Original Research / Özgün Araştırma

Micro V Doppler assessment of testicular blood supply in the pediatric age population: may reduce the need for senior guidance in the evaluation of prepubertal torsion

Pediatrik yaş popülasyonunda testiküler kan akımının mikro V Doppler ile değerlendirilmesi: prepubertal torsiyonun değerlendirilmesinde kıdemli rehberlik ihtiyacını azaltabilir

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Özet

Amaç: Pediatrik popülasyonda testis vaskülaritesini MicroV Doppler (MVD) ve Q pack incelemesi ile değerlendirdik ve deneyimsiz ile kıdemli radyologlar arasındaki interobserver variabiliteyi inceledik. Ayrıca çocuklarda testis kanlanmasını göstermede MVD ve Q pack incelemesini renkli ve power Doppler ile karşılaştırdık.

Gereç ve Yöntemler: Çalışmaya 114 testis (4-14 yaş arası) dahil edildi. Testis mikrodamar yapısı renk, power, MicroV Doppler ve Q-pack inceleme teknikleri kullanılarak incelendi. Testis parankiminin vaskülaritesini görsel olarak puanlamak için renk, Power ve MicroV Doppler için bir gruplama sistemi oluşturuldu.

Bulgular: Çalışmamızda tüm çocuklarda MVD ile testis kan akımının varlığını doğruladık. Renkli, power Doppler ve MVD'de gözlemciler arasında anlamlı bir fark olmadığını ve MVD'de tutarlılık değerinin renkli ve power Doppler'e göre daha yüksek olduğunu bulduk. Q-pack değerleri ile hasta yaşı arasında anlamlı bir pozitif korelasyon gözlemledik. Bu çalışmadan elde edilen Q-pac değerleri yaşla birlikte arttı. İstatistiksel olarak anlamlı yanlılığın olmaması, yöntemin yararlı olduğunu gösterir.

Sonuç: MVD, gözlemciler arası önemli bir değişkenlik olmaması ve çalışma hayatının ilk yıllarında daha az deneyimli radyologlar için prepubertal torsiyon gibi akut skrotal patolojileri

Abstract

Objective: We evaluated the testis vascularity in pediatric population with MicroV Doppler (MVD) and Q pack examination and to detect differences between a limited experience and a experienced senior radiologists. The inter-observer agreement in MVD and Q pack examination is evaluated. We also compared MVD and Q pack examination with color and power Doppler in demonstrating testicular blood supply in children.

Material and Methods: 114 testis (between the ages of 4-14) were included in the study. Testicular microvessel structure was examined by using color, power, MicroV Doppler and Q-pack examination techniques. A grouping system was created for color, Power and MicroV Doppler to score the vascularity of the testicular parenchyma visually.

Results: In our study, we confirmed the presence of testicular blood flow with MVD in all children. We found that there was no significant difference between the observers in color, power Doppler and MVD and the consistency value was higher in MVD compared to color and power Doppler. We observed a significant positive correlation between Q-pack values and patient age. Q-pac values obtained from this study increased with age. The lack of statistically significant bias indicates that the method is useful.

Conclusion: MVD is a reproducible method since there is no significant interobserver vari-

The study was approved by Ethical Committee of Bağcılar Training and Research Hospital (Approval No: 2020.01.1.09.009). All research was performed in accordance with relevant guidelines/regulations, and informed consent was obtained from all participants.

kolaylıkla tespit edebilmesi nedeniyle tekrarlanabilir bir yöntemdir. Böylece çocuklarda acil vakaların değerlendirilmesinde radyoloji asistanına eşlik eden kıdemli rehberliğe duyulan ihtiyaç azalabilir.

Anahtar Kelimeler: mikro V doppler, testis, kan akışı

ability and can easily detect acute scrotal pathologies such as prepubertal torsion for the less experienced radiologists in the early years of working life. Thus, the need for senior guidance accompanying radiology resident in the evaluation of emergency cases in children may decrease.

Keywords: blood supply, micro V doppler, pediatric age population

INTRODUCTION

Ultrasonography (US) and classical Doppler methods are among the most important diagnostic tools in the evaluation of the acute scrotum in the pediatric population (1). It is quite difficult to evaluate blood flow since testicles are small and flow rates are low in children (2, 3). In a significant proportion of healthy children in the pediatric age group, blood flow can not be monitored by classical methods in the testicles. In the testis with torsion, grayscale findings of parenchyma and the reactive increase in the scrotal fluid may not always be observed especially in the early period (4). Unfortunately, conventional methods such as color and power Doppler are insufficient in demonstrating testicular blood flow in the pediatric population, especially in small children. In cases such as the acute scrotum, it is important to evaluate the testicular blood supply quickly and accurately. Currently, the gold standard analysis for testicular blood flow is the color-power Doppler examination (2, 5, 6).

MicroV Doppler ultrasound is a newly developed noninvasive Doppler technique that qualitatively reveals the slow flow dynamics of small vascular structures (7). Conventional Doppler US methods detect small vessel flow as an artifact and therefore it can not demonstrate the slow flow of the microvessels effectively (7).

Recently, several researchers reported exploring testis vascularity in children by using microvascular imaging techniques. However, there is no study investigating the reliability and reproducibility of Micro V Doppler and Q pack in pediatric patients. Micro V Doppler can visualize the vascularity of microvessels within small organs. However, there is no data available about the interobserver agreement of this method and whether there is any change in the results obtained after the examination of an experienced radiologist (8).

In this prospective study, we evaluated the testis vascularity in the pediatric population with MicroV Doppler US and Q pack examination. And we aimed to detect differences between limited experienced and experienced senior radiologists. The inter-observer agreement in MicroV Doppler US and Q pack examination was evaluated. We also compared MicroV Doppler US and Q pack examination with color and power Doppler in demonstrating testicular blood supply in children.

MATERIAL AND METHODS

General Data

Fifty-seven boys with varying ages from 5 to 15 who applied to the outpatient clinic between 01.07.2019 and 01.12.2019 and were referred to our department with the request for scrotal Doppler ultrasound were included in the study. Our inclusion criteria for boys aged 3-14 years-old, are pre-pubertal and obtaining an informed consent form from their parents. Ethical approval was obtained from the scientific research ethics committee of our hospital (Approval number: 2020.01.1.09.009). Our exclusion criteria were being older than 14 years of age, having a history of previous testicular surgery, a history of undescended testicles, and the patient's mental disability.

Micro V Doppler and Q Pack Examination

Testicular microvessel structure was examined by using color, power, and MicroV Doppler ultrasound techniques. Ultrasonographic examinations were begun with color and power Doppler ultrasonography (Esaote MyLab 9, Genoa, Italy) using 12–5 MHz broadband linear array probes. After color and power Doppler, Micro V Doppler and Q pack examination were performed. During the examinations, care was taken to ensure that probe frequencies and other imaging parameters (general 2D optimization, persistence, etc.) were the same for each patient. The color setting, speed, and filter setings were selected to provide maximum Doppler sensitivity and Doppler angle was kept at between 30-60 degrees. During the Micro V Doppler examination, the scale was 1.5-2.5 cm/s, the mechanical index was 1.5, the wall filter was 50-100 Hz, and the frame rate was>50 Hz. A grouping system was created for color, power, and MicroV Doppler to score the vascularity of the testicular parenchyma visually. Accordingly, Group 1, was determined as testis parenchyma with no blood supply. In group 2, vascularization is detected only within the hilus. Group 3 has moderate vascularization on both testicular hilum and parenchyma. Group 4 was determined as testis with significant vascularization within both testicular hilum and parenchyma. The vascularity of the testis was scored by examining with color, power, and micro V Doppler US.

On Q-pack examination, quantitative values expressing the vascularity numerically were measured from testicular parenchyma. The vascularity was quantitatively measured within the area by placing ROI in the specific region (Region Of Interest) that we will select during the Doppler examination. Three different measurements were taken from the testicular hilum, 1/3 superior, and 1/3 lower part of the testis. Then the average of these 3 measurements was calculated, and the mean value for the testis parenchyma was created.

Image Evaluation

The observers were blinded to patient history and previous ultrasonography. Patients were evaluated by two radiologists with 6 years of experience (M.K) and 6 months of experienced (S. Ş.) in the field of microvascular imaging. Color, power, micro V Doppler and Q pack examinations of testis were first independently assessed by the two radiologists. Parenchymal vascularization was scored according to our grouping system. In the power analysis performed with the G * power 3.1 program related to our study, the effect size for Flow grades SMI in Testicular Masses was determined as 0.54 (Superb microvascular imaging for the detection of parenchymal perfusion in normal and undescended testes in young children) (alpha error probability = 0.05); The total number of samples required to be taken was found to be 38 in the sample size analysis performed with the power value of 0.80.

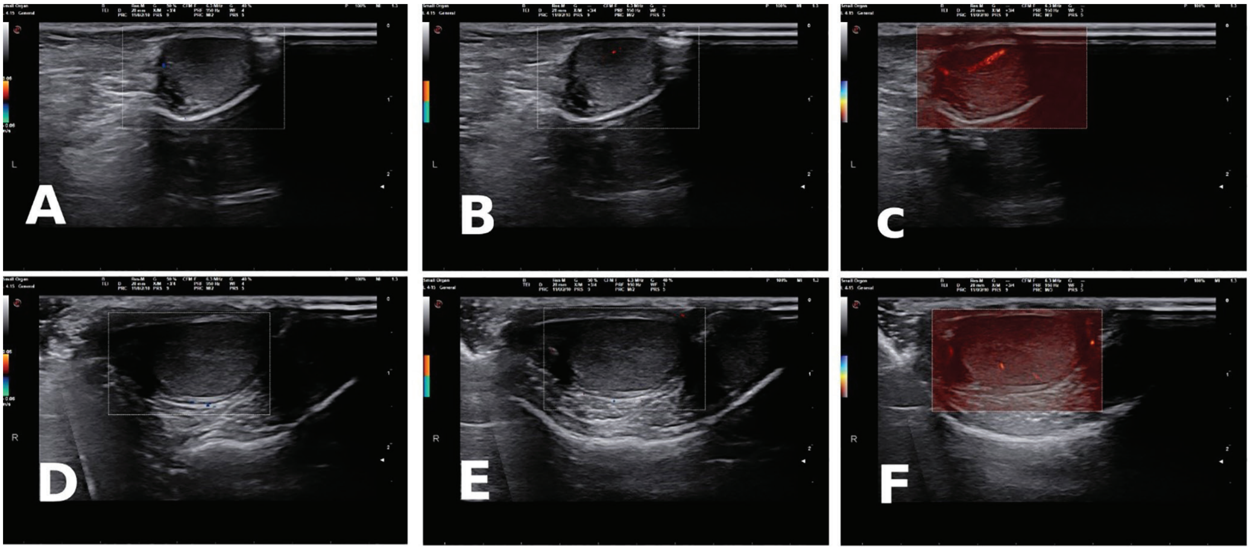

Figure 1. On the color Doppler, power Doppler and MicroV Doppler examination of a 6-year-old boy: vascularization of left testis was grade 0 on color Doppler (A), grade 0 was on power Doppler (B), grade 2 was on micro V Doppler (C). Vascularization of right testis was grade 0 on color Doppler (D), grade 1 was on power Doppler (E), grade 2 was on micro V Doppler (F) according to observer 1. Micro V Doppler imaging was more accurately showed microvascular structure of testis.

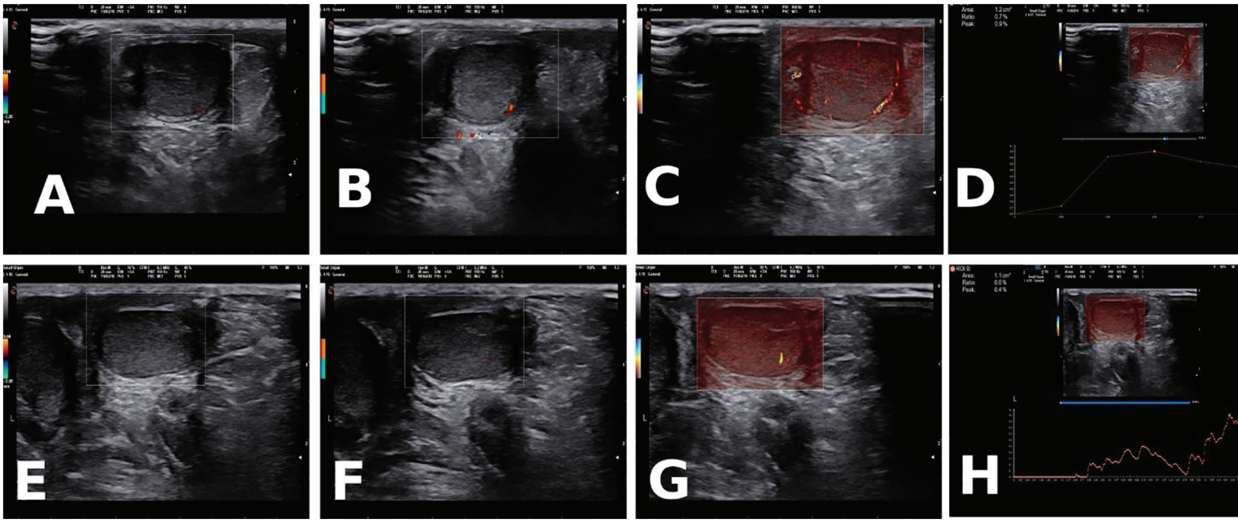

Figure 2. On the color Doppler, power Doppler and MicroV Doppler examination of a 9-year-old boy: vascularization of right testis was grade 1 on color Doppler (A), grade 1 was on power Doppler (B), grade 3 was on micro V Doppler (C). Q pack analysis and quantitative peak value is seen as 0.9 % (D), Vascularization of left testis was grade 0 on color Doppler (E), grade 1 was on power Doppler (F), grade 2 was on micro V Doppler (G) Q pack analysis and quantitative peak value is seen as 0.4 % (H), according to observer 1.

Table 1. Interobserver agreement in right testis color Doppler examination

Color Doppler US findings of right testis	1.Observer		2.Observer		P (Ki square)	Kappa
Group 1	15	26,3%	18	31,6%	0.139	0.812
Group 2	24	42,1%	27	47,4%		
Group 3	15	26,3%	9	15,8%		
Group 4	3	5,3%	3	5,3%		

Ki square test Kappa test

Table 2. Interobserver agreement in left testis color Doppler examination

Color Doppler US findings of left testis	1.Observer		2.Observer		P (Ki square)	Kappa
Group 1	15	26.3%	15	26.3%	0.153	0.809
Group 2	24	42.1%	30	52.6%		
Group 3	9	15.8%	6	10.5%		
Group 4	9	15.8%	6	10.5%		

Ki square test Kappa test

Table 3. Power Doppler US findings of right testis

Power Doppler US findings of right testis	1.Observer		2.Observer		P (Ki square)	Kappa
Group 1	3	5.3%	0	0	0.215	0.825
Group 2	21	36.8%	30	52.6%		
Group 3	21	36.8%	21	36.8%		
Group 4	12	21.1%	6	10.5%		

Ki square test Kappa test

Table 4. Left testis Power Doppler US findings

Power Doppler US findings of left testis	1.Observer		2.Observer		P (Ki square)	Kappa
Group 1	3	5.3%	6	10.5%	0.318	0.832
Group 2	24	42.1%	12	21.1%		
Group 3	21	36.8%	33	57.9%		
Group 4	9	15.8%	6	10.5%		

Table 5. Right testis Micro V Doppler US findings

Right testis Micro V Doppler US findings	1.Observer		2.Observer		P (Ki square)	Kappa
Group 1	0	0	0	0	0.315	0.936
Group 2	0	0	0	0		
Group 3	33	57.9%	30	52.6%		
Group 4	24	42.1%	27	47.4%		

Ki square test Kappa test

Tablo 6. Left testis Micro V Doppler US findings

Left testis Micro V Doppler US findings	1.Observer		2.Observer		P (Ki square)	Kappa
Group 1	0	0	0	0	0.593	0.942
Group 2	0	0	0	0		
Group 3	18	31.6%	16	28.1%		
Group 4	39	68.4%	41	71.9%		

Ki square test Kappa test

Table 7. Correlation analysis between right and left testicular Qpack values and patient ages

		Right testicle Qpack Observer 1	Left testicle Qpack Observer 1	Right testicle Qpack Observer 2	Left testicle Qpack Observer 2	Age
Right testicle Qpack Observer 1 value	rho	1	0.930**	0.659**	0.604**	0.857**
	p		0.000	0.000	0.000	0.000
Left testicle Qpack Observer 1 value	rho	0.930**	1	0.678**	0.677**	0.868**
	p	0.000		0.000	0.000	0.000
Right testicle Qpack Observer 2 value	rho	0.659**	0.678**	1	0.850**	0.786**
	p	0.000	0.000		0.000	0.000
Left testicle Qpack Observer 2 value	rho	0.604**	0.677**	0.850**	1	0.724**
	p	0.000	0.000	0.000		0.000
Age	rho	0.857**	0.868**	0.786**	0.724**	1
	p	0.000	0000	0.000	0.000	

Spearman correlation analysis

Statistical Evaluation

In this study, statistical analyzes is performed using the NCSS (Number Cruncher Statistical System) 2007 Statistical Software (Utah, USA) package program. In the evaluation of data, in addition to descriptive statistical methods (mean, standard deviation, frequency, and percentage distributions), Shapiro - Wilk normality test will be used to examine the distribution of variables. Independent t-test will be used for comparing normally distributed variables in binary groups, Mann Whitney U test for comparison of variables that do not show normal distribution between binary groups, and chi-square test for comparison of qualitative data. Logistic Regression analysis will be performed to determine the factors affecting the presence of malignancy. The intra-and inter-observer compatibility will be determined by the weighted kappa test, and between power and Micro V Doppler, sensitivity, specificity, positive predictive value, negative predictive value, and test accuracy will be calculated. A p-value less than 0.05 is considered as significant.

RESULTS

A total of 114 testicles were examined in the study. The mean age was 8.7 ± 3.7. Right and left testicular blood flows of each child were evaluated by two radiology physicians with color, power and Micro V Doppler. The agreement value for both observers is shown as the kappa (k) value. Table 2 shows the right testis color Doppler results. There was no statistically significant difference between the results of both observers (between the experienced and inexperienced observers). The agreement between observers was significantly higher (p= 0.139, k: 0.812) (Table 1).

Table 2 shows color doppler results of left testicles evaluated. There was no statistically significant difference between the results of both observers. Interobserver agreement was significantly higher (p= 0.153, k: 0.809) (Table 2). Table 3 shows right testis power Doppler US results. There was no statistically significant difference between the results of both observers. Interobserver agreement was significantly higher (p= 0.215, k: 0.825) (Table 3). Left testis power Doppler US findings are shown in Table 4. There was no statistically significant difference between the results of both observers. Interobserver agreement was significantly higher (p= 0.318, k: 0.832) (Table 4). On the color Doppler examination; no blood flow signal was observed within the parenchyma in 26.3% of the right testes for the first observer, and 31.6% for the second observer. No vascularization detected in 28.9% of all cases. Equally, no blood flow signal was observed within the parenchyma in 26.3% of the left testes for both observers. On the power Doppler examination; no blood flow signal was observed within the parenchyma in 5.3% of the right testes for the first observer, vascularization is detected all of the cases for the second observer. When all cases were evaluated jointly, it was seen that there was no flow in 2.6% of the right testes. On the power Doppler examination; no blood flow signal was observed within the parenchyma in 5.3% of the right testes for the first observer, and 10.5% for the second observer. There was no blood flow visualized in 7.9% overall of the cases. Right testis Micro V Doppler findings are demonsrated in Table 5. There was no statistically significant difference between the results of both observers.Inter-observer agreement was significantly higher (p= 0.315, k: 0.936) (Table 5).

The left testis Micro V Doppler findings are shown in Table 6. There was no statistically significant difference between the results of both observers. Inter-observer agreement was significantly higher (p= 0.593, k: 0.946) (Table 6). Table 7 shows correlation analysis between right and left testis Q pack values and patient ages. All Q pack correlations were highly significant for both observers. A significant correlation was observed between patient age and Q pack values ($p < 0.05$) (Table 7). In our study, we confirmed the presence of testicular blood flow with Micro V Doppler in all children. We observed that an average of 28.9% of the blood flow in the right testis and 26.3% of the left testis could not be observed with color Doppler, and it was dependent on age. We determined that blood flow could not be observed with power Doppler in 2.6% of cases, and this was dependent on age. We found that there was no significant difference between the observers in color, power Doppler, and Micro V Doppler methods, and the consistency value was highest in Micro V Doppler method compared to power and color Doppler method, respectively. We observed a significant positive correlation between Q-pack values and patient age.

DISCUSSION

The acute scrotum is seen most frequently in two different periods of life. Although the reasons are different, newborns and children aged 12-18 are the most common periods for acute scrotum (9-11). The most common clinical findings are scrotal swelling, pain, edema, and redness. However, it is difficult to reach a differential diagnosis since they are seen in almost every acute scrotum clinic (12). Although surgical exploration is a valid method independent of etiology in acute abdominal surgery, unfortunately, this is not the case in acute scrotum pathologies. In the past, emergency surgical exploration was performed especially in pediatric cases with suspicion of testicular torsion, but it was revealed that 60-85% of them were unnecessary surgery (13). In addition to clinical diagnosis difficulties, it creates the need for imaging techniques. In the studies in the literature; False-positive results were obtained with Doppler US in 38% of boys aged between 10 weeks and 13 years (14). The high rate of false positivity in the pediatric population with conventional methods has increased the need for new technological US methods.

Micro V Doppler is a newly developed Doppler imaging method used to detect blood flow, especially within the microvascular structures. In color or power Doppler techniques, the inability to receive the signals from the microvascular network is due to the need for blood flow above a certain speed. In the Micro V Doppler technique, blood flow signals of microvascular structures can be preserved even at a very low speed. Micro V Doppler is a new Doppler imaging method used to detect blood flow in microvascular structures. This new Doppler technique eliminates the complexity of signals from normal tissue and vascular structures and preserves only the signals obtained from vascular structures so that even very low-velocity blood flows can be detected. Micro V Doppler provides detailed information about very slow and very thin vascular structures and allows the visualization of microvascular structures (15). Tao et al. (16) demonstrated the effectiveness of microvascular imaging techniques in retinal pathologies. Ohno et al. (17) stated that Micro V Doppler may be effective in hepatobiliary pathologies. Arslan et al. (18) showed that microimaging Doppler gives correct findings in proportion to cancer diagnosis in breast cancer cases. It can be seen that Micro V Doppler technology will gain importance in any pathology involving the vascular network of microvascular structures. In our study, we investigated whether we could detect testicular blood flow with Micro V Doppler technology, the effectiveness of this technique according to color and power Doppler and whether there is a difference between operators. Thus, in our study, we found that blood flows that could not be detected by color or power Doppler in the testicular parenchyma could be revealed by examining the microvascular circulation with Micro V Doppler in the pediatric population. We observed that there was a significant observer agreement in all Doppler US types including Micro V Doppler, and there was no significant difference for both observers.

The lack of statistically significant bias indicates that the method is useful and suitable for establishing detecting testicular blood flow in the pediatric population with Micro V Doppler. Our study revealed that Micro V Doppler is a reproducible method since there is no significant interobserver variability. The observer agreement also demonstrated that both the experienced and less experienced radiologists had a higher agreement in detecting testicular blood flow in children. Our study shows that it is a method that can easily detect acute scrotal pathologies such as prepubertal torsion for the less experienced radiologists in the early years of working life. Thus, we think that the need for senior guidance accompanying radiology residents in the evaluation of emergency cases in children may decrease. As it is almost a perfect interobserver agreement; years of experience are not necessary any more thanks to microvascular imaging methods.

There was no blood flow in 28.9% of the right testicles and 26.3% of the left testicles in children on the color Doppler. In our study, blood flow could not be detected in 2.6% of the left testicles with power Doppler. Testicular flow visibility on Doppler methods can be change with the age (20). Since the flow is slower in early childhood, false-negative results are more frequent (21). In our study, it was observed that all children whose color and power Doppler flow could not be detected were between the ages of 5 and 6. Kalfa et al. report that we can accurately distinguish children with testicular torsion and healthy blood flow from each other with Micro V Doppler technology. In our prospective study, right and left testicular blood flows measured by Micro V Doppler method were positive in all cases among both observers. Thus, we think that the newly developed Doppler methods with a high frame rate can show the slow blood flow in all cases in the pediatric population. Lee et al. reported that finer vascular structures could be demonstrated more accurately by using the higher frame rate Doppler method in undescended testis. Karaca et al evaluated testicular flow with power, color, and Micro V Doppler and found that the most powerful method was Micro V Doppler (22). Ayaz et al. reported that blood flow that could not be traced in color and power Doppler can be easily demonstrated with Micro V Doppler in a study evaluating testicular blood flow of newborns (23). Durmaz et al. stated that Micro V Doppler is the most powerful method in testicular flow in children and that it gives clearer information compared to power and color Doppler (24). In another study, they stated that the best imaging and interobserver agreement rates were with Micro V Doppler rather than conventional Doppler methods in the pediatric population (25). In our study, we observed that Micro V Doppler was the most powerful method following the literature, and unlike other studies, the rate of detecting blood flow in the testicle with microvascular imaging methods was 100%.

Evaluation of the presence or absence of testicular flow is of course the most important step in scrotal pathologies. Ingram et al (19). reported that color Doppler in healthy children observed that there was no testicular blood flow in 38% of the cases. In another study, they stated that blood flow was not observed in 12% of the cases in color Doppler and power Doppler examination, while this rate was much lower in power Doppler. In our study, the Q pack software allows us to obtain quantitative values about the vascularity of this area by placing ROI in the area we want to examine specifically in the tissue we evaluate with Doppler US. In our study, the Q Pack values were examined for the first time in the literature. According to our findings, Q-pack values show a strong correlation with age. Due to the lack of any studies in the literature with Q-pack, further studies will be necessary with larger sample scale.

Our study had some limitations, first, we had a small sample size. We also did not evaluate patients with torsion.

CONCLUSION

In conclusion; we observed that the Micro V Doppler examination is more effective than classical Doppler examinations in the slow flow of small organs. Therefore, in patients with suspected prepubertal testicular torsion, the use of Micro V Doppler examination alone or in combination with classical Doppler methods will give more accurate results. It was determined that the testicular parenchyma Q pack values obtained from this study increased with age, and we think that it can be used as a reference value in future studies since there are no studies on this subject in the current literature. The lack of statistically significant bias indicates that the method is useful and suitable for establishing detecting testicular blood flow in the pediatric population with Micro V Doppler. Our study revealed that Micro V Doppler is a reproducible method since there is no significant interobserver variability and can easily detect acute scrotal pathologies such as prepubertal torsion for the less experienced radiologists in the early years of working life. Thus, we think that the need for senior guidance accompanying radiology residents in the evaluation of emergency cases in children may decrease. As it is almost a perfect interobserver agreement; years of experience are not necessary any more thanks to microvascular imaging methods.

Conflict of Interest

The authors declare to have no conflicts of interest.

Financial Disclosure

The authors declared that this study has received no financial support.

Informed Consent

Informed consent was obtained from all individual participants included in the study.

Ethical Approval

The study was approved by Ethical Committee of Bağcılar Training and Research Hospital (Approval Number: 2020.01.1.09.009) and written informed consent was received from all participants. The study protocol conformed to the ethical guidelines of the Helsinki Declaration.

Author Contributions

Conception and design; SŞ, FZA, Data acquisition; MK, Data analysis and interpretation; FZA, Drafting the manuscript; FZA, Critical revision of the manuscript for scientific and factual content; SÖ, Statistical analysis; MÖ, Supervision; ATC.

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