

Preliminary Study on Differences in Systemic Immune-Inflammation Index and Its Prognostic Correlation in Synovial Sarcoma

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Abstract

Objective

To analyze the differences in molecular characteristics and the systemic immune-inflammation index (SII) among different subtypes of synovial sarcoma (SS) through a comparative study, and to preliminarily evaluate the value of SII in assessing the malignancy degree of SS and predicting patient prognosis.

Methods

Clinical data of SS patients who underwent surgery at The First Affiliated Hospital of Nanjing Medical University between January 2010 and January 2024 were retrospectively analyzed. Recurrence-free survival (RFS) and overall survival (OS) served as the primary endpoints for prognostic evaluation. Statistical analysis was performed using SPSS software. The log-rank test was used to assess significant differences between groups. Univariate and multivariate analyses were conducted to identify factors influencing patient SII values and prognosis, thereby evaluating the utility of SII in determining the malignancy degree of SS and predicting patient outcomes.

Results

This study included 37 SS patients. The follow-up period ranged from 6 to 154 months, with a mean of (68.05 ± 37.07) months. The cohort comprised 17 males and 20 females, with a mean age of (47.54 ± 15.19) years. Primary tumor sites included the upper limb (11 cases), lower limb (15 cases), groin (8 cases), abdominal wall (1 case), intra-abdominal region (1 case), and thoracic spine (1 case). There were 26 monophasic SS cases and 11 biphasic SS cases. During follow-up, recurrence occurred in 16 cases (11 monophasic, 5 biphasic), and metastasis occurred in 6 cases (2 monophasic, 4 biphasic). The 5-year recurrence-free survival rate was 42.1%, and the 5-year overall survival rate was 91.3%. Univariate analysis suggested that surgical margin and tumor type were factors influencing RFS, while surgical margin was a factor influencing OS. Furthermore, correlations were observed between tumor type, recurrence/metastasis status, and SII values. Among 15 patients with tumor volume < 5 cm, 7 were initially misdiagnosed by imaging (4 by ultrasound suggesting benign, 3 by MRI suggesting benign), yielding an imaging misdiagnosis rate of 46.67%. The mean SII value in this group was (524.75 ± 155.22) . Among 18 patients with tumor volume ≥ 5 cm, 2 were misdiagnosed (1 by ultrasound as neurogenic tumor, 1 by MRI as a cyst), resulting in a misdiagnosis rate of 11.11%. The mean SII value for this group was (701.42 ± 167.60) . Additionally, 4 patients had multiple SS, and tumor size was not measured. Correlation analysis between SS subtype, tumor size, prognosis, and SII values revealed statistically significant associations ($P < 0.05$).

Conclusion

SII holds indicative significance for the diagnosis of synovial sarcoma. A high SII often indicates high malignancy and may help reduce the misdiagnosis rate for small tumors that are easily mistaken for benign lesions. Simultaneously, a high SII is frequently associated with poor prognosis, necessitating more careful comprehensive treatment planning for affected patients. Thus, SII is significantly important for the diagnosis of synovial sarcoma and for predicting patient prognosis.

1. Introduction

Synovial sarcoma (SS) is a rare malignant tumor, accounting for 5–10% of all soft tissue sarcomas (STS) [1]. SS can occur at any age, but at least one-third of patients are children, adolescents, and young adults, with a median age of onset around 35–40 years [2–3]. It occurs mainly in the limbs but can also arise in other locations. Despite its name suggesting synovial origin, it does not strictly originate from synovial tissue. Morphologically, SS presents as three distinct histological subtypes: monophasic, biphasic, and poorly differentiated. The monophasic type exhibits only mesenchymal spindle cells, the biphasic type shows both epithelial and spindle cells, and the poorly differentiated type features small round cells and is associated with a poorer prognosis. Diagnosis is based on the SS18-SSX fusion oncogene and corresponding fusion protein resulting from the characteristic chromosomal translocation $t(X;18)$ [4]. This pathognomonic translocation can be detected by fluorescence in situ hybridization (FISH) or by identifying the fusion transcript via reverse transcriptase polymerase chain reaction (RT-PCR). Notably, a rabbit monoclonal antibody (clone E9X9V) specifically detecting the endogenous human SS18-SSX fusion protein epitope has recently been used for immunohistochemical validation and is commercially available, simplifying SS diagnosis and related molecular biology research [5]. Several in vitro and in vivo experimental models, including conditional genetically engineered mouse models (GEMM) carrying the SS18-SSX translocation and patient-derived xenografts (PDX) from SS patients [6], have been developed. Preclinical research highlights numerous potential therapeutic targets. Through these models, a more comprehensive understanding of the fusion gene mechanism [7], the role of the tumor microenvironment, and tumor antigen expression now opens avenues for designing innovative epigenetic, targeted, or immunotherapeutic strategies, holding promise for significant advances in the treatment of advanced SS.

The current gold standard for SS diagnosis remains the detection of the SS18-SSX fusion gene by FISH and RT-PCR. The SS18-SSX fusion gene is detected in over 95% of SS cases [8–9], showing high specificity across all subtypes. Approximately two-thirds of SS express the SS18-SSX1 gene fusion, while SS18-SSX2 fusion is found in about one-third [10], and SS18-SSX4 gene fusion expression is rare. Specific gene fusions have been confirmed to correlate with SS histological type; almost all biphasic SS express the SS18-SSX1 fusion, whereas the SS18-SSX2 fusion is predominantly expressed in monophasic SS [11–14].

FISH using SS18 gene break-apart probes and RT-PCR techniques are recommended as common diagnostic tools for SS. Studies report sensitivities of 94% and 83% for FISH and RT-PCR, respectively^[15–16]. However, rare cases exist with typical SS morphological and immunohistochemical features but no detectable SS18-SSX fusion gene, which some scholars suggest may involve rare gene fusions or cryptic rearrangements^[17–18].

Imaging is commonly used for SS diagnosis, staging, and treatment planning. However, the imaging features of SS are non-specific. CT often shows low-density masses with calcification visible in 30% of cases^[19–20]. Magnetic resonance imaging (MRI) typically reveals heterogeneous masses: the "triple sign" describes areas of low, intermediate, and high signal intensity on T2-weighted imaging (WI) in SS^[21–22]. Another imaging presentation is "pseudocystic" SS, appearing as small, homogeneous high T2 signal lesions, potentially mistaken for cystic lesions on T2-WI^[23]. Due to misleading clinical and imaging features, these tumors are often misdiagnosed as benign, leading to inadequate surgical treatment.

Numerous studies indicate that cancer-related inflammation and the immune system play crucial roles in cancer initiation, progression, invasion, and metastasis^[24–26]. Many hematological indices, such as the platelet-to-lymphocyte ratio, lymphocyte-to-monocyte ratio, prognostic nutritional index, neutrophil-to-lymphocyte ratio, and systemic immune-inflammation index (SII), are considered effective markers for predicting prognosis in various cancers. The SII is calculated as: $SII = \text{Platelet count} \times \text{Neutrophil count} / \text{Lymphocyte count}$. Previous studies have reported that SII is significant for predicting prognosis in various solid tumors, including rectal cancer, non-small cell lung cancer, breast cancer, renal cell carcinoma, and pancreatic neuroendocrine tumors^[27–29]. However, no related studies exist for SS.

This study aims to improve the accuracy of SS diagnosis and reduce misdiagnosis rates. By retrospectively analyzing the medical records of monophasic and biphasic synovial sarcoma patients treated at The First Affiliated Hospital of Nanjing Medical University between January 2010 and January 2024, and conducting detailed post-discharge follow-up, we used the SPSS statistical platform to perform an in-depth analysis of the differences in SII values among different SS subtypes and their correlation with patient prognosis, thereby providing a basis for prognostic assessment. Simultaneously, we comprehensively analyzed patient imaging characteristics and tumor size, exploring their respective correlations with SII to aid in designing individualized treatment plans and improving patient outcomes.

2. Methods

2.1 Case Collection

This study conducted an in-depth analysis of synovial sarcoma patients treated at Nanjing Medical University from January 2010 to January 2024, who possessed complete pathological and medical records. Through meticulous data screening, a comprehensive analysis was performed on the subjects' gender, age distribution, surgical plans, primary tumor site, adjuvant treatment plans, recurrence and metastasis status, systemic immune-inflammation index, etc. Follow-up continued until January 2025.

Inclusion Criteria: 1) Pathologically confirmed SS patients; 2) No other concurrent tumor diseases; 3) Complete patient visit data; 4) Obtained patient informed consent; 5) Patients underwent regular postoperative MRI and CT examinations, with a follow-up time of at least 12 months.

Exclusion Criteria: 1) History of other malignant tumors; 2) Poor general condition, unable to tolerate surgery, radiotherapy, or chemotherapy; 3) Incomplete clinical data or follow-up time less than 12 months; 4) History of surgery within 3 months; 5) Presence of severe infection.

According to the inclusion and exclusion criteria, 37 SS patients were included: 26 monophasic (70.27%) and 11 biphasic (29.73%). The cohort consisted of 17 males and 20 females, aged 12–70 years, with a mean age of (47.54 ± 15.19) years. Primary sites included: upper limb (11 cases), lower limb (15 cases), groin (8 cases), abdominal wall (1 case), intra-abdominal region (1 case), thoracic spine (1 case). Among the 37 patients, 33 had solitary tumors, all with measured maximum diameters; 4 patients had multiple tumors, for which maximum diameter was not measured. The average maximum diameter for the 33 solitary tumors was (5.94 ± 3.71) cm.

2.2 Diagnosis

All patients underwent pathological examination. Preoperative CT/ultrasound-guided core needle biopsy or incisional biopsy was performed based on patient needs. To assess the presence of metastases, multi-detector CT chest plain scan + contrast enhancement or PET-CT was performed. Genetic testing was performed based on patient preference. Patients were classified as monophasic or biphasic synovial sarcoma according to the WHO Classification of Tumours of Soft Tissue and Bone (5th Edition, 2020). Characteristic descriptions: Monophasic: Composed of uniform spindle cells with moderate cytological atypia, arranged in fascicles. Biphasic tumor: In addition to fascicular spindle cell components, it also contains varying amounts of epithelial components, forming glandular structures, solid nests, or cord-like arrangements. Mucin may be seen within the cytoplasm, with prominent nucleoli.

2.3 Treatment Methods

All patients underwent surgical resection. The surgical margin was determined based on Enneking staging, including marginal resection and wide resection. Preoperative imaging examinations, including ultrasound, multi-detector CT, MRI, and plain X-ray, were the primary methods for determining surgical strategy. The goal of surgery was to radically remove the tumor while preserving limb function as much as possible. When the tumor was adjacent to or encased important vascular and nerve bundles or other critical structures, careful dissection of the vascular nerve sheath was performed while ensuring tumor capsule integrity. All patients first underwent wide resection. If bone erosion was severe, wide tumor resection + prosthetic (joint) reconstruction was performed. Amputation or disarticulation was performed when limb salvage was impossible.

2.4 Follow-up

This study used a combination of outpatient and remote telephone follow-up to collect and analyze postoperative patient follow-up data until January 2025. Follow-up records included tumor recurrence

and metastasis status, whether adjuvant or neoadjuvant therapy was received, and quality of life. Based on this, the time from surgery to death or the final follow-up endpoint was defined as overall survival (OS). The time interval from surgery to the first tumor recurrence was defined as recurrence-free survival (RFS).

2.5 Statistical Methods

This study used GraphPad Prism 10.0 software for detailed data analysis. The Kaplan-Meier method was used to plot survival curves to estimate patient survival probability. For continuous variables following a normal distribution, we described them as mean $\pm$ standard deviation ($\bar{x} \pm s$) and compared differences between groups using the independent samples t-test. For continuous variables not following a normal distribution, we used median and interquartile range M(Q25, Q75) and applied the Mann-Whitney U test for group comparison. For categorical data, we presented it as n (%) and analyzed differences between groups using the Chi-square test or Fisher's exact test. Additionally, this study used Logistic regression analysis to explore relationships among multiple variables and calculated odds ratios (OR) to assess the influence of each factor. The significance level was set at $P < 0.05$, indicating statistically significant differences.

3. Results

3.1 Patient Clinical Characteristics

According to the inclusion criteria, 37 patients were included in the study. Tumor specimens from all 37 patients were fixed in 10% buffered formalin and paraffin-embedded. FISH using SS18 gene break-apart probes was used to detect the SS18-SSX fusion gene. All pathological results were confirmed by pathology experts at Jiangsu Provincial People's Hospital. Tumors were classified using the 2020 WHO 5th Edition Classification of Soft Tissue Tumors. Among the 37 synovial sarcomas, 26 were monophasic (70.27%) and 11 were biphasic (29.73%). Data distribution and comparison after grouping are shown in Table 1. Surgical margins were determined based on Enneking staging: wide resection in 31 cases, marginal resection in 6 cases. Surgical margins were determined microscopically; a positive margin was defined as tumor cells present within 2 cm of the specimen edge under microscopy, and a negative margin was defined as no tumor cells within 2 cm of the specimen edge under microscopy. Final statistics showed 11 cases with positive margins and 26 cases with negative margins. 24 patients received postoperative adjuvant chemotherapy, 6 patients received postoperative adjuvant radiotherapy, and 6 patients received preoperative neoadjuvant chemotherapy. An additional 8 patients underwent genetic testing.

Table 1
Patient Clinical Data and Univariate Analysis

Clinical Characteristic		RFS P-value	OS P-value	SII Value P-value	SII Mean Value
Mean Age (years)	47.54 ± 15.19	0.059	0.012	0.165	-
Gender		0.653	0.507	0.125	
Male	17				659.27 ± 227.48
Female	20				615.93 ± 148.20
Surgical Margin		0.057	0.026	-	
Negative	26				
Positive	11				
Max Tumor Diam (cm)	5.94 ± 3.71	0.032	0.006	0.001	-
Tumor Subtype		0.098	0.041	0.039	
Monophasic	26				552.73 ± 126.27
Biphasic	11				832.29 ± 161.19
Tumor Location		0.378	0.087	0.204	
Extremities	26				
Non-extremities	11				
Prognosis		0.003	0.008	0.006	
Recurrence/Metastasis	19				736.26 ± 176.73
No Recurrence/Metastasis	18				529.84 ± 134.27

3.2 Follow-up Results

For the 37 SS patients, the follow-up period ranged from 6 to 154 months, with a mean of (68.05 ± 37.07) months. There were 17 males and 20 females. The mean age was (47.54 ± 15.19) years. Primary tumor sites included: upper limb (11 cases), lower limb (15 cases), groin (8 cases), abdominal wall (1 case), intra-abdominal region (1 case), thoracic spine (1 case). There were 26 monophasic SS cases and 11 biphasic SS cases. During follow-up, recurrence occurred in 16 cases (11 monophasic, 5 biphasic), and metastasis occurred in 6 cases (2 monophasic, 4 biphasic). 35 patients survived. The 5-year OS rate was

93.3% for monophasic and 87.5% for biphasic SS. The 5-year RFS rate was 55.6% for monophasic and 40% for biphasic SS.

3.3 SII Value Measurement

All 37 patients underwent preoperative complete blood count tests. Neutrophil count, lymphocyte count, and platelet count were collected, and SII values were calculated. SII values for monophasic synovial sarcoma ranged from 374.64 to 947.60, with a mean of (552.73 ± 126.27) . SII values for biphasic SS ranged from 454.60 to 1079.15, with a mean of (832.29 ± 161.19) . Correlation analysis between SII value and synovial sarcoma subtype showed a significant correlation ($P < 0.05$). Among recurrence patients, 11 were monophasic (42.30% of monophasic patients), and 5 were biphasic (45.45% of biphasic patients). Among lung metastasis patients, 2 were monophasic and 4 were biphasic; among deceased patients, 1 was monophasic and 1 was biphasic. Correlation analysis between SII and patient prognosis (Group A: no recurrence/metastasis; Group B: presence of recurrence or metastasis) showed: Group A SII ranged from 374.64 to 927.29, mean (529.84 ± 134.27) ; Group B SII ranged from 445.47 to 1079.15, mean (736.26 ± 176.73) . The correlation analysis P-value was 0.0002, indicating a significant correlation. Tumors were divided into two size groups: smaller volume ($< 5\text{cm}$) SII ranged from 374.64 to 947.60, mean (524.75 ± 155.22) ; larger volume ($\geq 5\text{cm}$) SII ranged from 454.60 to 1079.15, mean (701.42 ± 167.60) .

3.4 Imaging Characteristics

All 37 patients underwent preoperative imaging examinations. Among them, 3 patients with small tumor volume underwent only preoperative ultrasound and were all misdiagnosed as benign tumors. 33 patients underwent preoperative multi-detector CT; calcification within the tumor was visible in 18 cases. 31 patients underwent MRI; intratumoral hemorrhage was visible in 6 cases, cystic foci in 3 cases. MRI signal was homogeneous in 8 patients, of whom 2 were diagnosed as benign tumors and 1 as a cyst. Among patients with heterogeneous MRI signal, 1 was diagnosed as pigmented villonodular synovitis (PVNS). Imaging findings showed bone invasion in 5 cases.

3.5 Univariate Analysis

Univariate analysis indicated that patient age, surgical margin, and histological subtype were factors influencing OS ($P < 0.05$), while the presence of metastasis/recurrence and maximum tumor diameter were factors influencing RFS ($P < 0.05$). Factors influencing SII included tumor recurrence/metastasis, tumor pathological subtype, and maximum tumor diameter ($P < 0.05$). Patients with tumor recurrence/metastasis, biphasic SS, and maximum tumor diameter $\geq 5\text{cm}$ tended to have high SII levels. SII showed no significant difference concerning age or gender.

3.6 Multivariate Analysis

Variables with statistical significance in the univariate analysis were selected for multivariate analysis (detailed in Table 2). We found that elevated SII, positive margin, biphasic type, advanced age, and larger tumor size were independent risk factors for OS, all significantly increasing the risk of death.

Independent risk factors for RFS were positive margin and larger tumor size, significantly increasing recurrence risk; SII had a weaker but still significant influence. Tumor subtype only had a significant impact on OS; age was not correlated with OS.

Table 2
OS, RFS Multivariate Analysis

Factor	OS		RFS	
	HR (95% CI)	P-value	HR (95% CI)	P-value
Margin	2.45 (1.32–4.55)	0.007	2.10 (1.15–3.83)	0.016
Subtype	1.88 (1.05–3.37)	0.034	1.52 (0.89–2.60)	0.123
Age	1.03 (1.01–1.05)	0.012	1.01 (0.99–1.03)	0.214
Size	1.15 (1.04–1.27)	0.006	1.22 (1.10–1.35)	< 0.001
SII	1.02 (1.01–1.03)	0.004	1.01 (1.00-1.02)	0.038

4. Discussion

Synovial sarcoma (SS) is a malignant mesenchymal tumor. For many years, pluripotent mesenchymal stem cells have been considered the putative origin, but the precise origin of SS remains unknown. SS accounts for 5–10% of all soft tissue sarcomas (STS), occurring mainly in older children and young adults. In the pediatric population, SS is the most common soft tissue sarcoma after rhabdomyosarcoma^[30–32]. It can occur almost anywhere, but its occurrence within joints is very rare^[33–34]. Synovial sarcoma can appear in any location in soft tissue, usually presenting as a gradually enlarging mass^[35]. The most common clinical manifestation is a slow-growing mass in the soft tissues of the lower limb, especially around the knee and ankle. Head and neck, abdominal wall, retroperitoneum, mediastinum, pleura, lung, and other organs are less common sites. Different symptoms may be related to different locations (e.g., dysphagia and dyspnea, or voice changes in head and neck SS), with painless swelling being the most common presentation^[36]. In advanced stages, pain may be related to nerve involvement or perilesional inflammation. Slow tumor growth and seemingly innocuous symptoms often lead to delayed diagnosis. Synovial sarcoma is characterized by local aggressiveness and a tendency to metastasize. However, at diagnosis, metastasis is present in less than 10% of cases^[37–38]. Yet the incidence of late metastasis is high, reported in up to 50–70% of cases^[39]. Most metastases occur in the lungs (80%), with bone (9.9%) and liver (4.5%) also being sites^[40]. Some studies have found metastasis to be more common in elderly patients^[41]. In this cohort, initial patients included 17 males and 20 females, aged 12–70 years, mean (47.54 ± 15.19) years. Primary sites: upper limb (11), lower limb (15), groin (8), abdominal wall (1), intra-abdominal region (1), thoracic spine (1). Metastatic patients: 6 cases, mean age 61.83 years (51–70 years), consistent with the above research. 2 deaths occurred.

Based on tumor cell morphology, synovial sarcoma is divided into monophasic, biphasic, and poorly differentiated types^[42–43]. Monophasic SS is the most common, biphasic SS is less common than monophasic, and poorly differentiated SS is rare. Monophasic SS consists of hypercellular arrangements of small spindle cells, with uniform, ovoid, vesicular nuclei, dispersed chromatin, inconspicuous nucleoli, very scanty cytoplasm, and amphophilic cytoplasm^[44]. Intervening stroma is scanty, and cells are closely packed. SS stroma can be collagenous/hyalinized, rarely amyloid, or extensively myxoid. Hyalinized collagen increase may be seen in tumors recurring after radiotherapy (RT). A hemangiopericytoma-like pattern of sparse, dilated, thin-walled vessels is seen in about 60% of cases. Biphasic SS consists of a mixture of fibroblast-like spindle cells (appearance similar to the monophasic spindle cell subtype) and epithelial cells (usually forming glandular-like structures). Although the proportion of these two components fluctuates, they are usually roughly equal. Epithelial cells have round or ovoid vesicular nuclei with moderate amounts of amphophilic cytoplasm and distinct cell borders. The classic structure of the epithelial element consists of relatively well-formed glands containing mucin in their lumens, which may form papillary structures with cores containing spindled tumor cells rather than connective tissue^[46]. However, the epithelial component may also be less well-differentiated, forming solid nests. The poorly differentiated subtype is highly cellular, often composed of sheets of small round cells with hyperchromatic nuclei, amphophilic cytoplasm, frequent mitotic activity, and necrosis. Poorly differentiated components may be seen focally within SS or may constitute the entire tumor, thus resembling other small round cell tumors. Two other types of poorly differentiated SS have been recognized: one is a large cell epithelioid variant with polygonal cells with abundant cytoplasm, and the other is a highly pleomorphic spindle cell variant^[47]. The poorly differentiated type may be more common in the elderly^[48]. Focal calcification, with or without ossification, is seen in about 30% of SS, more commonly in the biphasic subtype^[45]. Due to limited collection numbers, this study only collected 26 monophasic and 11 biphasic cases; no poorly differentiated cases were collected.

In preoperative examination of SS, imaging is essential. Conventional plain radiography is often used as an initial screening tool, showing soft tissue masses, abnormal skin contour, high-density shadows, and displacement of adjacent structures^[49]. CT shows heterogeneous low-density masses within deep soft tissues, with small calcifications or peritumoral calcifications^[50–51]. Ultrasound shows heterogeneous echogenic masses, with hypoechoic or anechoic areas suggesting cystic/necrotic changes^[52]. MRI, with its excellent tissue contrast and multiplanar imaging capability, is the recommended imaging method^[52]. MRI helps assess tumor size, extent of surrounding soft tissue invasion, distinguish tumor from muscle tissue, and show involvement of neurovascular bundles, fascial/fat planes, tendons, and bone marrow. Synovial sarcoma often appears on MRI as a well-defined small mass with homogeneous signal^[53]. Although imaging features are non-specific, a calcified soft tissue density near a joint in a young patient is highly suggestive of synovial sarcoma. Cross-sectional imaging also aids in tumor staging and surgical planning. The "triple sign" is a characteristic manifestation, including lobulated structure, marked heterogeneity, septations, fluid-fluid levels, and hemorrhage^[54]. However, when the tumor volume is small, it often exhibits imaging features similar to benign tumors, such as homogeneous signal on MRI

with clear borders. When the tumor grows wrapped around nerves or along nerve tracts, it can exhibit characteristics of neurogenic tumors. Some synovial sarcomas may show homogeneous cystic foci, easily misdiagnosed as cysts. In this cohort, all 37 patients underwent preoperative imaging. Among them, 3 patients with small masses underwent only preoperative ultrasound and were all misdiagnosed as benign tumors. 33 patients underwent preoperative multi-detector CT; calcification within the tumor was visible in 18 cases. 31 patients underwent MRI; intratumoral hemorrhage was visible in 6 cases, cystic foci in 3 cases. MRI signal was homogeneous in 8 patients, of whom 2 were diagnosed as benign tumors and 1 as a cyst. Among patients with heterogeneous MRI signal, 1 was diagnosed as pigmented villonodular synovitis. Thus, imaging often leads to misdiagnosis for small-volume SS.

Increasing evidence suggests that cytokines and inflammatory cells play important roles in cancer cell proliferation and host anti-tumor immune responses in STS patients^[24–26]. Changes in SII values indicate fluctuations in platelet, neutrophil, or lymphocyte counts, partially reflecting the balance between host immunity and inflammation^[55]. Several recent studies have investigated potential mechanisms explaining the relationship between SII and tumor prognosis^[56]. Tumor cells induce inflammation by stimulating pro-inflammatory mediators, thereby promoting angiogenesis and inhibiting apoptosis, thus facilitating tumor cell proliferation and invasion^[55]. SII incorporates neutrophil, lymphocyte, and platelet counts from peripheral blood. As indicators of acute and chronic inflammation, peripheral neutrophils can enhance the adhesion of circulating tumor cells (CTCs) and promote CTC metastasis to target organs^[57]. They can also inhibit the cytolytic activity of immune cells by secreting cytokines and chemokines (such as matrix metalloproteinase-9), leading to tumorigenesis and metastasis^[58–59]. Platelets participate in tumor migration by secreting vascular endothelial growth factor (VEGF), transforming growth factor- β (TGF- β), and platelet-derived growth factor (PDGF)^[60–61]. PDGF can promote epithelial-mesenchymal transition (EMT) by activating the SMAD (signal transduction molecules downstream of the TGF- β receptor family) and nuclear factor kappa-light-chain-enhancer of activated B cells (NF- κ B) pathways, which play an important role in early tumor metastasis^[62]. The immune surveillance role of lymphocytes is attributed to inhibiting tumor cell proliferation, invasion, and migration^[63]. The results of these related studies may indicate that high SII levels contribute to cancer progression and lead to poorer survival. Although SII provides insights into tumor-host interactions, its consistent predictive value for individualized treatment decisions has not yet been proven in clinical practice. Some uncertainty stems from variations in defining cutoff values for high and low SII levels, as well as limited understanding of SII's interaction with other clinicopathological variables. Furthermore, systemic inflammation is influenced by multiple factors beyond cancer biology (such as comorbidities, lifestyle, and concurrent infections), which may confound its prognostic significance.

In this cohort study, univariate and multivariate analyses were performed for OS and RFS in SS. In univariate analysis, patient age, surgical margin, and histological subtype were factors influencing OS ($P < 0.05$), while the presence of metastasis/recurrence and maximum tumor diameter were factors influencing RFS ($P < 0.05$). Previous studies have found that surgical margin, pathological subtype, and tumor size are important factors influencing patient prognosis. Kaplan-Meier survival analysis and

survival curves were plotted for the above factors and SII values concerning patient OS and RFS (Fig. 1). Tumor size was divided at 5cm; SII was divided into high-SII and low-SII groups using 504.46 as the cutoff point. Positive margin was found to be the main factor affecting patient prognosis. Due to the small sample size, tumor size and histological subtype showed no clear statistical significance concerning prognosis, but the survival curves clearly showed a tendency for worse prognosis in biphasic SS and larger tumors. In this cohort, factors influencing SII included tumor recurrence/metastasis, tumor pathological subtype, and maximum tumor diameter ($P < 0.05$). Patients with tumor recurrence/metastasis, biphasic SS, and maximum tumor diameter $\geq 5\text{cm}$ tended to have high SII levels. SII showed no significant difference concerning age or gender. Multivariate analysis indicated that elevated SII, positive margin, biphasic type, and larger tumor size were independent risk factors for OS, all significantly increasing the risk of death. Independent risk factors for RFS were positive margin and larger tumor size, significantly increasing recurrence risk; SII had a weaker but still significant influence. Due to the limited sample size, the conclusions drawn from this study cannot fully reflect the value of SII in SS diagnosis and prognosis prediction. A study on the value of the systemic immune-inflammation index and high-sensitivity modified Glasgow prognostic score in assessing the prognosis of patients after radical resection of soft tissue sarcoma pointed out that in soft tissue sarcoma patients, $\text{SII} > 504.46$ could be classified into the high-SII group. Patients in this group had shorter median OS and lower 5-year OS rates (73.2 months vs. 86.5 months, $P = 0.012$; 69.7% vs. 85.7%, $P < 0.001$). Patients with elevated SII were more likely to have larger tumors (OR, 1.66; 95% CI, 1.17–2.36; $P = 0.011$), deep-seated tumors ($P = 0.018$), higher tumor grade ($P = 0.009$), and later AJCC stage ($P = 0.002$). This implies that the same association may exist in SS. In this cohort, there were 15 patients with tumor volume $< 5\text{cm}$, of whom 7 had initial imaging misdiagnosis (4 by ultrasound suggesting benign, 3 by MRI suggesting benign), resulting in an imaging misdiagnosis rate of 46.67%. The mean SII value for this group was (524.75 ± 155.22). If SII is combined for diagnosis, clinicians should be more cautious when diagnosing benign tumors in patients with high SII, requiring combination with multiple examinations and, if necessary, biopsy, thereby improving SS diagnosis rates, reducing unplanned surgery rates, and further improving patient prognosis.

Currently, surgery is the preferred treatment for early-stage SS^[64–65]. Complete surgical resection of the tumor is key to reducing postoperative recurrence and improving survival rates. Postoperative adjuvant chemotherapy can significantly improve treatment efficacy^[66–67]. Most chemotherapy regimens start with ifosfamide combined with doxorubicin or epirubicin as first-line therapy^[68–70]. The main purpose of preoperative chemotherapy is to potentially reduce tumor size, block tumor blood supply, accelerate tumor cell death, reduce or delay the possibility of tumor rupture and metastasis, and facilitate complete tumor resection by surgery. It also provides experience for postoperative adjuvant chemotherapy. Inevitably, while chemotherapy brings efficacy, it is also accompanied by varying degrees of drug side effects. Acute or subacute toxic reactions of chemotherapy drugs (e.g., gastrointestinal disorders, bone marrow suppression) and drug-specific side effects (e.g., liver damage, cardiac damage, pulmonary fibrosis) may significantly affect patient treatment outcomes and survival time. This study was limited by sample size; adjuvant therapy showed no significant statistical difference with patient OS. However, we

found that patients receiving adjuvant therapy had significantly better RFS than those without adjuvant therapy (Fig. 2). Besides conventional adjuvant chemotherapy, molecular targeted therapy also holds an important position in SS. Genetic testing technology can be used to screen targeted drugs specifically, helping to improve patient prognosis

5. Conclusion

Synovial sarcoma (SS) is a common high-grade sarcoma exhibiting biological behavior ranging from indolent to highly aggressive, with a generally poor prognosis. Its 5-year survival rate is 60% to 80%, with a tendency for late recurrence and metastasis. Diagnosis of SS by imaging often leads to misdiagnosis, resulting in unplanned surgery and frequently poor patient outcomes. SII often shows elevated levels in malignant tumors; when combined with imaging examinations, it can effectively reduce misdiagnosis rates. Furthermore, a high SII often indicates poor patient prognosis and thus can serve as a reference for clinicians in formulating treatment plans. Therefore, SII holds significant importance for the diagnosis of SS and for predicting patient prognosis. For advanced or metastatic SS, molecular targeted therapy guided by genetic testing shows potential, with various targeted drugs and emerging therapeutic strategies continuously being explored. This study has several limitations: 1. The sample size was small, comprising only 37 patients, with only 11 biphasic cases, and poorly differentiated SS was not included; 2. This was a single-center retrospective design, potentially introducing selection bias; 3. SII is influenced by confounding factors such as infection and chronic diseases, which were not fully corrected for in this analysis.

Abbreviations

SS	Synovial sarcoma
SII	systemic immune-inflammation index
RFS	Recurrence-free survival
OS	overall survival
STS	soft tissue sarcomas
FISH	fluorescence in situ hybridization
RT-PCR	reverse transcriptase polymerase chain reaction
MRI	Magnetic resonance imaging
CT	Computed Tomography
CTCs	circulating tumor cells

The following abbreviations are used in this manuscript

Declarations

Author Contributions: Conceptualization,Z.Y¹.and Y.W. and H.Y.M.; writing—original draft preparation,Z.Y¹ ; methodologyZ.Y¹. and Y.W. and C.L.Q; writing—review and editing, H.Y.M.; data curation , Z.Y.² and W.L.J; All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement This study was conducted in accordance with the ethical standards of the institutional research committee and with the 1964 Declaration of Helsinki and its later amendments. Ethical approval for this study was obtained from the Ethics Committee of Jiangsu Province Hospital (The First Affiliated Hospital of Nanjing Medical University). As this was a retrospective study based on existing medical records, a waiver of written informed consent was granted by the Ethics Committee. However, patient informed consent for participation in follow-up and data use was obtained from all participants prior to their inclusion in the study.

Consent to Publish Informed consent to participate in the study and consent to publish the findings were obtained from all individual participants included in this study as all participants were 18 years of age or older."

Data Availability Statement:No new data were created in this study. However, the original data supporting the findings are available from the corresponding author upon reasonable request, in Excel format.

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Figures

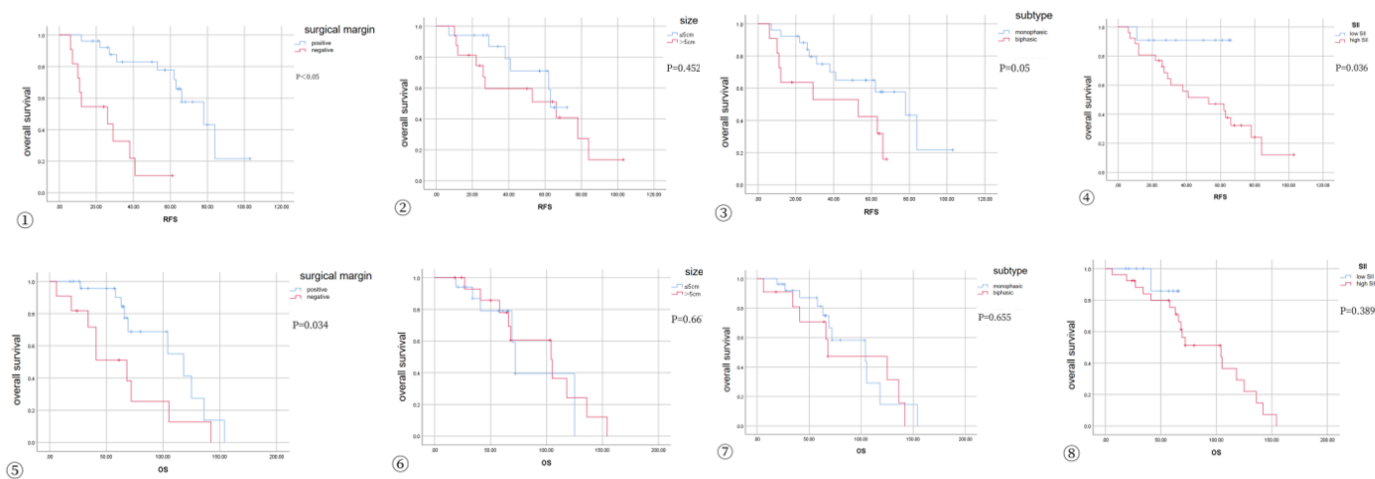


Figure 1

Univariate Kaplan-Meier survival curves. ☐ Margin-RFS; ☐ Size-RFS; ☐ Tumor Subtype-RFS; ☐ SII-RFS; ☐ Margin-OS; ☐ Size-OS; ☐ Tumor Subtype-OS; ☐ SII-OS. Surgical margin is the main factor affecting OS and RFS. SII can be used as an indicator to predict patient prognosis.

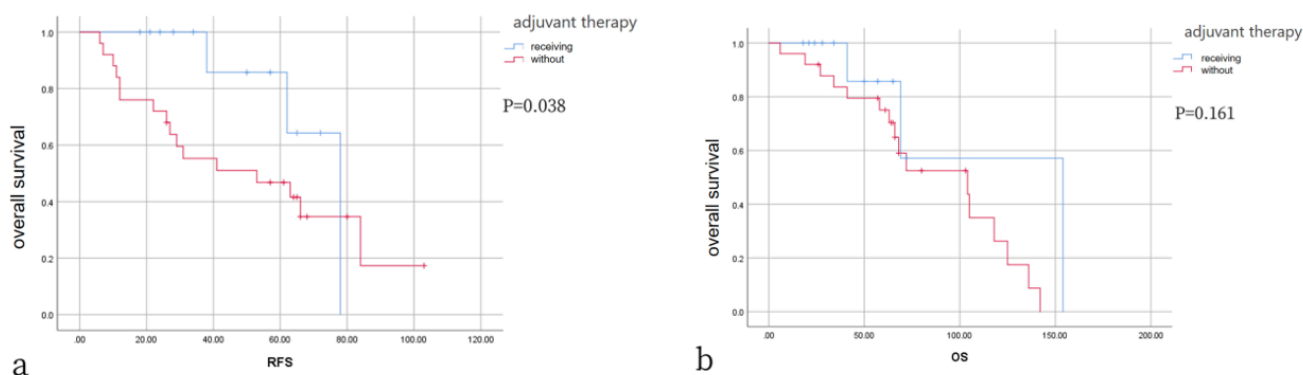


Figure 2

Survival analysis of adjuvant therapy and patient prognosis. a) Patients receiving adjuvant therapy had significantly better RFS than those without adjuvant therapy; b) Adjuvant therapy showed no significant statistical difference with patient OS.