionizing, easily available, reliable, and effective means of measuring the diameter of the head of the pancreas. It is reliable in trained hands (Obajimi et al., 2002).

Ultrasound guided percutaneous fine needle aspiration biopsy (PFNA) is for definite diagnosis and differentiating pancreatitis from malignancies.

Normal data for the antero-posterior diameter of the head of the pancreas has not yet been established in the Port-Harcourt, South-South of Nigeria.

Statistics from the medical records of the University of Port Harcourt teaching hospital (U.P.T.H) (Medical records UPTH 2005-2009) show an increase in the number of cases of carcinoma of the head of the pancreas, with one case each, in the years 2005, 2007, 2008, and two cases in the year 2009. This further buttresses the importance of this study in this part of the country.

The study therefore aims to establish a normal data for the diameter of the head of the pancreas in Port Harcourt South-South of Nigeria, and ascertain if there is significant correlation between it and the physical parameters of height and weight of the subjects.

MATERIALS AND METHODS

This was a three-month prospective study (from July to September, 2009) of normal adult population in the University of Port-Harcourt Teaching Hospital, Port-Harcourt, Nigeria. A total of four hundred adults were studied.

Sample size

The sample size of four hundred was obtained with the calculation for quantitative variable for an infinite population, using the formula;

$N = Z^2S^2/D^2$

Where N = Sample size

Z = value corresponding to level of significance = 1.96

S^2 = variance

D = tolerable error (usually 0.05)

Therefore N = 1.96^2 x 0.5^2 / 0.05^2 = 384.16

In order to reduce sampling error, a sample size of 400 was used. Participants recruited were normal adults referred to the department of radiology for medical examination, and volunteers from the University of Port-Harcourt and they are Nigerians from the age of eighteen years and above.

Participants with a past or present history of pancreatico-biliary disorder, diabetes mellitus, or chronic alcohol consumption were excluded.

In the course of scanning, patients whose pancreas showed abnormal echogenicity or with pathologies in contiguous structures, were dropped from the study.

Their heights and weights was measured with a dual weight and height measuring scale, and recorded in a prepared data sheet.

Real time ultrasonography using Aloka 3500(Aloka Inc Japan. 2004) with a multifrequency (3.5-8 MHz) convex transducer, as was used by Nakanishi et al., 1884.

Participants were scanned, after overnight fast. They were asked to come first thing in the morning without breakfast. This reduces interference from bowel gas, as well as maximizing measurement reliability.

Subjects were scanned in the supine oblique position. Using the left lobe of the liver, portal vein, superior mesenteric artery, inferior vena cava, splenic vein, and abdominal aorta as land marks, and with the head of the pancreas in full view, freeze-frame ultrasound capabilities and on-screen callipers were used for the measurement. The maximum antero-posterior diameter was then measured from the inner margins of the superior border to that of the inferior border (figures 1 and 2)

Some subjects were asked to drink about 250 mls of water. This, and change in position helped to overcome difficulties arising from bowel gas (Muffin, 2007). Water in the stomach acted as an acoustic window to visualize the pancreas.

In certain situations, where difficulty in visualizing the pancreas arose, the subjects concerned were scanned in the erect position so that the pancreas which is retroperitoneal remained fixed in position, while the liver and stomach descend, acting as acoustic windows. With this manoeuvre, bowel gas and faecal matter in the transverse colon moved inferiorly, affording better visualization of the pancreas.

Three different measurements and their mean were taken in order to reduce intra-observer error.

RESULTS

The data obtained included the sex distribution of the subjects aged 18 years and above, their weights and heights, and the antero-posterior diameters of the head of pancreas. Class intervals were used for ease of analysis.

Of the four hundred participants, two hundred and seventeen (54.25%) were females and one hundred and eighty three (45.75%) were males.

The greatest cluster of participants had a pancreatic head diameter of between 1.5 cm and 2.49 cm, and were within the age bracket of 18 years and 32 years. Only one participant in the age range 23 to 27 years had a pancreatic diameter greater than 3.59 cm (Table 1).

The weight distribution shows that the highest frequency weight range was 61 kg-70.9 kg, followed by the 71 kg-80.9 kg range. An equal number of participants weighed between 41 kg-50.9 kg, and 91 kg-100 kg respectively (Table 2).
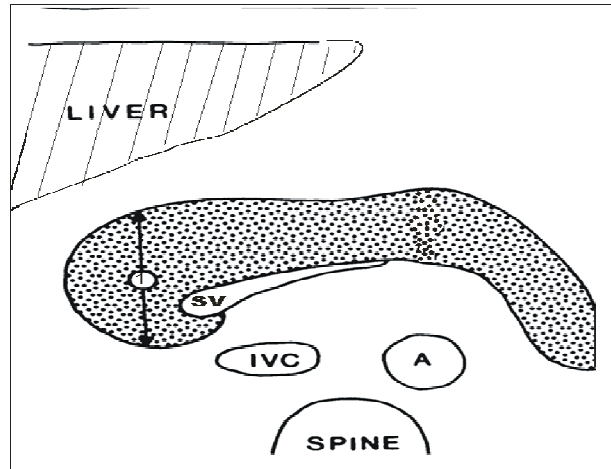
Figure 1. Diagram showing landmarks for measurement of the head of the pancreas. 1=Maximum antero-posterior diameter of the head of the pancreas; SV =Splenic vein; IVC=Inferior vena cava; A= Aorta
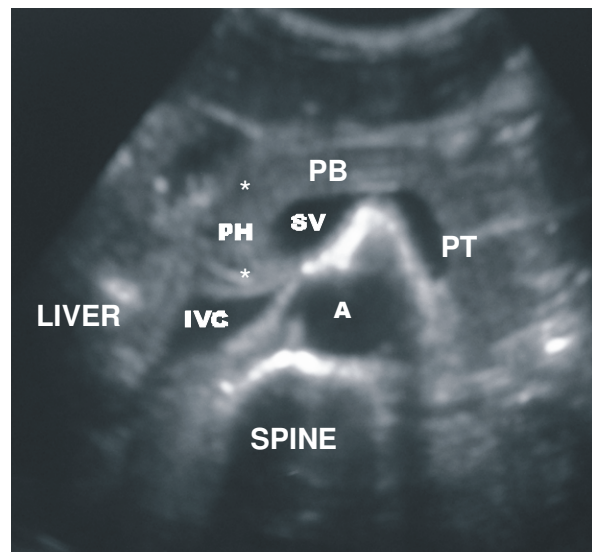
Figure 2.Transverse sonogram showing measurement of the head of the pancreas between callipers.
PH; Pancreatic head. PB; Pancreatic body. PT; Pancreatic tail. SV; Splenic vein. A; Aorta

Table 1. Pancreatic head diameter for various age groups in the study population

PHD(cm)	Age group(years)/Number of participants									Total No. of participants
	18-22	23-27	28-32	33-37	38-42	43-47	48-52	53-57	58-62	
1-1.49	3	0	3	1	1	0	0	0	0	8
1.5-1.99	39	39	56	31	10	0	0	0	0	175
2-2.49	39	28	69	31	5	0	0	0	0	172
2.5-2.99	13	6	12	11	1	0	0	0	1	44
3-3.59	0	1	0	0	0	0	0	0	0	1
Total	94	74	140	74	17	0	0	0	1	400

PHD-Pancreatic head diameter

Table 2. Weight distribution in the study population.

Weight(kg)	Age group(years)/Number of participants									Total no. of participants
	18-22	23-27	28-32	33-37	38-42	43-47	48-52	53-57	58-62	
41-50.9	8	1	5	1	0	0	0	0	0	15
51-60.9	31	24	25	11	2	0	0	0	1	94
61-70.9	33	24	51	20	5	0	0	0	0	133
71-80.9	15	13	41	22	6	0	0	0	0	97
81-90.9	7	8	14	14	3	0	0	0	0	46
91-100	0	4	4	6	1	0	0	0	0	15
Total	94	74	140	74	17	0	0	0	1	400

Table 3. Height distribution in the study population.

Height(m)	Age group (years)/Number of participants									Total no. of participants
	18-22	23-27	28-32	33-37	38-42	43-47	48-52	53-57	58-62	
1-1.49	0	1	0	0	0	0	0	0	0	1
1.5-1.59	19	14	32	8	5	0	0	0	0	78
1.6-1.69	45	32	57	35	6	0	0	0	0	175
1.7-1.79	24	22	41	25	1	0	0	0	1	114
1.8-1.89	6	5	10	6	5	0	0	0	0	32
1.9-1.99	0	0	0	0	0	0	0	0	0	0
Total	94	74	140	74	17	0	0	0	1	400

Table 4. Diameter of the head of the pancreas in the male study population.

PHD (cm)	Age group (years)/Number of participants									Total no. of participants
	18-22	23-27	28-32	33-37	38-42	43-47	48-52	53-57	58-62	
1-1.49	0	0	1	1	0	0	0	0	0	2
1.5-1.99	17	18	23	14	2	0	0	0	0	74
2-2.49	14	12	27	22	2	0	0	0	0	77
2.5-2.99	12	1	7	8	1	0	0	0	1	30
3-3.59	0	0	0	0	0	0	0	0	0	0
Total	43	31	58	45	5	0	0	0	1	183

PHD= Pancreatic head diameter

Table 5. Diameter of the head of the pancreas in the female study population.

PHD(cm)	Age group (years)/Number of participants									Total no. of participants
	18-22	23-27	28-32	33-37	38-42	43-47	48-52	53-57	58-62	
1-1.49	3	0	2	0	1	0	0	0	0	6
1.5-1.99	22	21	33	17	8	0	0	0	0	101
2-2.49	25	16	42	9	3	0	0	0	0	95
2.5-2.99	1	5	5	3	0	0	0	0	0	14
3-3.59	0	1	0	0	0	0	0	0	0	1
Total	51	43	82	29	12	0	0	0	0	217

PHD= Pancreatic head diameter

The heights of almost half of the subjects fell between 1.6 m and 1.79 m. A height of less than 1.5m was recorded in only one person. No participant was taller than 1.89 m (Table 3).

Table 4 shows that one hundred and eighty three males participated, with more than half having pancreatic head diameters of between 1.5 cm and 2.49 cm. No male subject had a diameter greater than 3.59 cm, while only two had diameters less than 2cm. Their mean diameter was 2.02 cm.

The result shows, there were two hundred and seventeen females, and the only participant with a pancreatic head diameter more than 3.59 cm was a female. However their distribution is similar to the male population. Their mean pancreatic head diameter was 2.01 cm (Table 5).

The means and standard deviations are as stated in 6. The mean pancreatic head diameter was 2.03 cm+/-0.03; the participants' height 1.66m+/-0.08cm; and their weights 68.52 kg+/-11.19 kg.

The bar chart (figure 3) shows that more than three-quarter of the subjects had pancreatic head diameters of between 1.5cm and 2.49 cm, and the participants weighed between 51 kg and 90 kg. Only one subject in the 71 kg-80.8 kg weight category had a pancreatic head diameter of 3.59 cm.

The height distribution versus the diameter of the head of the pancreas, is almost a mirror image of the weight versus pancreatic head diameter(figure 4), with the majority in the 1.5cm-2.49cm pancreatic head diameter range, corresponding to the height ranges of 1.5 m-1.59 m;1.6-1.69 m;1.7-1.79 m respectively. The participant with the pancreatic head diameter of 3 cm fell in the 1.6 m-1.69 m range.

The relationship between the antero-posterior diameter of the head of the pancreas, and the subjects' weights and heights, is shown in Tables 6 and 7, as well as the scatter plot graphs (figures 5 and 6).

From table 6, the parameters of the regression line is

$Y = B_0 + B_1X_1 + B_2X_2 + E$;

Where y is the pancreatic head diameter in centimetres
X_1 height in meters
X_2 the weight in kilograms
B_O, B_1, and B_2 are the coefficients, and E the random variation of the regression line.
$B_0 = 1.163$; $B_1 = 0.417$; and $B_2 = 0.003$.
Therefore, the fitted regression line is;
$Y = 1.163 + 0.417(\text{height}) + 0.003(\text{weight})$

This signifies that a unit change in the subjects' height increases the pancreatic head diameter by 0.417 mm, if the weight is assumed constant. Similarly, a unit change in the weight will increase the pancreatic head diameter by 0.003mm if the height is constant.

The above increases are statistically insignificant, indicating a poor linear correlation between the pancreatic head diameter, and the weights and heights of the participants respectively.

This is shown in the correlation table 7, where r=0.005 for pancreatic head diameter versus height, and 0.009 for pancreatic head diameter versus weight. Both values are closer to zero than one, indicating a poor linear correlation.

The scatter plot graphs also show the statistical relationship of the variables height and weight, and the diameter of the head of the pancreas. If extrapolated, the graphs intersect the negative x-axis. The plots in both graphs exhibit a non-uniform and unpredictable pattern/relationship between the parameters.

DISCUSSION

Ultrasonography remains the most readily available and least expensive of the imaging modalities used in assessing the upper abdomen (Kolmannskoy et al., 1982). It is especially very useful in the assessment of the pancreas.

The non-invasive nature of ultrasonography and the fact that it is devoid of radiation, allows for repeated evaluations and monitoring of disease processes of the pancreas. Also, with ultrasound, the surrounding blood vessels are clearly differentiated from the pancreatic tissue. This was corroborated by Kolmannskoy et al (1982) who compared CT with ultrasound in the assessment of the head of the pancreas. They concluded that in non-contrast CT, the pancreatic head diameters were significantly larger than that measured by ultrasonography. This is because the widths of the superior mesenteric and splenic veins were included in the diameter of the pancreas.

The sample selection criteria used in this study is similar to that used by Kolmannskoy et al (1982) in which subjects with a past history or clinical features suggestive of pancreatic disease were excluded.

In order to increase the reliability of measurements, the same timing of Vincenzo et al (1983), was employed, where the subjects were scanned in the morning at about 8am, after an overnight fast. They posited that overnight fast eliminates the difficulties caused by bowel gas in the measurement of the head of the pancreas, as was confirmed in this study. However, no such difficulty was encountered in our study.

With persistence and careful technique, the head of the pancreas was visualized in all the subjects examined in this study. Toh et al (2000) also recorded very high success rates. Den Orth et al (1986) however, recorded much lower success rates than this study and that of Toh et al (2000). In their study, Den Orth et al (1986) stated that the low success rate was due to fatty infiltration which increased the echogenicity of the pancreas, causing poor definition of its borders. Also, the fact that the convex transducer was used in our study, may have accounted for the high success rate. This is corroborated by Nakanishi et al (1984) who concluded that the convex transducer was more successful than the linear transducer in imaging the pancreas.

The participants in this study were neither underweight nor overweight. However, it must be stated that there was no deliberate attempt at excluding these extremes of weight, since one of the objectives of this study was to determine the effect, if any, of the height and weight on the pancreatic head diameter.
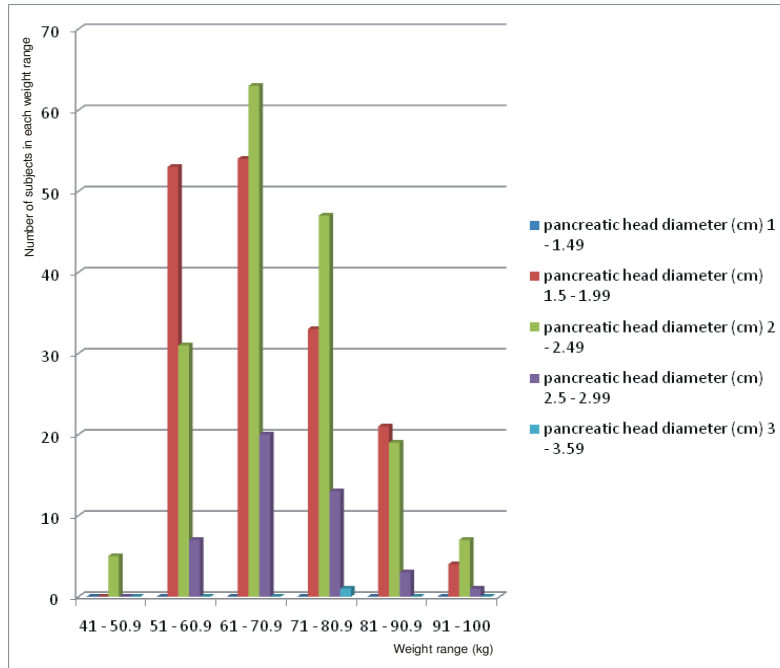
Figure 3. Bar chart showing relationship between subjects' weight and pancreatic head diameter.
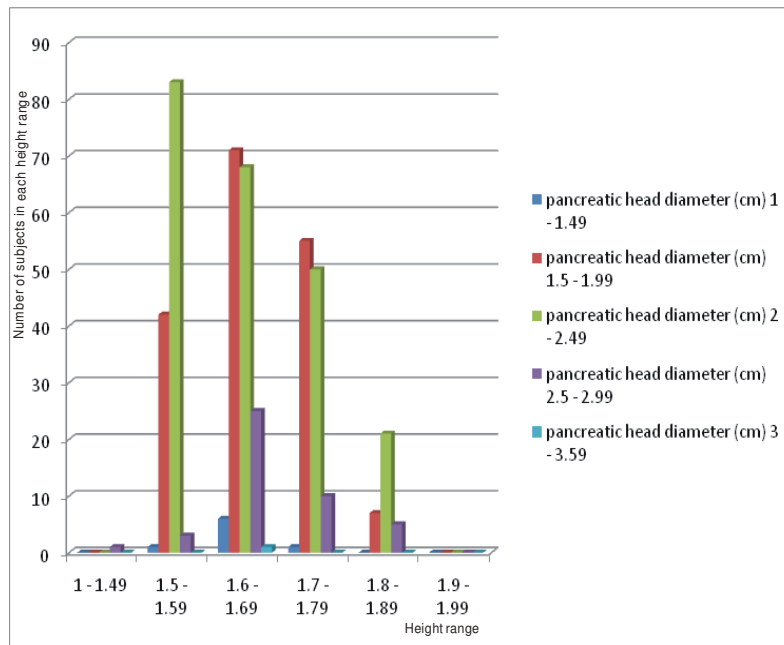
Figure 4. Bar chart showing relationship between subjects' height and pancreatic head diameter.

Table 6. Coefficients

Model	Unstandardized coefficients		Standadardized coefficients		
	B	Std Error	Beta	t	Sig.
Constant	1.163	.342		3.401	.001
HEIGHT	.417	.217	.101	1.924	.005
WEIGHT	.003	.002	.087	1.662	.097

Dependent Variable: PANCREATIC HEAD SIZE

Table 7. Correlations

		Pancreatic Head size	Height	Weight
Pearson Correlation	Pancreatic head size	1.000	.128	.119
	Height	.128	1.000	.319
	Weight	.119	.319	1.000
Sig. (1-tailed)	Pancreatic head size		.005	.009
	Height	.005		.000
	Weight	.009	.000	
N	Pancreatic head size	400	400	400
	Height	400	400	400
	Weight	400	400	400
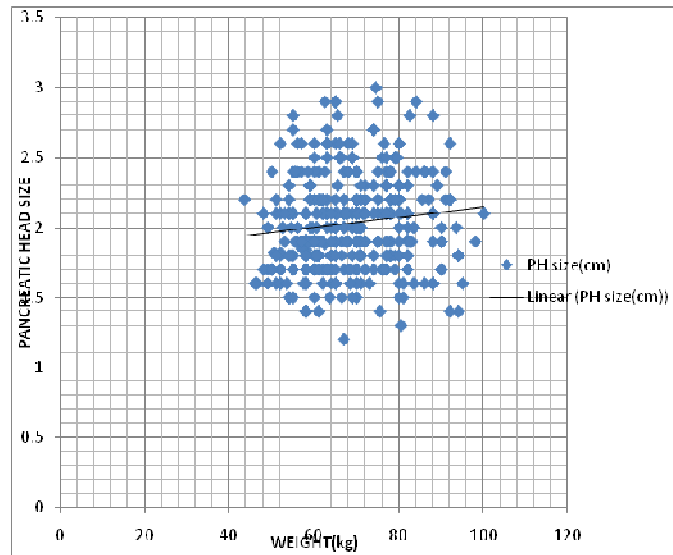
Figure 5. Scatter plot graph of pancreatic head size versus weight
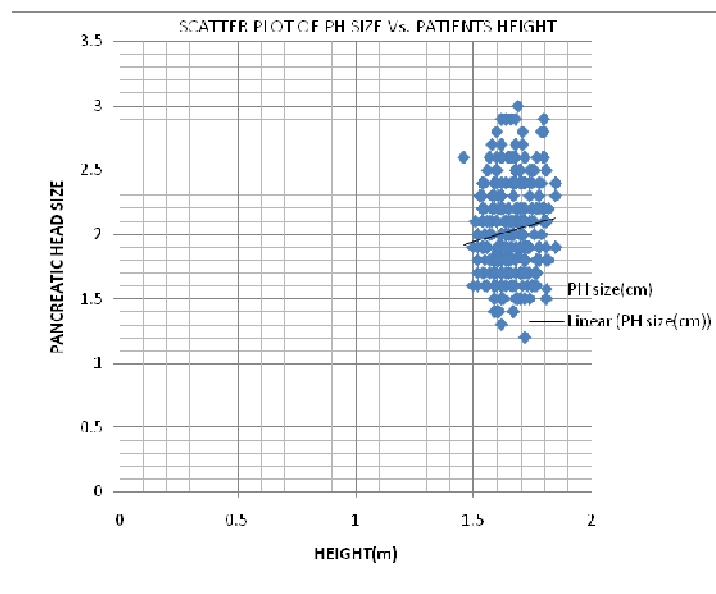
Figure 6. Scatter plot graph of pancreatic head size versus height.

The average height revealed that only a few subjects could be described as either very short or very tall.

The mean antero-posterior diameter of the head of the pancreas measured 2.03 cm+/-0.33 cm.This is in agreement with the study done by de Graaf et al (1978), who had a diameter of 2 cm+/-0.4 cm in their study of 100 sonograms of subjects without pancreatic disease. It also conforms to the works of Zimmerman et al (1981) and Niederau et al (1983), who established the antero-posterior diameter of the pancreas to be 2.41 cm+/-0.41cm and 2.2+/-0.3 cm respectively. Strate et al (2005) considered the head of the pancreas to be enlargedwhen its diameter is greater than 3.5 cm. This present work completely agrees with this study. De Graaf (1978), Zimmerman (1981), and Strate (2005), all utilized the same landmark for measuring the antero-posterior diameter of the head of the pancreas, as used in this study.

Omodele (1996), using the same landmarks, recorded comparatively similar values for the antero-posterior diameter of the head of the pancreas in South-West Nigeria. But no correlation with physical data (height, weight or B.M.I.) was carried out.

The result of this study differs slightly from the measurement by Weill et al (1977), who reported values ranging from 1.1 cm-3.0 cm. However this difference can be ignored, as it is not statistically significant. In addition, the difference is in the region of the lower limit of normal, which is not as important as the upper limit measurement, since most pathologies cause enlargement rather than reduction in pancreatic head diameters.

The mean antero-posterior diameter of the head of the pancreas measured in the female subjects was 2.01 cm, and in males 2.02 cm. This differs markedly from the work done by Pochhammer et al (1984), who measured 5.9cm in females and 6.2 cm in males. In their study, they measured the cranio-caudal diameter but did not state precisely how it was done. This may have accounted for the significantly greater values compared to this study and other works in literature.

This study disagrees with the work of Ulrich et al (2000), who concluded that pancreatic head size correlated with BMI. By this assertion, Ulrich et al (2000) differ from the other works cited in this study. However no reason could be ascribed for this difference.

The study agrees with that done by Weill et al (1977), who concluded that the pancreatic head diameter was not affected by height, weight, or BMI, and also with Claus Niederau et al (1983) who stated that pancreatic diameter correlated poorly with physical data. It also conforms to the work of Zimmerman et al (1981), in which a comparison between normal weight and obese patients showed no significant differences in their pancreatic diameters. All these were prospective studies, and no reasons were adduced for the similarities.

The linear correlation coefficient, regression equation, and scatter plot graphs show the poor linear correlation between the subjects' weights and heights respectively, and the antero-posterior diameters of the heads of the pancreas. This indicates that body weight and height cannot be used to predict the antero-posterior diameter of the head of the pancreas.

CONCLUSION

In this study, the antero-posterior diameter of the pancreas in normal adult population measured 2.0334 cm+/_0.3321 cm. Ultrasonography was found to be a reliable, cheap, accessible, and reproducible tool for assessing the pancreas.

The present study also showed a poor linear correlation between the diameter of the head of the pancreas and the anthropometric parameters of height and weight.

Therefore, sonographic measurement of the head of the pancreas can be used to evaluate the pancreas for disease detection and monitoring.

It is hoped that the normal values obtained in this study would serve as a reference for clinical and research work in this environment.

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