ORIGINAL ARTICLE

Determination of a Normogram for Testicular Volume Measured by Ultrasonography in a Normal Population Boys in Abuja

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ABSTRACT

Background: Reference values are necessary in clinical practice in order to correctly evaluate testicular volume and detect disorders.
Aim: To determine the normogram for testicular volume measured by ultrasound in normal boys aged 1-18years.
Methodology: This was a cross sectional prospective study conducted over a period of twelve months on 400 normal boys aged 1-18years who were attending outpatient care at paediatric department of University of Abuja Teaching Hospital, Abuja. Those who met the inclusion criteria had a testicular scan in the department of radiology. Both testes were scanned using a high resolution 7.5 MHz linear transducer. The length, width, depth were determined and the testicular volume was calculated using the empiric formula of Lambert: length x width x height x 0.71. Ethical clearance was obtained from University of Abuja Teaching Hospital Research and Ethical Committee.
Results: The mean age, height, weight, and Body Mass Index (BMI) were 6.96±4.67years, 1.18±0.29m, 24.79±14.76kg and 15.82±2.63kg/m^2. The mean testicular volume in the study population was 1.93±3.31ml. The right and left mean testicular volume were 2.27±+3.66ml and 2.23±3.61ml, respectively. Testicular volume correlated positively with age, height weight and BMI.
Conclusion: Normative values of testicular volume in boy's age 1-18years using ultrasound have been established. Age, weight and BMI have a significant effect on testicular volume.

Keywords: *Age, Androgen, Body mass index, Height, Length, Testicle, Weight*

INTRODUCTION

The testes are paired oval shaped male reproductive organ located in the scrotum. They descend into the scrotum by 35th to 40th week of gestation where they function optimally at 33^{o}C; a 3-4^{o}C less than core body temperature.[1] The testis has 2 main functions: an endocrine function to produce testosterone responsible for the male secondary sexual characteristics including erection and the exocrine function to produce sperm cells.

Testicular function has a direct correlation with testicular volume, since approximately 98% of testicular volume is made up of seminiferous tubules and germinal cell.[2,3] Therefore, a reduction in the number of these cells due to primary dysplasia or secondary damage is manifested as a reduction in testicular volume.[4,5] In children testicular volume measurement is an important tool for not only diagnosing disease conditions but

also in defining the onset of puberty, its progression and/or any pubertal disorders. It is also used in the evaluation of boys with a variety of disorders affecting testicular growth and development such as varicocele, testicular torsion and undescended testis.[6,7]

Several methods have been used to determine the testicular volume which include orchidometer which is widely used in the clinical practice, water displacement method and ultrasonography.[6,7,8] Overall, ultrasonography provides more accurate volumes than those obtained by orchidometer; also, it is very safe, readily available and affordable.[7,8] One of the well-studied and important parameters that depicts the reproductive capability of the man is the testicular volume. Testicular function has a direct correlation with testicular volume and the diagnosis of androgenic and testicular diseases depends on the ability to elicit minimal changes in the testicular volume.[9]

In clinical practice, the testicular volume can be evaluated by physical examination using the Prader's orchidometer because it is practical and less time consuming than ultrasound although it tends to overestimate testicular volume, especially in small testes, in which the epididymis and the scrotal skin are included in the measurement.[6] There is no consensus on its accuracy and reproducibility. Some studies have shown that orchidometer measurement of testicular volume correlated significantly with ultrasound measurement.[6,10]

There are no referential values for testicular volume ultrasound measurements in children available in our environment. Therefore, the aim of this study was to obtain ultrasonographically measured normative data for testicular volumes in 0 to 18-year old boys.

METHODOLOGY

Study area

The study was carried out at the Radiology Department University of Abuja Teaching Hospital, Gwagwalada FCT Abuja, Nigeria, over a period of twelve months. University of Abuja Teaching Hospital (UATH) is located in Gwagwalada, Gwagwalada Area Council in the Federal Capital Territory of Nigeria; it is a 350 beds hospital and 70 for paediatrics with facility for expansion to 500 beds.

Study Background and Sample Size

$$N = \frac{Z^2 \, p \, q \, (1-p)}{d^2}$$

where

N= Minimum sample size
Z = Standard deviation (constant of 1.96 corresponding to 95^0 confidence interval).
p = Proportion in target population estimated to have a particular characteristics. If no reasonable estimate 50% (0.5) was used.
q =1-p
d=Degree of accuracy desired, set at 5%
Therefore, n = 1.96^2 x 0.5 x 0.5 / 0.05^2
= 384.16

A total of 400 boys were however recruited for this study.

This hospital-based cross-sectional prospective study was carried out over a period of twelve months on 400 normal healthy boys recruited from the pediatric outpatient department of University of Abuja Teaching Hospital, with two descended testes at the time of the examination and who are not symptomatic for testicular and scrotal disorders. Patients excluded from the study include boys with undescended testes, retractile testes, hydrocoele, varicocoele, testicular torsion, epididymitis, history of trauma, urogenital surgery as well as boys who suffered from syndromes, growth disorders or other conditions that could influence testis growth such as Klinefelter's syndrome, hypopituitarism, chronic disease like malnutrition and sickle cell disease, those with abnormal testicular findings detected on ultrasound and those who did not give their consent. Informed consent was obtained from

the parents and guardians. Brief history and physical examination was obtained. The height and weight of all the boys were measured while they were wearing only underwear. The height was measured with a stadiometer which was routinely used at the outpatient clinic and the weight was determined with calibrated balance scales. The height and weight measurements were performed by the same physician.

Ultrasound Technique

The testicular scans were performed after an informed consent was obtained from the parents/guardians. The subjects were scanned in supine position on the couch. The scrotum was supported by a rolled towel placed below the scrotum to stabilize the testes and coupling gel was applied generously to minimize surrounding air interference. The testes were further stabilized by placing a finger on the median raphe of the scrotal skin before gently scanning to avoid distortion of its shape and dimension. Using EMP G70 ultrasound machine manufactured by Shenzhen Emperor Electronic Technology^R, China 2011 with high resolution 7.5MHz linear probe, images of the testes were acquired in the longitudinal and transverse planes with the patient in supine position following physical examination of the testes.

The testicular length and height were measured in the longitudinal view while the width was measured in the transverse view; first the right then the left using the mediastinum testes as land marks (figure 1). The epididymis was not included in the measurement. The testicular volume was calculated using the empiric formula of Lambert: *length x width x height 0.71.* Two separate volumes were obtained for each testis and the mean was recorded. All the scans were performed by a consultant radiologist to reduce inter-observer errors.

Data Analysis

Statistical analysis was done using the Statistical Package for Social Sciences (SPSS) version 19.0. Simple frequencies were determined for the age, while descriptive statistics were used for the testicular volume measurements. The paired sample *t*-test was used for evaluating the significance of testicular volumes, while the correlation was determined using the Pearson correlation coefficient. A *p-value* below 0.05 was considered significant.

RESULTS

A total of four hundred consecutive boys were studied with mean age of 6.96±4.67years (range 1-18years). The mean height was 1.18±0.29m with a range of 0.71-1.77m while the mean body weight was 24.79±14.76kg with range of 8.4-66kg. The mean body mass index was (BMI) was 15.82±2.63kg/m^2 with a range of 9.94-25.78kg/m^2 (Table 1).

Table 1. Descriptive statistics of anthropometric parameters and testicular dimensions

Variables	Mean	SD	Range
Age (years)	6.96	4.68	1 – 17
Height (m)	1.18	0.29	0.71 – 1.77
Weight (kg)	24.79	14.76	8.4 - 66.0
BMI (kg/m^2)	15.82	2.63	9.94 - 25.78
RTL (cm)	1.51	0.66	0.82 – 3.60
RTW (cm)	0.95	0.52	0.36 – 3.45
RTH (cm)	1.14	0.52	0.42 – 2.79
LTL (cm)	1.50	0.68	0.54 – 3.86
LTW (cm)	0.93	0.49	0.44 – 2.82
LTH (cm)	1.15	0.54	0.42 – 2.83
LTV (ml)	2.25	3.61	0.18 – 20.30
RTV (ml)	2.27	3.66	0.16 – 23.07
MTV (ml)	1.93	3.32	0.21 – 21.69

RTL=right testicular length;
RTW=right testicular width;
RTH=right testicular height;
RTV=right testicular volume.
LTL=left testicular length;
LTW=left testicular width;
LTH= left testicular height;
LTV= left testicular volume.

The overall mean testicular volume was 1.93±3.32ml (range 0.21-21.69ml) as shown in table 1.

The mean length, width, and height of the right testicle were 1.51±0.66cm, 0.95±0.52cm and 1.14±0.52cm respectively; measurements for the left testicle were 1.50±0.68cm, 0.93±0.49cm and 1.15±0.54cm, respectively.

The mean length and width of the right testicle was higher than left as shown in table 2. The mean testicular volume was 2.27±3.66ml (range 0.16-23.07ml) for the right and 2.25±3.61ml (range 0.18-20.30ml) for the left. The mean testicular volume on the right was higher than the left. This was statistically significant *p= 0.00* (Table 2).

Table 2. Testicular dimensions and side differences

Dimensions	Right testis	Left testis	P-value
Length (cm)	1.51 ± 0.66	1.50 ± 0.68	0.000
Width (cm)	0.95 ± 0.52	0.93 ±0.49	0.000
Height (cm)	1.14 ± 0.52	1.15 ± 0.54	0.13
Volume (ml)	2.27 ± 3.66	2.25 ± 3.61	0.000

There was significant association between age and mean testicular volume (*p=0.000*, r= 0.698,) Mean testicular volume, correlated positively with weight and height. This was statistically significant. (Weight; *p=0.000*, Pearson correlation 0.692, height; *p=0.000*; Pearson correlation 0.679) (Table 4).

Table 4. Pearson's correlation between Testicular Volume with age, length, weight and BMI

Parameter	Testicular Volume	
	Pearson's correlation	P – Value
Age	0.698	0.000
Height	0.679	0.000
Weight	0.692	0.000
BMI	0.379	0.000

A total of ninety–three boys scanned were within the age group 1-2 years (23.2%) account for the majority while four boys representing 1% were in the 17-18 years age group. This distribution was statistically significant *p=0.00, see Table 3*.

The mean testicular volume for boys at 1-2year age group was 0.45±0.21ml, 0.57±0.27 at 3-4year age group, 0.54±0.27ml at 5-6year age group, and 0.83±0.36ml at 9-10year age group with a rapid increase from age group 11-12years (2.68±2.56ml) to 17-18year age group (12.57±3.3ml) (Table 3). There was a progressive increase in testicular volume from 7-8year age group to 17-18year age group. There was a difference between the mean testicular volume in each age group, this was statistically significant (*p=0.05*)

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Body Mass Index (BMI) correlated positively with testicular volume. This was statistical significant too (*p=0.000*; Pearson correlation=0.379).

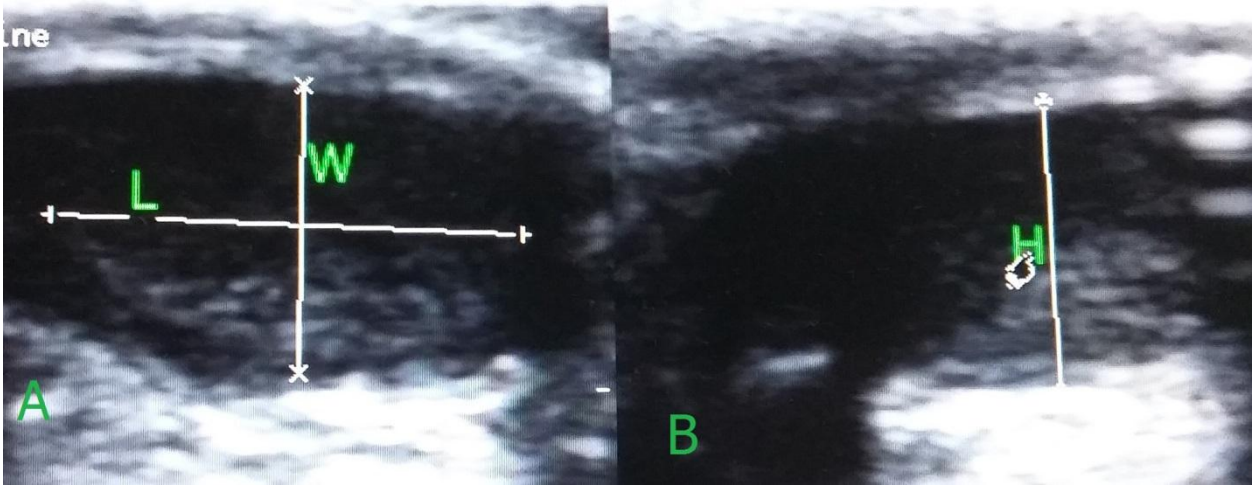
Right and left testicular volume correlated positively with age, height and weight. However, age and weight showed strong correlation with testicular volume in simple linear regression. This was statistically significant (coefficient of significance= 0.391 *p=0.000* for age; coefficient of significance 0.384, *p= 0.005* for weight) while height and BMI showed weak correlation with testicular volume (coefficient of significance =-0.011, *p= 0.870* for height and for BMI coefficient of significance =-0.019, *p=0.876*). This was however not statistically significant.

Table 3. Age with mean height, weight, BMI and testicular volume

Age	Freq (%)	Mean Height	Mean Weight	Mean BMI	RTV (ml)	LTV (ml)	Mean TV (ml)
1-2	93 (23.2)	0.84±0.09	19.81±14.20	15.5±1.9	1.4±2.1	1.3±2.0	0.45±0.21
3-4	70 (17.5)	0.98±0.09	19.48±11.69	14.7±2.4	1.5±3.3	1.4±3.1	0.57±0.27
5-6	45 (11.2)	1.10±0.12	22.73±13.33	13.6±4.5	1.9±4.0	1.8±3.8	0.54±0.27
7-8	36 (9.0)	1.22±0.03	24.49±10.60	14.5±0.8	1.8±2.8	1.9±3.4	0.83±0.36
9-10	46 (11.5)	1.36±0.96	27.69±12.69	15.5±2.1	2.3±3.4	2.4±3.7	0.87±0.52
11-12	49 (12.2)	1.46±0.11	29.50±13.60	16.3±3.1	2.6±3.7	2.5±3.4	2.68±2.56
13-14	27 (6.7)	1.52±0.06	29.83±17.93	19.1±3.5	2.7±2.3	2.8±2.5	4.47±1.99
15-16	30 (7.5)	1.66±0.06	38.09±16.70	17.8±2.1	6.5±6.3	6.3±5.9	10.47±5.6
17-18	4 (1.0)	1.73±0.00	34.85±27.89	19.7±0.0	13.9±3.6	11.2±3.6	12.57±3.3

RVT= right testicular volume LVT=left testicular volume TV= testicular volume

Figure 1. Longitudinal view (A) and transverse view (B) of a testis showing measurement of length, width and height



DISCUSSION

The empiric formula of Lambert; *length x width x height x 0.71* was used in calculating the testicular volume in this study. This formula has been proven to give the most accurate estimation of testicular volume on ultrasound and gives smallest mean difference from the actual testicular volume when compared to other formulae. In this study the mean testicular volume was 1.93±3.32ml. The mean right and left testicular volumes were 2.27±3.66ml and 2.25±3.61ml respectively. The mean testicular volume, right and left testicular volumes reported in this study were lower than the values obtained by Geode, *et al*. in a study in Netherlands using ultrasound to determine normal testicular volume in boys of age 1-18years (mean testicular volume=2.85ml; mean right testicular volume=285ml; mean left testicular volume 2.80ml) but higher than values obtained by Lawal *et al.* in Zaria, Nigeria where testicular volume in 450 boys aged 0-15years was determined by ultrasound (mean testicular volume =1.28ml; right testicular volume =1.43ml left testicular volume 1.26ml).[6,11] The differences in the mean testicular volumes may due to genetic, demographic, nutritional and environmental factors which have been shown to influence testicular volume.[11,12] The observed higher values in this study compared to values in Zaria may also be due to differences in the type of patients recruited. Infants (0-

12months) were included in the study in Zaria.

There was statistical significant difference between the right and left testicular volumes, with right larger than the left in this study. Similar findings were obtained in by Geode, and in a study by Kiridi where ultrasound was used to determine normal testicular volume in healthy adults.[6,9] However, this was contrary to the findings by Lawal and another study in Ibadan using ultrasound to determine testicular volume in neonates. [11,14] The slight differences between the left and right testicular volume may be explained by the fact that the pampiniform plexus of veins are more prominent on the left due to sluggish drainage of the left testicular vein into the left renal vein which may lead to increase in temperature on the left and hence decreased Sertoli cell proliferation.[9, 14]

There was a progressive increase in testicular volume from 7-8years age group to 17-18years age group, however testicular volume fluctuates before 6years old. In a study by Kuijper, there was progressive increase in testicular volume in the first 5months of life after which the testicular volume starts to decrease till 9months and remain relatively constant till the age of six years.[7] Kipper attributed this observation to the so called 'mini-puberty' due to rapid rise in gonadotrophic hormones at 3-4months when the inhibitory effect from the placental hormones disappears after delivery. The testicular volume begins to decline after this age due to absence of hormonal stimulation of the hypothalamic-pituitary–testicular axis by Follicle Stimulating Hormone (FSH) and Leutinizing Hormone (LH) and remains quiescent until puberty. The observed non progressive increase in testicular volume before age six in this study may be due to absence of hormonal stimulation of the hypothalamic-pituitary–testicular axis. The increase in testicular volume with age could be due to the fact that most organs tend to increase in size during the active growth phase.

Marked increase in testicular volume was seen at 11-12years age group which marks the age of onset of puberty. Similar age of onset of marked testicular volume was also reported in other studies.[6,11,15]

Traditionally it has been thought that the growth of the genitalia continues with increasing height and body weight, but there is no consensus about the relationship between testicular volume and body size or nutritional state. In a post mortem study, the mean testicular volume correlated with height and nutritional state.[16] In this study there was a strong positive correlation between weight, mean testicular volume, and both right and left testicular volumes. Similar finding were also obtained in young adults in Sinhalese and Ibadan.[13,17]

There was statistical significant correlation between height and mean testicular volume, right and left testicular volumes. However the strength of the correlation was weak in linear regression. This finding was also obtained in young adults in Sinhalese.[17] BMI correlated positively with testicular volume. This was also observed in other studies.[11,12] Simple linear regression showed weak correlation between BMI and mean testicular volume. The same observation was also made in other studies.[13,17]

CONCLUSION

We have established normal testicular volume in boys aged 1-18years using ultrasound. This can be used as baseline values by the clinician in management of testicular abnormalities in our environment. Age, weight, height and BMI have a significant effect on testicular volume.

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