Doppler sonographic evaluation of varicoceles.

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Purpose

There are approximately 5 million couples reporting difficulties in obtaining a pregnancy with a live birth. Of these, 1.3 million will receive counselling or treatment for infertility each year (1). Infertility can be considered a disease as long as it represents an abnormal function of the reproductive system, and exists when a couple is not able to achieve a pregnancy after 12 months of frequent intercourse without any contraceptive. Among the infertility causes in a couple, 30% are due to isolated problems of the male factor and in more than 20% of the additional cases both the male and female factors are present (1).

Varicocele is the dilation of the pampiniform plexus veins, and is diagnosed in 20 to 40% of infertile men. However, 80% of the patients with varicocele have normal spermograms (2,3). Varicocele occur on the left side in 80% to 95% of cases, bilaterally in 25% to 45% and only rarely on the right side (13%) (2). Diagnosis of varicocele is usually made in the physical exam, but this is a subjective method and is inadequate in subclinical varicoceles (2,3,4).

Most of the time ultrasound study of varicocele is made with the patient in supine position both before and after the Valsalva maneuver, taking into consideration the veins diameter (5,6) in the B-mode and a reflux longer than one second in the Doppler study (5,6). There is little correlation, however, with the physical exam and the daily life of the patient, as he remains in the orthostatic position most of the time. The objective of this study is to propose the use of the ultrasound exam performed in the orthostatic position, similar to the physical exam and the daily life of the patient. And also to evaluate the correlation of the ultrasound findings with the color Doppler of the pampiniform plexus vessels and the spermogram alterations in male infertility, as well as to assess the correlation between the diameter of one of the vessels of the pampiniform plexus and the spermogram alterations, according to the protocol usually followed in the medical literature.
Methods and Materials

The study was carried out during a one-year period, with a total of 405 male patients from the Hospital das Clínicas of the University of São Paulo, the complaint being the couple's infertility.

These patients underwent seminal analysis (spermogram with World Healthy Organization parameters) up to 15 days after the ultrasound study was performed.

Patients with previous history of infertility in periods longer than 12 months, with no previously determined cause, were included in the present study. They were enrolled in the reproduction/urology sector and underwent seminal analysis in the laboratory of this sector. Patients without semen analysis were excluded.

Of the total number of patients evaluated by ultrasound (405), 266 patients were enrolled in this study.

The examinations were performed with different equipments: the HDI 5000 model of ATL/Philips (Bothell, Washington, USA), manufactured in 2002, and Logic 7 and Logic 9 from GE (Milwaukee, USA), manufactured in 2002, with multi-frequency (8-14 MHZ) linear probes, adjusted with the same number of focuses.

The ultrasound exam included the color Doppler B-mode assessment and spectral analysis (pulsed Doppler). The digital documentation is then saved in a compact disc in the JPEG format. It was initially made with the patient in the supine position, the transducer on the skin and using warm gel (figure 1).

The patient remained then in the orthostatic position for the evaluation of the pampiniform plexus, and the effective evaluation was made after 5 minutes (figure 2).

A standardization was made including the use of the following parameters: grayscale, persistency, optical lateral resolution and equivalent dynamic range according to the different equipment brands that were used.

The variables analyzed in B-mode:
1) Morphology of the testicles and the epididymis, taking into consideration their contours and shape.

2) Texture of the testicles and the epididymis (homogeneous or heterogeneous).

3) Testicular volume. The measurements in centimeters were obtained in the longitudinal axis (L) at the largest bipolar diameter, transversal diameter (T) in the largest equator axis, anterior-posterior (AP) at the equator. To calculate the testicular volume (TV), the coefficient of ellipse correction was used (VT= LxAPxTx0. 52cc), considering as normal the values between # 12cc and # 25 cc (7, 8, 9).

4) The epididymis measurement in centimeters was made only on the cephalic portion, the region with the best longitudinal axis visualization.

The pampiniform plexus was initially studied in the B-mode, characterizing its course, selecting the largest caliber vessel and measuring from the inner wall on the longitudinal axis, in the supine position and in the orthostatic position after a 5 minutes waiting period, which is necessary for the blood to settle, and then evaluate both at rest and during the Valsalva maneuver (figure 3-A /B).

The color Doppler was used later on to characterize the reflux in the color map and in the spectral analysis, both at rest and after the Valsalva maneuver, and in both positions. The color Doppler mapping was obtained with the transducer in the longitudinal position, parallel to the pampiniform plexus.

The parameters in the protocol for the color mapping of the scrotal pouch: scale of velocity that was used, color scale and filtering (WF) equivalent, according to the different equipment brands that were used.

In the pulsed Doppler evaluation to characterize the venous reflux, the cursor was positioned in the center of the vessel to be analyzed. The venous reflux was considered to be pathological when longer than one second and at a velocity higher than 2.00 cm/s (figure 4 - A/B).

All patients underwent semen analyses following the standards recommended by World Healthy Organization. The spermogram analysis took into consideration the following parameters: WHO morphology (normal > 15%), Kruguer morphology (normal >8%), normal concentration > 20 million/ml) and total motility (normal > 50%). The following
criteria are considered in the statistical analysis: normal; only one altered variable; two altered variables, and three or more altered variables.

Averages, standard deviation, minimum and maximum were the descriptive statistics used. The relative (%) and the absolute frequencies (n) were presented in tables for the classes of each qualitative variable. The following statistical methods were used: Variance Analysis (ANOVA) to compare the averages of more than two groups; multiple Tukey’s comparison to identify categories with differences; Chi-square (x2) to verify if there was an association between the category variables (qualitative); the Fisher’s Exact Test when more appropriate, that is, when more than 20% of the expected values in the table are lower than five.
Images for this section:

**Fig. 0:** FIG 1. PATIENT IN THE SUPINE POSITION

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Fig. 0: FIG 2. PATIENT IN THE ORTHOSTATIC POSITION

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**Fig. 0:** Figure 3. B-mode measurement of the pampiniform plexus in the orthostatic position, transverse section, both at rest and during the Valsalva maneuver (A). Panoramic reconstruction of the pampiniform plexus (B).

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**Fig. 0:** Figure 4. Venous reflux of the pampiniform plexus in the color Doppler study in orthostatic position (A). Venous reflux in the pampiniform plexus longer than one second in the color Doppler study in orthostatic position (B).

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Results

The age of the 266 patients enrolled in the study varied from 15 to 79 years, the average age being 32.9 years (standard deviation - 9.1 years).

1) In the variables analyzed in B-mode it was found that:

- The testicles volume varied from 1.70 cc to 22.90 cc on the right side with a standard deviation of 4.5 cc, and on the left side from 1.50 cc to 27.80 cc with a 4.40 cc standard deviation.

- Texture of the testicles and the epididymis: 253 (95.1%) had an homogeneous texture, with no characterization of a solid or cystic lesion; 13 (4.9%) had microlithiasis with a diffuse distribution pattern. In relation to the epididymis, we characterized 94 (35.3%) cases of simple cysts (independent of topography).

2) Variables of the pampiniform plexus in B-mode and with the duplex color Doppler:

The variations in the pampiniform plexus diameter in supine and in orthostatic position were the following: supine position at rest, on the right side (0.11 cm to 0.45 cm); supine position during Valsalva, on the right side (0.14 cm to 0.53 cm); supine position at rest, on the left side (0.10 cm to 0.56 cm); supine position during Valsalva, on the left side (0.10 cm to 0.64 cm); orthostatic rest, on the right side (0.1 cm to 0.47 cm); orthostatic Valsalva, on the right side (0.12 cm to 0.71 cm); orthostatic rest, on the left side (0.12 cm to 0.7 cm); orthostatic Valsalva, on the left side (0.15 cm to 0.76 cm).

<table>
<thead>
<tr>
<th>POSITION</th>
<th>RIGHT</th>
<th>LEFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUPINE</td>
<td>AT REST (0.11 to 0.45cm)</td>
<td>AT REST (0.10cm to 0.56cm)</td>
</tr>
<tr>
<td></td>
<td>VALSALVA (0.14cm to 0.53cm)</td>
<td>VALSALVA ( 0.10cm to 0.64cm)</td>
</tr>
<tr>
<td>ORTHOSTATIC POSITION</td>
<td>AT REST (0.10 to 0.47cm)</td>
<td>AT REST (0.12cm to 0.70cm)</td>
</tr>
<tr>
<td></td>
<td>VALSALVA (0.15cm to 0.71cm)</td>
<td>VALSALVA (0.15cm to 0.76cm)</td>
</tr>
</tbody>
</table>
The following criteria were used in the statistical analysis of the pampiniform plexus with the duplex color Doppler: **normal**, when the diameters were \# 0.20cm, with no reflux during the Valsalva maneuver in Doppler \# 2.00cm/s; **varicocele**, when there was venous reflux independent of the pampiniform plexus diameter, both at rest and with the Valsalva maneuver; **absent**, cases that were not characterized in the B-mode study. We found 175 (65.8%) varicocele cases on the right side, 231 (86.8%) varicocele cases on the left side; 170 bilateral varicocele cases (63.9%); 55 (20.7%) cases with caliber larger than 0.20cm without venous reflux on the right side and 17 (6.4%) cases on the left side; 31 (11.7%) cases were normal on the right side and 15 (5.6%) on the left side; and 5 (1.9%) absent on the right side and 3 (1.1%) absent on the left side.

Correlating the testicular volume with the presence or absence of venous reflux, a reduction in the testicular volume was found in patients with ectasia and ipsilateral varicocele, being more marked in patients that have both alterations at the same time (caliber larger than 0.20cm with reflux in the Doppler examination) and similar in those that have only ectasia or only varicocele (venous reflux longer than one second in the Doppler exam).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Volume on the Right Side</th>
<th>Volume on the Left Side</th>
<th>Average</th>
<th>SD</th>
<th>N</th>
<th>Average</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>31</td>
<td>10</td>
<td>3.8</td>
<td></td>
<td>15</td>
<td>9.3</td>
<td>5.1</td>
</tr>
<tr>
<td>Ectasia</td>
<td>55</td>
<td>12.5</td>
<td>5.0</td>
<td></td>
<td>17</td>
<td>14.3</td>
<td>4.5</td>
</tr>
<tr>
<td>Varicocele</td>
<td>175</td>
<td>12.1</td>
<td>4.5</td>
<td></td>
<td>231</td>
<td>11.3</td>
<td>4.3</td>
</tr>
<tr>
<td>Total</td>
<td>261</td>
<td>11.9</td>
<td>4.5</td>
<td></td>
<td>263</td>
<td>11.5</td>
<td>4.4</td>
</tr>
</tbody>
</table>

There was a statistically significant association between the venous reflux and the diameters of the pampiniform plexuses with diameter \# 0.2cm \( (x^2=36.96, \ p< 0.001) \), with an increase in the number of reflux cases following the increase in the diameter. We find, however, patients that have venous reflux with a pampiniform plexus \# 0.20cm: on the right side with the patient in supine position (2.3%), in orthostatic position (3.6%); on the left side with the patient in supine position (0.9%), in orthostatic position (2.6%). The opposite situation was also found, cases where the pampiniform plexus was \# 0.20cm and without venous reflux in the Doppler exam: 8.6% on the right side with the patient in supine position; 9.7% on the right side in orthostatic position, 4.1% on the left side in supine position and 4.8% on the left side in orthostatic position.

As to the presence of venous reflux with the alterations found in the spermogram, the findings were: 175(65%) patients on the right side and 231(86%) patients on the left...
side. Comparing the analyzed variables, venous reflux and the larger pampiniform plexus diameter, with the spermogram alterations evaluated in the orthostatic position, a 99% was found for venous reflux predicting alterations in the spermogram, whatever the diameter of the vessel. This is around 80% when only the diameter is considered, with vessels larger than 0.22cm, a finding similar to those reported in the literature (10,11,12).
Conclusion

In the examination in the orthostatic position a good agreement was found between the venous reflux and the alterations in the spermogram (99% sensitivity). There was no agreement, however, between the diameter and the spermogram alterations (80% sensitivity). According to our findings, the diameter of the venous plexus by itself has a low sensitivity when compared to the venous reflux and its relation with the spermogram alterations, essential in the treatment of infertility. Besides, subclinical varicoceles are often not diagnosed in the physical exam and their diameter is generally # 0.2cm in 63% of patients who complain about infertility, thus demonstrating the importance of venous reflux in tests for infertility.

In 1977, Dubin et al. reported a high incidence of varicocele on the left side, approximately 80 to 95%, bilaterally in 25 to 45%, and rarely on the right side, only 13% (16,17,18). When the examination was performed in the orthostatic position, 65.8% of varicocele cases were on the right side, 86.8% were on the left side and 63.9% were bilateral. When compared to Dubin et al. (1977), a higher sensitivity and specificity is thus shown for the diagnosis of varicocele on the right side and bilaterally, because in the orthostatic position there are two factors that increase the pressure on the pampiniform plexus, one being the Valsalva maneuver and the other the liquid column on the scrotal venous system. We were also able to solve the problem of the testicles involuntary mobility, as in the orthostatic position the testicles settle in their scrotal compartments, as a result of both the gravitational force and the increased pressure of the abdominal content on the inguinal-scrotal region. Significant alterations were also found when the diameter of the pampiniform plexus in supine position was compared to the diameter in the orthostatic position, with a real increase of 0,10 cm in the orthostatic position, and this variation is higher on the right side. An increase was also found in the venous reflux with more than one second in the exam performed in the orthostatic position.

The increase in the diameter and in the number of reflux cases can be explained as being due to the weight of the hydrostatic column and the pressure exerted in the Valsalva maneuver on the pampiniform plexus. Another hypothesis to explain the larger variation on the right side could be the anatomical variation in the venous drainage of the right and of the left side. The left internal spermatic vein drains perpendicularly to the renal vein, while the right spermatic vein drains directly into the inferior vena cava, forming an acute angle. For a better understanding, it can be said that the straight angle formed between the left internal spermatic vein and the left renal vein would allow the direct transmission of pressure, without a valve mechanism, allowing the free passage of venous flow, independently of the position in which the patient is examined, thus explaining the small variation in the left diameter with the change in position. The patient in supine position would already be under the effects of the pressure overload. In relation to the right spermatic vein, the acute angle formed at its end in the inferior
vena cava would not allow high pressures to be transmitted directly to the right spermatic vein, as it forms an anatomic valve mechanism in the orthostatic position increasing the hydrostatic pressure of the venous column. As a result, the anatomic valve mechanism of the right testicular vein is overburdened, leading to a larger variation in the diameter of the pampiniform plexus, stressing the importance of carrying out the examination in the orthostatic position, as the real diameter of the plexus could be underestimated when evaluated only in the supine position.

In our findings a correlation was found between the presence of venous reflux longer than one second and the alterations found in the spermogram (one or more alterations). The same, however, was not observed between the diameter and the spermogram, as there were patients that had a diameter larger than 0.20 cm and had no reflux, and were classified by us as having "ectasia". These patients did not have alterations in the spermogram or had only one alteration, while those with reflux, independently of the diameter, had more than one alteration in the spermogram, showing the importance of our methodology, mainly in the diagnosis of subclinical varicoceles that were not detected in the studies of these authors. In patients with corrected subclinical varicocele, Jarow et al. found that the quality of the ejaculate was improved by more than 50%.

CONCLUSION:

- The ultrasound exam with color Doppler should be carried out in the orthostatic position, after a latency period of at least five minutes, in a comfortable environment and with a Valsalva maneuver.

- There was a significant agreement between the venous reflux in the pampiniform plexuses and the alterations in the spermogram.

- There was no significant correlation between the diameter of one of the pampiniform plexuses vessels and the spermogram.
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