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Research article

Impact of surgical compliance on survival prognosis of patients with ovarian cancer and associated influencing factors: A propensity score matching analysis of the SEER database

Yanhua Zhang [a,1], Wenlei Yao [a,1], Jianbo Zhou [a], Lingyan Zhang [a], Yanhong Chen [a], Fangfang Li [b], Haidong Gu [c], Hongyou Wang [a,*]

[a] Department of Obstetrics and Gynecology, Binhai County People's Hospital, Yancheng, 224500, Jiangsu, China
[b] Department of Oncology, Binhai County People's Hospital, Yancheng, 224500, Jiangsu, China
[c] Department of Anesthetic, Binhai County People's Hospital, Yancheng, 224500, Jiangsu, China

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ABSTRACT

Purpose: To evaluate the impact of surgical compliance on overall survival (OS) and cancer-specific survival (CSS) in ovarian cancer patients and identify factors influencing surgical compliance.

Materials and methods: Data from patients with ovarian cancer in the SEER database (2004–2015) were analyzed to compare the characteristics of patients with high and low surgical compliance. Kaplan-Meier curves and Cox regression models were used to assess the impact of surgical compliance on survival outcomes. Nomograms incorporating surgical compliance and independent prognostic factors were constructed to predict OS and CSS and were validated using internal validation sets. Predictive accuracy was evaluated using Harrell's concordance index (C-index), decision curve analysis (DCA), receiver operating characteristic (ROC) curves, and calibration plots. Binary logistic regression analysis identified factors significantly affecting surgical compliance, and propensity score matching (PSM) was used to adjust for confounders.

Results: Among the 41,859 patients, 783 (1.87 %) demonstrated poor surgical compliance, while 41,076 (98.13 %) exhibited good compliance. Surgical compliance has emerged as an independent prognostic indicator for ovarian cancer. Patients with high compliance had significantly better OS and CSS rates ($P < 0.0001$). The prognostic models were internally validated and showed strong discriminative and calibration capabilities. Factors affecting compliance included older age, advanced pathological stage, metastasis, elevated CA-125 levels, and lower income. After PSM, Kaplan-Meier analysis revealed significantly improved survival in patients with good compliance ($P < 0.0001$).

Conclusion: Surgical compliance is a pivotal and independent predictor of overall and cancer-specific survival in patients undergoing OC. Factors contributing to lower surgical compliance include advanced age, later tumor stage, metastatic spread, elevated CA-125 levels, and reduced family income.

* Corresponding author. Department of Obstetrics and Gynecology ,Binhai County People's Hospital, Seaside Avenue 299, Binhai, Yancheng, 224500,Jiangsu, China.
E-mail address: wanghy-1983@outlook.com (H. Wang).
[1] Contributed equally.

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1. Introduction

Ovarian cancer is one of the deadliest gynecological malignancies affecting women globally. Despite advancements in the prevention, diagnosis, and treatment of ovarian malignancies over recent decades, which have led to increased survival rates, the 5-year survival rate for these tumors remains relatively low at approximately 30–40 %, compared with other cancers [1,2]. Surgery remains an important cornerstone of ovarian cancer treatment [3], and R0 resection is generally recommended for patients with ovarian cancer to achieve ideal tumor cell reduction that maximizes survival [4]. Owing to the poor prognosis of ovarian cancer and the low five-year survival rate after surgery, some patients have difficulty deciding between surgery and non-surgery, considering the unknown risks, pain, and economic and social pressures associated with surgery.

In recent years, there has been a proliferation of studies on compliance. In many chronic diseases, poor compliance with prescribed medications and other aspects of medical care may adversely affect treatment outcomes. An observational study on medication compliance in elderly chronic patients [5] showed that the population was always compliant (71.43 %), compliant (9.79 %), sometimes compliant (14.89 %), rarely compliant (3.87 %), and never compliant (1 %). Surgical compliance is pivotal in the treatment of medical conditions and plays a significant role in surgical treatment. Good postoperative compliance can accelerate recovery and shorten postoperative hospitalization [6]. Patient compliance is an independent prognostic factor for survival in patients with Stage T1-2 non-small-cell lung cancer [7]. The survival of gastric cancer patients with poor surgical compliance is low [8] and comparable with that of non-surgical patients.

However, no studies have shown that surgical compliance is important for the survival of patients with ovarian cancer. This study utilized the SEER database to investigate the impact of surgical compliance on survival prognosis and to explore the factors that contribute to poor surgical compliance using a large sample to establish effective interventions to ensure surgical compliance and improve prognosis in patients with ovarian cancer.

2. Methods

2.1. Data selection

Data were obtained from the SEER database(https://seer.cancer.gov), and we selected data on patients with ovarian cancer from 18 regional registries using SEER*Stat version 8.4.1. Our inclusion criteria were as follows: (1) confirmation of ovarian cancer according to the morphologic codes of the WHO International Classification of Diseases of Oncology, Third Edition (ICD-*O*-3) and (2) diagnosis from 2004 to 2015. The exclusion criteria were as follows: (1) age <18 years, (2) unknown ethnicity, (3) unknown AJCC stage, (4) not recommended for surgery, (5) non-first primary malignant foci, and (6) unknown income. Finally, 41,860 eligible patients with OCs were enrolled in this study. Fig. 1 illustrates these processes in detail.

Therefore, this study used retrospective and anonymized data from the SEER program and was exempt from ethical approval.

2.2. Study variables and data processing

Variables extracted from the SEER database included demographic information (e.g., patient ID, age, time of diagnosis, household

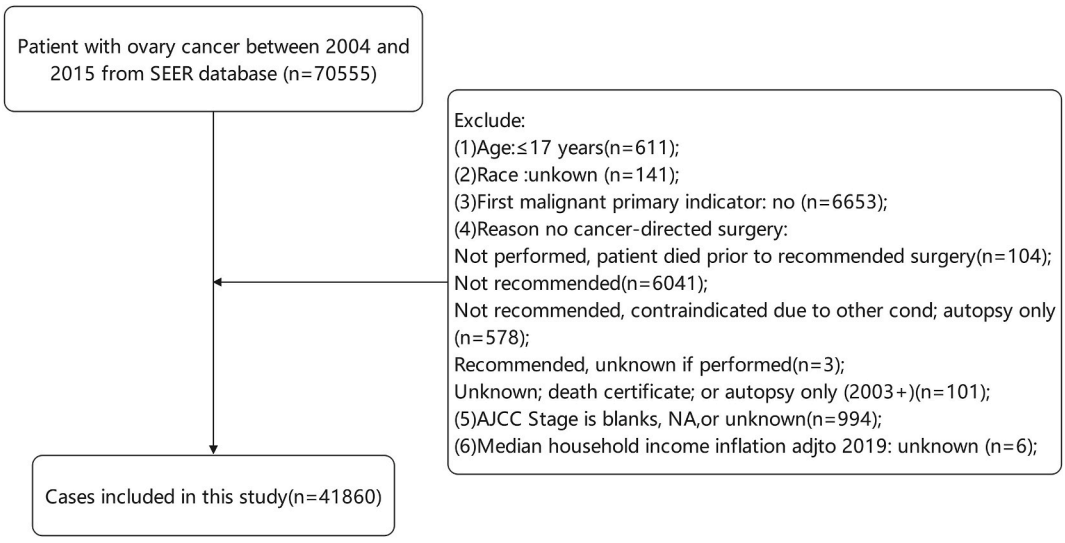

Fig. 1. Patient selection flowchart.
SEER: Surveillance, Epidemiology, and End Results.

income, and ethnicity), tumor characteristics (e.g., tumor size, pathologic classification, grade, SEER historical stage, AJCC stage, and CA125), and disease treatment (e.g., surgical status, duration of survival follow-up (months of survival), study time, life, and death status).

Overall survival (OS) was defined as the time interval from diagnosis to death due to any cause [9]. Cancer-specific survival (CSS) is the period between ovarian cancer diagnosis and death [10,11]. These two metrics were the outcome endpoints of the study.

The patients were divided into two groups based on patient compliance. For descriptive purposes, patients who underwent surgery were referred to as the surgical compliance group, and those who were recommended surgery but did not undergo surgery were categorized into the poor compliance group. The demographic information included race (white, black, other), time of diagnosis (2004–2007, 2008–2011, and 2012–2015), and household income was categorized into three groups, ≤$49,999, $50,000-$69,999, and ≥$70,000. Pathology is classified according to the "ICD-*O*-3" standard into the following categories: Epithelial tumors (ICD-*O*-3 codes: 8005/3, 8011/3, 8022/3, 8050/3, 8052/3, 8070/3, 8071/3, 8072/3, 8074/3, 8084/3, 8130/3, 8260/3, 8310/3, 8313/3, 8340/3, 8341/3, 8344/3, 8380/3, 8381/3, 8382/3, 8383/3, 8384/3, 8440/3, 8441/3, 8442/3, 8443/3, 8450/3, 8452/3, 8460/3, 8461/3, 8462/3, 8463/3, 8470/3, 8471/3, 8472/3, 8480/3, 8481/3, 8482/3, 8507/3, 8560/3, 8562/3, 8570/3) Germ cell tumors (ICD-*O*-3 codes: 8010/3, 9060/3, 9071/3, 8120/3, 8070/3, 8951/3, 9084/3, 8670/3, 9064/3, 8230/3, 8576/3, 9082/3, 9091/3, 8430/3, 9070/3), Sex cord stromal tumors (ICD-*O*-3 codes: 8320/3, 8590/3, 8620/3, 8621/3, 8622/3), Other types of tumors (ICD-*O*-3 codes: 8000/3, 8002/3, 8003/3, 8012/3, 8013/3, 8020/3, 8021/3, 8030/3, 8031/3, 8032/3, 8033/3, 8040/3, 8041/3, 8045/3, 8046/3, 8123/3, 8140/3, 8141/3, 8144/3, 8200/3, 8255/3, 8262/3, 8263/3, 8290/3, 8312/3, 8323/3, 8330/3, 8337/3, 8410/3,

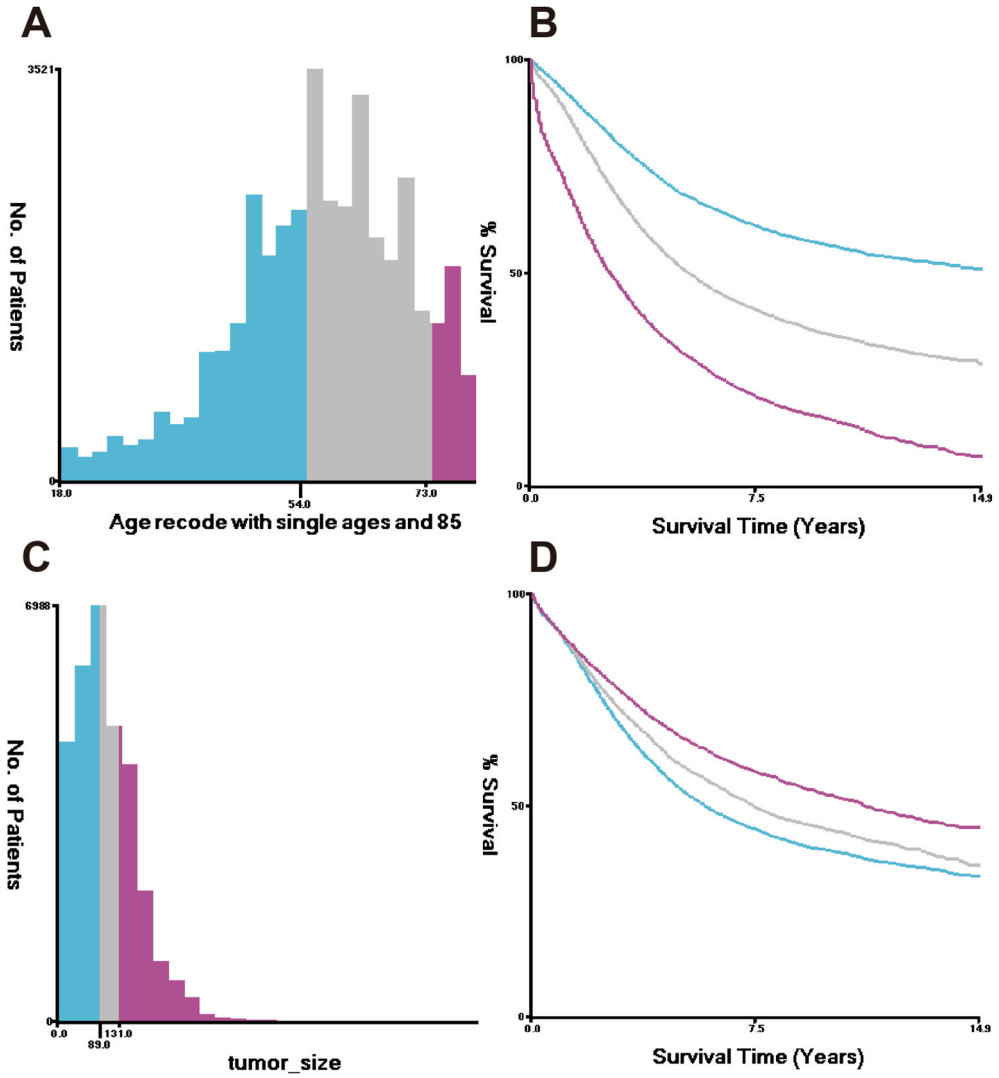

Fig. 2. The results of the X-tile program for optimal cutoff points of age and tumor size.
The age optimal cutoff value is shown by a histogram of the entire cohort (A) and a Kaplan-Meier plot (B); tumor size optimal cutoff value is shown by a histogram of the entire cohort (C) and a Kaplan-Meier plot (D).

8490/3, 8504/3, 8542/3, 8574/3, 8575/3, 8593/3, 8600/3, 8623/3, 8631/3, 8634/3, 8640/3, 8650/3, 8940/3, 8950/3, 9081/3, 9085/3, 9090/3).

Grades were defined as well-differentiated, Grade I, moderately differentiated, Grade II, poorly differentiated, Grade III, undifferentiated, anaplastic, Grade IV, or unknown. The SEER historic stage was classified as Localized, Regional, and Distant. The AJCC stage (I, II, III, IV, or Unknown) and CA125 status were defined as Negative, Positive, or Unknown).

X-tile software (version 3.6.1) was used to calculate the optimal cutoff values for converting continuous variables (e.g., age at diagnosisFig. 2A and tumor size Fig. 2C) into categorical variables. Age at diagnosis was categorized into three groups: 18–54 years, 55–73 years, and ≥74 years. Unknown tumor size was grouped separately, and known tumor size was divided into three groups (≤89, 90–131, and ≥132 mm groups) using X-tile software (Fig. 2A-D).

2.3. Statistical methods

The chi-square test was used to compare categorical variables between different groups and to analyze the demographic and clinical characteristics of the differences in surgical compliance. Univariate and multivariate Cox proportional regression analyses were used to evaluate the risk ratios (HR) and 95 % confidence intervals (CI) of potential prognostic factors and to analyze independent

Table 1
Baseline demographic and clinical characteristics of patients with ovarian cancer.

Characteristics	total	Surgical Compliance	Surgical Noncompliance	P value
	(NO.)	(NO.)	(NO.)	
Total	41859(100.00)	41076(98.13)	783(1.87)	
Age, years				<0.001
18-54	15806(37.80)	15711(38.20)	95(12.10)	
55-73	19559(46.70)	19283(46.90)	276(35.20)	
≥74	6494(15.50)	6082(14.80)	412(52.60)	
Race				<0.001
White	34828(83.20)	34200(83.30)	628(80.20)	
Black	3016(7.20)	2915(7.10)	101(12.90)	
Others	4015(9.60)	3961(9.60)	54(6.90)	
Year of diagnosis				<0.001
2004–2007	13674(32.70)	13356(32.50)	318(40.60)	
2008–2011	14089(33.70)	13863(33.70)	226(28.90)	
2012–2015	14096(33.70)	13857(33.70)	239(30.50)	
Grade				<0.001
Well differentiated	3564(8.50)	3557(8.70)	7(0.90)	
Moderately differentiated	6081(14.50)	6067(14.80)	14(1.80)	
Poorly differentiated	15019(35.90)	14938(36.40)	81(10.30)	
Undifferentiated	8034(19.20)	7998(19.50)	36(4.60)	
Unknown	9161(21.90)	8516(20.70)	645(82.40)	
Histology				<0.001
Epithelial	33230(79.40)	32959(80.20)	271(34.60)	
Germcell	2049(4.90)	1914(4.70)	135(17.20)	
Sexualcord-mesenchymal	809(1.90)	806(2.00)	3(0.40)	
Uncategorized	5771(13.80)	5397(13.10)	374(47.80)	
historic_stage				<0.001
Localized	10695(25.60)	10655(25.90)	40(5.10)	
Regional	4575(10.90)	4518(11.00)	57(7.30)	
Distant	26589(63.50)	25903(63.10)	686(87.60)	
AJCC_Stage				<0.001
I	12107(28.90)	12039(29.30)	68(8.70)	
II	4130(9.90)	4077(9.90)	53(6.80)	
III	17088(40.80)	16808(40.90)	280(35.80)	
IV	8534(20.40)	8152(19.80)	382(48.80)	
tumor_size,mm				<0.001
0-89	14558(34.80)	14379(35.00)	179(22.90)	
90-131	7723(18.50)	7649(18.60)	74(9.50)	
132-989	9240(22.10)	9156(22.30)	84(10.70)	
unknown	10338(24.70)	9892(24.10)	446(57.00)	
CA-125				<0.001
Negative	4188(10.00)	4162(10.10)	26(3.30)	
Positive	28254(67.50)	27710(67.50)	544(69.50)	
unknown	9417(22.50)	9204(22.40)	213(27.20)	
Household income				<0.001
≤$49,999	5305(12.70)	5147(12.50)	158(20.20)	
$50,000 - $69,999	19517(46.60)	19164(46.70)	353(45.10)	
≥$70,000	17037(40.70)	16765(40.80)	272(34.70)	

Abbreviations: SEER, Surveillance, Epidemiology, and End Results; Percentages may not total 100 because of rounding.

prognostic factors related to OS and CSS in patients with ovarian cancer.

Kaplan-Meier and log-rank tests were used to analyze the differences in compliance between the two groups for OS and CSS. Patient data were randomly assigned to the training group based on independent prognostic factors predicted using multivariate Cox regression. The validation group had a ratio of 7:3. Column line plots of OS and CSS were created, and the predictive power of the column line plots was assessed using Harell's concordance index (C-index), decision curve analysis (DCA), receiver operating characteristic (ROC) curves, and calibration curves. Binary logistic regression analysis was used to explore the potential variables affecting patient compliance with surgery. A 1:1 propensity score matching (PSM) analysis was used to adjust for differences between patients with poor and better surgical compliance. Kaplan-Meier analyses were used to compare the differences between the two groups after PSM. Statistical analyses were performed using SPSS version 26.0 and R software version 4.2.3.

Differences were considered statistically significant when the P value was <0.05.

Table 2
Univariate and multivariate Cox regression analysis for the overall survival(OS) of patients with ovarian cancer.

Characteristic	Univariate analysis		Multivariate analysis	
	HR(95 % CI)	P value	HR (95 % CI)	P value
Age, years				
18-54	Reference		Reference	
55-73	1.791 (1.735–1.847)	<0.001	1.344 (1.302–1.388)	<0.001
≥74	3.381 (3.257–3.509)	<0.001	2.364 (2.275–2.456)	<0.001
Race				
White	Reference		Reference	
Black	1.187 (1.131–1.247)	<0.001	1.23 (1.17–1.292)	<0.001
Others	0.76 (0.723–0.798)	<0.001	0.964 (0.917–1.013)	0.145
Year of diagnosis				
2004–2007	Reference		Reference	
2008–2011	0.912 (0.885–0.941)	<0.001	0.941 (0.912–0.97)	<0.001
2012–2015	0.813 (0.785–0.842)	<0.001	0.836 (0.807–0.866)	<0.001
Grade				
Well differentiated	Reference		Reference	
Moderately differentiated	2.24 (2.066–2.428)	<0.001	1.47 (1.355–1.595)	<0.001
Poorly differentiated	4.233 (3.932–4.557)	<0.001	1.683 (1.56–1.817)	<0.001
Undifferentiated	4.171 (3.864–4.502)	<0.001	1.671 (1.544–1.808)	<0.001
Unknown	3.116 (2.886–3.364)	<0.001	1.53 (1.413–1.656)	<0.001
Histology				
Epithelial	Reference		Reference	
Germcell	0.598 (0.556–0.644)	<0.001	0.846 (0.785–0.912)	<0.001
Sexualcord-mesenchymal	0.238 (0.202–0.281)	<0.001	0.563 (0.475–0.667)	<0.001
Uncategorized	1.212 (1.168–1.257)	<0.001	1.105 (1.064–1.147)	<0.001
historic_stage				
Localized	Reference		Reference	
Regional	2.598 (2.435–2.772)	<0.001	0.948 (0.831–1.082)	0.432
Distant	6.629 (6.321–6.952)	<0.001	1.45 (1.295–1.623)	<0.001
AJCC_Stage				
I	Reference		Reference	
II	2.322 (2.176–2.477)	<0.001	1.963 (1.73–2.229)	<0.001
III	5.818 (5.561–6.088)	<0.001	3.232 (2.908–3.592)	<0.001
V	8.965 (8.545–9.406)	<0.001	4.525 (4.065–5.036)	<0.001
tumor_size,mm				
0-89	Reference		Reference	
90-131	0.867 (0.834–0.901)	<0.001	0.926 (0.891–0.963)	<0.001
132-989	0.698 (0.671–0.725)	<0.001	0.947 (0.911–0.985)	0.007
unknown	1.373 (1.33–1.418)	<0.001	1.127 (1.091–1.165)	<0.001
CA-125				
Negative	Reference		Reference	
Positive	2.913 (2.744–3.092)	<0.001	1.378 (1.296–1.466)	<0.001
unknown	2.002 (1.877–2.136)	<0.001	1.312 (1.228–1.401)	<0.001
Household income				
≤$49,999	Reference		Reference	
$50,000-$69,999	0.865 (0.831–0.901)	<0.001	0.902 (0.866–0.939)	<0.001
≥70000	0.817 (0.784–0.851)	<0.001	0.83 (0.797–0.866)	<0.001
Patients' Compliance				
Surgical Compliance	Reference		Reference	
Surgical Noncompliance	4.878 (4.525–5.259)	<0.001	2.665 (2.46–2.887)	<0.001

Abbreviations:[a]Model was adjusted by age,race, the time of diagnosis, grade,histology,historic stage,AJCC stage, tumor size, CA-125, and household income.

3. Results

3.1. Clinical baseline characteristics

The patient details are shown in Table 1. Our study cohort consisted of 41859 patients with ovarian cancer. For patients recommended for surgery, the majority (41076 (98.13 %] with good compliance) underwent surgery, while 783 (1.87 %) did not.

There were significant differences in surgical compliance according to age, race, grade, pathology, SEER historical stage, AJCC stage, CA125 level, tumor size, and household income (all $p < 0.001$). The findings showed that patients over 74 years of age, those with distant AJCC stages, and those with low income (<$49999) were less likely to undergo surgery. Younger patients (55–73 years) had good surgical compliance.

3.2. Impact of surgical compliance on survival

Univariate and multivariate Cox regression analyses showed that patient compliance, age, race, grade, pathology, SEER historical stage, AJCC stage, CA125 level, tumor size, and family income were independent prognostic factors for OS and CSS ($p < 0.05$) (Tables 2

Table 3
Univariate and multivariate Cox regression analysis for the cancer-specific survival (CSS) of patients with ovarian cancer.

Characteristic	Univariate analysis		Multivariate analysis	
	HR (95 % CI)	P value	HR (95 % CI)	P value
Age, years				
18-54	Reference		Reference	
55-73	1.716 (1.659–1.776)	<0.001	1.235 (1.193–1.279)	<0.001
≥74	2.871 (2.753–2.994)	<0.001	1.92 (1.839–2.005)	<0.001
Race				
White	Reference		Reference	
Black	1.143 (1.082–1.207)	<0.001	1.186 (1.122–1.253)	0.174
Others	0.766 (0.726–0.809)	<0.001	0.963 (0.912–1.017)	<0.001
Year of diagnosis				
2004–2007	Reference		Reference	
2008–2011	0.902 (0.872–0.933)	<0.001	0.928 (0.897–0.960)	<0.001
2012–2015	0.795 (0.766–0.826)	<0.001	0.816 (0.785–0.848)	<0.001
Grade				
Well differentiated	Reference		Reference	
Moderately differentiated	3.029 (2.728–3.364)	<0.001	1.824 (1.642–2.027)	<0.001
Poorly differentiated	6.258 (5.678–6.898)	<0.001	2.172 (1.967–2.399)	<0.001
Undifferentiated	6.273 (5.678–6.93)	<0.001	2.183 (1.972–2.417)	<0.001
Unknown	4.345 (3.93–4.803)	<0.001	1.926 (1.738–2.134)	<0.001
Histology				
Epithelial	Reference		Reference	
Germcell	0.569 (0.523–0.619)	<0.001	0.843 (0.774–0.918)	<0.001
Sexualcord-mesenchymal	0.185 (0.15–0.228)	<0.001	0.524 (0.424–0.648)	<0.001
Uncategorized	1.185 (1.138–1.234)	<0.001	1.096 (1.051–1.143)	<0.001
Historic_stage				
Localized	Reference		Reference	
Regional	3.796 (3.492–4.127)	<0.001	1.26 (1.077–1.475)	0.004
Distant	11.029 (10.329–11.778)	<0.001	2.065 (1.802–2.367)	<0.001
AJCC_Stage				
I	Reference		Reference	
II	3.114 (2.871–3.377)	<0.001	2.053 (1.772–2.377)	<0.001
III	9.046 (8.521–9.602)	<0.001	3.646 (3.224–4.124)	<0.001
IV	13.825 (12.992–14.711)	<0.001	5.065 (4.472–5.736)	<0.001
Tumor_size,mm				
0-89	Reference		Reference	
90-131	0.844 (0.809–0.881)	<0.001	0.903 (0.865–0.942)	<0.001
132-989	0.639 (0.612–0.668)	<0.001	0.895 (0.856–0.936)	<0.001
unknown	1.359 (1.312–1.408)	<0.001	1.106 (1.067–1.147)	<0.001
CA-125				
Negative	Reference		Reference	
Positive	3.529 (3.285–3.791)	<0.001	1.466 (1.362–1.577)	<0.001
unknown	2.234 (2.068–2.414)	<0.001	1.346 (1.244–1.456)	<0.001
Household income				
≤$49,999	Reference		Reference	
$50,000 - $69,999	0.899 (0.859–0.94)	<0.001	0.928 (0.887–0.971)	0.001
≥70000	0.852 (0.814–0.892)	<0.001	0.854 (0.815–0.895)	<0.001
Patients' Compliance				
Surgical Compliance	Reference		Reference	
Surgical Noncompliance	4.486 (4.115–4.89)	<0.001	2.569 (2.344–2.815)	<0.001

and 3). Surgical compliance played an important role in both OS and CSS. A multifactorial Cox regression analysis showed that the HR of the risk ratio of death for surgically noncompliance patients was 2.665 (95 % CI 2.46–2.887, $p < 0.001$) for patients with good compliance relative to those with good compliance in OS (Table 2). The multivariate Cox regression analysis showed that patient compliance was an independent prognostic factor in patients with ovarian cancer (Table 3).

As shown in Fig. 3, we evaluated the effect of surgical compliance on survival prognosis in ovarian cancer using Kaplan-Meier survival curves. The results showed that surgical compliance was significantly associated with OS(Fig. 3A) and CSS(Fig. 3B). Patients with good surgical compliance had significantly better survival rates than those with poor compliance ($p < 0.001$). Subgroup analyses of the different stages of ovarian cancer showed that surgical compliance was statistically significant in the prognosis of patients with different stages of ovarian cancer, as detailed in Supplementary Fig. 1:OS with different Stage Fig. S1 (A1-D1),CSS with different Stage Fig. S1 (A2-D2).

3.3. Nomogram Construction and validation

The study data were randomized into a training set (n = 29301) and a validation set (n = 12558) according to a ratio of 7:3. Other independent prognostic factors derived from surgical compliance and Cox analysis were utilized in the training set to construct column line plots of OS(Fig. 4A) and CSS (Fig. 4B) to predict OS and CSS at one, three, and five years. Different subtypes of each independent prognostic factor were projected onto a rating scale, and the resulting scores were summed to generate a total score. Vertical lines were made on the total score [12]to obtain the total scores corresponding to OS and CSS. The columns of the line graph show that surgical AJCC staging contributed the most to OS and CSS in women with ovarian cancer, followed by surgical compliance, age, and SEER historical stage, which also had moderate effects on OS.

In the present study, as shown in Fig. 5, the training group predicted OS, and the AUC of the OS column line graph(Fig. 5A1) (AUC = 0.820) was higher than that of AJCC staging (0.771) and pathological grading (0.556). Similarly, the AUC of the CSS column line graph(Fig. 5A2) (AUC = 0.789) was also higher than the AJCC staging (0.757) and pathological grading (0.552). In the test set, the nomogram also had better performance(Fig. 5B1、5B2). In addition, we compared the 1-year, 3-year, and 5-year time-dependent AUC curves of OS and CSS nomograms, which performed well in both the training and validation sets, with all AUC >0.75, and the results are shown in Supplementary Fig. 2(AUC for predicting OS(Fig. 2 A1-A3) and CSS(Fig. 2 B1–B3) in the training set; AUC for predicting OS (Fig. 2 C1–C3) and CSS (Fig. 2 D1-D3) in the validation set).

The DCA curve shown in Fig. 6 suggests that the nomogram performed well in both the training (Figs. 6A1–A2)and validation sets (Fig. 6B1-B2). It outperforms the AJCC staging system and grades, and consistently predicts overall survival (OS) and cancer-specific survival (CSS).

In the training group, the new model showed a C-index of 0.733 for OS and 0.741 for CSS, which were greater than those of the AJCC Staging System (0.693, 0.707) and grade (0.554, 0.558). In the validation queue, the new model exhibited a C-index of 0.736 for OS and 0.744 for CSS, demonstrating its superiority over the AJCC stages (0.696, 0.709) and grades (0.553, 0.554).

The calibration curves for 1-, 3-, and 5-year OS in the training and validation cohorts were close to the diagonal gray line of the actual survival results (Supplementary Fig. 3S A1-A3,C1–C3). Similarly, the predicted survival of the column-line plots for CSS(Fig. 3S B1–B3,D1-D3) was in good agreement with the actual survival in both the training and validation cohorts.

3.4. Factors influencing surgical compliance

Binary logistic regression analysis was used to explore the variables associated with surgical compliance in patients with ovarian cancer (Supplementary Table 1 and Fig. 7).

Compared with patients aged 18–53 years, patients aged ≥74 years had worse compliance, with an OR of 8.637 (95 % CI

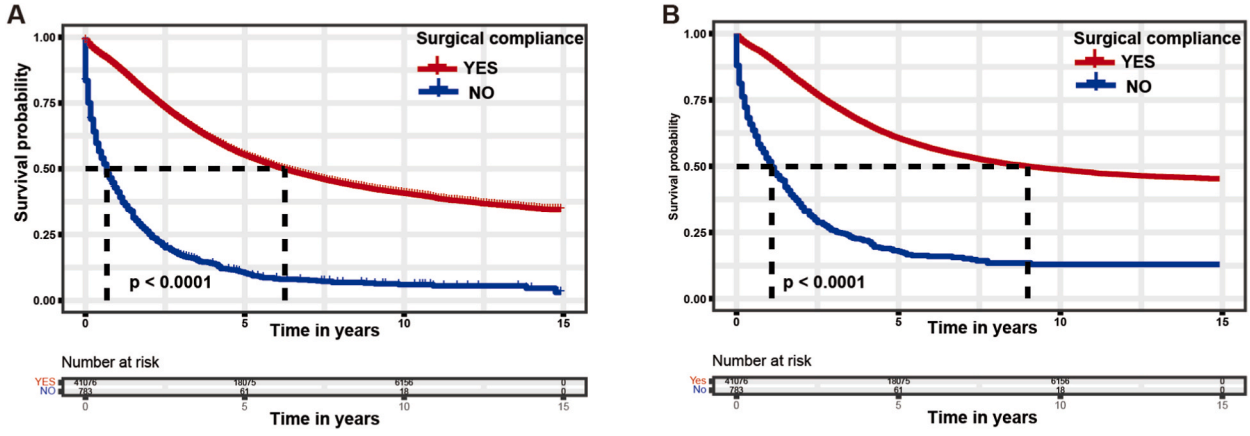

Fig. 3. Kaplan-Meier curve depicting OS(A)and CSS(B) for ovarian cancer patients divided into two groups based on surgical compliance.

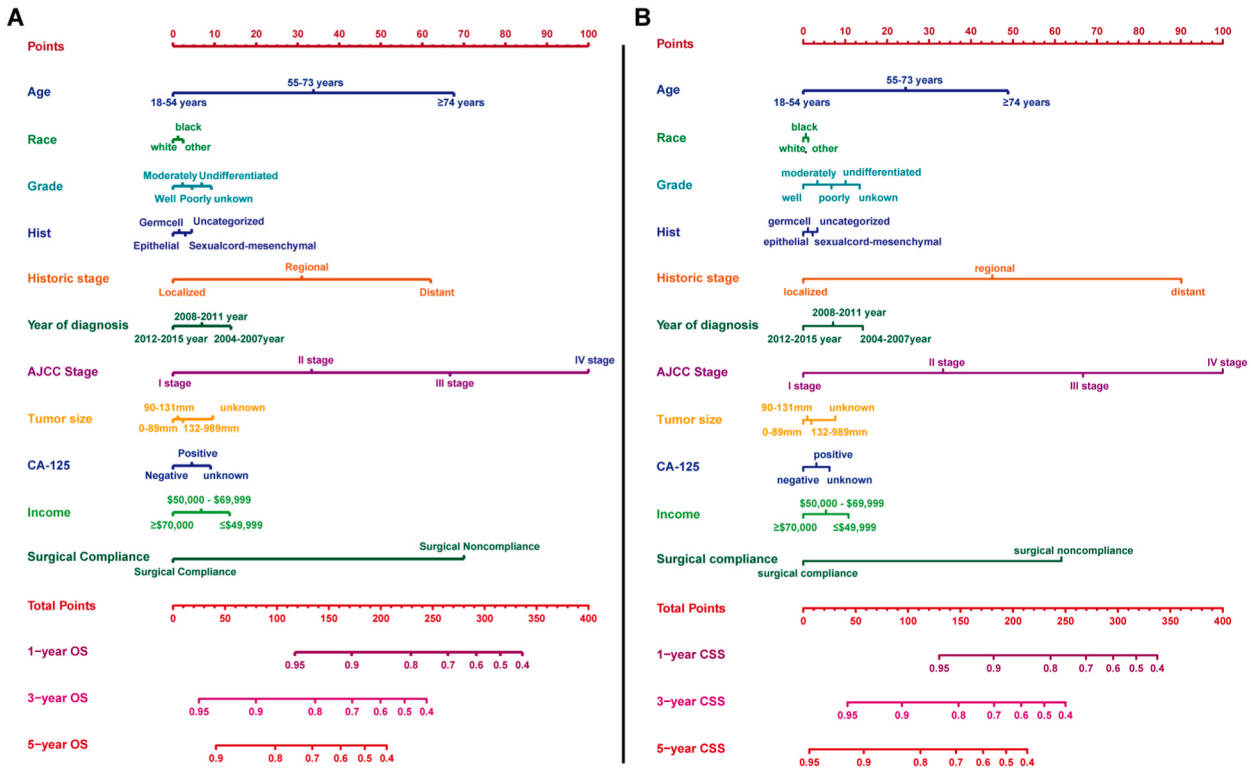

Fig. 4. Nomograms for predicting the 1-year,3-year and 5-year overall survival(A),and the 1-year,3-year and 5-year cancer-specific survival(B)of patients with ovarian cancer in the training set.
AJCC:American Joint Committee on Cancer staging system staging system(7th edition); OS:Overall survival; CSS:Cancer-specific survival.

6.716–11.106); black women were 1.813 times more likely to have poor compliance than white women (95 % CI 1.413–2.326). In addition, compared with patients with well-differentiated grades, those with unknown grades had worse compliance with an OR of 8.751, 95 % CI (4.091–18.717), and patients with unknown pathology and germ cell pathology had worse compliance than those with clear epithelial pathology. Patients with regional (OR 4.814 (95 % CI 2.396–9.671) and distant (OR 4.937 (95 % CI 2.906–8.388) stages were less compliant than those with localized SEER historical stage.

In contrast, the economy is a protective factor associated with compliance. Compared with those with a household income of less than $49,999, individuals with incomes ranging from $50,000 to $69,999 have a risk ratio of 0.72 (0.577–0.897) for poor compliance, while those with incomes equal to or greater than $70,000 have a risk ratio of 0.651 (0.517–0.821) for poor compliance. In other words, individuals with higher-income had a lower risk of poor compliance.

3.5. Impact of surgical compliance on survival after PSM

Given the significant disparity in numbers between the groups with good and poor surgical compliance, 1:1 propensity score matching (PSM) was employed to balance confounding factors among participants [13]. After adjusting for differences using PSM (Supplementary Fig. 4S), 712 pairs of participants were included in the study and divided into groups based on good or poor surgical compliance. Even after adjusting for variables such as age, year of diagnosis, Grade, histology, historic stage, AJCC_stage, income, CA-125 levels, and tumor size, the group with good surgical compliance still demonstrated better OS (Fig. 8A) and CSS (Fig. 8B) outcomes.

4. Discussion

Previous studies have shown that the age of the tumor patient, stage of disease, type of pathology, pathological differentiation, extent of surgery, and patient's postoperative follow-up all affect patient survival, as demonstrated in previous studies on endometrial, breast, and lung cancer [14–17]. Our study used a large and widely recognized public database (SEER database) to investigate the effect of surgical compliance on survival outcomes in patients with ovarian cancer. Univariate and multivariate Cox regression analyses showed that surgical compliance was an independent prognostic factor for OS and CSS. As expected, regarding OS and CS survival analyses, the effect of differences in compliance on survival prognosis was statistically significant across all stages of ovarian cancer, with the surgical noncompliance group having a significantly lower prognosis than the surgical compliance group ($p < 0.001$).

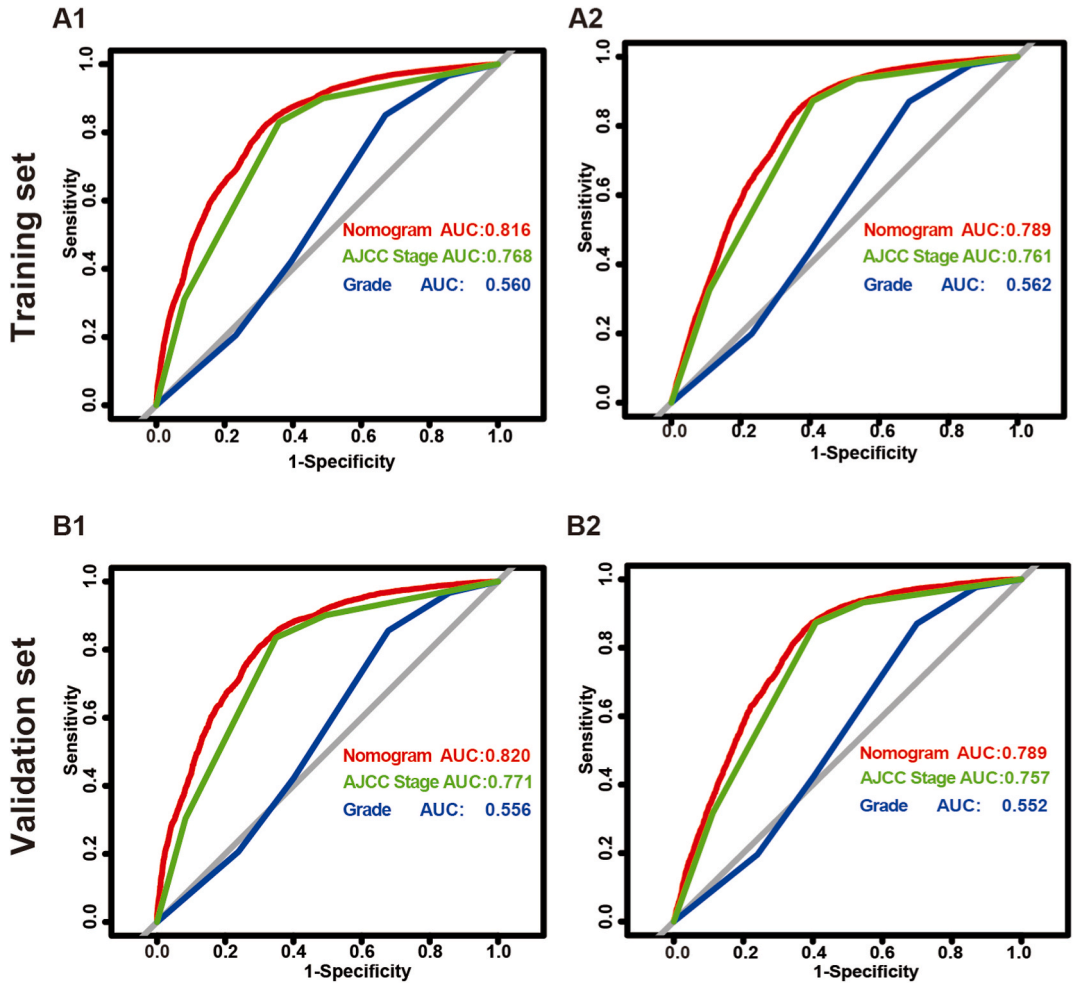

Fig. 5. Subject operating characteristics (ROC) analysis in three models (Nomogram, AJCC stage, Grade) for ovarian patients.
ROC curves for overall survival (OS) in the training (A1) and validation (B1) sets, and ROC curves for Cancer-specific survival (CSS) in the training (A2) and validation(B2) sets.

Surgical resection is crucial for the prognosis of ovarian cancer. When customizing surgical plans, expert surgeons initially perform personalized assessments based on specific circumstances and anticipate the survival benefits for each patient. Lymph node dissection is no longer recommended for patients with advanced ovarian cancer because of its lack of a significant survival advantage [18]. Conversely, in patients with advanced epithelial ovarian cancer that has metastasized to the hepatobiliary system, hepatobiliary resection has been shown to significantly improve both PFS and OS [19]. In the management of borderline ovarian tumors, which are known for their lower recurrence rates and favorable prognosis, conservative surgery may be an option for some young patients, despite the need to balance the preservation of fertility with the increased risk of recurrence [20]. Therefore, surgical decisions should be based on factors such as the patient's age, desire for children, and specific tumor characteristics to devise a treatment plan that meets the patient's physiological needs while effectively controlling the tumor. Consequently, patient compliance with the surgeon's recommendations, that is, surgical compliance, is critical for achieving optimal treatment outcomes.

Nomograms have been used for data visualization in recent years [21], and several studies have constructed nomograms [22–25] to assess the survival prognosis of ovarian cancer. In our study, we included surgical compliance, constructed OS and CSS nomograms, validated the constructed nomograms, and found that the ROC curves of the model incorporating compliance were superior to those of the traditional AJCC staging, grade classification, and the time-ROC index. Furthermore, the calibration curve results of the new model were also satisfactory. The impact of surgical compliance on survival prognosis was confirmed.

Although the percentage of patients with poor surgical compliance was significantly lower than that in the good surgical compliance group, the number of patients choosing not to undergo surgery is still increasing, and the disease status and prognosis of this group of patients require attention. Under the idea of precision medicine [26], we should prioritize individualized treatment of patients. Patient compliance plays an important role in prognosis; therefore, we should intervene in the factors affecting compliance to achieve a good therapeutic effect. To determine the factors affecting compliance, a logistic regression analysis was performed.

The results indicate that patients with poor compliance have the following characteristics: older age; pathological type of tumor,

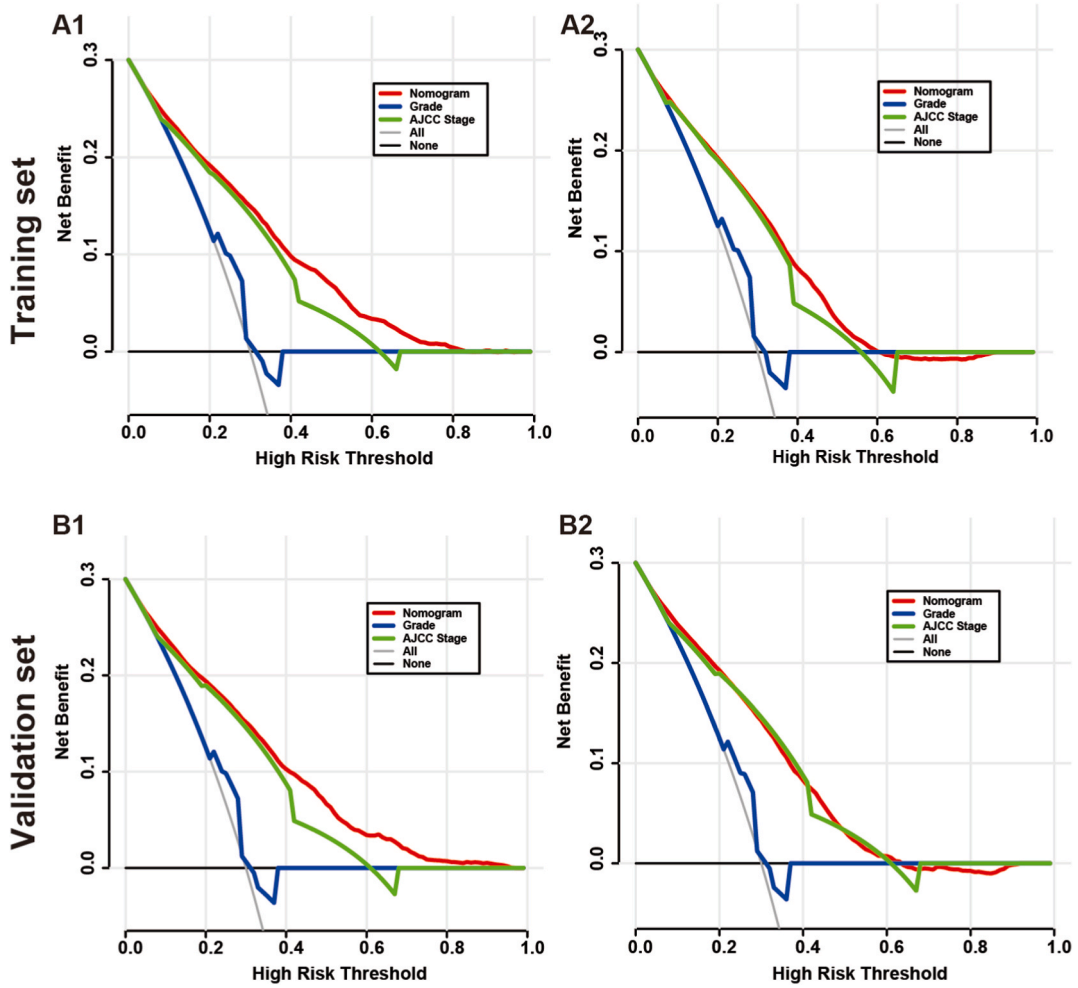

Fig. 6. Decision curve analysis (DCA) in three models (Nomogram, AJCC stage, Grade) for ovarian patients.
DCA overall survival (OS) in the training (A1) and validation (B1), and DCA Cancer-specific survival (CSS) in the training (A2) and validation groups (B2).

such as germ cell tumor; advanced tumor stage; presence of local and distant metastasis; higher CA-125 levels; and lower family income.

Our study showed that the older the patient, the worse the compliance. Patients older than 73 years were more than eight times more likely to refuse surgery. This may be due to the poorer general condition of older patients, reduced organ function, possible combination of more preoperative comorbidities [27] such as hypertension and diabetes mellitus, higher surgical risk, intolerance to surgery, other postoperative complications such as intestinal obstruction and thrombosis, and a poorer prognosis for patients [28]. Uncertainty regarding surgical risk, postoperative pain, and a relatively poor prognosis can lead to conservative treatment and poor compliance in elderly patients. However, surgical treatment in later life may improve survival, and treatments such as surgery may still be worth considering relative to the risks and pain associated with abandoning treatment.

Logistic regression results indicated that patients with germ cell tumors have poorer surgical compliance than those with other types of pathologic tumors. Germ cell tumors mostly occur in relatively young women [29], most of whom are unmarried and childless. Because of reproductive requirements, surgery is performed with great caution and has relatively poor compliance. Germ cell tumors are the most common benign teratomas [30], and refusal of surgery does not significantly affect survival, which is one of the reasons for poor surgical compliance in such patients.

Patients with advanced-stage disease, both local and distant metastases, and high CA-125 levels have relatively poor surgical compliance. In some patients with advanced tumors, surgery may not eliminate or control tumor progression. Currently, surgery is less effective in prolonging survival or improving the prognosis of patients who prefer other treatment modalities such as radiotherapy, chemotherapy, or palliative care [31]. Finally, fewer patients with late-stage tumors chose to comply with their doctor's opinion regarding surgery.

Family economic status is another important factor affecting surgical compliance. Some studies have shown that ovarian cancer

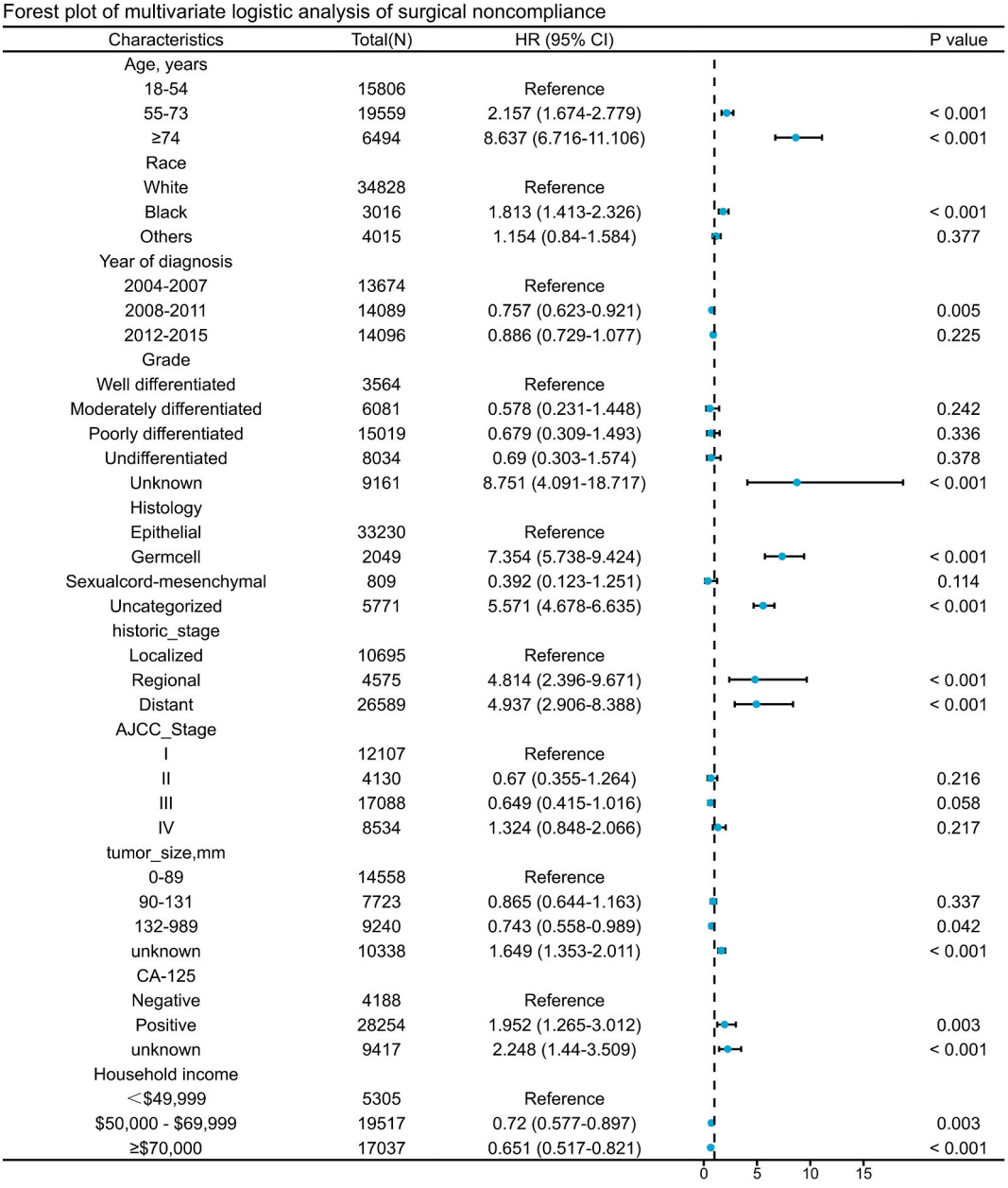

Fig. 7. Forest plot of multivariate logistic analysis of surgical noncompliance adjusted by age,race, the time of diagnosis, grade,histology,historic stage,AJCC stage, tumor size, CA-125, and household income.
Blue dots on the horizontal line indicate the odds ratio (OR), and the horizontal line indicates the 95 % CI. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

prognosis is related to a patient's economic status [11]. The effects of socioeconomic status on cancer have received increasing attention [32,33]. Studies have shown that when patients have a good income (i.e., good socioeconomic status) or adequate Medicare living insurance benefits [34], they are more likely to undergo surgery or receive radiotherapy [35–38]. These results are consistent with our analysis, showing that ovarian cancer patients with higher household incomes are more likely to undergo surgical treatment. The economic base is an important factor in active disease management as it influences treatment choices and compliance.

According to the logistic regression analysis results, factors influencing surgical compliance, such as age, pathological type, stage, CA-125 level, and family income, also affected survival prognosis. Additionally, the participants needed to be significantly imbalanced between the good and poor surgical compliance groups. To determine the impact of surgical compliance on survival and reduce the aforementioned confounding bias, a propensity score matching (PSM) study was conducted, and 712 pairs of participants were included after 1:1 PSM. We analyzed the Kaplan-Meier curves of the included patients in both the good and poor compliance groups.

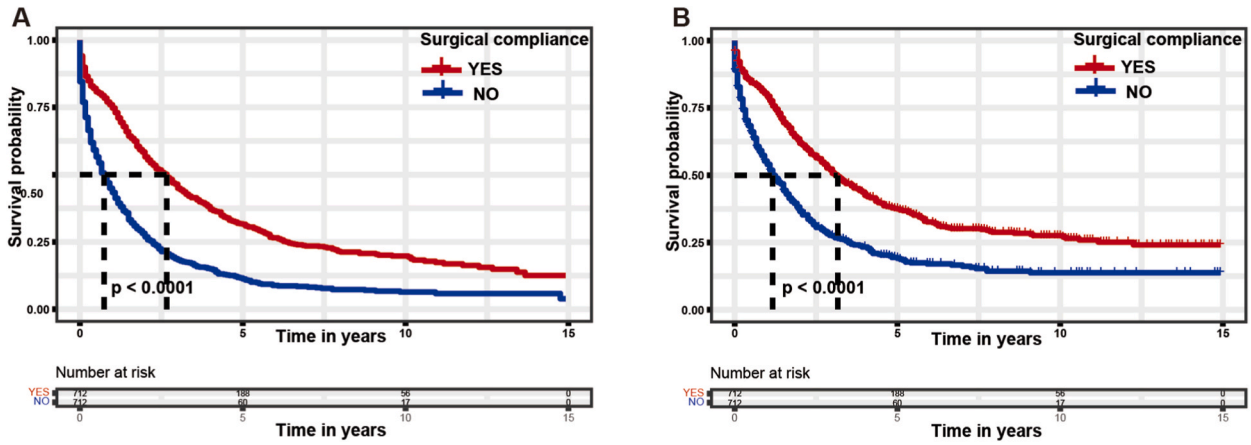

Fig. 8. Kaplan-Meier curve depicting OS(A)and CSS(B) for ovarian cancer patients after PSM.

We found that the median survival prognosis of patients in the poor surgical compliance group was worse than that of patients in the good surgical compliance group, consistent with previous results, confirming the significant impact of surgical compliance on survival.

Although this is the first study based on the SEER database that focuses on surgical compliance in ovarian cancer, our study has some limitations. First, some partial confounders associated with surgical compliance, such as patients' health insurance status, literacy level, and marital status, were required to be included in the data. In addition, patient data do not guarantee uniformly standardized treatments, and more information is needed on whether patients receive radiotherapy, chemotherapy, or targeted therapies. Finally, the small sample size may have contributed to bias, which could have affected the results of our analysis, despite using data over a longer period and evolving treatment regimens, cancer incidence, and survival rates.

The clinical significance of this study was underscored by the identification of surgical compliance as a critical and independent prognostic indicator of survival in patients with ovarian cancer. This study delineated the factors affecting surgical compliance, including advanced age, later stage of tumor progression, metastatic spread, elevated CA-125 levels, and reduced family income. These insights are pivotal for medical teams to optimize treatment strategies, particularly for assessing the feasibility and necessity of surgical intervention. The findings not only enhance patient management but also support the development of personalized treatment plans, increasing the likelihood of treatment success and improving patients' quality of life. Moreover, the documentation of these results provides empirical support for the existing literature and may inspire future research to devise strategies that improve surgical compliance, potentially enhancing the prognosis for patients with ovarian cancer. These advancements have enriched our understanding of the dynamics involved in treating ovarian cancer and have promoted innovation in therapeutic approaches for this group of patients.

5. Conclusion

In this retrospective population-based study using the Surveillance, Epidemiology, and End Results (SEER) database, we found that patient compliance was an independent prognostic factor for survival in patients with ovarian cancer. Better surgical compliance was associated with better survival, whereas poor surgical compliance was associated with poorer OS and CSS. In addition, poor surgical compliance was associated with older age, pathological staging of germ cell-type tumors, late staging, presence of local and distant metastases, higher CA-125 values, and lower family income. Identifying those at high risk of non-compliance within our capacity can lead to targeted interventions to maximize compliance and improve survival prognosis.

Ethics statement

The study data were obtained from publicly available databases, ensuring anonymity and obviating the need for informed consent. Consequently, no ethical approval was obtained for this study.

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Data availability statement

The dataset supporting the conclusions of this study is available in the Surveillance, Epidemiology, and End Results (SEER) repository and can be accessed via the following hyperlink: https://seer.cancer.gov/seerstat/, version number 8.4.1.2. Data included in

this study are available upon request.

CRediT authorship contribution statement

Yanhua Zhang: Writing – original draft. **Wenlei Yao:** Methodology, Formal analysis, Data curation. **Jianbo Zhou:** Supervision, Resources, Formal analysis. **Lingyan Zhang:** Data curation. **Yanhong Chen:** Data curation. **Fangfang Li:** Validation. **Haidong Gu:** Validation. **Hongyou Wang:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e33639.

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