

## Could Systemic Immune Inflammation Index Predict Adnexial Torsion?

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### ABSTRACT

**Purpose:** We examined the potential of the systemic immune-inflammation index (SII) as an effective biomarker for early diagnosis and timely treatment of adnexal torsion, aiming to prevent organ dysfunction or loss.

**Methods:** This study included cases of adnexal torsion, admitted to our clinic between 2012 and 2022, who underwent surgery based on clinical suspicion of torsion and had the diagnosis confirmed intraoperatively. The control group comprised healthy patients who presented with pelvic pain, underwent surgery for benign adnexal masses, and had the diagnosis confirmed pathologically. Preoperative complete blood count (CBC) parameters of all patients were retrieved from the hospital database. Absolute neutrophil, lymphocyte, and platelet counts, along with neutrophil-lymphocyte ratio (NLR) and SII, were calculated. Differences between the torsion and control groups for inflammatory hematologic parameters and SII were compared.

**Results:** The patient group included 210 cases while the control group numbered 200 women. There was a significant difference between the mean SII value of the adnexal torsion cases (1,898.5) and the mean SII value of the control group cases (618.6) ( $p < 0.001$ ). According to receiver operating characteristic curve analysis, the SII cut-off value for diagnosing torsion was 821, with a sensitivity of 82% and a specificity of 81%. In addition, the mean NLR was 2.16 in the control group and 6.28 in the torsion group, showing a significant difference ( $p < 0.001$ ). The NLR cut-off value for adnexal torsion was 3.06, with a specificity of 80% and a sensitivity of 79%. The cut-off value for leukocyte white blood cells count was found to be  $9,225/\mu\text{L}$ , with a sensitivity of 77% and a specificity of 76%.

**Conclusion:** This study indicated that the SII, an economical, straightforward, and easily accessible inflammatory marker derived from CBC parameters, shows potential utility in the diagnosis of adnexal torsion.

**Keywords:** Adnexal torsion, systemic immune inflammation index, ovarian torsion

### INTRODUCTION

Adnexal torsion represents a significant gynecologic emergency, potentially leading to organ dysfunction, or even organ loss, if diagnosis and intervention are delayed. The condition arises from the twisting of adnexal structures around their supporting tissues, disrupting blood flow and leading to ischemia and tissue necrosis. Its incidence is approximately 2.7%, making it the fifth most common gynecologic emergency.<sup>1</sup> Risk factors include previous episodes of torsion, presence of adnexal masses, pregnancy, and prior tubal ligation. Untreated adnexal or ovarian torsion can lead to necrosis of the adnexa and ovaries, resulting in infections, peritonitis, thrombophlebitis, and potential loss of the affected organs. These acute complications can also have significant

long-term consequences, including infertility. Therefore, prompt diagnosis and intervention are important to prevent complications and preserve organ function.<sup>2-4</sup>

The diagnosis of torsion remains challenging due to the non-specific nature of its clinical presentation, physical examination findings, and laboratory and imaging tests. Consequently, delays in diagnosis can adversely affect treatment outcomes and prognosis. Although diagnostic and imaging techniques have advanced, the definitive diagnosis of torsion is generally confirmed through the surgical identification of the torsed adnexa. This underscores the need for prompt patient referral and highlights the importance of improving diagnostic accuracy through enhanced laboratory and imaging assessments, as emphasized by numerous studies.<sup>5-9</sup>



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The systemic immune-inflammation index (SII) is currently used as a marker of systemic inflammatory response across various diseases. The SII serves as a predictive and prognostic marker, derived from complete blood count (CBC) parameters, [platelet count  $\times$  neutrophil count/lymphocyte count (P  $\times$  N/L)] in peripheral blood. It is easily accessible, cost-effective, and widely used in oncological and chronic inflammatory conditions.

The SII was initially developed by Hu et al.<sup>10</sup> in a retrospective study involving 133 hepatocellular carcinoma patients between 2005 and 2006. Its applicability was later confirmed in a prospective study of 123 patients between 2010 and 2011, establishing the SII as an independent prognostic marker in the postoperative period. Moreover, the prognostic value of SII has been explored in gynecologic cancers, including endometrial, cervical, and epithelial ovarian cancers, with several studies available in the literature.<sup>11-13</sup>

Studies have shown that neutrophilia and lymphopenia are indicators of systemic inflammation, and that an increase in platelet count enhances inflammation due to the active secretion of inflammatory mediators by platelets.<sup>14,15</sup> In light of this data, it is evident that the SII is a reliable marker for indicating inflammation. Thus, we hypothesize that detecting the inflammatory changes associated with adnexal torsion using the SII would facilitate the diagnosis of suspected torsion cases, thereby preventing treatment delays and reducing the risk of organ dysfunction or loss. The aim of this study was to evaluate the efficacy of SII in preventing diagnostic and therapeutic delays in adnexal torsion and mitigating the risk of organ dysfunction or loss.

## METHODS

In our retrospective observational study, we identified all patients who presented to the emergency department with suspected torsion and were subsequently diagnosed with torsion through surgery between 2012 and 2022. The control group consisted of patients who presented with pelvic pain, were diagnosed with benign adnexal masses upon examination, and underwent surgical procedures for these masses, with no evidence of adnexal torsion. Patients with chronic inflammatory diseases, such as inflammatory bowel disease or autoimmune disease or who had concurrent acute inflammatory processes, including acute pneumonia or acute gastroenteritis, those who were pregnant, with a history of endometriosis, who were previously diagnosed with premalignant or malignant lesions, who had pelvic inflammatory disease or tubo-ovarian abscess and those whose data could not be accessed were excluded in both groups.

Ethics committee approval for our retrospective observational study was received from the University of Health Sciences Turkey, Bakırköy Dr. Sadi Konuk Training and Research Hospital Clinical Research Impact Committee (approval number: 2022-12-06, date: 20/06/2022).

Preoperative CBC parameters at the initial presentation of these patients were retrieved from the hospital database. In addition, socio-demographic characteristics, surgical details, and pathology results were collected. Absolute neutrophil,

lymphocyte, and platelet counts, as well as neutrophil-lymphocyte ratio (NLR) and SII were calculated. Comparisons were subsequently performed to assess the significance of inflammatory hematologic parameters and SII between the torsion and control groups.

## Statistical Analysis

Statistical analyses were conducted using SPSS for Windows, version 20.0 (IBM Inc., Armonk, NY, USA). Variables with a normal distribution between the two groups were compared using the Paired samples t-test, while the Mann-Whitney U test was employed for variables that did not follow a normal distribution. In addition, the cut-off values, sensitivity, and specificity of white blood cells (WBC), NLR, and SII for diagnosing torsion were determined using receiver operating characteristic (ROC) curve analysis. Continuous variables are reported as mean  $\pm$  standard deviation, and a p-value of  $<0.05$  was considered statistically significant.

## RESULTS

Based on our exclusion criteria, 210 patients diagnosed with torsion were included in our study (Table 1) and the control group consisted of 200 women who were confirmed not to have had torsion. The age and parity values of both groups were subjected to statistical analysis and there was no significant differences in the age and parity distributions between the groups. Descriptive statistics for the patients in both groups are presented in Table 2.

Analysis of the torsion group revealed that 75% of cases (n=157) occurred during the reproductive period, 10% (n=21) during childhood/adolescence, and 15% (n=32) during the postmenopausal period (Table 2).

In the control group, 70% of cases (n=140) were in the reproductive period, 8% (n=16) were in childhood/adolescence, and 22% (n=44) were in the postmenopausal period (Table 2). The available data indicate that the groups were distributed homogeneously.

In the torsion group, the most common presenting complaint was abdominal pain reported by 83% of women (n=174), 10% (n=21) experienced a feeling of pelvic pressure, 2%

**Table 1. Exclusion criteria and number of patients**

Exclusion criteria	Number of patients (n)
Cases of torsion during pregnancy	19
Cases of torsion with endometriosis/endometrioma	7
Previously diagnosed with premalignant/malignant lesions	3
Pelvic inflammatory disease or tuboovarian abscess	7
Simultaneous surgery for torsion and other causes of acute abdomen	10
Cyst rupture in addition to torsion	19
Patients whose data could not be accessed	20
<b>Total</b>	<b>85</b>

(n=4) had abnormal uterine bleeding, and 5% (n=11) were asymptomatic (Table 2).

In cases operated on for torsion, detorsion was performed in 80% (n=168) of instances, salpingo-oophorectomy in 10% (n=21), oophorectomy in 7% (n=15), and salpingectomy in 3% (n=6) (Table 2).

In the torsion group, the average leukocyte count was 12,087/ $\mu\text{L}$ , the average neutrophil count was 9,643/ $\mu\text{L}$ , the average lymphocyte count was 1,684/ $\mu\text{L}$ , and the average platelet count was 264,000 cells/mL. In the control group, these values were 8,185/ $\mu\text{L}$ , 4,899/ $\mu\text{L}$ , 2,265/ $\mu\text{L}$ , and 270,000 cells/mL, respectively. The average SII value was 1,898.5 in the torsion group, compared to 618.6 in the control group (Table 3). A significant difference was found between the two groups in terms of average WBC, lymphocyte, neutrophil, and SII values ( $p < 0.0001$ ).

Upon categorizing the control group cases based on their pathology results, statistical analysis revealed no significant differences in the mean values of leukocytes, neutrophils, lymphocytes, platelets, SII across the subgroups (Table 4). In the present study, a significant difference was identified between the median WBC counts of individuals in the control group (7,650/ $\mu\text{L}$ ) and those in the torsion group (11,900/ $\mu\text{L}$ ) ( $p < 0.001$ ) (Table 5). ROC curve analysis showed that the cut-

off value for WBC in adnexal torsion was 9,225/ $\mu\text{L}$ . This value had a specificity of 76% and a sensitivity of 77% for torsion (Figure 1).

A significant difference was observed between the median NLR values of the control group (2.09) and the patients in the torsion group (5.87) ( $p < 0.001$ ) (Table 5). ROC curve analysis showed that the cut-off value for NLR in adnexal torsion was 3.06, with a specificity of 80% and a sensitivity of 79% for torsion (Figure 1).

Finally, a significant difference was observed between the median SII values of the patients in the torsion group (1464.2) and the individuals in the control group (566.2) ( $p < 0.001$ ) (Table 5). The cut-off value for SII in torsion cases was 821.0 with a sensitivity of 82% and a specificity of 81% for the diagnosis of adnexal torsion (Figure 1).

## DISCUSSION

Adnexal torsion is a gynecological emergency that can affect women of all ages and may result in severe comorbidities if diagnosis is delayed. Although history, physical examination, laboratory tests, and imaging studies contribute to the diagnostic process, definitive diagnosis of adnexal torsion still relies on intraoperative visualization of the torsioned adnexa. However, not all suspected cases necessitate surgical

**Table 2. Common descriptive characteristics of patients**

		Adnexal torsion group, (n=210)	Control group, (n=200)	p
<b>Age</b>				
Mean $\pm$ SD		27 $\pm$ 9	32 $\pm$ 5	p=0.064
Minimum-maximum		6-52	13-69	
Parity (mean)		2	3	p=0.091
Life cycle stage	Reproductive stage	157	140	
	Childhood - adolescent stage	21	16	
	Postmenopausal stage	32	44	
		<b>Number of patients (n)</b>	<b>(%)</b>	
Symptom	Abdominal and pelvic pain	174	83	
	Pelvic pressure	21	10	
	Abnormal uterine bleeding	4	2	
	Asymptomatic	11	11	
Operation name	Detorsion	168	80	
	Salpingo-oophorectomy	21	10	
	Oophorectomy	15	7	
	Salpingectomy	6	3	
SD: Standard deviation				

**Table 3. Mean leukocyte, neutrophil, lymphocyte, platelet and SII values in adnexal torsion and control groups**

	Leukocyte	Neutrophil	Lymphocyte	Platelet	SII
Adnexal torsion (mean)	12,087.5	9643.7	1684.2	264,000	1898.5
Control group (mean)	8,185.7	4899.4	2265.4	270,000	618.6
p	<0.0001	<0.0001	<0.0001	0.084	<0.0001
SII: Systemic immune-inflammation index					

**Table 4. Mean leukocyte, neutrophil, lymphocyte, platelet and SII values according to pathology results of the cases in the control group**

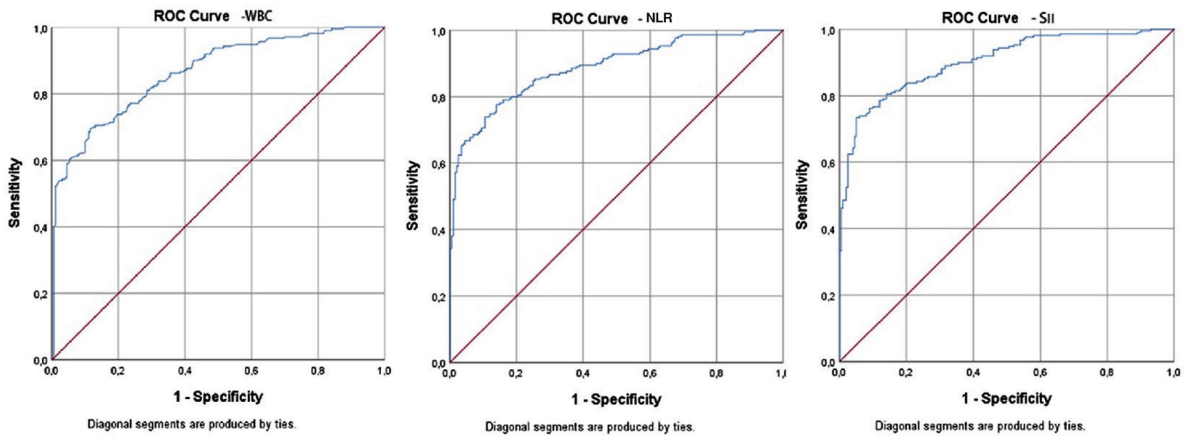
Pathology result	Leukocyte	Neutrophil	Lymphocyte	Platelet	SII
Follicle cyct	7721.3	5028	2099.7	257.4	671.1
Benign serous cyst	7877.7	4963.7	2264.4	280.9	648.5
Benign mucinous cyst	10760.8	4609.1	2510	277.2	525.7
Dermoid cyct	7592.6	4838.6	2210.6	280.2	638.0
Cystadenofibroma	8053.0	5102.3	2486.9	279.6	568.5
Fibroma	7984	4764	2566	202.4	364.3
<b>p</b>	<b>0.355</b>	<b>0.508</b>	<b>0.058</b>	<b>0.091</b>	<b>0.050</b>

SII: Systemic immune-inflammation index

**Table 5. Analysis of WBC, NLR and SII values of torsion and control group**

Groups	n	Mean ± SD leukocyte count	Min.-max. leukocyte count	Median leukocyte count	p
Control	200	8,186±1,500	1,070-27,043	7,650	<0.001
Torsion	210	12,087±2,500	5,700-32,000	11,900	
		Mean ± SD NLR	Min.-max. NLR	Median NLR	
Control	200	2.16±0.25	0.5-4.6	2.09	<0.001
Torsion	210	6.28±1.28	1.2-12	5.87	
		Mean ± SD SII value	Min.-max. SII value	Median SII value	
Control	200	618.6±23	103.9-2008.3	566.2	<0.001
Torsion	210	1898.5±91	307.8-8022.9	1464.2	

WBC: White blood cells, NLR: Neutrophil-lymphocyte ratio, SII: Systemic immune-inflammation index, SD: Standard deviation, Min.: Minimum, Max.: Maximum



Marker	AUC (95%)	Cut-off value	p	Sensitivity (%)	Specificity (%)
WBC	0.865 (0.831-0.899)	9,225	<0.0001	77.2	76.5
NLR	0.887 (0.856-0.919)	3.06	<0.0001	79	80
SII	0.903 (0.874-0.932)	821.03	<0.0001	82	81

**Figure 1.** Cut-off value of WBC, NLR and SII values of the patients included in the study according to ROC curve analysis and sensitivity-specificity ratio of this value

WBC: White blood cells, NLR: Neutrophil-lymphocyte ratio, SII: Systemic immune-inflammation index, ROC: Receiver operating characteristic, AUC: Area under the curve

intervention, as this could lead to unnecessary procedures. Therefore, accurate identification of true cases of adnexal torsion is essential. Also, in the case of acute torsion, the possibility that the time between the patient's diagnosis and surgery may result in organ dysfunction and resection has led clinicians to search for more specific and effective diagnostic methods such as WBC, NLR, SII and further imaging methods. Recent studies have predominantly investigated the predictive and diagnostic capabilities of laboratory and imaging tests in suspected cases of adnexal torsion.<sup>7,16</sup> Despite evidence indicating that these methods can aid in diagnosis, there remains a lack of consensus and standardization concerning their clinical applicability.

Adnexal torsion predominantly occurs during the reproductive years and rarely affects women in the postmenopausal period.<sup>17,18</sup> Consistent with existing literature, 75% of the patients with adnexal torsion in the present study were in the reproductive age group, 10% were in childhood or adolescence, and 15% were postmenopausal.

Detorsion was performed in 80% of patients in the current study undergoing surgery for adnexal torsion. This result aligns with contemporary approaches to managing torsion cases, as reported in recent literature.<sup>19-21</sup> Furthermore, salpingo-oophorectomy was conducted in approximately 10% of patients. The reason for this was that the majority of patients who underwent salpingo-oophorectomy were in the postmenopausal period.

Current research focuses on the use of laboratory and imaging modalities to diagnose adnexal torsion. Studies have investigated the effectiveness of Doppler ultrasound, computed tomography (CT), and magnetic resonance imaging (MRI) in this context. Béranger-Gibert et al.<sup>22</sup> reported that MRI exhibited a sensitivity of 77% and a specificity of 86% for detecting adnexal torsion. Conversely, Lee et al.<sup>23</sup> found MRI sensitivity to be 77% with a specificity of 100%, while Mandoul et al.<sup>24</sup> identified CT as having 97% sensitivity and 81% specificity. Bar-On et al.<sup>25</sup> reported a Doppler ultrasound sensitivity of 43% and specificity of 91%, whereas Lee et al.<sup>26</sup> noted a sensitivity of 87% for Doppler ultrasound. Although these studies provide promising insights, their sample sizes are limited. Furthermore, the cost, accessibility, applicability, and subjective interpretation of MRI, CT, and Doppler ultrasound pose challenges to their widespread use, particularly in developing and underdeveloped regions.

The limitations associated with imaging tests have led researchers to explore alternative diagnostic tools that offer greater objectivity, affordability, and accessibility, while maintaining comparable effectiveness. Recent studies have highlighted the clinical relevance of SII in a range of gynecological and non-gynecological malignant and inflammatory conditions.<sup>27-29</sup> Numerous studies have shown the NLR to be a significant marker of inflammation in adnexal torsion.<sup>7-9,30</sup> A retrospective study assessing NLR's diagnostic performance identified a cut-off value of 2.44, yielding a sensitivity and specificity of 70%.<sup>31</sup> Another study reported an NLR cut-off value of 3.35, with sensitivity of 62% and specificity

of 86% for diagnosing torsion.<sup>32</sup> In our study, the average NLR values were significantly higher in the torsion group compared to the control group. The cut-off value for NLR in our analysis was lower than previously reported at 3.06, with sensitivity of 80% and specificity of 79%.

Elevated WBC count is a well-established marker of inflammation, as demonstrated in previous studies of adnexal torsion.<sup>5,33</sup> In the present study, the population WBC count was significantly higher in the torsion group compared to the control group, with 70% of cases in the torsion group exhibiting leukocytosis. Chiou et al.<sup>34</sup> reported leukocytosis in 64% of torsion cases. We identified a WBC cut-off value of 9,225/ $\mu$ L for diagnosing adnexal torsion, which demonstrated 77% sensitivity and 76% specificity. Additionally, Ercan et al.<sup>8</sup>, in a retrospective analysis of 27 cases, established a WBC cut-off value of 8,800/ $\mu$ L, achieving 73% sensitivity and 84% specificity.

In the present study, when comparing the sensitivity and specificity of WBC, NLR, and SII for diagnosing torsion, SII demonstrated higher sensitivity and specificity compared to both WBC and NLR. This suggests that SII may be a slightly more effective biomarker than WBC and NLR in diagnosing torsion due to the inclusion of thrombocytosis as a third parameter in its calculation. Therefore using SII instead of WBC or NLR in adnexal torsion cases may give clinicians somewhat better information to make a diagnosis.

Studies have also examined the prognostic value of SII in gynecological cancers, such as endometrial, cervical, and epithelial ovarian cancers. Matsubara et al.<sup>11</sup> found SII to be an independent prognostic marker in endometrial cancer. A retrospective study conducted by Nie et al.<sup>12</sup> demonstrated that SII is an independent marker of poor prognosis in epithelial ovarian cancer. Huang et al.<sup>13</sup> showed that in cervical cancer, SII is a strong marker of post-surgical prognosis, and high levels of SII indicated poor prognosis. Furthermore, in studies conducted in the field of obstetrics, Tanacan et al.<sup>35</sup> identified SII as a predictor of poor neonatal outcomes in cases of premature preterm rupture of the membranes. Keles et al.<sup>36</sup> found SII to be an effective marker in predicting the spectrum of placenta accreta in cases of placenta previa. In our study, we found that SII demonstrated an 82% sensitivity and an 81% specificity in diagnosing adnexal torsion, suggesting its potential applicability in this clinical setting. The difference between the torsion group and the control group in WBC, NLR and SII levels can provide information to clinicians about whether the masses are torsioned and also inflammatory processes of the masses before the operation.

Even in low resource settings SII can be an accessible and efficient way to help diagnose ovarian torsion. The results of this study suggest that clinicians may have a firmer diagnosis of ovarian torsion with a single blood test that may shorten the process between diagnosis and surgery, with the attendant proven benefits. Integrating SII into the diagnostic algorithm may prevent loss of time during the diagnostic process, which may provide better surgical outcomes such as reducing resectional processes and better reproductive results in the future. This would all contribute to better patient outcomes.

## Study Limitations

The limitations of our study were mainly represented by its retrospective nature and dependency on the hospital database to gain patient data.

## CONCLUSION

This study, which included a larger cohort of torsion cases compared to previous studies, is the first to investigate the association between the SII and adnexal torsion. We determined that SII, a cost-effective, straightforward, and readily accessible inflammatory marker derived from CBC parameters, could be advantageous in the diagnosis of adnexal torsion. Further large scale, prospective studies may provide additional evidence about the diagnostic effectiveness of SII in case of adnexal torsion.

## Ethics

**Ethics Committee Approval:** This study was approved by the Ethics Committee of the University of Health Sciences Turkey, Bakırköy Dr. Sadi Konuk Training and Research Hospital (approval number: 2022-12-06, date: 20/06/2022).

**Informed Consent:** Retrospective study.

## Authorship Contributions

Surgical and Medical Practices: D.E.A., Y.C., T.Ö.A., Ö.D.S., H.G., Concept: D.E.A., Y.C., T.Ö.A., Ö.D.S., H.G., Design: D.E.A., Y.C., T.Ö.A., Ö.D.S., H.G., Data Collection or Processing: D.E.A., Y.C., T.Ö.A., Ö.D.S., H.G., Analysis or Interpretation: D.E.A., Y.C., T.Ö.A., Ö.D.S., H.G., Literature Search: D.E.A., Y.C., T.Ö.A., Ö.D.S., H.G., Writing: D.E.A., Y.C., T.Ö.A., Ö.D.S., H.G.

**Conflict of Interest:** No conflict of interest was declared by the authors.

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