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Development and validation of a nomogram for predicting outcomes in ovarian cancer patients with liver metastases

Huifu Xiao[1], Ningping Pan[2], Guohai Ruan[1], Qiufen Hao[1] and Jiaojiao Chen[1*]

Abstract

Purpose To develop and validate a nomogram for predicting the overall survival (OS) of ovarian cancer patients with liver metastases (OCLM).

Methods This study identified 821 patients in the Surveillance, Epidemiology, and End Results (SEER) database. All patients were randomly divided in a ratio of 7:3 into a training cohort ($n=574$) and a validation cohort ($n=247$). Clinical factors associated with OS were assessed using univariate and multivariate Cox regression analyses, and backward stepwise regression was applied using the Akaike information criterion (AIC) to select the optimal predictor variables. The nomogram for predicting the OS of the OCLM patients was constructed based on the identified prognostic factors. Their prediction ability was evaluated using the concordance index (C-index), receiver operating characteristic (ROC) curve, calibration curve, and decision curves analysis (DCA) in both the training and validation cohorts.

Results We identified factors that predict OS for OCLM patients and constructed a nomogram based on the data. The ROC, C-index, and calibration analyses indicated that the nomogram performed well over the 1, 2, and 3-year OS in both the training and validation cohorts. Additionally, in contrast to the External model from multiple perspectives, our model shows higher stability and accuracy in predictive power. DCA curves, NRI, and IDI index demonstrated that the nomogram was clinically valuable and superior to the External model.

Conclusion We established and validated a nomogram to predict 1,2- and 3-year OS of OCLM patients, and our results may also be helpful in clinical decision-making.

Keywords Ovarian cancer, Nomogram, Liver metastases, SEER

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Introduction

Ovarian cancer(OC) is one of the deadliest gynecologic cancers of the female reproductive system, with higher mortality and morbidity rates worldwide [1, 2]. An estimated 19,680 new cases and 12,740 deaths due to ovarian cancer are projected to occur in the US in 2024 [3]. Many factors affect the outcome of ovarian cancer, including the FIGO stage, the volume of residual disease after initial debulking surgery, histological tumor type, pathological grade, serum tumor markers (CA125), and treatment modalities [4]. In addition, health conditions, along with other comorbid conditions and the response to the treatment, were shown to adversely impact the outcome of patients [5]. Currently, the primary treatment modalities for ovarian cancer in clinics are surgery, chemotherapy, and targeted therapy [6]. However, due to its insidious onset, patients are often in the middle and late stages when diagnosed. Furthermore, ovarian cancer shows a high rate of recurrence and resistance to platinum-based chemotherapy, which brings significant challenges to the treatment of ovarian cancer [7].

The most common site of distant metastasis from ovarian cancer is the liver, followed by the lymph nodes, lung, bone, and brain [8]. The estimated incidence of liver metastases in patients with ovarian cancer is 7.18%, and the median overall survival was 11 months [9]. It has been estimated that up to 50% of patients who died of ovarian cancer were found to have liver metastasis; therefore, the actual incidence of OCLM is probably considerably higher [10]. The prognosis of OCLM is correlated with various factors, including clinicopathological characteristics and treatment regimens. With numerous factors influencing the outcome of OCLM, accurately predicting the survival of OCLM patients remains problematic. Hence, developing survival prediction tools has become a dire clinical need for clinicians. However, many current prediction models suffer from limitations such as lacking external validation, inadequate sample size, and insufficient applicability in particular populations.

Therefore, developing a more precise and personalized prognostic model is particularly important, especially for those with OCLM. In the present study, we expect to develop and validate a more precisely prognostic model to predict survival in patients with OCLM by extracting a large number of cases from the Surveillance, Epidemiology, and End Results (SEER) database, and fairly comparing with the External model which established based on the data of SEER database similarly (Fig. 1B) [9]. It aims to improve and optimize prognostic models for OCLM patients and can provide clinicians with more effective tools to assess and manage the long-term survival of OCLM patients.

Materials and methods

Data collection and processing

Data were extracted from the SEER database(https://seer.cancer.gov/data/) with the help of SEER*Stat software (version 8.4.3), and we identified ovarian cancer cases based on the International Classification of Diseases for Oncology, 3rd edition (ICD-O-3) and site codes C56.9-Ovary. Liver metastases are determined according to the "SEER Combined Mets at DX-liver (2010+)" field, and the record is "Yes." Evaluation of distant metastasis based on physical examination, imaging examination, and pathologic examination of metastasis; the most important of these is that pathologic examination was positive. As there was no recording of metastases before 2010, we analyzed patients diagnosed with primary ovarian cancer between 2010 and 2021. Clinical data were collected, including Age, Race, Marital status, Laterality, Tumour size, T stage, N stage, Grade, Histology, LBB-Met (lung, bone, and brain metastases), Treatment information(treatment for primary site, surgery of metastases and chemotherapy) and Follow-up information. CA125 is the most widely used tumor marker in ovarian cancer for progress and prognosis. However, in more than 85% of OCLM patients in our data, the CA125 examination showed elevated or positive levels, which we did not include in our study to avoid severe selection bias. In this study, we only included patients with complete data and excluded patients with incomplete information to improve the accuracy of model predictions. The screening process was detailed in the flowchart (Fig. 2). The primary survival outcome was overall survival(OS), and from the date of diagnosis to either death or last follow-up, OS was defined. Our hospital ethics committee exempted ethics approval because the SEER is a publicly available database, and all patient data were anonymous.

Statistical analysis

Age and tumor size, as continuous variables, were transformed into categorical variables based on the optimal cut-off value generated by X-tile software version 3.6.1 (Yale University School of Medicine, United States) (Fig. s1). A chi-square test was employed to compare the differences between the training and validation sets. Clinical factors associated with OS were assessed using univariate and multivariate Cox regression analyses, and backward stepwise regression was applied using the Akaike information criterion (AIC) to select the optimal predictor variables. The R packages "rms," "survival," "foreign," "ggplot2," and "survIDI" were used to construct a prognostic nomogram. We evaluated the predictive ability and accuracy of the nomogram and External model in the training and validation cohorts with the C-index, receiver operating characteristic(ROC) curve, calibration curve, decision curve analysis (DCA), Net reclassification index

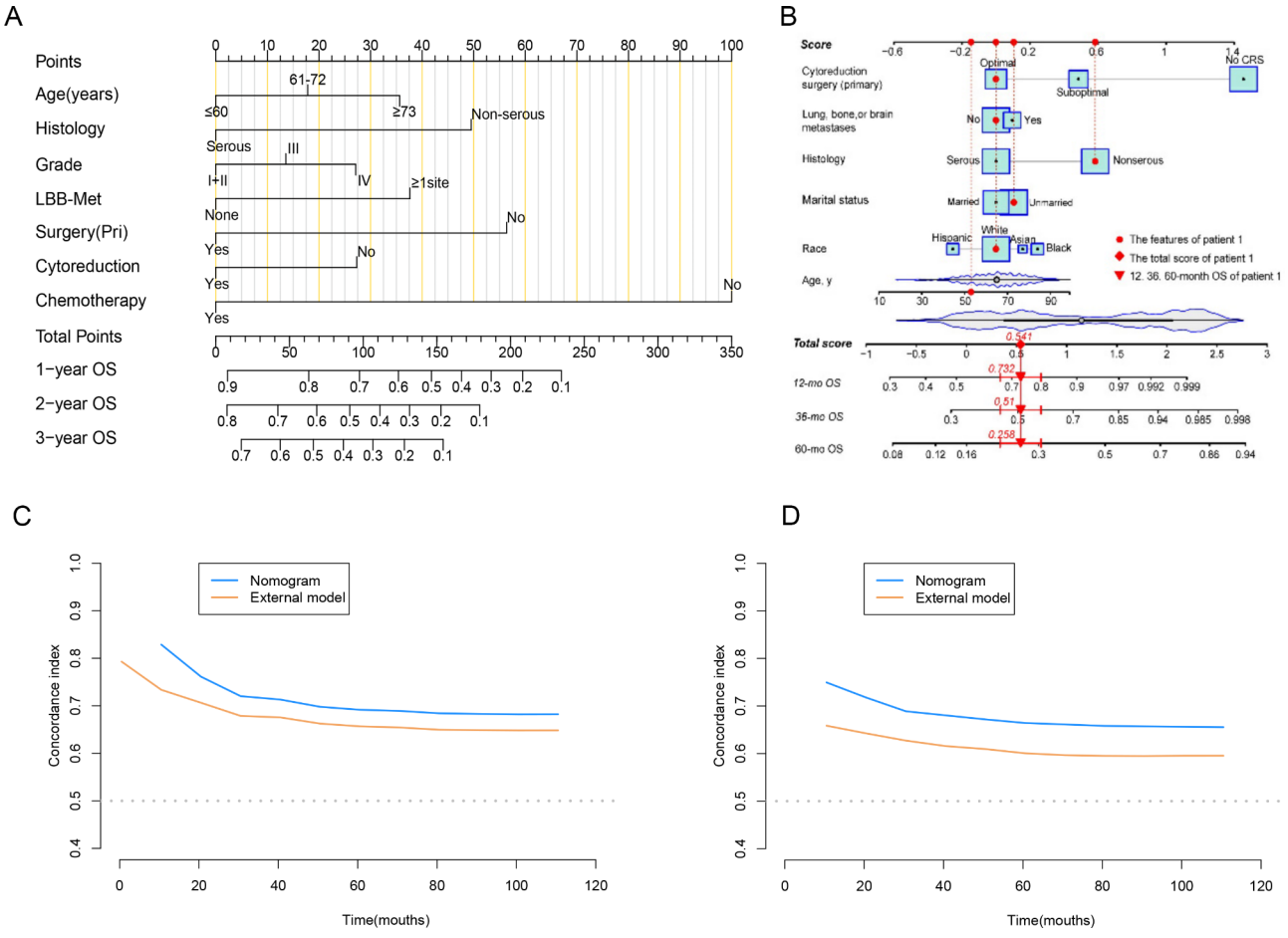

Fig. 1 Nomogram and time-dependent C-index curves of overall survival. (**A**) Nomogram for predicting 1-, 2-, and 3-year OS of patients with OCLM. (**B**) Nomogram of the External model. (**C**, **D**) The time-dependent C-index curves correspond to 1-120 months in the training and verification cohorts

(NRI) and integrated discrimination improvement (IDI). Based on the median calculated from the total score of our nomogram, we divided patients into low-risk and high-risk groups, and the log-rank test was used to determine differences among subgroups of patients based on Kaplan-Meier curves. All analyses were performed using R software, version 4.4.1, and there were two-sided statistical tests performed, and a Pvalue < 0.05 was considered statistically significant.

Results

Clinical baseline data

Based on the inclusion and exclusion criteria, 821 patients were included. All patients were randomly divided into training (n = 574) and validation (n = 247) cohorts at a ratio of 7:3. According to the American Joint Committee on Cancer (AJCC) stage (8th edition), if liver metastases were found, it should belong to the advanced stage of ovarian cancer. The majority of patients were treated surgically on the primary site, including oophorectomy, hysterectomy, and cytoreductive surgery, and combined with chemotherapy concurrently. Moreover, this is also what the current NCCN guidelines recommend. Furthermore, there were no significant differences between the training and the validation cohort, and patients in the two cohorts were comparable. The clinical characteristics of the study population are shown in Table 1.

Variable screening

The univariate Cox regression analysis showed that Age, Histology, Grade, Laterality, Tumour size, T stage, LBB-Met, Surgery of Primary Site, Cytoreduction, and Chemotherapy were risk factors affecting the survival of OCLM, finally, after backward stepwise selection based on AIC, multivariate Cox regression analysis identified Age, Histology, Grade LBB-Met, Surgery of Primary Site, Cytoreduction and Chemotherapy as independent prognostic factors associated with OS (Table 2). These seven predictors were used to construct a predictive model of OS for OCLM patients.

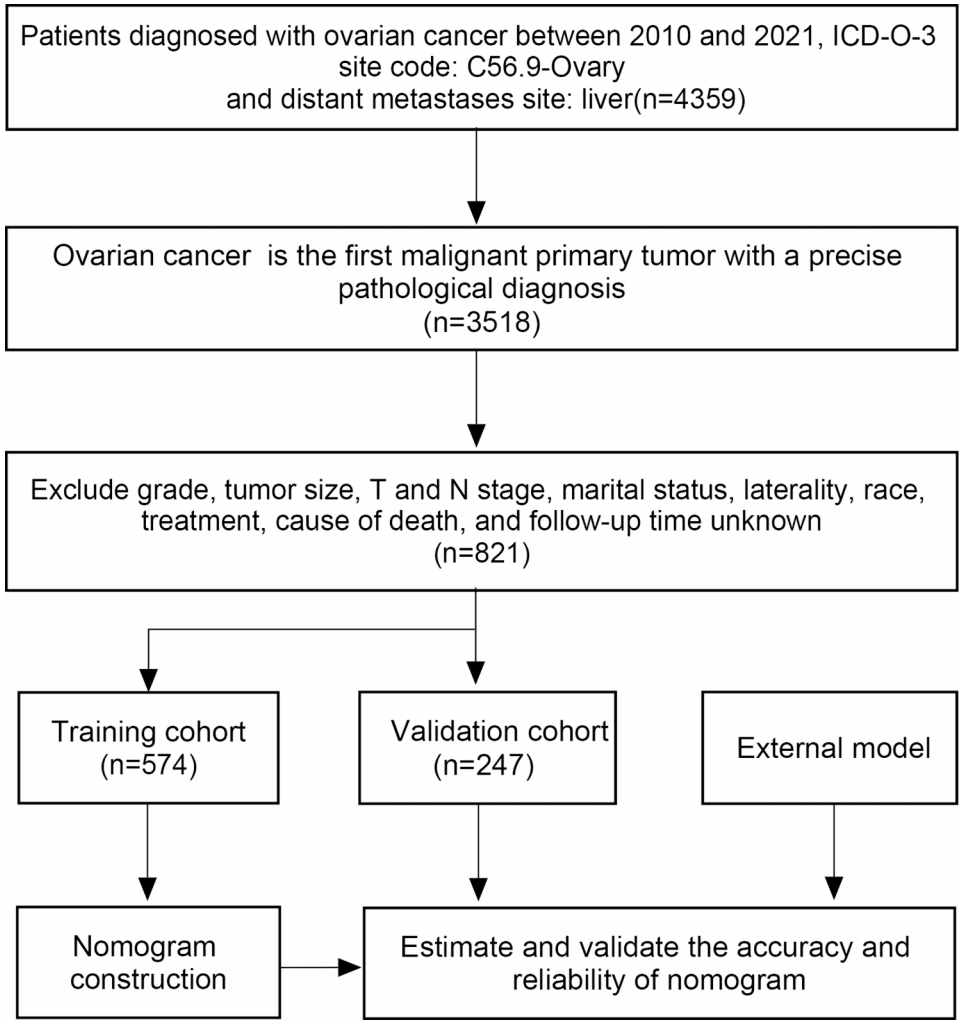

Fig. 2 Flow diagram for selecting ovarian cancer patients with liver metastases

Model establishment and validation

Based on AIC results, seven factors significantly associated with OS of OCLM were selected to establish the predictive nomogram (Fig. 1A). In the training and validation cohorts, the C-index for the nomogram was 0.718(95%CI: 0.691 ~ 0.745) and 0.711(95%CI:0.666 ~ 0.756), and the time-dependent C-index analysis shown that the model was of good stability (Fig. 1C/D). The areas under the ROC curves at 1, 2, and 3 years were 0.835, 0.748, and 0.736 in the training cohort (Fig. 3A/B/C) and 0.801, 0.727 and 0.689 in the validation cohort, respectively (Fig. 3D/E/F). Calibration curves after 1000 bootstraps demonstrated strong concordance between actual and predicted values in the two cohorts (Fig. 4A/B). We calculated the total scores of each patient from the training cohort based on our new nomogram, and based on the median risk score, patients were grouped into high- and low-risk groups. According to Kaplan-Meier analysis, patients from low-risk groups had significantly better survival prognoses in both cohorts (Fig. 4C/D). DCA curves showed good positive net benefits of the nomogram at different time points (1,2, and 3 years) (Fig. 5). All validation results indicate that the accuracy and reliability of the nomogram model are satisfactory.

Comparisons with the external model

To further evaluate the predictive ability of our model, we compared our model with an External model from multiple perspectives (Fig. 1B). In the training and validation cohorts, the C-index for the nomogram was 0.718(95%CI: 0.691 ~ 0.745) and 0.711(95%CI:0.666 ~ 0.756), compared with 0.677(95%CI:0.650 ~ 0.704) and 0.643(95%CI:0.598 ~ 0.688) for the External model. It can be seen from the time-dependent C-index curves that our model was superior to the External model within 0-120 months in terms of accuracy and stability (Fig. 1C/D). The ROC curve also showed similar results that our nomogram model still outperforms the External model in predicting 1,2 and 3 years of overall survival (Fig. 3). Moreover, DCA results showed that the

Table 1 Baseline demographic and clinical characteristics of OCLM patients in the training and validation cohorts

Characteristics	All cohort	Training cohort	Validation cohort	*P*
	(*n* = 821),n(%)	(*n* = 574),n(%)	(*n* = 247),n(%)	
Race				0.316
White	665 (81.00)	472 (82.23)	193 (78.14)	
Black	66 (8.04)	45 (7.84)	21 (8.50)	
Other	90 (10.96)	57 (9.93)	33 (13.36)	
Age(years)				0.940
≤60	385 (46.89)	268 (46.69)	117 (47.37)	
61–72	293 (35.69)	207 (36.06)	86 (34.82)	
≥73	143 (17.42)	99 (17.25)	44 (17.81)	
Marital status				0.103
Un-married	186 (22.66)	139 (24.22)	47 (19.03)	
Married	635 (77.34)	435 (75.78)	200 (80.97)	
Histology				0.583
Non-serous	247 (30.09)	176 (30.66)	71 (28.74)	
Serous	574 (69.91)	398 (69.34)	176 (71.26)	
Grade				0.238
I + II	239 (29.11)	162 (28.22)	77 (31.17)	
III	339 (41.29)	232 (40.42)	107 (43.32)	
IV	243 (29.60)	180 (31.36)	63 (25.51)	
Laterality				0.756
Unilateral	399 (48.60)	281 (48.95)	118 (47.77)	
Bilateral	422 (51.40)	293 (51.05)	129 (52.23)	
Size (cm)				0.875
≤9.4	420 (51.16)	297 (51.74)	123 (49.80)	
9.5–12.6	167 (20.34)	115 (20.03)	52 (21.05)	
≥12.7	234 (28.50)	162 (28.22)	72 (29.15)	
T				0.269
T1 + T2	113 (13.76)	74 (12.89)	39 (15.79)	
T3	708 (86.24)	500 (87.11)	208 (84.21)	
N				0.123
N0	449 (54.69)	324 (56.45)	125 (50.61)	
N1	372 (45.31)	250 (43.55)	122 (49.39)	
LBB-Met				0.504
None	663 (80.76)	467 (81.36)	196 (79.35)	
≥1 site	158 (19.24)	107 (18.64)	51 (20.65)	
Surgery(Pri)				0.317
No	77 (9.38)	50 (8.71)	27 (10.93)	
Yes	744 (90.62)	524 (91.29)	220 (89.07)	
Surgery(Met)				0.771
No	606 (73.81)	422 (73.52)	184 (74.49)	
Yes	215 (26.19)	152 (26.48)	63 (25.51)	
Cytoreduction				0.453
No	176 (21.44)	119 (20.73)	57 (23.08)	
Yes	645 (78.56)	455 (79.27)	190 (76.92)	
Chemotherapy				0.492
No	103 (12.55)	75 (13.07)	28 (11.34)	
Yes	718 (87.45)	499 (86.93)	219 (88.66)	

Abbreviations:

LBB-Met: lung, bone, or brain metastases

Surgery(Pri): Surgery of Primary Site

Surgery(Met): Surgery of metastases

Table 2 Univariable and Multivariable Cox Regression for analyzing the factors associated with OS of OCLM

Characteristics	Univariable		Multivariable	
	HR(95%CI)	*P*	HR(95%CI)	*P*
Race				
White	Reference			
Black	1.286(0.894–1.850)	0.175		
Other	1.137(0.815–1.586)	0.449		
Age(years)				
≤60	Reference		Reference	
61–72	1.399(1.119–1.750)	0.003	1.310(1.044–1.644)	0.020
≥73	1.739(1.336–2.263)	< 0.001	1.576(1.197–2.074)	0.001
Marital status				
Un-married	Reference			
Married	0.895(0.711–1.128)	0.349		
Histology				
Non-serous	Reference		Reference	
Serous	0.466(0.379–0.573)	< 0.001	0.527(0.424–0.656)	< 0.001
Grade				
I + II	Reference		Reference	
III	1.364(1.032–1.803)	0.029	1.456(1.094–1.938)	0.010
IV	1.255(0.940–1.677)	0.123	1.511(1.120–2.039)	0.007
Laterality				
Unilateral	Reference			
Bilateral	0.655(0.536–0.799)	< 0.001		
Size (cm)				
≤9.4	Reference			
9.5–12.6	0.893(0.683–1.167)	0.406		
≥12.7	1.290(1.029–1.618)	0.028		
T				
T1 + T2	Reference			
T3	0.579(0.436–0.769)	< 0.001		
N				
N0	Reference			
N1	1.064(0.872–1.297)	0.543		
LBB-Met				
None	Reference		Reference	
≥1 site	1.711(1.348–2.173)	< 0.001	1.661(1.300-2.122)	< 0.001
Surgery(Pri)				
No	Reference		Reference	
Yes	0.281(0.203–0.390)	< 0.001	0.477(0.316–0.719)	< 0.001
Surgery(Met)				
No	Reference			
Yes	0.781(0.622–0.980)	0.033		
Cytoreduction				
No	Reference		Reference	
Yes	0.512(0.400-0.656)	< 0.001	0.677(0.495–0.925)	0.014
Chemotherapy				
No	Reference		Reference	
Yes	0.272(0.207–0.358)	< 0.001	0.271(0.204–0.361)	< 0.001

Abbreviations:

LBB-Met: lung, bone, or brain metastases

Surgery(Pri): Surgery of Primary Site

Surgery(Met): Surgery of metastases

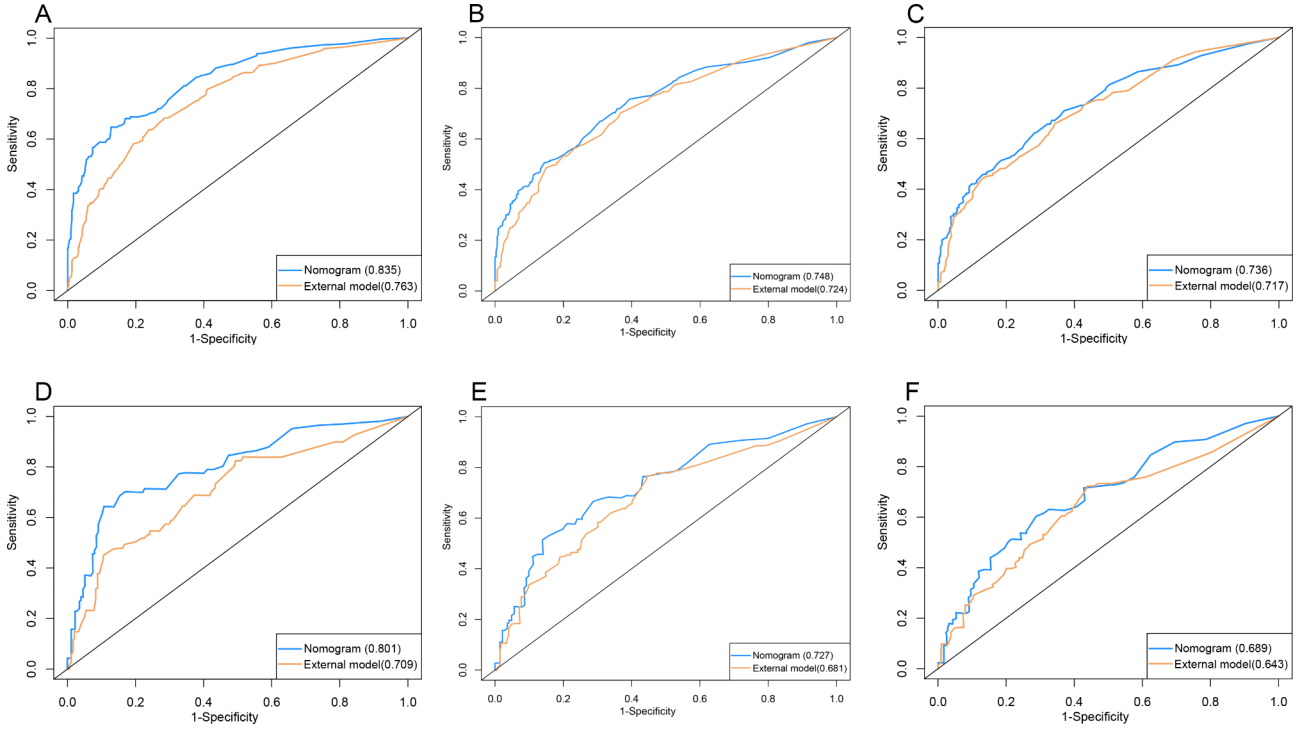

Fig. 3 The ROC curves of the nomogram and External model in the training and validation cohorts. (**A**) The AUC at 1 year in the training cohort. (**B**) The AUC at 2 years in the training cohort. (**C**) The AUC at 3 years in the training cohort. (**D**) The AUC at 1 year in the validation cohort. (**E**) The AUC at 2 years in the validation cohort. (**F**) The AUC at 3 years in the validation cohort

predictive value of the nomogram was significantly more significant than the External model in predicting patient survival of OCLM (Fig. 5). NRI and IDI were calculated to compare the performance between nomogram and External model, and bootstrap resampling tests also were performed 1000 times. All of the NRI and IDI values on both the training and validation cohorts were greater than zero, further indicating that the predictive capacity of our nomogram model was improved (Table 3).

Discussion

In this study, we aim to construct and validate a predictive model based on the SEER database to predict the prognosis of OCLM patients. It also provides valuable predictive information for individualized treatment decisions. We wish to use the prediction model we constructed to screen out those potential patients with low survival and aggressive management at the earliest opportunity to improve survival rates. After rigorous screening, we obtained 821 OCLM patients from the SEER database, and all patients were randomly classified into training and validation cohorts to ensure the generalization of the prediction model. Then, we exploited seven factors significantly associated with the OS of OCLM to establish the predictive nomogram. Subsequently, we validated the nomogram and compared it with the External model in several ways. The validation and comparison results illustrate that the nomogram had excellent predictive ability and clinical applicability and performed better than the External model simultaneously. NRI and IDI values were greater than zero, indicating that our nomogram model's predictive ability was increased. The Kaplan-Meier curve analysis shows that the nomogram can effectively separate low-risk and high-risk populations.

The prognosis of ovarian cancer is affected by various factors, including age, tumor histology, and treatment modalities [11]. Advanced age was also an independent risk factor for OS of OCLM, and the finding was generally consistent with the present study [12]. As the population ages, preoperative evaluation is essential, including assessing the patient's age, physical condition, nutritional status, and comorbidities. These factors have been shown to contribute to elderly patients undergoing surgical tumor resection to poor prognosis, such as increasing the incidence of postoperative complications, prolonged hospital stays, and increasing postoperative mortality [13–15]. In addition, intolerance to adverse events of surgery or chemotherapy may further exacerbate poor outcomes for elderly patients [16]. Pathological type is an independent unfavorable prognostic factor. Compared to those with serous ovarian cancer, non-serous advanced ovarian cancer was associated with a significant increase in the risk of death, and the result was consistent with this

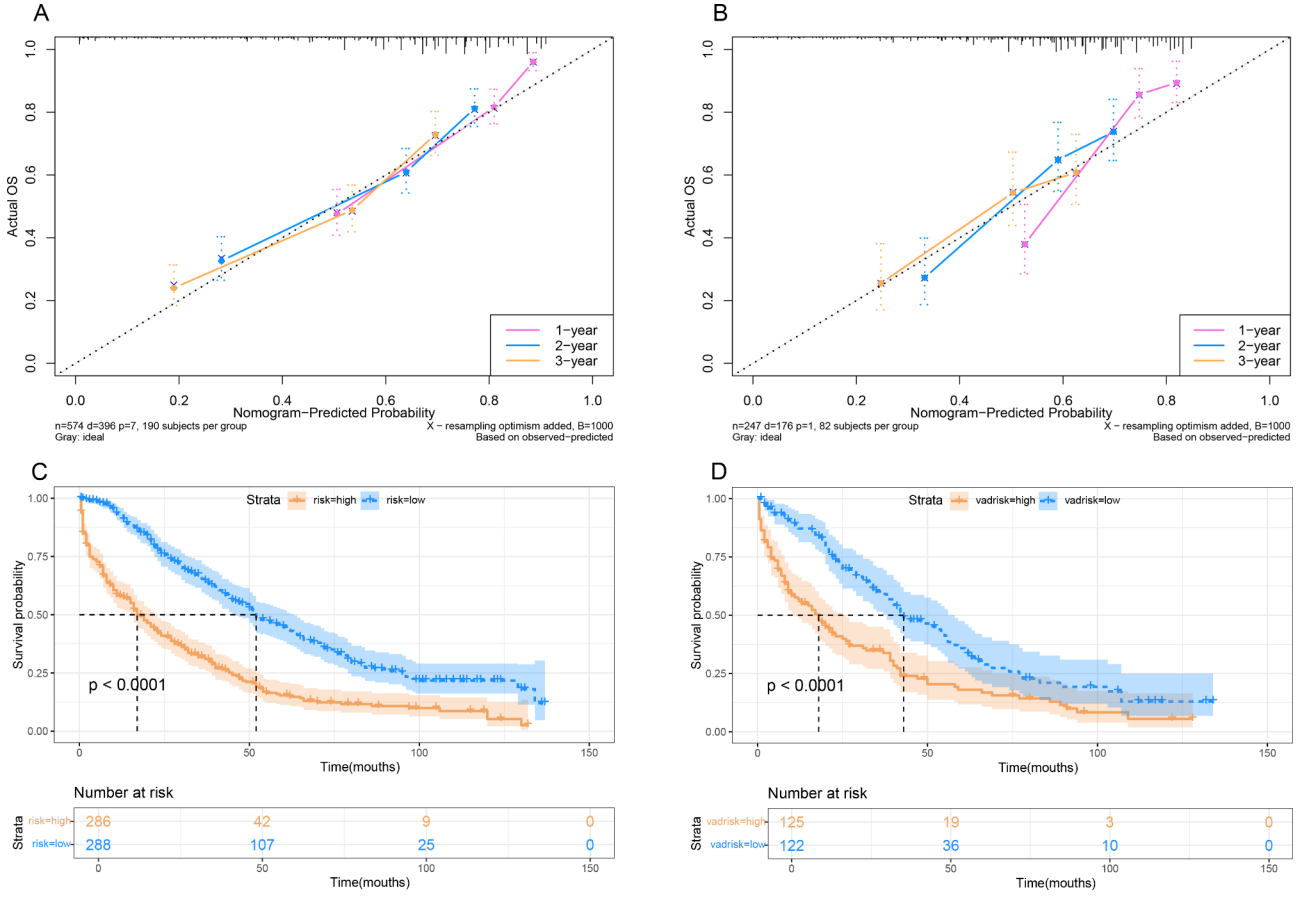

Fig. 4 Calibration curves and the analysis of risk stratification. Calibration curves for 1-, 2-, and 3-year OS of the training cohort (**A**) and validation cohort (**B**). Risk stratification in the training cohort (**C**) and validation cohort (**D**) for OS

study [17]. This could be due to the BRCA gene mutation is common in serous ovarian cancers, and such patients are more sensitive to platinum-based chemotherapy [18]. It is now clear that the less differentiated and the higher the tumor aggression, the worse the prognosis. In our study, the proportion of OCLM patients with undifferentiated and poorly differentiated is greater than 70%, and this part of patients exhibit an even worse prognosis, which the hazard of death was significantly higher for poorly differentiated patients compared to well-differentiated patients(HR=1.456/HR=1.511). In our study, we found that the most common sites of ovarian cancer with distant metastases are the liver and lung. In contrast, brain and bone metastases were relatively uncommon, generally aligning with prior research [8]. OC patients with lung, bone, and brain metastasis experienced shorter survival than those with liver metastasis who underwent chemotherapy, and patients with multiple metastasis sites showed a poorer prognosis than those with one site of metastases [19, 20]. Surgical treatment is the preferred therapy, aiming to achieve an R0 type of surgery resection(optimal surgery). Early OC patients (stage IA and IB) can often harvest a preferable survival after surgical treatment [21]. However, advanced ovarian cancer patients usually fail to achieve radical resection; fortunately, the therapy combining surgery and chemotherapy has already been confirmed to be an efficient treatment. Those patients assessed by the specialist surgeon to achieve satisfactory debulking could proceed directly to surgery; this type of treatment was termed primary debulking surgery(PDS). When the systemic treatment effect is less effective, the surgical treatment also helps to alleviate the tumor burden. If it was difficult to achieve satisfactory debulking assessed by the specialist surgeon, neoadjuvant chemotherapy(NACT) was followed by interval debulking surgery(IDS) in patients only after anapathological results [22, 23]. Most ovarian cancer patients respond well to platinum-based chemotherapy and obtain clinical remission after receiving chemotherapy. However, most patients display a higher recurrence rate, and platinum-based chemotherapy resistance is common [24]. In this research, treatment modality was an independent protective factor for survival. Of note, patients can benefit from either surgery resection or debulking for the primary tumor site or chemotherapy. A prolonged survival utilizing surgery combined with

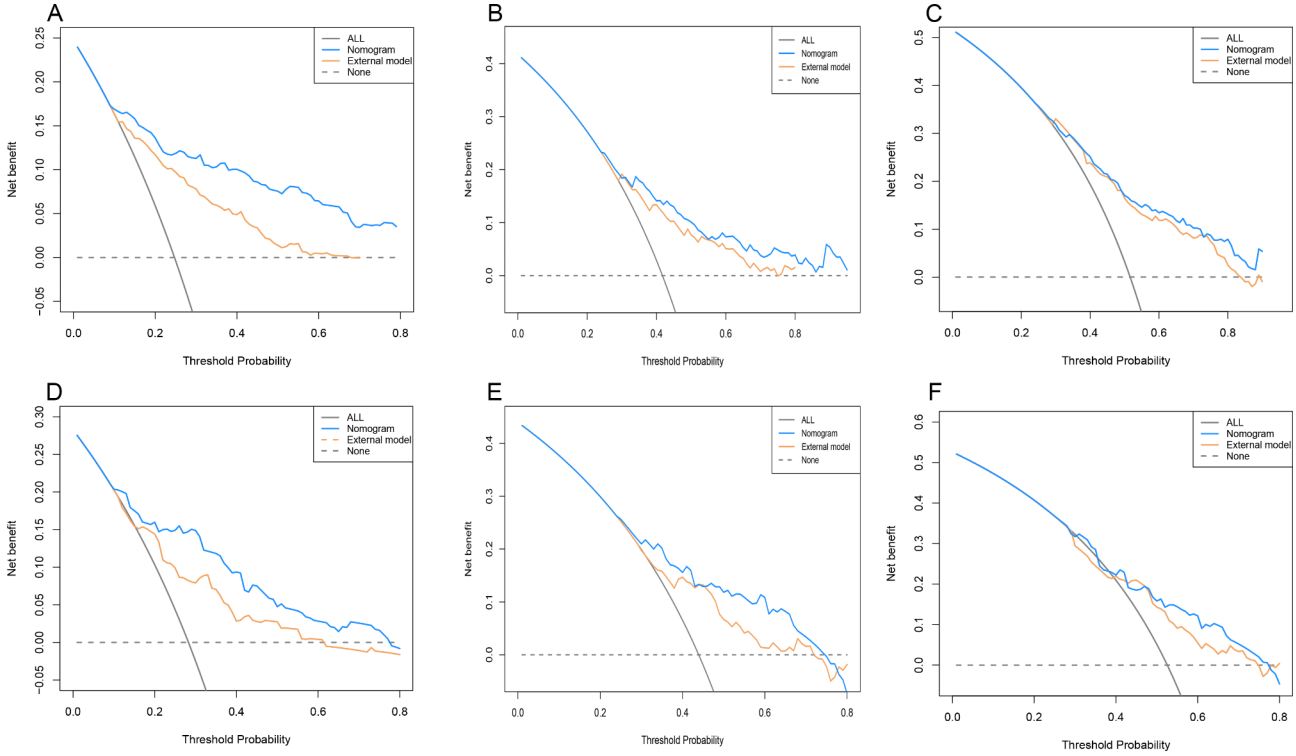

Fig. 5 Decision curves of two models. (**A**) Decision curves of 1-year OS in the training cohort. (**B**) Decision curves of 2-year OS in the training cohort. (**C**) Decision curves of 3-year OS in the training cohort. (**D**) Decision curves of 1-year OS in the validation cohort. (**D**) Decision curves of 2-year OS in the validation cohort. (**D**) Decision curves of 3-year OS in the validation cohort

Table 3 Compares the NRI and IDI index of two models in the training and validation cohorts

Time	Training cohort					Validation cohort				
	Index	95%CI			*P*-value	Index	95%CI			*P*-value
1-year										
IDI	0.153	0.091	-	0.208	<0.001	0.092	0.030	-	0.182	0.002
NRI	0.350	0.189	-	0.516	<0.001	0.237	0.015	-	0.417	0.030
2-year										
IDI	0.072	0.034	-	0.108	<0.001	0.051	0.009	-	0.110	0.016
NRI	0.193	0.057	-	0.301	<0.001	0.077	-0.059	-	0.266	0.262
3-year										
IDI	0.044	0.014	-	0.075	0.002	0.038	0.002	-	0.084	0.032
NRI	0.144	0.016	-	0.251	0.028	0.033	-0.102	-	0.202	0.507

chemotherapy, as NCCN guidelines recommended treatment modalities for advanced OC [6].

CA125 is a high molecular weight glycoprotein expressed by epithelial cells and has been a well-established tumor marker for ovarian cancer. The serum CA125 levels during treatment would be able to monitor residual tumor condition in vivo, therapeutic effect, predict the outcome of a tumor, and have a high positive predictive value [25]. Regrettably, for CA125 in the SEER database, only elevated or positive levels were documented, and the exact values were not openly disclosed. In our data, the CA125 examination showed elevated levels or positive in almost all OCLM patients, so we excluded this variable to avoid severe selection bias. Moreover, the anatomy of the surgical area and improvements in surgical modalities and perioperative management were also associated with the outcome of OCLM patients. The result of one large-sample study suggested that according to the anatomic-surgical classification, metastatic patterns are related to both different surgical outcomes and postoperative complication profiles, but liver procedures during advanced ovarian cancer surgery are feasible with acceptable complication rates [26]. Long-term follow-up data also show that the survival rate of patients with primary cytoreduction, including liver resection, was significantly higher [27]. The survival outcome of microwave ablation was similar to surgical resection, with fewer postoperative complications

and shorter operating times [28]. Another study revealed that the 3-year progression-free survival rate was 81.0% in BRCA-mutated patients compared to 15.2% in wild-type ones [29]. Hence, The influence of germline and somatic mutations on the prognosis of OCLM patients must be considered when discussing therapeutic options. With improved surgical techniques and new therapeutic agents, aggressive therapeutic interventions combining various factors are warranted. For OCLM patients, mental well-being and quality of life also needed to be considered rather than simply for improving survival. Regretfully, they were not considered for this study, for information on such factors was unavailable in the SEER database.

Our study is one of the few studies that compare a self-built predictive model of predicting the OS for OCLM with an external model from multiple perspectives. However, some limitations of this study must be recognized. First, the study was retrospective, and the potential risk for selection bias cannot be excluded. Secondly, the SEER database only records demographic characteristics, clinicopathological information, and follow-up data of cancer patients; no specific details about therapeutic were included, such as the particular chemotherapy regimens, postoperative complications, imaging and laboratory examination results, tumor recurrence, and subsequent treatments. Third, We only conducted internal validation and lacked external validation from multiple centers. These limitations prompted us to further incorporate data from more centers and larger sample sizes to improve and optimize the model in subsequent clinical studies. Despite these limitations, a large amount of clinical data and important follow-up outcomes of patients were documented in the SEER database. Using the big data for modeling and validation while eliminating factors that quickly cause model overfitting before establishing a predictive model makes our research more convincing and widely applicable. The nomogram model can also be used as a clinical tool to guide therapeutic decision-making or as a prognostic tool to predict the survival probability. For instance, whether patients benefit from surgery or chemotherapy treatment can be comprehensively assessed based on age, differentiation status, and histological type. If, after assessment, certain patients might be expected to fall into the high-risk group with a worse prognosis, these patients may not benefit from current treatment, and other active treatment measures, including immunotherapy or targeted therapy, are required. To better predict the individual survival of ovarian cancer patients, we recommend combining future prediction models with genetic markers, immune factors, anatomical factors, details of surgery, radiomics features, metabolomics, and other factors.

In conclusion, we developed a predictive model based on clinical data to predict the prognosis of OCLM patients. In patients with poor predicted survival, aggressive combination treatment strategies to extend patient survival should be instituted early. In contrast to the External model, our model shows higher stability and accuracy in predictive power and can provide a reference for clinical decision-making. In future studies, we will further verify the clinical application value of the model.

Abbreviations

OC	Ovarian cancer
OS	Overall survival
OCLM	Ovarian cancer patients with liver metastases
SEER	The Surveillance, Epidemiology, and End Results
AIC	The Akaike information criterion
C-index	The concordance index
ROC	Receiver operating characteristic curve
DCA	Decision curves analysis
NRI	Net reclassification index
IDI	Integrated discrimination improvement
ICD-O-3	International Classification of Diseases for Oncology, 3rd edition
AJCC	The American Joint Committee on Cancer stage
NCCN	National Comprehensive Cancer Center
PDS	Primary debulking surgery
NACT	Neoadjuvant chemotherapy
IDS	Interval debulking surgery

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12957-024-03608-x.

Supplementary Figure S1: Identification of the best cut-off point of age (A, B) and size (C, D) through X-tile software

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Author contributions
Huifu Xiao: Project development, Data Collection, Manuscript writing. Ningping Pan: Data Collection. Guohai Ruan: Data analysis. Qiufen Hao: Data analysis. Jiaojiao Chen: Project development, Manuscript writing. The first draft of the manuscript was written by [Huifu Xiao] and reviewed and edited by [Jiaojiao Chen], and all authors read and approved the final manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
The study only used the patients' anonymous clinical data, and no patient privacy was involved; therefore, ethical approval was not required.

Competing interests
The authors declare no competing interests.

Conflict of interest
The authors have no conflict of interest.

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