Research Article

Ultrasound Characteristics of the Nutcracker Syndrome

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Abstract

The article presents the results of color Doppler ultrasonography of the left renal vein and gonadal vein with the determination of the peak systolic velocity of blood flow and abnormal blood reflux in patients with left-sided varicocele.

The objective of the research was to compare preoperative ultrasound characteristics of the left renal vein, left gonadal vein, peak systolic velocity of blood flow and the presence of abnormal blood reflux, the formation of ultrasound criteria for the selection of patients for surgical correction of phlebohypertension.

Results. Ultrasound signs of aorta mesenteric compression were absent in 24 (24.5%) patients; the signs of aorta mesenteric compression without critical left renal vein stenosis were observed in 64 (65.3%) patients; critical stenosis of the left renal vein was diagnosed in 10 (10.2%) patients. The patients with critical stenosis of the left renal vein underwent left renal vein transposition.

Conclusions. Ivanissevich surgery with prognostically low risk of relapse is recommended for the patients with left-sided varicocele without any signs of aorta mesenteric compression. Patients with the signs of aorta mesenteric compression require clear determination of the degree of left renal vein stenosis. We consider the transposition of the left renal vein to be indicated in case of critical stenosis when the correlation of the diameters of the distal and proximal segments of the left renal vein is $\geq 3$ and the ratio of peak systolic velocities in the proximal and distal segments is $\geq 6$. Thus, the diagnosis of phlebohypertension in the patients with varicocele by means of color Doppler ultrasonography with the determination of blood flow velocity indicators in the left renal vein circulation and the determination of the critical stenosis of the left renal vein is decisive in choosing the surgical method of treatment. This provides an opportunity to evaluate the cause of varicocele occurrence and choose the optimal method of surgical treatment.

Keywords

nutcracker syndrome; color Doppler ultrasonography; critical stenosis of the left renal vein; left renal vein transposition

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Problem statement and analysis of the latest research

Nutcracker syndrome is a rare phenomenon occurring in case of the left renal vein compression between the aorta and the superior mesenteric artery leading to the development of phlebohypertension in the left renal vein [5, 11].

The anatomical preconditions for the development of nutcracker syndrome are the origin of the superior mesenteric artery from the aorta at an acute angle causing the left renal vein compression. Normally, the superior mesenteric artery arises from the aorta at a right angle, is directed ventrally within 4-5 mm, and then falls caudally. This anatomical feature prevents the compression of the left renal vein by the superior mesenteric artery. However, the angle of the superior mesenteric artery origin is sharp and usually constitutes 38° - 56° in case of nutcracker syndrome [4].

The first description of this abnormality was made by anatomist Grant in 1937 [10]. Clinically, this nosology was described by the doctors A.R.El.-Sadr, E. Mina [8]. In 1971, Belgian physician De Schepper compared the aorta and the superior mesenteric artery with the jaws of the nutcracker compressing the left renal vein [7].

The gold standard for diagnosing nutcracker syndrome is phlebography and phlebomanometry with the determination of the pressure gradient between the inferior vena cava and the left renal vein. However, invasiveness, cost, risk of allergic reactions and the duration of this procedure make color Doppler ultrasonography the method of choice. According to different data, the informativeness of color Doppler ultrasonography is 78-100% [19].

The objective of the research was to compare preoperative ultrasound characteristics of the left renal vein, left gonadal vein, peak systolic velocity of blood flow and the presence of abnormal blood reflux, the formation of ultrasound criteria for the selection of patients for surgical correction of phlebohypertension.
1. Materials and Methods

Ninety-eight patients with left-sided varicocele were examined in Lviv Regional Clinical Hospital from 1999 to 2013. All the patients underwent color Doppler ultrasonography of the kidneys, the renal and gonadal veins with the use of Esaote Technos (Italy), Aloka SSD 3500 (Japan) ultrasonic diagnostic apparatus at the real time scale, gray scale, color flow mapping. Sectoral and linear array transducers of 3.5-12 MHz were used.

The size, location, mobility, presence of changes in renal parenchyma, the diameter and location of the renal and gonadal veins, rate characteristics and the presence of abnormal blood reflux were assessed according to ultrasonography of the kidneys, the renal and gonadal veins. Particular attention was paid to the difference in the diameters of the left renal vein in the distal part and the aorta mesenteric segment as well as to the difference between the peak blood flow velocities in these areas.

The illustration of the process of determining the type of blood flow and rate indicators in the left renal vein is depicted in Fig. 1.

Statistical data processing was performed using statistical software package Statistica 6.0. The methods of descriptive statistics were used.

2. Results

Ninety-eight patients with left-sided varicocele were examined. The patients’ age was from 14 to 29 years. Physical examination detected stage I varicocele in 26 patients, stage II varicocele in 39 patients, and stage III varicocele in 33 individuals. The results are presented in Fig. 2.

According to ultrasound data, different degrees of aorta mesenteric compression were diagnosed in 74 (75.5%) patients. The ultrasound picture of nutcracker syndrome was characterized by the sharp narrowing of the left renal vein diameter in the aorta mesenteric segment and post-stenotic dilatation in the distal part which correlated with the corresponding increase in peak systolic velocity in the stenotic part of the left renal vein (Fig. 3).

According to the observations, clinical manifestations of nutcracker syndrome occurred in case of an increase in the diameter of the distal (post-stenotic) part of the left renal vein by 3-6 times (by 4.3 times on average) in comparison with its proximal (aorta mesenteric) segment, as well as in case of an increase in the peak systolic velocity by 6-14 times (by 8.7 times on average) in the stenotic proximal (aorta mesenteric) segment as compared to the distal segment of the left renal vein. The indicators of the correlation of the distal and proximal segments diameters of the left renal vein \( \geq 3 \) and the ratio of peak systolic velocities in the proximal and distal segments \( \geq 6 \) were evaluated as a critical stenosis of the left renal vein requiring surgical correction.

The patients were divided into 3 groups. Group I included the patients without ultrasound signs of aorta mesenteric com-
Nutcracker syndrome is rarely diagnosed due to the lack of symptom specificity, diagnostic algorithms and insufficient physicians’ awareness on this pathology.

Anterior (aorta mesenteric clamp), posterior (retroaortic position of the left renal vein) and combined (ring-shaped renal vein) variants of nutcracker syndrome are distinguished. Thus, according to Sahalevych A.I., 87.3% of patients with left-sided varicocele are diagnosed with the pathology of the renocaval segment (one of the variants of nutcracker syndrome) [2].

The main clinical symptoms include hematuria (macro or micro), proteinuria, pain in the left lumbar region increasing in the vertical and sitting positions, left sided varicocele in men and pudendal varicosity in women [1, 9, 12].

One of the most common clinical manifestations of this pathology is the left-sided varicocele. Today it is a problem among urologists due to the high frequency of relapses after Ivanissevich surgery, since this intervention does not eliminate the main pathogenetic mechanism of varicocele occurrence, namely phlebohypertension in the left renal vein [20].

In clinical practice, varicocele is classified into III types according to Coolsaet depending on hemodynamic disorders. Type I is renospermatic or renotesticular, type II is ileospermatic or ileotesticular, type III is mixed [6]. Type I usually occurs in case of aorta mesenteric compression, sometimes it is combined with phlebohypertension in the system of the iliac vein. Varicocele of hemodynamic type II is caused by venous hypertension in the system of the iliac veins. The mixed type is characterized by a combination of the two abovementioned types of reflux, namely renospermatic and ileospermatic.

Pathogenetically substantiated surgical treatment of nutcracker syndrome is the transposition of the left renal vein providing an opportunity to eliminate hypertension in the left renal vein [13]. It is performed in isolation or in combination with the application of proximal or distal testicular ileac anastomosis (according to Lopatkin) depending on reflux type [1].

The transposition of the left renal vein was first performed in 1982 by Stewart. It consisted in the detachment of the left renal vein from the inferior vena cava, suturing of inferior vena cava defect and reanastomosis below the superior mesenteric artery. The advantages of left renal vein transposition included a short period of renal ischemia, the disadvantages comprised the risk of left renal vein thrombosis, bleeding, intestinal distention.

Despite the attempts to diversify the surgical correction of this pathology (superior mesenteric artery transposition, laparoscopic extravascular stenting, endovascular stenting, etc.), the best results in the remote postoperative period are demonstrated by left renal vein transposition [15].

### 3. Discussion

Nutcracker syndrome is rarely diagnosed due to the lack of symptom specificity, diagnostic algorithms and insufficient physicians’ awareness on this pathology.

Anterior (aorta mesenteric clamp), posterior (retroaortic position of the left renal vein) and combined (ring-shaped renal vein) variants of nutcracker syndrome are distinguished. Thus, according to Sahalevych A.I., 87.3% of patients with left-sided varicocele are diagnosed with the pathology of the renocaval segment (one of the variants of nutcracker syndrome) [2].

The main clinical symptoms include hematuria (macro or micro), proteinuria, pain in the left lumbar region increasing in the vertical and sitting positions, left sided varicocele in men and pudendal varicosity in women [1, 9, 12].
Table 1. Doppler ultrasound parameters of the left renal vein in patients of 3 groups

| Parameters                  | Group without ultrasound signs of aorta mesenteric compression, n=24 | Group with aorta mesenteric compression without critical stenosis of the left renal vein, n=64 | Group with critical stenosis of the left renal vein, n=10 | p        |
|-----------------------------|---------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|----------------------------------------------------------|----------|
|                              | Diameter, mm                                                        |                                                                                               |                                                          |          |
|                              | Hilum of the kidneys                                                | 6.1 ± 0.87                                                                                     | 10.4 ± 1.13                                               | 12.2 ± 1.87 | 0.001    |
|                              | Aorta mesenteric segment                                            | 3.9 ± 0.5                                                                                      | 3.3 ± 0.43                                               | 3.0 ± 0.96 | <0.001   |
|                              | Peak systolic velocity of blood flow, cm/sec                        |                                                                                               |                                                          |          |
|                              | Hilum of the kidney                                                 | 28 ± 1.9                                                                                      | 30 ± 0.94                                                | 21.6 ± 0.75 | <0.001   |
|                              | Aorta mesenteric segment                                            | 34 ± 1.45                                                                                     | 84 ± 0.86                                                | 178.3 ± 1.93 | <0.001   |

Table 2. Doppler ultrasound parameters of the left TV and the presence of abnormal blood reflux in it in the patients of 3 groups

| Parameters                  | Group without ultrasound signs of aorta mesenteric compression, n=24 | Group with aorta mesenteric compression without critical stenosis of the left renal vein, n=64 | Group with critical stenosis of the left renal vein, n=10 | p        |
|-----------------------------|---------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|----------------------------------------------------------|----------|
|                              | Diameter of the left TV, mm                                          |                                                                                               |                                                          |          |
|                              | Abnormal blood reflux in the TV                                      | Abnormal blood reflux was absent                                                                | Abnormal blood reflux was absent or +1                   | +2/3     |

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