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Original article

Assessment of testicular volume: A comparison of fertile and sub-fertile West African men



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KEYWORDS

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Abstract

Background: While the semen analysis appears to be the cornerstone in the evaluation of testicular function, the testicular volume has long been associated with testicular function. However, racial variations in testicular volume do exist. Neither the critical minimum testicular volume that guarantees adequate function, nor the optimal testicular volume that indicates peak testicular function are also known.

Objective: To evaluate the relationship between testicular volume and function using scrotal ultrasound scan in black West African men.

Patients and methods: The study examined 236 subjects over a period of one year. The subjects comprised of 136 patients with diagnosis of male infertility, as well as 100 healthy individuals as control. The relevant clinical history of each patient was extracted from their case notes. All the subjects had their testes examined using a high frequency (7.5 MHz) linear transducer of an ultrasound scanner. The results were expressed as percentages and tests of significance were done using the chi-square and Student's *t*-test. A *P*-value < 0.05 was considered statistically significant.

Results: The mean testicular volume for the sub-fertile patients was 15.32 ml while it was 19.89 ml in the control group. There was a statistically significant difference between the testicular volumes in fertile and

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infertile men at different age groups, while there was an inverse relationship between testicular volume and severity of oligospermia. This was, however, not directly linear as a mean testicular volume of 18–20 ml was associated with highest semen density. Volumes higher than 20 ml and lower than 18 ml were associated with reduced sperm density. There was also a sharp decline in sperm density when the mean testicular volume reduced from 14 ml to 13 ml. Severe oligospermia (<5 million/ml) was associated with mean testicular volume less than 12 ml.

Conclusion: Testicular volume on scrotal ultrasound correlates well with severity of oligospermia in men with sub-fertility. While the critical mean testicular volume necessary for adequate spermatogenesis has not been determined, it appears there is an optimal testicular volume of 18–20 ml at which spermatogenesis is at its peak in sub-fertile Nigerian men.

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Introduction

Male infertility refers to the inability of a male to achieve a pregnancy in a fertile female [1]. Male infertility is commonly due to deficiencies in the semen quality.

The male factor plays a role in approximately 50% of infertility cases [1,2]. The testes are the central organs for male fertility. Traditional evaluation of testicular function has included clinical evaluation, semen fluid analysis (SFA), vasography, scrotal ultrasonography (scrotal US) and testicular biopsy [2]. However, unlike vasography and testicular biopsy, scrotal US is non-invasive with no risk to either the patient or physician. Scrotal US has since become the primary imaging modality in the evaluation of testicular function [2–5].

Scrotal US is used to evaluate testicular size and location in addition to detection of subclinical varicocele, which have been reported to be associated with testicular atrophy [6]. Assessment of testicular volume is also important as atypical dimensions have been reported to be present in as many as 64% of men with infertility [7].

Effective assessment of testicular size and atrophy in adolescents is done by comparing the differences in sizes between testicles on scrotal US [8]. Serial testicular volume assessment using scrotal US is also an effective means to assess improvement after varicocelectomy [8].

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. The Leydig cells are responsible for the former while the seminiferous tubules which constitute over 80% of testicular size are responsible for the later [3]. As a result an impotent man is more likely to have normal sized testes when compared with an infertile man.

While the semen analysis appears to be the cornerstone in the evaluation of testicular function, the testicular volume has long been associated with testicular function. However, racial variations in testicular volume do exist. The critical minimum testicular volume that guarantees adequate function is also yet to be clearly defined. This is a prospective study that evaluated the relationship between testicular volume and function using scrotal US in black West African men.

The objectives of this study were to determine and compare the mean testicular volume in fertile and sub-fertile Nigerian men and

to assess the relationship between testicular volume and testicular function in sub-fertile Nigerian men.

Subjects and methods

The study was conducted at our centre, a tertiary medical institution located in an urban and cosmopolitan area in Nigeria.

The study was done over a period of one year (December 2009–November 2010) in which 136 patients diagnosed with male infertility were studied. Main inclusion criterion for the subjects was a history of infertility of at least 2 years duration and at least 2 consecutive SFA showing a sperm density less than 20 million/ml of semen [9].

One hundred subjects with apparently normal fertility were recruited from among the hospital patients with unrelated problems for comparison. The main inclusion criteria for the fertile subjects were the absence of any history of fertility challenge and history of impregnation of sexual partner within the last 2 years. Eleven of them also had an SFA available (which were normal) while in 89 it was based on history alone.

Approval for the study was granted by the hospital research and ethics board, and the informed consent was taken from all subjects.

Assessment of testicular volume

Aloka Prosound SDD-3500 Plus, Japan 2005 scan machine with high resolution (7.5 MHz) was used. Images with B mode USS were acquired in the longitudinal and transverse planes. The testicular length was measured on the longitudinal view while the antero-posterior (AP) and transverse diameters were measured on the transverse view. All the scans were performed by the radiologist (OBO).

Testicular volume was then calculated manually using the formula:

– length × AP diameter × transverse diameter × 0.71 [8].

Semen collection and assessment

The semen was collected after a 3–4 days abstinence by masturbation, processed and analyzed using the 1999 WHO criteria.

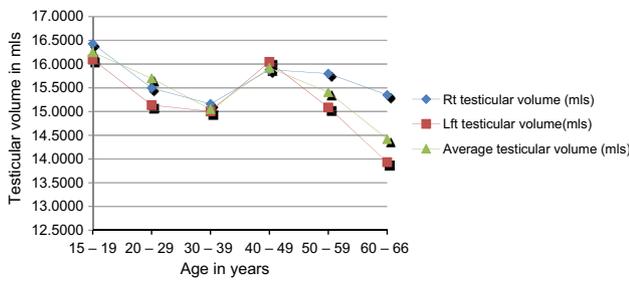


Figure 1 Testicular volume and age in the sub-fertile group.

Data analysis

The results were expressed as percentages and tests of significance were done using the chi-square and Student’s *t*-test. A *P*-value of less than 0.05 was considered statistically significant.

Results

A total of 236 men were prospectively evaluated between December 2009 and November 2010. They were made up of 136 infertile men comprising of 132 oligospermic and 4 azoospermic men as well as 100 fertile men.

The age range of the sub-fertile men was 16–64 years with a mean of 36.8 ± 7.2 years while it was 15–69 years (mean 38.1 ± 5.8) for the fertile men.

There was no statistically significant difference between the age distributions of the 2 groups.

The relationship between the age and testicular volume for the sub-fertile is summarized in Fig. 1. There was a decline in the mean testicular volume as the age increased on both sides ($P = 0.28$). The mean testicular volumes were 15.85 ml and 15.23 ml on the right and the left, respectively ($P = 0.064$). The cumulative average testicular volume for both sides was 15.3 ± 3.1 ml.

The relationship between the age and testicular volume for the fertile group is summarized in Fig. 2. There was a decline in the mean testicular volume as the age increased ($P = 0.23$).

In the fertile group, the mean testicular volumes were 19.84 ml and 19.69 ml on the right and the left, respectively ($P = 0.77$). The cumulative average testicular volume for both sides was 19.9 ± 3.8 ml. The comparison of the average testicular volumes of the infertile and fertile men is summarized in Fig. 3. The mean testicular volume was generally higher for each age group when compared to the infertile group ($P < 0.05$).

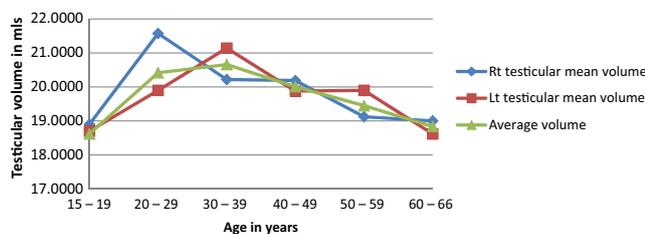


Figure 2 Testicular volume and age in the fertile group.

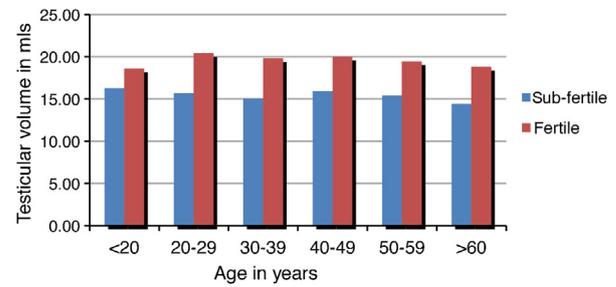


Figure 3 Comparison of average testicular volumes in sub-fertile and fertile.

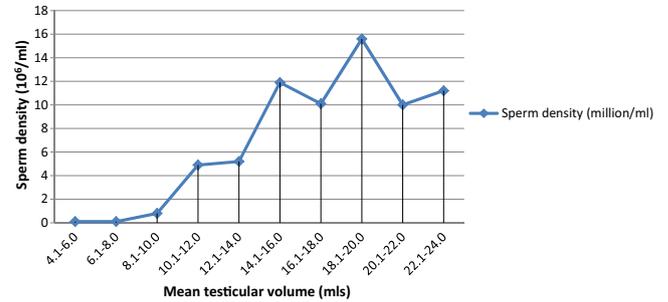


Figure 4 Sperm density and testicular volume in the sub-fertile group.

The comparison between the age-specific mean testicular volume of the fertile and sub-fertile group and their respective *P*-values are summarized in Table 1. There was a statistically significant difference between the testicular volume of the fertile and sub-fertile in all age groups 20 years and above.

The relationship between the mean testicular volume and the sperm density in the sub-fertile group is summarized in Fig. 4. Testicular volume correlated with sperm density ($P < 0.05$). Mean testicular volume of 18–20 ml was associated with peak sperm density, while severe oligospermia (< 5 million/ml) was associated with testicular volume of 12 ml or less.

Discussion

Evaluation of the semen is the primary investigative tool in the assessment of male fertility. Over the last few decades, there have been reports to suggest decreased human semen quality (defined as sperm density) in the general population [10] while scrotal US has also become the primary imaging modality in the evaluation of men with reduced semen quality [3,5,10–12]. The accuracy of

Table 1 Comparison of age–testicular volume in the fertile and sub-fertile subjects.

Age group (years)	Mean testicular volume (ml)		<i>P</i> -value
	Subjects	Control	
<20	16.25	18.61	>0.05
20–29	15.70	20.42	<0.05
30–39	15.05	19.82	<0.05
40–49	15.92	20.00	<0.05
50–59	15.41	19.45	<0.05
>60	14.42	18.80	<0.05

ultrasonography is within 10% of the actual volume and is better than physical examination in detecting testicular asymmetry [11,12].

In this study, most of the subjects and controls were in the 30–39 years age group. This is to be expected since patients in the reproductive age group are the ones that tend to present to the fertility clinic.

The average testicular volume in the control group was 19.89 ml. This is consistent with studies by others which have reported a volume of approximately 20 ml for Caucasians and blacks with Asians reported as having slightly smaller testes [3,12]. This was significantly higher than the average testicular volume in the sub-fertile group of 15.32 ml. This is consistent with the reports of other authors that have documented lower testicular volumes in men with infertility and oligospermia [3,5,11,12], as the seminiferous tubules responsible for spermatogenesis constitute about 80% of testicular volume. The relationship between the age and the average testicular volume was not statistically significant in the both groups. The peak testicular volume in the control group was in the 3rd decade while it was in the 2nd decade in the sub-fertile group. This is consistent with reports that have suggested that men are at peak fertility between the 2nd and 3rd decades [13]. Beyond 50 years serum testosterone and spermatogenesis reduce with time [3,13]. In the sub-fertile group the testicular volume was smallest in patients above 60 years of age while in the control it was in patients below 20 years. For all age groups the mean testicular volume was higher in the control. This was statistically significant in all age groups except the age group <20 years. Possible explanations for these findings may include the possibility of progression with age of the primary disease responsible for the impaired spermatogenesis. For example the deleterious effect of varicoceles on testicular volume and spermatogenesis are known to get worse with time [3,14,15].

In both the subjects and controls, the overall average left testicular volume was less than the right. Others have reported similar findings [16]. Despite not statistically significant, there was a more noticeable difference between the right and left testicular volume in the sub-fertile patients ($P=0.06$) when compared with the control (0.77). Possible explanation for this may be the reported higher incidence of left sided varicoceles in men with sub-fertility [2,3,14,15].

As expected the testicular volume was an indicator of severity of infertility with a statistically significant relationship between the testicular volume and the sperm density. Even though the lowest volumes corresponded to the lowest sperm density, the relationship was however not directly linear as the sperm density appeared to deteriorate with MTV above 20 ml. It does appear that there may be an optimal testicular volume (OTV) above and below which testicular function deteriorates. While the quality of testicular function is not determined by the testicular volume alone, the implications of these findings are unclear. Other workers have tried to exclude patients with pathologies thought to affect spermatogenesis from their study [16,17]. We however feel that this is practically impossible as not all the factors affecting testicular function are known. An MTV change from 16 to 14 ml was associated with a sharp reduction in sperm density from 11 million to 5.2 million/ml. In this study severe oligospermia (<5 million/ml) was associated with MTV of 12 ml or less. The minimum testicular volume necessary for adequate spermatogenesis is also yet to be determined. Using the punched-out orchidometer, others have reported a critical MTV of 14 ml as the minimum for adequate spermatogenesis and

a critical total testicular volume (TTV) of 30 ml as the minimum for normal testicular function. However, orchidometers are known to overestimate testicular size especially the smaller testes [16,17]. Sikamoto in Japan in an assessment of 397 infertile patients using USS reported that patients with TTV of 20 ml (or mean 10 ml) or more had normal sperm parameters [17]. They also reported a TTV below 15 ml (MTV – 7.5 ml) as indicative of severe oligospermia (< 5×10^6 ml⁻¹). It was, however, difficult to compare their findings with ours as their definition of infertility was not clear as some of their patients had normal sperm density. The study also had no control subjects and also excluded all patients with history suggestive of pathologies that could affect semen parameters (excluding varicocele). Racial differences may also account for the conflicting results as blacks are known to have bigger testes than Asians [2]. More recently, Condorelli also found reduced semen parameters in patients with MTV of less than 12 ml [18]. It was however a retrospective study and the fertility status of the patients were not clearly defined as the average sperm density in these patients with MTV less than 12 ml was still 28×10^6 ml⁻¹.

This study had some limitations. While a minimum of 2-year history of infertility and sperm density <20 million/ml were the main inclusion criterion for the sub-fertile patients, fertility was only assumed in most of the control group based on the history alone thereby, making accurate comparison of volume and degree of spermatogenesis between the 2 groups impossible. In our environment, due to cultural beliefs, convincing male patients with fertility challenges to perform an SFA can be very challenging, while to convince a volunteer with no fertility challenge is almost impossible. Thus, the relevance of the OTV in normal and sub-fertile men and the critical MTV necessary for normal sperm density remain undetermined.

Conclusion

In this study, even though the testicular volume on Scrotal US correlated well with sperm density, a higher testicular volume did not necessarily mean a better sperm density. There, however, appears to be an optimal testicular volume (OTV) of 18–20 ml as sperm density appears to be at its peak at this volume in the sub-fertile Nigerian men. Testicular volumes less than 18 ml and higher than 20 ml were both associated with less sperm density. Both the MTV necessary for adequate spermatogenesis and the exact clinical relevance of the OTV are yet to be determined. Large population studies are needed. Overcoming the ethical and cultural challenges of doing SFA in apparently normal volunteers in our environment will go a long way in answering some of these questions.

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