

Correlation between Triglyceride-Glucose Index and Clinical Features and Prognosis of Multiple Myeloma

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Research Article

Keywords: TyG index, Multiple myeloma, Prognosis, Retrospective studies

Posted Date: July 9th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-9907270/v1>

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Additional Declarations: No competing interests reported.

Abstract

Purpose

To investigate the association between the triglyceride-glucose (TyG) index and the prognosis of multiple myeloma (MM).

Methods

This retrospective study included 60 newly diagnosed MM patients. Patients were stratified into high and low TyG groups based on the cohort median TyG index (8.49). Associations of TyG index with overall survival (OS) and progression-free survival (PFS) were analyzed using Kaplan-Meier and Cox regression.

Results

The high TyG group had lower bone marrow plasma cell percentage and higher hemoglobin level. Survival analysis showed lower OS and PFS rates in the high TyG group. Multivariate Cox regression identified high TyG index as an independent risk factor for OS (HR = 78.31, 95% CI: 3.99–1536.47, P = 0.004), but not for PFS.

Conclusion

A higher baseline TyG index may be an independent risk factor for poorer OS in MM patients. As a simple, economical metabolic indicator, the TyG index warrants further investigation as a potential metabolic biomarker, with comparative validation against established staging systems in future studies.

Introduction

Multiple Myeloma (MM) is the second most common hematologic malignancy, accounting for about 10% of cases ^[1]. Its epidemiology varies globally, with an incidence of 4–5/100,000 in Europe and the US versus 1–2/100,000 in Asia. In China, approximately 17,000 new cases and 13,000 deaths occurred in 2021 ^[2, 3]. MM predominates in individuals over 60 years, with a male-to-female ratio of 1.3:1, and a trend toward younger onset has emerged, with a continuously increasing disease burden ^[2, 3].

Current prognostic assessment for MM primarily relies on the DS, ISS, R-ISS, and R2-ISS staging systems, each with limitations. The DS system focuses on tumor burden but lacks cytogenetic information. ISS is simple but fails to capture biological heterogeneity. R-ISS incorporates LDH and genetic abnormalities but its clinical use is limited by dependence on FISH testing. R2-ISS, based on European data, requires further validation in China ^[4–7]. Hence, exploring simple, economical novel prognostic markers holds significant clinical value.

The triglyceride-glucose (TyG) index is a simple indicator of insulin resistance. Mechanisms including excessive insulin-IGF-1 axis activation, chronic inflammation, oxidative stress, and altered lipid metabolism have been linked to MM prognosis [8–14]. Studies confirm that glucose and lipid metabolism disorders are closely associated with MM outcomes. In MM patients with diabetes mellitus, median OS and PFS were significantly shorter (by 33% and 47%, respectively) [8]. Regarding lipid abnormalities, MM patients predominantly exhibit hypocholesterolemia, and low levels of HDL-C, LDL-C, total cholesterol, and apolipoprotein B are significantly associated with shorter survival and poor chemosensitivity [9–12]. The TyG index integrates both glucose and lipid metabolism and has demonstrated independent prognostic value in coronary heart disease, thyroid cancer, DLBCL, and other diseases; however, systematic research on the TyG index in MM is lacking [15–18].

This study is the first to systematically introduce the TyG index—a simple, economical metabolic indicator—into MM prognostic research, aiming to investigate its independent prognostic value and complementary role to current staging systems. Through a retrospective cohort analysis, the associations of the TyG index with OS and PFS were examined, correlations with clinical characteristics were assessed, and its potential predictive value for prognostic stratification was evaluated. This work attempts to complement the precision prognostic system for MM from a metabolic perspective, providing evidence-based support for early identification and individualized treatment of high-risk patients.

Methods

1. Study Subjects

This was a single-center retrospective cohort study. Consecutive newly diagnosed MM patients at the Department of Hematology, Jiangsu Provincial Hospital of Traditional Chinese Medicine from January 2019 to June 2023 were enrolled. Inclusion criteria: (1) meeting the diagnostic criteria of the Chinese Guidelines for the Diagnosis and Treatment of Multiple Myeloma (2024 revision) [19]; (2) had not received anti-MM specific therapy before diagnosis; (3) had complete baseline serum triglyceride (TG) and glucose (Glu) testing data; (4) had complete clinical data and follow-up records with a follow-up duration of at least 6 months; (5) had a documented date of death or loss to follow-up. Exclusion criteria: (1) incomplete data at initial diagnosis; (2) presence of other malignant tumors at initial diagnosis; (3) presence of severe infection or immunodeficiency at enrollment; (4) less than 6 months of consecutive medical records from the date of diagnosis.

2. Data Collection and Variable Definition

Baseline data were collected from the electronic medical record system, including demographic information, history of present illness, comorbidities, smoking and drinking habits, and laboratory test results. All laboratory tests were performed by the clinical laboratory of our hospital according to

standard procedures. The TyG index was defined as $\ln[\text{fasting triglycerides (mg/dL)} \times \text{fasting glucose (mg/dL)} / 2]$.

3. Follow-up and Prognosis Evaluation

Data were collected through a combination of outpatient follow-up, hospital records, and telephone follow-up. Follow-up started on the date of diagnosis and ended on December 31, 2025. The endpoint was defined as disease progression, death, or loss to follow-up.

4. Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables that did not follow a normal distribution were expressed as median (Q1, Q3). Categorical variables were expressed as frequencies (percentages). Group comparisons were performed using the Mann-Whitney U test, chi-squared test, or Fisher's exact test. Overall survival (OS) and progression-free survival (PFS) were analyzed using the Kaplan-Meier method. Univariate and multivariate Cox proportional hazards regression models were used to identify prognostic factors. Variables with $P < 0.10$ in univariate analysis and clinically important variables (ISS stage, renal function status, bone marrow plasma cell proportion, etc.) were included in the multivariate analysis. A two-sided $P < 0.05$ was considered statistically significant.

Results

1 Baseline Characteristics

A total of 60 newly diagnosed MM patients were included in this study, and their clinical baseline characteristics are detailed in Table 1. The median age of the patients was 68.0 years, and there were 32 males (53.33%). In terms of disease characteristics, IgG (30 cases, 50.00%) and IgA (19 cases, 31.67%) were the main M protein types. According to the Durie-Salmon (DS) staging system, the vast majority of patients (56 cases, 93.33%) were in stage III. According to the ISS staging system, 11.67% of patients were in stage I, 38.33% in stage II, and 50.00% in stage III. Laboratory findings indicated that patients commonly had anemia (median hemoglobin 85.50 g/L) and hypoalbuminemia (median albumin 31.80 g/L). The median TyG index, the core variable of this study, was 8.49. It should be noted that 33.33% of the patients did not undergo R-ISS staging due to incomplete fluorescence in situ hybridization (FISH) data, which may lead to differences in characteristics between this subgroup and those who completed R-ISS staging, thereby affecting the statistical power of relevant comparisons.

Table 1
Baseline Characteristics

Characteristics	Full group of patients (n = 60)
Demographic data	
Age [years, M(Q1,Q3)]	68.00 (61.50, 72.75)
Gender [n(%)]	
Male	32 (53.33)
Female	28 (46.67)
Presence or absence of comorbidities [n(%)]	
No	25 (41.67)
Yes	35 (58.33)
Alcohol and tobacco habits [n(%)]	
No	49 (81.67)
Yes	11 (18.33)
Disease characteristics	
M protein type [n(%)]	
IgG type	30 (50.00)
IgA Type	19 (31.67)
Other type	11 (18.33)
DS stage [n(%)]	
Stage I	2 (3.33)
Stage II	2 (3.33)
Stage III	56 (93.33)
Group A	41 (68.33)
Group B	19 (31.67)
ISS stage [n(%)]	
Stage I	7 (11.67)
Stage II	23 (38.33)
Stage III	30 (50.00)
R-ISS staging [n(%)]	

Characteristics	Full group of patients (n = 60)
Stage I	3 (5.00)
Stage II	21 (35.00)
Stage III	16 (26.67)
Unstaged	20 (33.33)
R2-ISS stage [n(%)]	
Low risk	3 (5.00)
Low-intermediate risk	21 (35.00)
Intermediate-high risk	16 (26.67)
High risk	20 (33.33)
Laboratory indicators	
Percentage of bone marrow plasma cells [%, M(Q1,Q3)]	24.00 (17.63, 34.75)
Hemoglobin [g/L, M(Q1,Q3)]	85.50 (71.00, 102.75)
Serum calcium [mmol/, M(Q1,Q3)]	2.33 (2.21, 2.64)
β 2-microglobulin [mg/L, M(Q1,Q3)]	4.26 (2.99, 7.93)
Albumin [g/L, M(Q1,Q3)]	31.80 (27.93, 38.65)
Lactate dehydrogenase [U/L, M(Q1,Q3)]	168.00 (141.00, 198.75)
Renal function status [n(%)]	
Normal	41 (68.33)
Abnormal	19 (31.67)
Core Research variables	
TyG index [M(Q1,Q3)]	8.49 (8.24, 8.92)

2. Correlation between TyG index and clinicopathological features

According to the median TyG index (8.49), the patients were divided into a high TyG group (n = 30) and a low TyG group (n = 30). The comparison of clinical characteristics between the two groups is shown in Table 2. The results showed that there were no significant differences in demographic data (age, gender, comorbidities, smoking and alcohol habits) and disease characteristics (M protein type, DS stage, ISS stage, R-ISS stage) between the two groups (all $P > 0.05$). Regarding R2-ISS risk stratification, although the difference in distribution between the two groups was not statistically significant ($P = 0.097$), the

proportion of low-risk patients in the high TyG group (36.67%, 11/30) was higher than that in the low TyG group (10.00%, 3/30).

In terms of laboratory indicators, the proportion of bone marrow plasma cells in the high TyG group was significantly lower than that in the low TyG group [19.00% (9.50, 30.63) vs. 30.50% (21.50, 42.50), $P = 0.003$]. The hemoglobin (Hb) level in the high TyG group was significantly higher than that in the low TyG group [91.50 g/L (74.50, 115.75) vs. 75.50 g/L (68.00, 97.00), $P = 0.049$]. There were no significant differences in serum calcium, β 2-microglobulin, albumin, lactate dehydrogenase (LDH) levels, or renal function status between the two groups (all $P > 0.05$).

Table 2
TyG index and clinicopathological features

Characteristics	Low TyG (n = 30)	High TyG (n = 30)	Z / χ	P
Demographic data				
Age [years, M(Q1,Q3)]	68.00 (60.50, 72.00)	68.00 (62.25, 73.00)	-0.518	0.604
Gender [n(%)]			1.071	0.301
Male	18 (60.00)	14 (46.67)		
Female	12 (40.00)	16 (53.33)		
Presence or absence of comorbidities [n(%)]			3.360	0.067
No	16 (53.33)	9 (30.00)		
Yes	14 (46.67)	21 (70.00)		
Alcohol and tobacco habits [n(%)]			0.111	0.739
No	25 (83.33)	24 (80.00)		
Yes	5 (16.67)	6 (20.00)		
Disease characteristics				
M protein type [n(%)]			0.698	0.705
IgG type	14 (46.67)	16 (53.33)		
IgA Type	11 (36.67)	8 (26.67)		
Other type	5 (16.67)	6 (20.00)		
DS stage [n(%)]			3.537	0.112
Stage I	0 (0.00)	2 (6.67)		
Stage II	0 (0.00)	2 (6.67)		
Stage III	30 (100.00)	26 (86.67)		
ISS stage [n(%)]			4.004	0.147
Stage I	1 (3.33)	6 (20.00)		
Stage II	12 (40.00)	11 (36.67)		
Stage III	17 (56.67)	13 (43.33)		
R-ISS staging [n(%)]			3.517	0.352
Stage I	0 (0.00)	3 (10.00)		

Characteristics	Low TyG (n = 30)	High TyG (n = 30)	Z / χ	P
Stage II	12 (40.00)	9 (30.00)		
Stage III	9 (30.00)	7 (23.33)		
Unstaged	9 (30.00)	11 (36.67)		
R2-ISS stage [n(%)]			6.239	0.097
Low risk	3 (10.00)	11 (36.67)		
Low-intermediate risk	16 (53.33)	10 (33.33)		
Intermediate-high risk	8 (26.67)	7 (23.33)		
High risk	3 (10.00)	2 (6.67)		
Laboratory indicators				
Proportion of bone marrow plasma cells [% , M(Q1,Q3)]	30.50 (21.50, 42.50)	19.00 (9.50, 30.63)	-2.980	0.003
Hemoglobin [g/L, M(Q1,Q3)]	75.50 (68.00, 97.00)	91.50 (74.50, 115.75)	-1.968	0.049
Serum calcium [mmol/, M(Q1,Q3)]	2.31 (2.15, 2.62)	2.37 (2.24, 2.66)	-0.466	0.641
β 2- Microglobulin [mg/L, M(Q1,Q3)]	2.00 (1.00, 3.00)	2.00 (1.00, 3.00)	-0.770	0.441
Albumin [g/L, M(Q1,Q3)]	30.65 (27.98, 37.53)	34.90 (27.50, 41.00)	-0.747	0.455
Lactate dehydrogenase [U/L, M(Q1,Q3)]	171.50 (133.75, 201.00)	166.50 (153.00, 194.00)	-0.296	0.767
Renal function status [n(%)]			1.926	0.165
Normal	23 (76.67)	18 (60.00)		
Abnormal	7 (23.33)	12 (40.00)		

3 Prognostic survival analysis

3.1 Survival analysis of TyG index and prognosis

Kaplan-Meier survival analysis showed that a high TyG index was associated with shorter OS and PFS. As shown in Fig. 1, the cumulative survival probability of patients in the high TyG group was significantly lower than that in the low TyG group (log-rank $P < 0.05$). Similarly, as shown in Fig. 2, the cumulative progression-free survival probability of patients in the high TyG group was also significantly lower than that in the low TyG group (log-rank $P < 0.05$).

3.2 Univariate and multivariate Cox regression analysis of prognostic factors

To clarify whether the TyG index was an independent prognostic factor for MM, Cox proportional hazards regression analysis was performed.

3.2.1 Prognostic factor analysis of OS

The results of univariate analysis showed (Table 3) that older age (HR = 1.095, 95% CI: 1.005–1.192, $P = 0.037$), a high TyG index (HR = 11.525, 95% CI: 1.484–89.503, $P = 0.019$), and a high LDH level (HR = 1.013, 95% CI: 1.002–1.024, $P = 0.017$) were significantly associated with poor OS. After including the above variables with $P < 0.05$ and other important confounding factors such as ISS stage, renal function status, and bone marrow plasma cell proportion in the multivariate Cox regression model, the high TyG index remained an independent risk factor for OS (HR = 78.311, 95% CI: 3.991–1536.465, $P = 0.004$) (Table 3). However, the 95% confidence interval around this effect estimate was extremely wide, suggesting that the point estimate based on the small sample size is subject to substantial uncertainty and should be interpreted with caution.

Table 3
Univariate and multivariate Cox regression analysis of influencing factors of OS in patients with multiple myeloma

Characteristics	Single factor			Multiple factors		
	P	HR	95%CI	P	HR	95%CI
Age	0.037	1.095	1.005 ~ 1.192	0.133	6.456	0.568 ~ 73.443
Gender						
Male		1.000				
Female	0.347	1.737	0.549 ~ 5.493			
Presence or absence of comorbidities						
No		1.000				
Yes	0.094	3.672	0.802 ~ 16.811			
Alcohol and tobacco habits						
No		1.000				
Yes	0.840	0.854	0.184 ~ 3.953			
DS stage	0.325	0.570	0.186 ~ 1.746			
ISS stage	0.773	1.135	0.480 ~ 2.684	0.129	12.138	0.482 ~ 305.356
R2-ISS stage	0.351	0.691	0.317 ~ 1.503			
Laboratory indicators						
Proportion of bone marrow plasma cells	0.732	1.007	0.966 ~ 1.050	0.244	0.970	0.921 ~ 1.021
Hemoglobin	0.346	0.992	0.975 ~ 1.009	0.560	1.897	0.221 ~ 16.313
Serum calcium	0.147	0.245	0.037 ~ 1.639	0.990		
β2 -microglobulin	0.599	0.947	0.772 ~ 1.161			
Albumin	0.095	0.932	0.858 ~ 1.012			

Characteristics	Single factor			Multiple factors		
	P	HR	95%CI	P	HR	95%CI
Lactate dehydrogenase	0.017	1.013	1.002 ~ 1.024	0.090	9.765	0.701 ~ 135.983
Renal function status						
Normal		1.000				
Abnormal	0.155	0.331	0.072 ~ 1.517	0.002	0.027	0.003 ~ 0.275
TyG						
Low TyG		1.000				
High TyG	0.019	11.525	1.484 ~ 89.503	0.004	78.311	3.991 ~ 1536.465

3.2.2 Prognostic factor analysis of PFS

The results of univariate analysis showed (Table 4) that older age (HR = 1.094, 95% CI: 1.024–1.168, P = 0.008), a high serum calcium level (HR = 0.195, 95% CI: 0.041–0.930, P = 0.040), and a high LDH level (HR = 1.010, 95% CI: 1.001–1.020, P = 0.031) were significant factors affecting PFS. Multivariate analysis further confirmed that renal function status was an independent risk factor for PFS (HR = 0.231, 95% CI: 0.058–0.916, P = 0.037). However, in this cohort, the association between the TyG index and PFS did not reach statistical significance (P = 0.079).

Table 4

Univariate and multivariate Cox regression analysis of influencing factors of PFS in patients with multiple myeloma

Characteristics	Single factor			Multiple factors		
	P	HR	95%CI	P	HR	95%CI
Age	0.008	1.094	1.024 ~ 1.168	0.138	2.630	0.733 ~ 9.436
Gender						
Male		1.000				
Female	0.815	1.111	0.460 ~ 2.682			
Presence or absence of comorbidities						
No		1.000				
Yes	0.471	1.403	0.559 ~ 3.520			
Alcohol and tobacco habits						
No		1.000				
Yes	0.987	0.991	0.328 ~ 2.991			
DS stage	0.746	1.205	0.390 ~ 3.722			
ISS stage	0.404	1.327	0.683 ~ 2.577	0.140	4.308	0.619 ~ 29.984
R2-ISS stage	0.670	1.124	0.656 ~ 1.925			
Laboratory indicators						
Proportion of bone marrow plasma cells	0.336	1.015	0.984 ~ 1.047			
Hemoglobin	0.541	0.997	0.987 ~ 1.007			
Serum calcium	0.040	0.195	0.041 ~ 0.930	0.986		
β 2 -microglobulin	0.749	1.024	0.885 ~ 1.186			
Albumin	0.136	0.953	0.895 ~ 1.015			

Characteristics	Single factor			Multiple factors		
	P	HR	95%CI	P	HR	95%CI
Lactate dehydrogenase	0.031	1.010	1.001 ~ 1.020	0.188	2.325	0.662 ~ 8.160
Renal function status						
Normal		1.000				
Abnormal	0.187	0.477	0.159 ~ 1.432	0.037	0.231	0.058 ~ 0.916
TyG						
Low TyG		1.000				
High TyG	0.302	1.603	0.655 ~ 3.927	0.079	2.824	0.888 ~ 8.979

Discussion

As a single-center retrospective study, this analysis included clinical data from 60 newly diagnosed MM patients and, for the first time, explored the relationship between the TyG index and their clinical characteristics and prognosis. Two main findings emerged. First, patients with a higher TyG index tended to have a lower proportion of bone marrow plasma cells but a higher hemoglobin level, with no significant correlation with disease stage or other conventional tumor burden markers. Second, a high TyG level was identified as an independent risk factor for OS, while its association with PFS did not reach statistical significance. These findings suggest that the TyG index, an easily accessible metabolic indicator, may provide prognostic information distinct from traditional tumor burden markers.

The observed relationship between the TyG index and certain clinical features warrants further investigation. The seemingly paradoxical phenomenon of a lower bone marrow plasma cell percentage but higher hemoglobin level in patients with a high TyG index may reflect the complex impact of metabolic abnormalities on MM. A high TyG index typically indicates insulin resistance and glucose/lipid metabolism disorders, potentially reflecting a systemic metabolic-inflammatory state rather than directly measuring tumor cell quantity^[9]. Such a state could reshape the bone marrow microenvironment, promoting insulin resistance-induced release of free fatty acids and pro-inflammatory cytokines, thereby driving MM cell proliferation, survival, and drug resistance^[9-12, 20]. We hypothesize that systemic metabolic inflammation, reflected by a high TyG index, may exacerbate local bone marrow inflammation and metabolic dysregulation, endowing tumor cells with enhanced survival and clonal evolution advantages. Thus, even with a low initial tumor burden, tumor cells may become more aggressive and drug-resistant, manifesting a “dissociation” between tumor burden indicators and metabolic markers, ultimately leading to poor prognosis. These trends require prospective validation.

Survival analysis revealed that a high TyG index was an independent adverse predictor of OS, consistent with reports in various malignancies. Multivariable Cox regression, adjusting for age and lactate dehydrogenase level, confirmed this (HR = 78.311, 95% CI: 3.991–1536.465, P = 0.004). The extremely high point estimate and wide confidence interval are likely attributable to the small sample size and limited endpoint events, limiting the stability of the effect estimate. Thus, while this strong association is suggestive, it cannot be interpreted as confirmatory. Future larger studies are needed. Nevertheless, this signal suggests that metabolic disturbance may be an independent prognostic factor in MM, reflecting aggressive tumor biology. The non-significant association with PFS may be because PFS is more susceptible to confounding factors (e.g., treatment efficacy, response homogeneity, subsequent therapies), whereas OS more comprehensively reflects long-term outcomes.

If confirmed by future large-scale prospective studies, the TyG index—calculated from routine fasting triglyceride and glucose levels, low-cost and easily implementable—could serve as a simple adjunctive risk assessment tool for newly diagnosed MM patients, complementing conventional ISS or R-ISS staging. It may help identify patients classified as low- or intermediate-risk by traditional systems but who have a worse prognosis due to significant metabolic abnormalities.

This study has several limitations. First, its single-center retrospective design with a small sample size, as evidenced by the extremely wide confidence interval for OS, limits generalizability. Second, only baseline TyG was assessed; dynamic changes during treatment were not evaluated. Third, causality cannot be established: it is unclear whether a high TyG index causes poor prognosis, is a consequence of MM-induced metabolic deterioration, or shares common upstream mechanisms. Fourth, specific treatment regimens were not included in the analysis. Fifth, residual confounding from baseline comorbidities and performance status may exist due to retrospective data. Sixth, substantial missing R-ISS staging data (mainly from missing FISH results) may introduce selection bias.

Future research directions include: large-scale prospective cohorts to validate the TyG index's prognostic value in MM; longitudinal monitoring of TyG changes within clinical trials to analyze relationships with treatment response and minimal residual disease; and basic/translational research using MM cell lines and animal models to investigate insulin resistance-related signaling pathways affecting myeloma cell biology and the bone marrow microenvironment, providing a theoretical basis for metabolic intervention as an adjunctive treatment strategy.

Declarations

Acknowledgments None.

Funding None.

Ethical approval and Accordance Statement This study was approved by the Ethics Committee of Jiangsu Provincial Hospital of Traditional Chinese Medicine (Approval No. 2025NL-015-02). All procedures performed in this study involving human participants were in accordance with the ethical

standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Consent to participate Due to the retrospective nature of this study and the use of existing clinical data, the requirement for informed consent was waived by the Ethics Committee of Jiangsu Provincial Hospital of Traditional Chinese Medicine.

Consent to publish No individual person's data (such as images, videos, or identifying information) are presented in this manuscript. Therefore, consent for publication is not applicable.

Conflict of interest The authors declare no conflict of interest.

Clinical trial number Not applicable.

Author contributions Jingyi Liu was responsible for the study conceptualization, data curation, formal analysis, investigation, methodology, and writing of the original draft. Wanyi Sun contributed to data curation and investigation. Yun Bai participated in formal analysis and investigation. Xingbin Dai oversaw the study conceptualization, project administration, resource allocation, and supervision, and was involved in reviewing and editing the manuscript. Xingbin Dai also served as the corresponding author for this study.

Data Availability Statement All data generated or analyzed during this study are included in this published article [DOI: <https://doi.org/10.5281/zenodo.20529208>]. Additional raw data are available from the corresponding author upon reasonable request.

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Figures

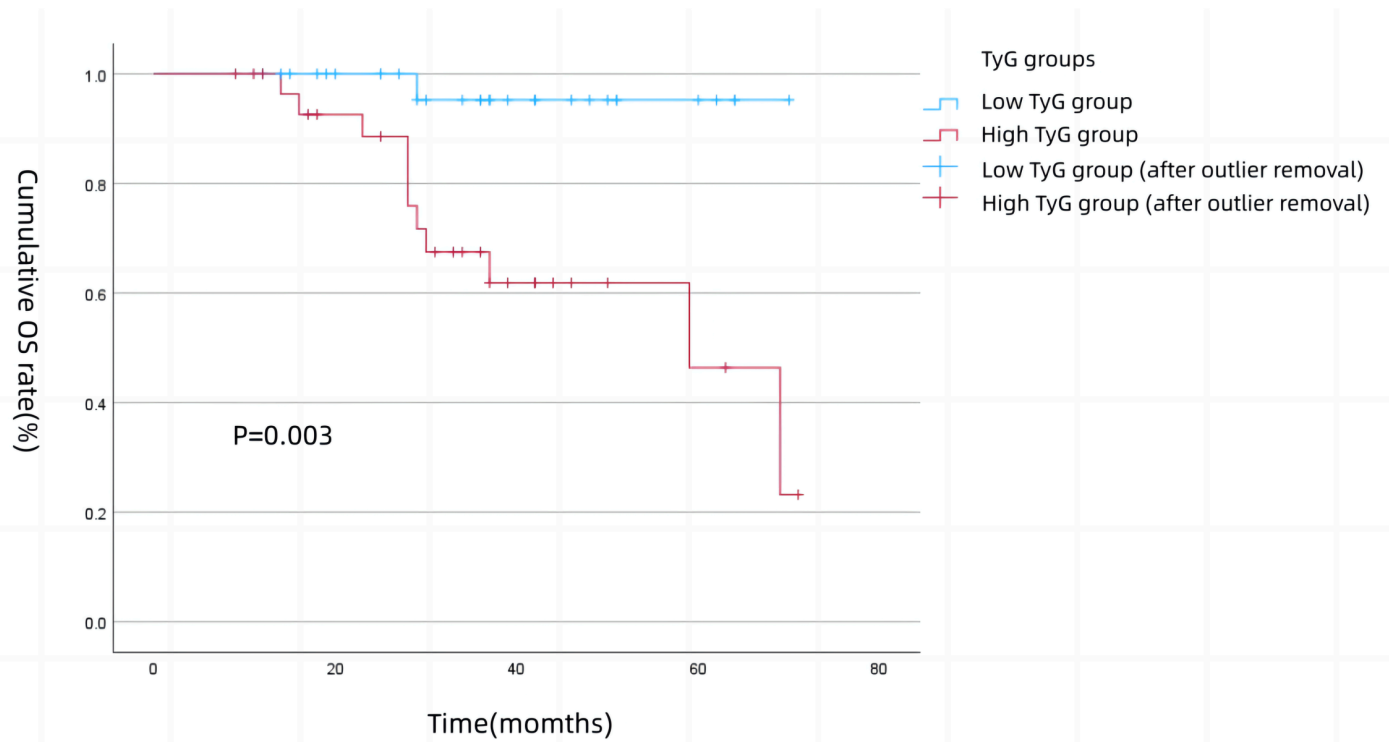


Figure 1

Kaplan-Meier survival curves for OS in the high TyG group versus the low TyG group

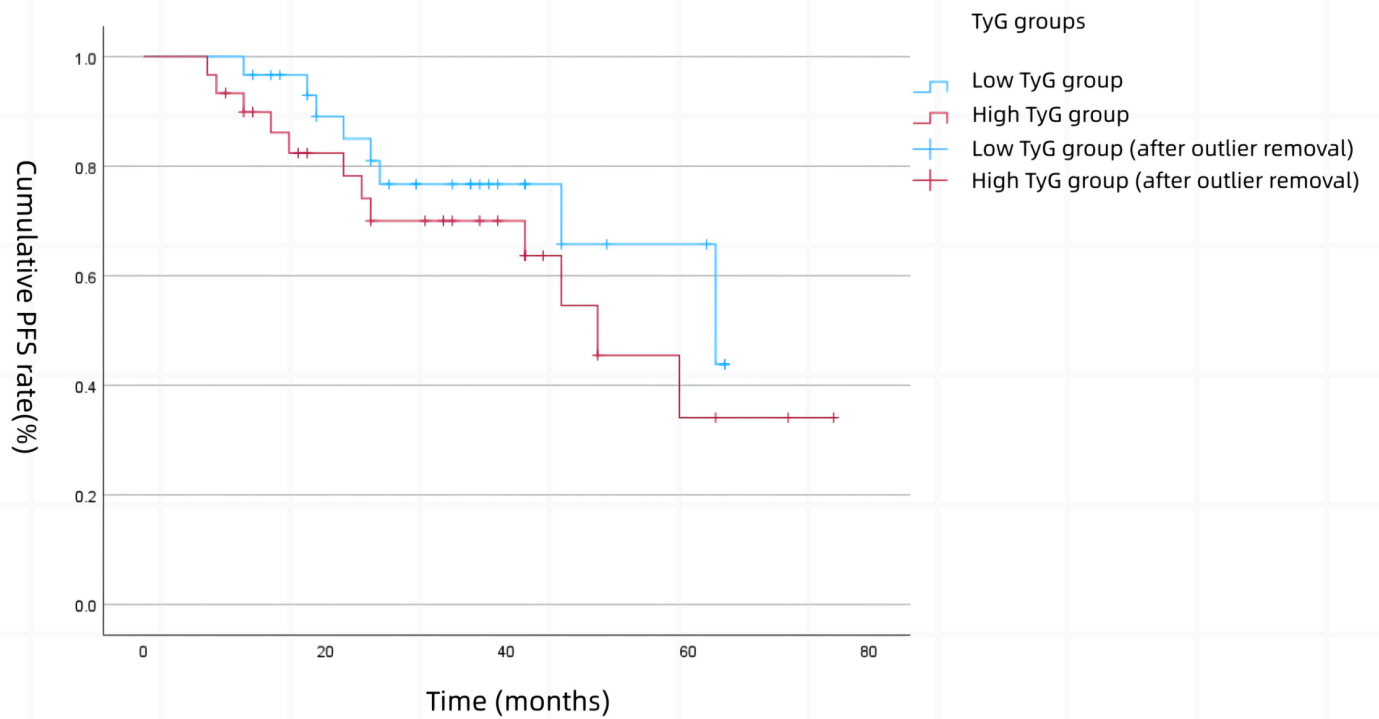


Figure 2

Kaplan-Meier survival curves for PFS in the high TyG group versus the low TyG group

Figure legend: Patients were grouped according to the median baseline TyG index (8.49). The vertical axis represents the cumulative survival probability, and the horizontal axis represents the follow-up time (months). P values from the log-rank test are indicated.