

Mean Monocyte Count Predicts Testicular Salvage in Children with Testicular Torsion

Ortalama Monosit Sayısı Çocuklarda Testis Torsiyonunda Testisin Kurtarılmasını Öngörüyor

Kamil Gökhan Şeker¹ , Yusuf Arıkan² , Deniz Noyan Özlü³ , Yurdagül Çetin Şeker⁴ , Ekrem Güner⁵ 

¹Liv Hospital Vadistanbul, Department of Urology, İstanbul, Türkiye

²University of Health Sciences, Tepecik Training and Research Hospital, Department of Urology, İzmir, Türkiye

³Bitlis State Hospital, Department of Urology, Bitlis, Türkiye

⁴University of Health Sciences, Sisli Etfal Training and Research Hospital, Department of Emergency Medicine, İstanbul, Türkiye

⁵University of Health Sciences, Bakirkoy Dr. Sadi Konuk Training and Research Hospital, Department of Urology, İstanbul, Türkiye

Cite as: Şeker KG, Arıkan Y, Özlü DN, Çetin Şeker Y, Güner E. Mean monocyte count predicts testicular salvage in children with testicular torsion. Grand J Urol 2025;5(1):6-12

Submission date: 11 September 2024 **Acceptance date:** 04 December 2024 **Online first:** 09 December 2024 **Publication date:** 20 January 2025

Corresponding Author: Deniz Noyan Özlü / Bitlis State Hospital, Department of Urology, Bitlis, Türkiye / noyanozlu@hotmail.com / ORCID ID: 0000-0003-2435-5482

Abstract

Objective: This study aimed to investigate hematological parameters and related factors predicting testicular salvage in patients diagnosed with testicular torsion in children.

Materials and Methods: The data of 86 patients under the age of 18 years, who underwent emergency scrotal exploration for testicular torsion between January 2013 and December 2019, were retrospectively analyzed. The patients were divided into two groups as Group 1 (Successful Salvage - Detorsion: 63 patients), and Group 2 (Failed Salvage - Orchiectomy: 23 patients). Demographic data, clinical features, laboratory tests and radiological examinations were evaluated.

Results: The mean age was 13.7 ± 3.3 years (Group 1: 13.50 ± 3.84 , Group 2: 14.47 ± 1.64 years). The duration of symptoms was significantly higher in Group 2 (5.12 ± 2.54 vs. 15.08 ± 6.30 hours, $p < 0.001$). Among the hematological parameters, the mean monocyte count was statistically significantly higher in Group 2 than in Group 1 (Group 1: 0.62 ± 0.27 , Group 2: 0.99 ± 0.51 $10^3 \mu/L$, $p = 0.001$). Multivariate analysis showed that the duration of symptoms and monocyte count were independent risk factors in predicting testicular salvage. ($p < 0.001$, $p = 0.042$, respectively)

Conclusion: This study shows that the mean monocyte count, in addition to the duration of symptoms, is a simple hematological parameter that can contribute to the prediction of testicular salvage in children with testicular torsion.

Keywords: testicular torsion, testicular fixation, orchiectomy, monocytes, salvage, viability.

Özet

Amaç: Bu çalışmada, çocuklarda testis torsiyonu tanısı almış hastalarda testisin kurtarılmasını öngören hematolojik parametreler ve ilgili faktörler araştırıldı.

Gereçler ve Yöntemler: Ocak 2013 ile Aralık 2019 arasında testis torsiyonu nedeniyle acil skrotal eksplorasyon uygulanan 18 yaş altı 86 hastanın verileri retrospektif olarak analiz edildi. Hastalar Grup 1 (Başarılı Kurtarma - Detorsiyon: 63 hasta) ve Grup 2 (Başarısız Kurtarma - Orşiektomi: 23 hasta) olmak üzere iki gruba ayrıldı. Demografik veriler, klinik özellikler, laboratuvar testleri ve radyolojik incelemeler değerlendirildi.

Bulgular: Ortalama yaş $13,7 \pm 3,3$ yıldır (Grup 1: $13,50 \pm 3,84$, Grup 2: $14,47 \pm 1,64$ yıl). Semptomların süresi Grup 2'de anlamlı olarak daha yüksekti ($5,12 \pm 2,54$ vs. $15,08 \pm 6,30$ saat, $p < 0,001$). Hematolojik parametreler arasında, ortalama monosit sayısı Grup 2'de Grup 1'den istatistiksel olarak anlamlı şekilde daha yüksekti (Grup 1: $0,62 \pm 0,27$, Grup 2: $0,99 \pm 0,51$ $10^3 \mu/L$, $p = 0,001$). Çok değişkenli analiz, semptomların süresi ve monosit sayısının testis kurtarmayı tahmin etmede bağımsız risk faktörleri olduğunu gösterdi. (sırasıyla $p < 0,001$, $p = 0,042$)

Sonuç: Bu çalışma, semptomların süresine ek olarak ortalama monosit sayısının testis torsiyonu olan çocuklarda testis kurtarmayı tahmin etmeye katkıda bulunabilecek basit bir hematolojik parametre olduğunu göstermektedir.

Anahtar kelimeler: testis torsiyonu, testis fiksasyonu, orşiektomi, monosit, kurtarma, yaşayabilirlik.

ORCID ID: K.G. Şeker 0000-0003-4449-9037 Y. Çetin Şeker 0000-0002-3809-9398
Y. Arıkan 0000-0003-0823-7400 E. Güner 0000-0002-4770-7535

Introduction

Testicular torsion is a urological emergency requiring urgent diagnosis and treatment which may lead to organ loss as a result of gonadal necrosis and may cause infertility problems in the future. Although it is observed in all age groups, it is more common in children [1].

The main treatment of testicular torsion is emergency surgery and the decision of detorsion and testicular fixation or orchiectomy is made during surgery. In the absence of objective criteria for assessing testicular viability, the fate of the testis is entirely at the discretion and experience of the surgeon. There are a limited number of parameters that can be used to predict preoperative testicular salvage. The most important factor known to predict testicular salvage is the duration of symptoms. As reported in the literature, irreversible testicular loss begins after the first 6 hours [2].

In recent years, there have been many studies evaluating hematological parameters in the differential diagnosis of testicular torsion [3]. However, only a limited number of studies have investigated the role of hematological parameters in predicting the possibility of preoperative testicular viability/orchiectomy. The results are conflicting and there is still no consensus. In addition, most of these studies include the adult age group [4-9].

In this study, we investigated the role of preoperative hematological parameters in predicting testicular salvage in children undergoing emergency scrotal exploration for testicular torsion.

Materials and Methods

After obtaining local ethics committee approval (Decision no: 2020/482), the medical records of 131 patients operated on for testicular torsion between January 2013 and December 2019 were retrospectively reviewed. 86 patients under 18 years of age with complete medical records were included in the study. Exclusion criteria: Patients who underwent manual detorsion, patients over 18 years of age, missing study data, liver dysfunction, renal dysfunction, hematological diseases, inflammatory diseases and known malignancy. Demographic data (age), clinical characteristics (duration of symptoms, place of presentation, time of presentation, season of presentation), complete blood count (CBC), radiological parameters (scrotal color Doppler ultrasonography [CDUS]), and operative results (viability, degree of torsion) were analyzed.

Complete blood counts were obtained using a hematology analyzer (Coulter Gen-S Haematology Analyser; Beckman Coulter Corp, Hialeah, FL, USA). Hematological parameters included white blood cell (WBC), neutrophil, lymphocyte, monocyte, eosinophil, basophil, platelet count (PLT), mean platelet volume (MPV) and mean corpuscular volume (MCV). Neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) were calculated by dividing neutrophil count by lymphocyte count and platelet count by lymphocyte count, respectively. All patients underwent scrotal CDUS before surgery.

All patients were taken to emergency surgery. After determining the type and degree of testicular torsion during scrotal exploration, the testes were detorsioned and rewarmed with warm saline for more than 10 minutes. For testicular viability, a three-step bleeding

test was performed as recommended by Arda and Özyaylalı [10]. According to the results of the bleeding test, orchiectomy or detorsion-testicular fixation was decided. All testes removed after orchiectomy were subjected to histopathological examination for final confirmation. Tissue necrosis was confirmed in all patients. Patients who underwent successful salvage - detorsion were defined as Group 1 and patients who underwent failed salvage-orchiectomy were defined as Group 2.

The parameters determined between the two groups were compared. The primary aim of this study was to determine the role of preoperative hematological parameters in predicting testicular salvage in patients undergoing emergency surgery for testicular torsion. The secondary aim was to investigate the factors influencing the prediction of testicular salvage.

Statistical Analysis

Categorical data were presented as percentages and numbers. For continuous variables, data were presented as mean and standard deviation. The normality of the distribution of continuous variables was assessed using the Shapiro-Wilk test. Means of two normally distributed groups were compared using the Student t-test. The Mann-Whitney U test was used when they were not normally distributed. Frequencies of categorical variables were compared using the Pearson chi-square test or Fisher's exact test. Statistical significance was accepted at $P < 0.05$. Univariable and multivariable logistic regression tests were used to determine factors predicting testicular salvage. Receiver operating characteristic (ROC) curve analysis was performed to determine cut-off values and areas under the curve (AUC) for the variables. Statistical analysis was performed using the Statistical Package of Social Sciences version 21 (IBM SPSS Statistics; IBM Corp., Armonk, NY).

Results

The mean age of the patients was 13.7 ± 3.3 years and the age range was 2-18 years. Age, degree of torsion, place of presentation, time of presentation, season of presentation and scrotal CDUS results were not significantly different between the groups ($p > 0.05$). There was a statistically significant difference in the duration of symptoms between the two groups (group 1: 5.12 ± 2.54 , group 2: 15.08 ± 6.30 hours, $p < 0.001$). Although mean WBC, neutrophil, lymphocyte, platelet, and hemoglobin levels were higher in Group 2, no statistically significant difference was found ($p > 0.05$). The mean monocyte count was statistically significantly higher in Group 2 than in Group 1 (group 1: 0.62 ± 0.27 , group 2: 0.99 ± 0.51 μL , $p: 0.001$). Although the mean MCV, MPV, NLR, and PLR were higher in Group 1 than in Group 2, no statistically significant difference was found ($p > 0.05$). The results of the comparisons between groups are shown in **Table 1**.

Univariate analysis showed that testicular salvage was associated with the duration of symptoms and monocyte count. Multivariate analysis showed that monocyte count (OR = 4.308, $P = 0.042$) and symptom duration (odds ratio [OR] = 1.052, $P < 0.001$) were independent risk factors for testicular salvage (**Table 2**). The monocyte count was significantly lower in the successful salvage group than in the failed salvage group ($P < 0.01$).

Table 1. Comparison of patient characteristics and haematological parameters between groups

Variables	Group 1 (Successful Salvage-detorsion)	Group 2 (Failed salvage- orchiectomy)	P value
Number of patients	63	23	
Mean age \pm SD, year	13.50 \pm 3.84	14.47 \pm 1.64	0.685¥
Duration of symptoms, hour	5.12 \pm 2.54	15.08 \pm 6.30	<0.001¥
Torsion degree	513 \pm 182	592 \pm 149	0.070*
Mean WBC count \pm SD, $10^3 \mu/L$	11.91 \pm 4.16	13.06 \pm 4.88	0.283*
Mean Neutrophil count \pm SD, μ/L	8.99 \pm 3.88	9.83 \pm 4.77	0.417*
Mean Lymphocyte count \pm SD, μ/L	1.92 \pm 0.74	2.00 \pm 1.61	0.818*
Mean Monocyte count \pm SD, μ/L	0.62 \pm 0.27	0.99 \pm 0.51	0.001¥
Mean PLT count \pm SD, $10^3 \mu/L$	285 \pm 70	301 \pm 57	0.320*
Mean Hemoglobin count \pm SD, g/dL	14.0 \pm 1.56	14.3 \pm 1.34	0.376*
Mean MCV count \pm SD, fL	83.1 \pm 6.6	82.9 \pm 5.2	0.904*
Mean MPV count \pm SD, fL	8.25 \pm 1.34	8.21 \pm 1.27	0.923*
Mean NLR count \pm SD	7.09 \pm 5.31	5.0 \pm 3.94	0.099*
Mean PLR count \pm SD	210 \pm 145	179 \pm 74	0.904¥
Admission place Emergency department Urology clinic	59 (96.7) 2 (3.3)	21 (91.3) 2 (8.7)	0.301&
Admission date Weekdays Weekend	46 (75.4) 15 (24.6)	20 (87) 3 (13)	0.250#
Admission season Spring Summer Autumn Winter	18 (29.5) 9 (14.8) 13 (21.3) 21 (34.4)	6 (26.1) 1 (4.3) 8 (34.8) 8 (34.8)	0.423#
Scrotal CDUS No blood flow Equal Decreased	51 (83.6) 4 (6.6) 6 (9.8)	21 (91.3) 0 (0.0) 2 (8.7)	0.657&

SD: standart deviation; WBC: white blood cell; PLT: platelet; MCV: mean corpuscular volume; MPV: mean platelet volume; NLR: neutrophil-to-lymphocyte ratio; PLR: platelet-to-lymphocyte ratio; CDUS: colour Doppler ultrasonography; *Independent T test; #Yates' Chi-Square; ¥ Mann-Whitney U test; & Fisher's Exact Test

The prediction of preoperative testicular salvage by duration of symptoms and monocyte count was further evaluated using the ROC curve. According to the ROC analysis, the best cut-off point for the duration of symptoms was 7.5 hours (sensitivity 100%, specificity 80.6%, area under the curve (AUC) 0.968, $p < 0.001$, 95% confidence interval 0.938-0.999), the best cut-off point for monocyte count was 0.82 μ/L (sensitivity 59.1%, specificity 74.1%, AUC: 0.672, $p = 0.018$, 95% confidence interval 0.533-0.812) (Table 3.) The ROC analysis of these parameters is shown in Figure 1.

Discussion

Testicular torsion is a urological emergency with adverse outcomes such as orchiectomy. Studies show that initial misdiagnosis, degree of torsion, ischemia time and sonographic findings are predictors of testicular salvage [11-14]. In addition to anamnesis, physical examination, clinical features and radiological findings, simple hematological parameters have been investigated in limited studies to determine testicular salvage. Most of these studies have included adult populations.

Table 2. To predict preoperative testicular salvage univariable and multivariable binary logistic regression analysis

	Univariable			Multivariable		
	OR	95% CI	P value	OR	95% CI	P value
Age (year)	1.102	0.934-1.301	0.250			
Duration of symptom (hour)	1.051	1.028-1.075	<0.001	1.052	1.028-1.077	<0.001
Torsion degree	1.003	1.000-1.006	0.074			
WBC count	1.000	1.000-1.000	0.282			
Neutrophil count	1.051	0.934-1.182	0.413			
Lymphocyte count	0.957	0.663-1.381	0.815			
Monocyte count	4.574	1.293-16.176	0.018	4.308	0.804-23.091	0.042
PLT count	1.004	0.996-1.011	0.318			
Hemoglobin	1.175	0.824-1.675	0.372			
MCV	0.995	0.920-1.076	0.903			
MPV	0.981	0.674-1.429	0.922			
NLR	0.910	0.812-1.020	0.104			
PLR	0.998	0.994-1.002	0.346			
Admission (Urology clinic)	2.810	0.372-21.227	0.317			
Admission (weekdays)	2.174	0.566-8.354	0.258			
Admission seasonal	1.127	0.757-1.679	0.556			
Scrotal CDUS (No blood flow)	2.059	0.415-10.207	0.377			

OR: oddsratio; CI: confidence; WBC: white blood cell; PLT: platelet; MCV: mean corpuscular volume; MPV: mean platelet volume; NLR: neutrophil-to-lymphocyte ratio, PLR: platelet-to-lymphocyte ratio; USG: ultrasonography

Table 3. ROC curve analysis of duration and monocyte count for testicular salvage

	AUC	95% CI	P-value	Cut of value	Sensitivity - specificity
Variables					
Duration	0.968	0.938-0.999	<0.001	7.5	% 100 - % 80.6
Monocyte count (μ /L)	0.672	0.533-0.812	0.018	0.82	% 59.1- % 74.1

ROC: receiver operating characteristic; AUC: area under the curve; CI: confidence interval

Our study was conducted only in children under 18 years of age. In our study, multivariate analysis for determinants of testicular salvage showed that the duration of symptoms was a significant determinant, similar to previous studies [12,15]. However, among hematological parameters, multivariate analysis showed that only mean monocyte count was a significant determinant. According to the results of our study, in ROC analysis, mean monocyte count was found to be an independent predictive factor in addition to symptom duration in predicting testicular salvage.

Our study is consistent with the results of the study conducted by Merder et al. on pediatric and adult patients [4]. In

this study, data of 88 patients, 61 of whom had orchidopexy and 27 of whom had orchidectomy, were retrospectively analyzed. According to the results of this study, the duration of symptoms and monocyte count were found to be statistically significantly higher in the orchidectomy group [4]. Similarly, in another study, Yılmaz et al. reported that monocyte count, monocyte-to-eosinophil ratio (MER), and C-reactive protein (CRP) levels were found to be statistically higher in the orchidectomy group in patients with testicular torsion, while the only significant variable in multivariate logistic regression analysis for testicular viability was monocyte count [8]. In another study conducted

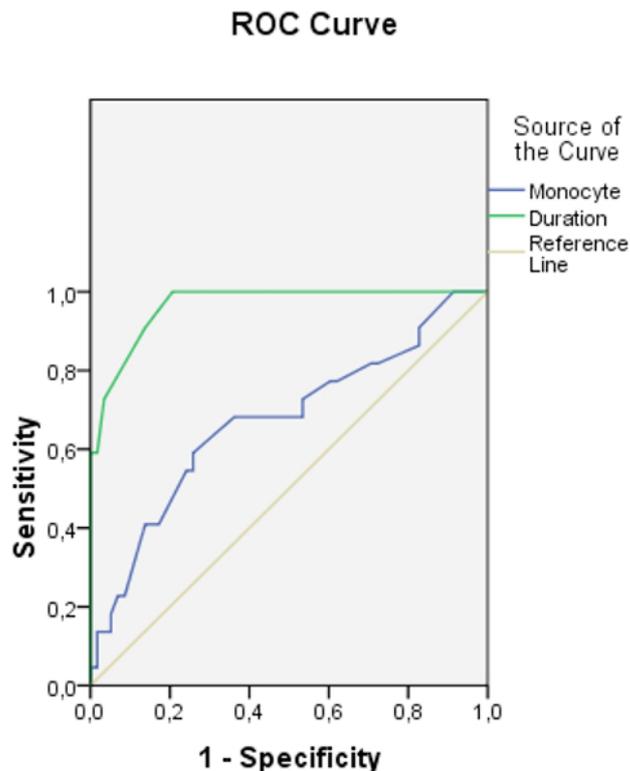
by Chen et al. only in the pediatric age group, it was reported that monocyte count was an independent predictive factor for testicular salvage [16]. Monocytes are the largest white blood cell type and one of the most basic components of the innate immune system. Approximately 3-10% of white blood cells are monocytes. Circulating monocytes and their differentiated forms play an important role in inflammation and have both pro- and anti-inflammatory effects [17]. In addition to the inflammatory response, monocytes play a role in the ischaemic process [18]. In our study, the fact that the mean monocyte count was found to be higher in the orchiectomy group may be interpreted as a result of a longer inflammatory and ischaemic process.

Hematological parameters have been investigated in some studies in the literature due to their cheap, easy and quick results. NLR is a laboratory marker of systemic inflammation and is routinely measured in peripheral blood [19]. In the study by Barkasi et al. in which complete blood count parameters and CRP were evaluated, although NLR, PLR, and CRP levels were found to be high in the orchiectomy group, they did not find a statistically significant relationship with laboratory parameters in predicting testicular viability [9]. Although the duration of symptoms was the most reliable parameter predicting testicular viability in the study by Jang et al., the authors showed that NLR may be useful in predicting testicular viability in patients between 3-12 hours [6]. In our study, except for monocytes among hematological parameters, other parameters and NLR and PLR derived from these parameters did not show a statistically significant difference between both groups.

Another study in the literature reported that the duration of symptoms, the degree of torsion of the spermatic cord and especially the MPV may be predictive of testicular viability in cases of testicular torsion [7]. The authors found that, in patients with testicular torsion, MPV was significantly higher. In another study evaluating the predictive role of MPV, Peretti et al. reported that MPV was a parameter predictive of testicular viability in patients with testicular torsion presenting with symptom duration of less than 6 hours [5]. According to the results of multivariate analyses of another study performed in the pediatric age group, WBC and MPV were shown to be associated with the risk of surgical outcome in addition to the cause of testicular torsion and intervention time [20]. In our series, the duration of symptoms and the degree of testicular torsion were higher in the orchiectomy group and the MPV was lower in contrast to the literature data. Although there was a statistically significant difference in symptom duration, there was no statistically significant difference between the degree of torsion and MPV values.

A recent study of retrospective histopathological examination of viability in cases of testicular torsion concluded that at least 10% of testicular torsion cases undergoing orchiectomy could be salvaged. The authors stated that the duration of symptoms is not a clear predictor of testicular damage and that it is not always correct to decide whether or not to perform orchiectomy based on the subjective macroscopic appearance of the affected testis [21]. Therefore, hematological parameters may help determine viability.

In a 7-year retrospective cohort study of factors predicting testicular viability by analyzing the American Child Health Information System database, orchiectomy was reported in 918 (31.9%) of 2,876 patients operated on with the diagnosis



Diagonal segments are produced by ties.

Figure 1. Receiver operating characteristic (ROC) curve for testicular salvage

of testicular torsion. The analysis did not show any difference according to season or geographical region. Factors that increased the risk of orchiectomy included age between 1 and 9 years, race, and lack of private insurance [22]. Another study investigating factors predictive of testicular salvage in children reported that the duration of symptoms and degree of torsion predicted testicular salvage on multivariate analysis. In addition, the authors stated that testicular torsion is more common in the winter season and caution should be taken [23]. In our study, there was no statistically significant difference between groups according to age and season.

One of the most important limitations of our study is its retrospective methodology. Secondly, some acute phase reactants such as CRP level, erythrocyte sedimentation rate and procalcitonin level were not included because they are not routinely checked and are expensive. Thirdly, detorsion and orchiectomy were performed by different surgeons with different surgical volumes and experience with testicular torsion. Finally, although our study was a single-center study, this was compensated for by the large sample size.

Conclusions

This study demonstrated that the mean monocyte count, in addition to the duration of symptoms, is a simple hematological laboratory finding that may contribute to the differentiation of testicular salvage in cases diagnosed with testicular torsion. There is a need for prospective, controlled studies with larger patient series on this subject.

Ethics Committee Approval: Ethical approval for this study was obtained from Bakırköy Dr. Sadi Konuk Training and Research Hospital Clinical Research Ethics Committee (Decision no: 2020/482).

Informed Consent: An informed consent was obtained from all the patients.

Publication: The results of the study were not published in full or in part in form of abstracts.

Peer-review: Externally peer-reviewed.

Authorship Contributions: Any contribution was not made by any individual not listed as an author. Concept – K.G.Ş., Y.A.; Design – K.G.Ş., Y.A.; Supervision – K.G.Ş., E.G.; Resources – D.N.Ö., Y.Ç.Ş.; Materials – D.N.Ö., Y.Ç.Ş.; Data Collection and/or Processing – D.N.Ö., Y.Ç.Ş., Y.A.; Analysis and/or Interpretation – D.N.Ö., Y.Ç.Ş., Y.A.; Literature Search – D.N.Ö., Y.Ç.Ş.; Writing Manuscript – K.G.Ş., Y.A.; Critical Review – K.G.Ş., E.G.

Conflict of Interest: The authors declare that they have no conflicts of interest.

Financial Disclosure: The authors declare that this study received no financial support.

Informing: Due to the presence of the name of the journal editor's among the authors, the assessment process of the study was conducted by the guest editor.

References

- [1] Ringdahl E, Teague L. Testicular torsion. *Am Fam Physician* 2006;74(10):1739-43.
<https://pubmed.ncbi.nlm.nih.gov/17137004/>
- [2] Boettcher M, Bergholz R, Krebs TF, Wenke K, Aronson DC. Clinical predictors of testicular torsion in children. *Urology* 2012;79(3):670-4.
<https://doi.org/10.1016/j.urology.2011.10.04>
- [3] Zhu J, Song Y, Chen G, Hu R, Ou N, Zhang W, et al. Predictive value of haematologic parameters in diagnosis of testicular torsion: Evidence from a systematic review and meta-analysis. *Andrologia* 2020;52(2):e13490.
<https://doi.org/10.1111/and.13490>
- [4] Merder E, Bozkurt M, Arıman A, Sezgin MA, Culha MG, Altunrende F. Comprehensive examination of haematological parameters of patients operated due to testicular torsion. *Andrologia* 2020;52(9):e13674.
<https://doi.org/10.1111/and.13674>
- [5] Peretti M, Zampieri N, Bertozzi M, Bianchi F, Patanè S, Spigo V, et al. Mean platelet volume and testicular torsion: New findings. *Urol J* 2019;16(1):83-5.
<https://doi.org/10.22037/uj.v0i0.4042>
- [6] Jang JB, Ko YH, Choi JY, Song PH, Moon KH, Jung HC. Neutrophil-lymphocyte ratio predicts organ salvage in testicular torsion with marginal diagnostic delay. *World J Mens Health* 2019;37(1): 99-104.
<https://doi.org/10.5534/wjmh.180049>
- [7] He M, Zhang W, Sun N. Can haematologic parameters be used to predict testicular viability in testicular torsion? *Andrologia* 2019;51(9):e13357.
<https://doi.org/10.1111/and.13357>
- [8] Yılmaz M, Sahin Y, Hacibey I, Ozkuvanci U, Suzan S, Muslumanoglu AY. Should haematological inflammatory markers be included as an adjuvant in the differential diagnosis of acute scrotal pathologies? *Andrologia* 2022;54(4):e14374.
<https://doi.org/10.1111/and.14374>
- [9] Barkai E, Dekalo S, Yossepowitch O, Ben-Chaim J, Bar-Yosef Y, Beri A, et al. Complete blood count markers and c-reactive protein as predictors of testicular viability in the event of testicular torsion in adults. *Urol Int* 2023;107(8):801-6.
<https://doi.org/10.1159/000531145>
- [10] Arda IS, Ozyaylali I. Testicular tissue bleeding as an indicator of gonadal salvageability in testicular torsion surgery. *BJU Int* 2001;87(1):89-92.
<https://doi.org/10.1046/j.1464-410x.2001.00021.x>
- [11] Jacobsen FM, Rudlang TM, Fode M, Østergren PB, Sønksen J, Ohl DA, et al. The impact of testicular torsion on testicular function. *World J Mens Health* 2020;38(3):298-307.
<https://doi.org/10.5534/wjmh.190037>
- [12] Zheng WX, Hou GD, Zhang W, Wei D, Gao XL, Chen MH, et al. Establishment and internal validation of preoperative nomograms for predicting the possibility of testicular salvage in patients with testicular torsion. *Asian J Androl* 2021;23(1):97-102.
https://doi.org/10.4103/aja.aja_31_20
- [13] Castañeda-Sánchez I, Tully B, Shipman M, Hoefft A, Hamby T, Palmer BW. Testicular torsion: A retrospective investigation of predictors of surgical outcomes and of remaining controversies. *J Pediatr Urol* 2017;13(5):516.e1-516.e4.
<https://doi.org/10.1016/j.jpuro.2017.03.030>
- [14] Chmelnik M, Schenk JP, Hinz U, Holland-Cunz S, Günther P. Testicular torsion: Sonomorphological appearance as a predictor for testicular viability and outcome in neonates and children. *Pediatr Surg Int* 2010;26(3):281-286.
<https://doi.org/10.1007/s00383-009-2534-4>
- [15] Zvizdic Z, Aganovic A, Milisic E, Jonuzi A, Zvizdic D, Vranic S. Duration of symptoms is the only predictor of testicular salvage following testicular torsion in children: A case-control study. *Am J Emerg Med* 2021;41:197-200.
<https://doi.org/10.1016/j.ajem.2020.11.023>

- [16] Chen P, Huang W, Liu L, Chen N, Zhou G, Sun M, et al. Predictive value of hematological parameters in testicular salvage: A 12-year retrospective review. *Front Pediatr* 2022;10:989112. <https://doi.org/10.3389/fped.2022.989112>
- [17] Canpolat U, Çetin EH, Cetin S, Aydin S, Akboga MK, Yayla C, et al. Association of monocyte-to-HDL cholesterol ratio with slow coronary flow is linked to systemic inflammation. *Clin Appl Thromb Hemost* 2016;22(5):476-82. <https://doi.org/10.1177/1076029615594002>
- [18] ElAli A, Jean LeBlanc NJ. The role of monocytes in ischemic stroke pathobiology: new avenues to explore. *Front Aging Neurosci* 2016;8:29. <https://doi.org/10.3389/fnagi.2016.00029>
- [19] Imtiaz F, Shafique K, Mirza SS, Ayoob Z, Vart P, Rao S. Neutrophil lymphocyte ratio as a measure of systemic inflammation in prevalent chronic diseases in Asian population. *Int Arch Med* 2012;5(1):2. <https://doi.org/10.1186/1755-7682-5-2>
- [20] Zhang K, Zhang Y, Chao M. Clinical characteristics and identification of risk factors of testicular torsion in children: A retrospective study in a single institution. *Front Surg* 2023;9:1040487. <https://doi.org/10.3389/fsurg.2022.1040487>
- [21] Marcou M, Hartmann A, Wullich B, Apel H, Hirsch-Koch K. Retrospective histological evaluation of orchiectomy specimens following testicular torsion reveals a 10% incidence of reversible injury. Is it time for a change of strategy? *Andrology* 2023;11(6):1044-9. <https://doi.org/10.1111/andr.13368>
- [22] Cost NG, Bush NC, Barber TD, Huang R, Baker LA. Pediatric testicular torsion: demographics of national orchiopexy versus orchiectomy rates. *J Urol* 2011;185(6 Suppl):2459-63. <https://doi.org/10.1016/j.juro.2011.01.016>
- [23] Feng S, Yang H, Lou Y, Ru W, Wang A, Liu W. Clinical Characteristics of Testicular Torsion and Identification of Predictors of Testicular Salvage in Children: A Retrospective Study in a Single Institution. *Urol Int* 2020;104(11-12):878-83. <https://doi.org/10.1159/000506236>