

Prognostic performance of Asian Working Group for Sarcopenia 2019 and 2025 sarcopenia definitions in cirrhosis

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Abstract

Background/purpose of the study The Asian Working Group for Sarcopenia (AWGS) updated its criteria in 2025, adding a body mass index (BMI)-adjusted muscle index (ASM/BMI) to the conventional skeletal muscle index (SMI). We aimed to compare the prognostic performances of the AWGS 2019 and AWGS 2025 in patients with liver cirrhosis. **Methods** This retrospective cohort study included 505 patients ≥ 50 years of age with liver cirrhosis who underwent bioelectrical impedance analysis between 2016 and 2025. Sarcopenia was defined using the AWGS 2019 SMI, AWGS 2025 SMI, and AWGS 2025 ASM/BMI criteria. Landmark analysis was performed on day 180, and overall survival was evaluated. The prognostic performance was assessed using Cox regression, time-dependent ROC analysis, and Harrell's C-index. **Results** During a median follow-up of 5.4 years, 140 deaths occurred. Sarcopenia, as defined by each definition, was independently associated with mortality. The baseline clinical model (age, sex, etiology, and ALBI score) showed a C-index of 0.732. The addition of sarcopenia improved discrimination for SMI-based definitions (Δ C-index 0.033 for AWGS 2025 SMI; 0.023 for AWGS 2019 SMI) but not for AWGS 2025 ASM/BMI (Δ C-index 0.005). At 3 years, the AUC values were 0.828 (AWGS 2025 SMI), 0.822 (AWGS 2019 SMI), and 0.800 (AWGS 2025 ASM/BMI), relative to 0.792 for the baseline model. **Conclusions** AWGS 2025 SMI demonstrated robust prognostic performance comparable to or slightly better than that of the AWGS 2019, whereas the AWGS 2025 ASM/BMI provided limited incremental prognostic value. The height-adjusted SMI remains a reliable metric for risk stratification in cirrhosis.

Background/purpose of the study

Sarcopenia, characterized by a progressive loss of skeletal muscle mass and strength, is increasingly recognized as a clinically important complication in elderly populations and patients with chronic liver disease [1,2]. Sarcopenia is highly prevalent in individuals with liver cirrhosis and is associated with poor clinical outcomes, including mortality, hepatic decompensation, and quality of life [3,4]. Therefore, accurate assessment and standardized diagnostic criteria for sarcopenia are essential for risk stratification and clinical management in patients with cirrhosis.

In 2019, the Asian Working Group for Sarcopenia (AWGS) updated its diagnostic criteria specifically designed for Asian populations. The AWGS 2019 consensus provided thresholds for muscle mass and strength and has been broadly applied in both clinical practice and research [5]. Recently, the AWGS released updated diagnostic recommendations as the AWGS 2025 consensus, which incorporates several modifications aimed at improving diagnostic applicability and expanding the target population [6]. An important modification is the extension of diagnostic applicability to individuals of ≥ 50 years of age, whereas the AWGS 2019 criteria primarily focused on the older population. This modification seems to be particularly relevant for patients with liver cirrhosis, in whom disease-related metabolic alterations promote early muscle depletion, leading to the development of sarcopenia even at a relatively younger age [2,7]. Another important update in AWGS 2025 is the introduction of alternative methods for assessing muscle mass, including body mass index (BMI)-adjusted skeletal muscle indices, in addition to the conventional height-adjusted skeletal muscle index (SMI).

The Japanese Society of Hepatology (JSH) proposed diagnostic criteria for sarcopenia that are specific to patients with cirrhosis [7]. Nonetheless, the cutoff values for indices of skeletal muscle mass measured by bioelectrical impedance analysis (BIA) and handgrip strength are largely derived from AWGS recommendations [5]. Consequently, revisions to the AWGS criteria have significant implications for the current JSH diagnostic frameworks. However, evidence validating the updated AWGS 2025 criteria in cirrhosis is still limited, and the need for modifications to the JSH criteria is uncertain. In particular, it remains unclear whether BMI-adjusted indices provide prognostic information comparable to or better than the conventional SMI.

Accordingly, the present study aimed to evaluate the prognostic significance of sarcopenia, as defined by the updated AWGS 2025 criteria, in patients with liver cirrhosis. We further assessed whether the addition of sarcopenia, defined by AWGS 2025 or AWGS 2019, improved the prediction of mortality in comparison to established clinical risk factors.

Methods

Study design and population

This retrospective single-center cohort study was conducted at a university hospital between January 2016 and December 2025. Patients with liver cirrhosis who underwent body composition assessment using BIA were consecutively enrolled. The inclusion criteria were as follows: (1) age ≥ 50 years; (2) availability of body composition and grip strength measurements at baseline; and (3) ability to ambulate independently without continuous assistance in activities of daily living. The exclusion criteria were as follows: (1) presence of malignant tumors at baseline, including hepatocellular carcinoma (HCC); (2) extracellular water/total body water (ECW/TBW) >0.40 measured by BIA or grade ≥ 2 ascites [8,9]; and (3) severe comorbidities including renal, cardiopulmonary, musculoskeletal, and cerebrovascular diseases. Patients ≥ 50 years of age were included according to the age criteria of the AWGS 2025 [6]. Patients with edema or ascites were excluded because fluid retention may lead to overestimation of body weight and skeletal muscle mass [10]. Based on previous reports, individuals with ECW/TBW >0.40 were considered to be in an overhydrated state and were therefore excluded [11].

For a landmark analysis, patients who survived for at least 180 days after the baseline assessment were included in the landmark cohort (LM180). A total of 916 patients with liver cirrhosis were screened between 2016 and 2025. After applying the predefined exclusion criteria, 505 patients who survived for at least 180 days after the baseline assessment were included in the LM180 cohort (Supplementary Figure 1). Informed consent was obtained using an opt-out approach approved by the institutional ethics committee. This study was conducted in accordance with the Declaration of Helsinki (1975), as revised in 2013, and was approved by the Ethics Committee of Iwate Medical University Hospital (MH2025-118).

Clinical and laboratory assessments

Clinical characteristics and laboratory data were collected at the baseline. Blood samples were obtained after overnight fasting and analyzed using standard clinical laboratory methods at our institution. Serum albumin, total bilirubin, creatinine, and prothrombin time–international normalized ratio (INR) levels were measured.

The liver function was evaluated using the albumin–bilirubin (ALBI) score and modified ALBI (mALBI) grade, as previously described [12]. The etiology of liver disease was determined according to the guidelines of the JSH and the European Association for the Study of the Liver [13-15]. The etiology was classified as viral (hepatitis B or hepatitis C) or nonviral (alcohol-related liver disease, metabolic dysfunction–associated steatotic liver disease (MASLD), and other causes). Liver cirrhosis was diagnosed based on a comprehensive evaluation of clinical and laboratory findings (e.g., elevated fibrosis markers or platelet count $<10 \times 10^4/\mu\text{L}$), characteristic imaging findings of cirrhosis, presence of collateral blood vessels or esophageal varices, and liver biopsy results [8,9].

Body composition measurement

Skeletal muscle mass and grip strength were measured during the initial visit. Skeletal muscle mass was assessed using a BIA (InBody 720; Biospace, Seoul, Korea), a tetrapolar eight-point tactile electrode system capable of separately measuring the impedance of the arms, trunk, and legs. The patients stood on the device while holding the hand electrodes with their arms abducted at approximately 20° from the torso. The device automatically measured the body weight, ECW/TBW, and skeletal muscle mass of the limbs and trunk. Appendicular skeletal muscle mass (ASM) was calculated as the sum of the skeletal muscle masses of both arms and legs. Grip strength was measured using a Smedley-type digital hand dynamometer (T.K.K.5401; Takei Scientific Instruments, Niigata, Japan). Measurements were performed in the standing position with the elbows fully extended. The maximum value from two attempts for each hand was averaged as the representative value.

Definition of sarcopenia

Sarcopenia was diagnosed according to three diagnostic frameworks based on the AWGS criteria: AWGS 2019, AWGS 2025 using height-adjusted SMI, and AWGS 2025 using a BMI-adjusted muscle index [5,6]. Skeletal muscle mass was normalized by height squared or BMI. The SMI was defined as ASM divided by the square of height (kg/m^2), whereas the BMI-adjusted muscle index was defined as ASM divided by BMI (ASM/BMI).

According to the AWGS 2019 definition, low muscle mass was defined as SMI $<7.0 \text{ kg}/\text{m}^2$ in men and $<5.7 \text{ kg}/\text{m}^2$ in women. Age-specific thresholds were applied according to the AWGS 2025 criteria. For individuals aged 50–64 years, low muscle mass was defined as SMI $<7.5 \text{ kg}/\text{m}^2$ in men and $<5.7 \text{ kg}/\text{m}^2$

in women for the height-adjusted index and ASM/BMI <0.90 in men and <0.63 in women for the BMI-adjusted index. For individuals ≥ 65 years of age, low muscle mass was defined as SMI $<7.0 \text{ kg/m}^2$ in men and $<5.7 \text{ kg/m}^2$ in women for the height-adjusted index and ASM/BMI <0.83 in men and <0.57 in women for the BMI-adjusted index.

Muscle strength was assessed using handgrip strength measurements. Low handgrip strength was defined according to the AWGS 2025 thresholds as $<34 \text{ kg}$ for men and $<20 \text{ kg}$ for women of 50–64 years of age, and $<28 \text{ kg}$ for men and $<18 \text{ kg}$ for women ≥ 65 years of age. The AWGS 2019 criteria define low grip strength as $<28 \text{ kg}$ for men and $<18 \text{ kg}$ for women, regardless of age. Sarcopenia was diagnosed when both low muscle mass and low muscle strength were present. The AWGS 2025 height-adjusted (AWGS 2025 SMI) and BMI-adjusted (AWGS 2025 ASM/BMI) muscle indices and the AWGS 2019 height-adjusted skeletal muscle index (AWGS 2019 SMI) were evaluated as independent diagnostic frameworks for sarcopenia.

Landmark analysis

A landmark analysis was performed to minimize reverse causation and reduce the influence of early events reflecting unstable clinical conditions. A landmark time of 180 days was selected to allow stabilization of clinical status after the baseline assessment and to exclude early events, as reported previously [16]. Patients who survived for at least 180 days after baseline were included in the LM180 cohort, with the follow-up time calculated from the landmark time point.

Outcome and follow-up

The primary outcome was the overall survival (OS). Survival time was calculated from the landmark time point to death from any cause or the last follow-up. Patients who were alive at the end of the observation period (December 31, 2025) and those who underwent liver transplantation during follow-up were censored on the date of the last contact or transplantation.

Statistical analysis

All statistical analyses were performed using R version 4.5.0 (R Foundation for Statistical Computing, Vienna, Austria). This study was reported in accordance with the TRIPOD statement. Baseline characteristics are summarized as median (interquartile range [IQR]) for continuous variables and number (percentage) for categorical variables. Continuous variables were compared using the Mann–Whitney U test, and categorical variables were compared using the chi-square test. Cases with missing data were excluded from the analysis. The median follow-up time was estimated using the reverse Kaplan–Meier method. Overall survival was analyzed using the Kaplan–Meier method and compared

among groups using the log-rank test. Multivariable Cox proportional hazards regression analyses were performed to identify independent prognostic factors associated with OS. Clinically relevant variables were selected a priori based on clinical relevance, including age, sex, etiology and severity of liver disease, and sarcopenia. The etiology was categorized as viral (hepatitis B or hepatitis C) or nonviral to ensure model stability. The proportional hazards assumption was assessed using the Schoenfeld residuals.

To evaluate the prognostic performance of the sarcopenia definitions, a baseline clinical model was constructed using Cox proportional hazards regression, including age, sex, viral etiology, and ALBI score. Each sarcopenia definition was then added individually to construct extended models, and their incremental predictive values were assessed by comparison with the baseline model. Time-dependent receiver operating characteristic (ROC) curves were constructed at 3 and 5 years after the landmark using the timeROC package. The area under the ROC curve (AUC) was calculated, and differences between the models were assessed using bootstrap resampling (1,000 iterations). Model discrimination was further evaluated using Harrell's concordance index (C-index). The differences in the C-indices between the models were estimated using paired bootstrap resampling (1,000 iterations). The calibration performance was evaluated using calibration plots, calibration-in-the-large (CITL), and calibration slope. Calibration plots were generated using bootstrap resampling (1,000 iterations). Predicted survival probabilities were calculated for each individual, and the observed risk was estimated using the Kaplan–Meier method. The CITL and calibration slope were estimated using the `rms::val.surv` function to account for censoring. Internal validation was performed using bootstrap resampling (1,000 iterations) to estimate the optimism-corrected model performance. The model performance was evaluated in the overall cohort, with selected analyses stratified by sex. Two-sided P values of <0.05 were considered statistically significant.

Results

Patient characteristics

The baseline characteristics of the study population are summarized in Table 1. The median age of the patients was 69 years, and 282 (55.8%) patients were male. The median BMI was similar between males and females (24.4 vs. 24.2 kg/m², P = 0.891), whereas SMI and handgrip strength were significantly higher in males than in females (both P < 0.001). The etiology distribution differed according to sex, with alcohol-related liver disease being more common in males and MASLD being more frequent in females.

The prevalence of sarcopenia did not differ significantly between females and males under the AWGS 2025 SMI definition (19.9% in males vs. 22.9% in females, P = 0.443). In contrast, both the AWGS 2019 and AWGS 2025 ASM/BMI definitions demonstrated a higher prevalence of sarcopenia in women than in men (AWGS 2019: 13.8% vs. 22.0%, P = 0.018; AWGS 2025 ASM/BMI: 20.6% vs. 32.3%, P = 0.003).

Sex-specific prevalence of sarcopenia across BMI categories

The prevalence of sarcopenia across BMI categories stratified by sex is shown in Figure 1 and Supplementary Table 1. In males, the prevalence of sarcopenia decreased across all definitions with an increase in BMI. In the lowest BMI category ($<20 \text{ kg/m}^2$), the prevalence was highest for AWGS 2025 SMI (60.0%), followed by 48.0% by AWGS 2019 SMI and 36.0% and AWGS 2025 ASM/BMI. With an increase in BMI, the prevalence declined consistently, with a value of 0% in the highest BMI category ($\geq 35 \text{ kg/m}^2$) across all definitions. In females, the prevalence of sarcopenia by SMI-based definitions (AWGS 2019 SMI and AWGS 2025 SMI) showed an inverse relationship with BMI, with the prevalence declining to 0% at a BMI $\geq 30 \text{ kg/m}^2$. In contrast, the AWGS 2025 ASM/BMI definition identified sarcopenia in approximately 40% of women in the same BMI category.

Overall survival

During a median follow-up of 5.4 years (IQR, 3.3–8.0), 140 deaths occurred. The 1-, 3-, and 5-year overall survival rates were 94.2%, 82.9%, and 73.7%, respectively (Figure 2). A Kaplan–Meier analysis demonstrated a significantly lower survival rate in patients with sarcopenia than in those without sarcopenia, consistently across all definitions (AWGS 2025 SMI, AWGS 2019 SMI, and AWGS 2025 ASM/BMI) (all log-rank $P < 0.001$).

Multivariable Cox regression analyses demonstrated that older age, higher mALBI grade, viral etiology, and male sex were independently associated with increased mortality. Sarcopenia was also identified as an independent prognostic factor across all definitions (AWGS 2025 SMI, AWGS 2019 SMI, and AWGS 2025 ASM/BMI) (Table 2).

Time-dependent ROC analysis

Time-dependent ROC analysis showed good discrimination for both the baseline clinical model and the extended models incorporating sarcopenia definitions (Figure 3). At 3 years after the landmark, the AUC values were 0.792 (95% CI 0.738–0.847) for the baseline model, 0.828 (95% CI 0.780–0.876) for AWGS 2025 SMI, 0.822 (95% CI 0.771–0.874) for AWGS 2019 SMI, and 0.800 (95% CI 0.747–0.853) for AWGS 2025 ASM/BMI. At 5 years, the corresponding AUC values were 0.808 (95% CI 0.757–0.860), 0.828 (95% CI 0.779–0.876), 0.822 (95% CI 0.773–0.871), and 0.809 (95% CI 0.758–0.859), respectively. When added to the baseline model, SMI-based sarcopenia had better prognostic value at 3 years (ΔAUC 0.036, 95% CI 0.004–0.067, $P = 0.028$ for AWGS 2025 SMI; ΔAUC 0.030, 95% CI 0.000–0.059, $P = 0.049$ for AWGS 2019 SMI), whereas ASM/BMI did not (ΔAUC 0.007, 95% CI -0.014 – 0.028 , $P = 0.490$; Supplementary Table 2). At 5 years, however, none of the sarcopenia definitions contributed to the prediction of prognosis when compared to the baseline model. In sex-stratified analyses, the incremental

prognostic value of sarcopenia by the definitions was more pronounced in males, whereas no significant improvement was found in females.

Overall, SMI-based sarcopenia definitions, particularly the AWGS 2025 SMI, provided a greater increment in prognostic value than ASM/BMI.

Incremental prognostic value based on Harrell's C-index

C-index analysis showed results consistent with the time-dependent ROC analysis (Table 3). In the overall cohort, the baseline clinical model showed a C-index of 0.732. After adding sarcopenia according to the definitions, the C-index increased to 0.762 for AWGS 2025 SMI, 0.754 for AWGS 2019 SMI, and 0.736 for AWGS 2025 ASM/BMI. In comparison to the baseline model, the addition of SMI-based sarcopenia significantly improved the prediction (Δ C-index 0.033, 95% CI 0.005–0.059, $P = 0.006$ for AWGS 2025 SMI; Δ C-index 0.023, 95% CI 0.003–0.051, $P = 0.032$ for AWGS 2019 SMI), whereas ASM/BMI did not (Δ C-index 0.005, 95% CI –0.006–0.022, $P = 0.532$). In sex-stratified analyses, the increase in the prognostic value of sarcopenia was more pronounced in males. In men, AWGS 2025 SMI and AWGS 2025 ASM/BMI significantly improved discrimination, whereas AWGS 2019 SMI showed a non-significant trend. In contrast, none of the definitions significantly improved the prediction in women.

Overall, the AWGS 2025 SMI provided the greatest increment in prognostic value among the sarcopenia definitions.

Calibration analysis

The calibration plots showed good agreement between the predicted and observed risks at 3 and 5 years after the landmark across all sarcopenia definitions (Supplementary Figure 2). The calibration curves were closely aligned with the ideal line, indicating an accurate risk estimation. The calibration slopes were close to 1.0, and the CITL values were near zero across all models, suggesting minimal overfitting. Consistent findings were observed across time points, including 1 year, as detailed in Supplementary Table 3.

Discussion

In this landmark analysis of patients with liver cirrhosis, we demonstrated that the prognostic performance of sarcopenia defined according to the updated AWGS 2025 framework varies depending on the application of the muscle index. A key finding of this study is that the AWGS 2025 SMI definition showed comparable or slightly improved prognostic performance in comparison to the AWGS 2019 SMI definition, with consistent calibration and improvements in distinction. These findings support the validity of the AWGS 2025 SMI definition in patients with cirrhosis and indicate that the transition from AWGS 2019 SMI to AWGS 2025 SMI is appropriate for prognostic performance. To our knowledge, this is

the first study to directly compare the prognostic performances of the AWGS 2019 and AWGS 2025 definitions in patients with liver cirrhosis.

Although AWGS 2025 introduced a BMI-adjusted skeletal muscle index (ASM/BMI), its increment in the prognostic value was limited in this study. This observation suggests that BMI-based adjustment may not sufficiently capture clinically relevant skeletal muscle depletion in cirrhosis. In addition, we observed sex-specific differences in sarcopenia assessment across BMI categories. While all definitions showed a consistent decrease in the prevalence of sarcopenia with increasing BMI in males, a distinct pattern was found in females, with persistently higher prevalence at higher BMI levels, particularly under the AWGS 2025 ASM/BMI definition. These findings suggest that sarcopenia may be influenced by sex-specific differences in body composition. One possible explanation is that indices influenced by body size may underestimate skeletal muscle depletion in female, because women generally have a high proportion of body fat. In contrast, height-adjusted SMI is less affected by adiposity and may better reflect skeletal muscle reserve.

Our results are consistent with those of previous reports demonstrating sex differences in the prognostic impact of body composition in cirrhosis [17-19]. Skeletal muscle mass appears to be more strongly associated with prognosis in males, whereas adiposity, particularly subcutaneous fat, may play a more prominent role in females. In this context, the prognostic impact of sarcopenia may be attenuated in females, which may partly explain the lower increase in prognostic value in female patients.

The above-mentioned results have important clinical implications. Given that the AWGS 2025 SMI definition demonstrated consistent prognostic performance and robustness across analyses, it may remain the preferred metric for evaluating skeletal muscle depletion in patients with cirrhosis. Importantly, our findings support the continued use of the current JSH sarcopenia criteria, which are primarily based on height-adjusted skeletal muscle assessment [7]. This concept is further supported by our calibration analysis, which showed that all models achieved good agreement between the predicted and observed risks, with calibration slopes close to 1.0 and minimal deviation in the CITL. These results suggest the reliability of these models for predicting clinical risks.

Another important feature of the AWGS 2025 framework is the expansion of the target population to individuals ≥ 50 years of age, along with the introduction of higher cutoff values for skeletal muscle mass and strength [6]. While patients < 50 years of age were excluded from this study, sarcopenia can occur even in younger patients with cirrhosis, and, in fact, the current JSH criteria do not impose a strict age restriction [7]. Accordingly, the inclusion of younger patients may enhance the generalizability and clinical applicability of these criteria for earlier identification and intervention for sarcopenia.

This study had several strengths and limitations. First, the landmark design minimized reverse causation and ensured appropriate temporal alignment between sarcopenia assessment and outcome predictions. Second, we comprehensively evaluated the prognostic performance using complementary metrics, including time-dependent ROC curves, C-index, and a calibration analysis. Third, we obtained consistent

findings in the overall and sex-stratified analyses. This was a retrospective single-center study, which may limit its generalizability. Therefore, external validation is warranted. Residual confounding due to unmeasured variables could not be excluded. In addition, the landmark design may have introduced selection bias by excluding patients who died early after baseline assessment. Finally, skeletal muscle mass was assessed by a BIA, which may be influenced by fluid status, such as less prominent ascites and overhydration.

In conclusion, the AWGS 2025 SMI definition demonstrated robust prognostic performance comparable to or slightly better than that of the AWGS 2019 SMI definition in patients with cirrhosis. The height-adjusted skeletal muscle index remains a practical and reliable metric for assessing sarcopenia in this population.

Declarations

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Conflicts of interest: The authors declare no conflicts of interest in association with the present study.

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Ethical standards: The study complied with the provisions of the 1975 Declaration of Helsinki, as revised in 2013 and was approved by the Ethics Committee of our hospital (MH2025-118).

Informed consent was obtained using an opt-out method approved by the institutional ethics committee.

Author Contributions

Kei Endo: Conceptualization, Methodology, Investigation, Formal analysis, Writing - Original Draft, Visualization. Keisuke Kakisaka: Data Curation, Investigation, Writing - Review & Editing. Tokio Sasaki, Tamami Abe, Yuichi Yoshida, Hidekatsu Kuroda: Investigation. Takayuki Matsumoto: Writing - Review & Editing, Supervision.

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Tables

Table 1
Baseline characteristics of the study population

Variable	Overall (n = 505)	Male (n = 282)	Female (n = 223)	P value
Age, years	69 [62–75]	68 [61–74]	71 [63.5–77]	0.001
Body mass index, kg/m ²	24.3 [21.8–26.7]	24.4 [21.7–26.8]	24.2 [21.0–27.8]	0.891
Skeletal muscle index, kg/m ²	6.88 [6.09–7.68]	7.41 [6.82–8.09]	6.08 [5.48–6.77]	< 0.001
Grip strength, kg	27.0 [19.6–34.7]	33.6 [28.9–38.6]	18.9 [15.4–23.0]	< 0.001
Albumin, g/dL	4.0 [3.6–4.2]	4.0 [3.6–4.3]	3.9 [3.5–4.2]	0.043
Total bilirubin, mg/dL	0.85 [0.60–1.20]	0.90 [0.60–1.20]	0.80 [0.60–1.20]	0.072
Creatinine, mg/dL	0.79 [0.65–0.92]	0.87 [0.74–1.00]	0.68 [0.57–0.80]	< 0.001
Platelet count, ×10 ⁴ /μL	12.4 [8.8–16.1]	12.2 [9.0–16.0]	12.6 [8.7–16.3]	0.866
ALBI score	–2.65 [– 2.95 to – 2.21]	–2.68 [– 2.96 to – 2.28]	–2.62 [– 2.93 to – 2.14]	0.217
Etiology, n (%)				< 0.001
Viral	220 (43.6)	121 (42.9)	99 (44.4)	
Alcohol	137 (27.1)	117 (41.5)	20 (9.0)	
MASLD	88 (17.4)	31 (11.0)	57 (25.6)	
Others	60 (11.9)	13 (4.6)	47 (21.1)	
Diabetes mellitus, n (%)	230 (45.5)	133 (47.2)	97 (43.5)	0.420
Hypertension, n (%)	279 (55.2)	159 (56.4)	120 (53.8)	0.589
Dyslipidemia, n (%)	92 (18.2)	51 (18.1)	41 (18.4)	1.000
Data are presented as median (interquartile range) or number (%).				
P values were calculated using the Mann–Whitney U test for continuous variables and the chi-square test for categorical variables.				
Sarcopenia was defined according to the Asian Working Group for Sarcopenia (AWGS) 2019 and updated AWGS 2025 criteria using the height-adjusted skeletal muscle index (SMI) and BMI-adjusted skeletal muscle index (ASM/BMI).				

Variable	Overall (n = 505)	Male (n = 282)	Female (n = 223)	P value
Sarcopenia (AWGS 2025 SMI), n (%)	107 (21.2)	56 (19.9)	51 (22.9)	0.443
Sarcopenia (AWGS 2019 SMI), n (%)	88 (17.4)	39 (13.8)	49 (22.0)	0.018
Sarcopenia (AWGS 2025 ASM/BMI), n (%)	130 (25.7)	58 (20.6)	72 (32.3)	0.003
Data are presented as median (interquartile range) or number (%).				
P values were calculated using the Mann–Whitney U test for continuous variables and the chi-square test for categorical variables.				
Sarcopenia was defined according to the Asian Working Group for Sarcopenia (AWGS) 2019 and updated AWGS 2025 criteria using the height-adjusted skeletal muscle index (SMI) and BMI-adjusted skeletal muscle index (ASM/BMI).				

Table 2
Factors Associated with Overall Survival (LM180 Cohort)

Variables	AWGS 2025 SMI HR (95% CI)	P value	AWGS 2019 SMI HR (95% CI)	P value	AWGS 2025 ASM/BMI HR (95% CI)	P value
Age	1.05 (1.03–1.07)	< 0.001	1.04 (1.02–1.07)	< 0.001	1.05 (1.03–1.07)	< 0.001
mALBI grade						
1	Reference		Reference		Reference	
2a	1.27 (0.77–2.10)	0.35	1.22 (0.74–2.02)	0.43	1.23 (0.75–2.03)	0.41
2b	2.97 (1.98–4.47)	< 0.001	2.97 (1.97–4.47)	< 0.001	2.95 (1.95–4.45)	< 0.001
3	10.03 (5.42–18.55)	< 0.001	11.47 (6.19–21.26)	< 0.001	10.08 (5.48–18.53)	< 0.001
Diabetes mellitus	0.87 (0.62–1.23)	0.43	0.85 (0.60–1.20)	0.35	0.79 (0.56–1.11)	0.17
Dyslipidemia	0.64 (0.38–1.08)	0.09	0.64 (0.38–1.09)	0.10	0.69 (0.41–1.16)	0.16
Hypertension	0.72 (0.51–1.04)	0.08	0.73 (0.51–1.04)	0.08	0.70 (0.49–1.02)	0.07
Sex (female)	0.67 (0.47–0.95)	0.03	0.63 (0.44–0.89)	0.01	0.57 (0.40–0.83)	0.003
Viral etiology (vs non-viral)	2.16 (1.47–3.19)	< 0.001	2.23 (1.52–3.29)	< 0.001	1.81 (1.24–2.64)	0.002
Sarcopenia	2.67 (1.87–3.83)	< 0.001	2.93 (1.98–4.32)	< 0.001	1.93 (1.34–2.77)	< 0.001
The model columns represent multivariable Cox proportional hazards models, including age, sex, etiology of liver disease, mALBI grade, metabolic comorbidities, and sarcopenia, defined according to each criterion. AWGS, Asian Working Group for Sarcopenia; SMI, skeletal muscle index; BMI, body mass index.						

Table 3

Incremental prognostic value of sarcopenia definitions for overall survival based on Harrell's C-index

Group	Model	n	Events	C-index (baseline)	C-index (extended model)	Δ C-index (95% CI)	P value
Overall	Baseline	505	140	0.732	–	–	–
	AWGS 2025 SMI	505	140		0.762	0.033 (0.005– 0.059)	0.006
	AWGS 2019 SMI	505	140		0.754	0.023 (0.003– 0.051)	0.032
	AWGS 2025 ASM/BMI	505	140		0.736	0.005 (– 0.006– 0.022)	0.532
Male	Baseline	282	83	0.688	–	–	–
	AWGS 2025 SMI	282	83		0.727	0.040 (0.002– 0.090)	0.026
	AWGS 2019 SMI	282	83		0.719	0.032 (– 0.001– 0.069)	0.066
	AWGS 2025 ASM/BMI	282	83		0.722	0.033 (0.002– 0.083)	0.026
Female	Baseline	223	57	0.799	–	–	–
	AWGS 2025 SMI	223	57		0.821	0.020 (– 0.007– 0.059)	0.188
	AWGS 2019 SMI	223	57		0.817	0.022 (– 0.006– 0.062)	0.184
	AWGS 2025 ASM/BMI	223	57		0.796	0.002 (– 0.012– 0.011)	0.640

The C-index values were estimated using Harrell's concordance statistic. The optimism-corrected C-index was calculated using bootstrap internal validation with 1,000 resamples. The incremental value of sarcopenia was assessed as the change in the C-index (Δ C-index) after adding each sarcopenia definition to the baseline model (age, sex, viral etiology, and ALBI score). Confidence intervals and P-values were estimated using bootstrap resampling. ASM, appendicular skeletal muscle mass; SMI, skeletal muscle index; BMI, body mass index; AWGS, Asian Working Group for Sarcopenia.