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Research Article

ROLE OF COLOR DOPPLER ULTRASONOGRAPHIC PARAMETER AS A PREDICTOR OF SPERMATOGENESIS AND INFERTILITY

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ABSTRACT

Objective: Androgens target the testicular arteries, which may be aberrant in men who are infertile. One of the fastest and most accurate ways to measure testicular blood flow is by color Doppler ultrasonography (CDUS), which combines anatomical and velocity data. The goal of this research is to determine whether testicular artery end-diastolic velocity (EDV), peak systolic velocity (PSV), and resistive index (RI) can be used to differentiate between various types of dyspermia.

Methods: This was a prospective observational study. In total, 90 patients were enrolled in the study which includes 27 patients with nonobstructive azoospermia (NOA), 19 patients with oligospermia (OL), 24 with obstructive azoospermia (OA), and 20 in the control group having normal sperm count and recent paternity. We compared variables such as EDV, PSV, RI, bilateral testicular volume, testosterone, and follicle-stimulating hormone among different dyspermic groups with the control group.

Results: The mean age of the study participants was 31.5 years. PSV and RI in the NOA and OL groups were significantly lower compared to the control groups while the OA group was comparable with the control group. With respect to EDV, we observed a significantly lower value only in the NOA group compared to the control group. Significantly lower mean testicular volume and higher follicle-stimulating hormone levels were observed in the NOA group.

Conclusion: Investigating male infertility can be challenging, but CDUS might be very helpful. When used routinely in clinical settings, the RI and PSV can be trustworthy markers for identifying infertility or dyspermic males, especially distinguishing between obstructive and unobstructive azoospermia.

Keywords: color Doppler , spermatogenesis , infertility

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INTRODUCTION

Mature and functional testis must have a consistent blood supply. Combining anatomical and velocity data, color Doppler ultrasonography (CDUS) is one of the fastest and most accurate ways to measure testicular blood flow. Doppler indices are being used to collect data on vascular impedance and blood flow that would not be possible to get from velocity data alone. According to research by Atilla *et al.*, arterial impedance was a better predictor of histology of totes compared to testicular volume among adults with undescended testes [1]. Infertile men have narrow testicular arteries due to enlarged/thickened endothelial or subendothelial cells and abundance of connective tissue or ground substance in adventitia [2].

Color Doppler evidence from the testicular artery may be regarded as an indicator of spermatogenesis because it is implied that the structural form of testicular arteries is correlated with spermatogenesis. The objective of this research is to determine whether end-diastolic velocity (EDV), peak systolic velocity (PSV), and resistive index (RI) of the testicular artery can be used to differentiate between different types of dyspermia and how these indexes relate to spermatogenesis.

METHODS

This prospective study, carried out in the Urology Department, involved 70 patients who had 12–45 months of unprotected intercourse and complained of primary infertility. Twenty males who were age matched and had normal sperm analysis and paternity 2–14 months before enrollment constituted the control group. After enrollment into the study, written informed consent was taken from individuals before participation in the study. All patients underwent a thorough evaluation, including a review of their medical and surgical histories (particularly about childhood cryptorchidism, genital infections, prior surgeries, and trauma), lifestyle habits (such as drug abuse or tobacco use), physical examinations, reproductive hormone tests, analyses of two consecutive semen cycles, scrotal greyscale, and CDUS investigation. Exclusion from the study was granted to patients having a history of testicular injuries, previous lower abdominal surgery, or clinically identifiable illnesses.

Following 2–5 days of sexual abstinence, semen samples were used for seminal fluid analysis in accordance with the 2010 World Health Organization guidelines. Sperm concentrations >15 million/mL were used to define a normal sperm count, while sperm concentrations <15 million/mL were used to characterize oligospermia (OL) [3]. Genetic examination of the patients with severe OL (sperm count <5 million/mL) or nonobstructive azoospermia (NOA) was carried out, and any "Y" chromosome microdeletion was evaluated. The significant presence of leukocytes (>106/mL) in semen samples was evaluated using culture. Chemiluminescent immunoassays (IMMULITE 1000 analyzer, Siemens) were used to measure the serum concentrations of total testosterone, luteinizing hormone (LH), and follicle-stimulating hormone (FSH). The normal reference ranges for men were as follows: testosterone: 160–726 nano-g/dL (depending on age), LH: 0.8–7.6 mIU/mL, and FSH: 0.7–11.1 mIU/mL). Every azoospermia subject with a normal testis, bilaterally palpable VAS, and a normal FSH level had a percutaneous testicular biopsy.

Table 1: Mean (SD) values of FSH, TV, PSV, EDV, and RI in different groups of patients and controls (C)

Group	No. of patients	FSH (mIU/mL)	TV (mL)	PSV (cm/s)	EDV (cm/s)	RI
C	20	5.3 (1.7)	19.8 (2.7)	12.9 (1.2)	2.4 (0.4)	0.81 (0.4)
NOA	27	18.5 (9.2)	11.7 (3.5)	4.5 (1.2)	1.8 (0.6)	0.65 (0.6)
OA	24	4.7 (2.5)	19.6 (3.2)	12.9 (1.4)	2.2 (0.4)	0.81 (0.3)
OL	15	6.5 (2.0)	16.8 (4.1)	6.8 (1.0)	2.6 (0.3)	0.72 (0.3)

SD: Standard deviation, TV: Testicular volume, PSV: Peak systolic velocity, EDV: End-diastolic velocity, FSH: Follicle-stimulating hormone, RI: Resistive index, NOA: Nonobstructive azoospermia, OA: Obstructive azoospermia, OL: Oligospermia

Table 2: PSV, EDV, and RI distinguishing different types of dyspermia

Group	PSV	EDV	RI
C	↔	↔	↔
NOA	↓↓	↓	↓↓
OA	↔	↔	↔
OL	↓	↔	↓

PSV: Peak systolic velocity, EDV: End-diastolic velocity, RI: Resistive index, NOA: Nonobstructive azoospermia, OA: Obstructive azoospermia, OL: Oligospermia

Supine scrotal ultrasonography and CDUS with the penis rested on the abdomen were performed in the Radiology Department. The volume of each testicle was determined three-dimensionally and applying the ultrasonographic formula: Length×Width×Height×0.71 [4,5]. Using a trans-scrotal approach, a 7.5 megaHz linear probe quantified the Doppler flow in each testis. Any subclinical varicocele was searched for in the testicular vein. Each patient's testicular artery was located bilaterally in front of the hilum, and Doppler images were captured in a perpendicular plane with the insonation angle adjusted to get the highest possible color intensity. The instrument computed and recorded the PSV and EDV for each subject bilaterally and expressed the results in centimeter per second. Following that, the RI value was computed using the formula: (PSV-EDV)/PSV.

Of the 70 infertile individuals, 15 had OL, 24 had obstructive azoospermia (OA), and 27 had NOA. It was found that four OL individuals had varicocele. Due to the small sample size, these patients were placed in a different category and were not analyzed statistically. Analysis of variance was used to compare the variables such as FSH, testosterone, PSV, EDV, RI, and bilateral testicular volume both in the dyspermic groups and control group. Bonferroni *post hoc* test was used to analyze the association between the two groups. A significant association was established when $p<0.05$. The Statistical Package for the Social Sciences software version 25 was used to perform statistical test.

RESULTS

Patients' average age was 31.5 years (ranging from 26 to 40 years). In the NOA group, the mean testicular volume was significantly reduced ($p<0.01$). No discernible variation in the volume of tests was observed between other groups. Similar to this, the NOA group's serum FSH level was considerably greater ($p<0.001$) than that of the other groups, while FSH levels were comparable between the other groups. We observed a comparable mean serum testosterone level between the groups ($p>0.05$). In the NOA and OL groups, the mean PSV was considerably lower ($p<0.01$). There was no significant difference in PSV between the OA and control groups. The mean EDV was found to be considerably lower ($p<0.01$) only in NOA patients; no significant difference was observed in the other groups. Patients in the OL and NOA groups had RIs that were noticeably lower.

DISCUSSION

The spermatic cord connects the internal spermatic arteries, which anastomose with the cremasteric and deferential arteries, to the testis, establishing blood flow. Ischemia and injury may result from a decrease in blood flow through the testicles. Spermatogenesis was either completely missing or existed in just a tiny percentage of tubules in the artery-restricted testes according to Kay *et al.*'s findings from their animal experiment using a bull [6]. Combining anatomical and velocity data, CDUS is one of the fastest and most accurate ways to measure testicular blood flow and offers a quick examination for regular tests. Blood flow characteristics and impedance parameters may not be derived from flow velocity data obtained through the use of Doppler indices alone.

The RI is a measure of testicular microcirculation and relates to tissue perfusion in the situation of normal vasculature. Numerous studies have evaluated the RI as a measure of intratesticular blood flow in both humans and animals. The importance of RI in infertile patients has been supported by a few research. According to Pinggera *et al.*, a RI of >0.6 may indicate a problematic sperm count and can be a trustworthy signal for regular clinical usage in identifying men who are infertile or dyspermic [7]. In their research, RI was evaluated in the intratesticular artery and oligoasthenospermia was present in every case. Nevertheless, a limited number of studies have assessed the significance of velocity data (PSV and EDV) and RI in infertile individuals and have shown correlations with FSH and testicular volume.

Infertile patients' initial lines of inquiry include assessment of testicular volume, serum FSH, and testosterone levels, along with semen analysis. Testicular volume and serum FSH level are commonly utilized to differentiate between NOA and OA. Nonetheless, there is a stronger correlation between the total number of spermatogonia and the serum FSH level than there is between sperm count and spermatids. Again, even in people with NOA, the FSH level may be normal. Only the NOA patients in our research had a substantially higher mean FSH level. However, five individuals in the NOA group had blood FSH levels that were within normal range. Testicular size may not correlate with sperm count, a tiny testis can produce normal sperm count, while an individual with large testes may be azoospermic (having maturation arrest). To identify the kind of azoospermia in an individual with normal FSH levels and testicular volume, a testicular biopsy is recommended. This invasive procedure has the risk of patient pain and complications such as inflammation and hematoma. Sometimes, even, there may not be enough biopsy tissue to provide a meaningful diagnosis.

In our study, we found that PSV and RI are the two important parameters that can be useful in distinguishing different types of dyspermia. Both OL and NOA have impaired spermatogenesis and have decreased PSV and RI, but NOA patients in whom spermatogenesis is significantly impaired have a more significant decrease in PSV and RI. Patients with OA have normal spermatogenesis and normal PSV and RI values similar to those of the fertile control group. In our present study, the maximum PSV in the NOA group was 6.4 cm/s and RI – 0.72, whereas the minimum PSV in the OA group was 10.2 cm/s and RI – 0.77. Thus, both PSV and RI can be reliable in differentiating NOA and OA.

It was discovered that four of our OL patients had varicocele. It was discovered that these patients had extremely high RI, high PSV, and low testicular volume. Increased arterial blood flow was found to be the primary mechanism responsible for oligoasthenozoospermia and varicosity in clinical experiments according to Turner [8]. Furthermore, a number of investigations unambiguously demonstrated that spermatogenesis may be compromised by elevated levels of reactive oxygen species resulting from a changed connection between the venous and arterial testicular supplies, such as in the case of a scrotal varicocele [9,10].

Our findings aligned with the research conducted by Battaglia *et al.* [11]. To differentiate between the different causes of dyspermia, they measured all the parameters similar to our study. PSV and RI were shown to be considerably elevated in persons with varicoceles, varicoceles with male accessory gland inflammation (MAGI), and healthy patients with varicoceles. Men with unobstructive azoospermia were found to have lower PSV and RI, but patients having OA and MAGI had much lower PSV and RI.

CONCLUSION

When a patient is infertile, color Doppler ultrasound might be a very helpful examination. When used routinely in clinical settings, the RI and PSV can be trustworthy markers for identifying infertile or dyspermic males and distinguishing between obstructive and unobstructive azoospermia.

AUTHORS CONTRIBUTION

1. Dr. Pranab Patnaik – Acquisition of data, writing manuscript, and interpretation of data.
2. Dr. Sameer Trivedi – Concept and designing and final approval.
3. Dr. Deepak Shaw – Acquisition of data and data collection.

CONFLICTS OF INTEREST

No conflicts of interest.

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