Preoperative Risk Factors of Pelvic/Para-Aortic Lymph Node Metastases in Ovarian Cancer: A Multi-Center Retrospective Study

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Abstract

Background

Ovarian cancer (OC) patients benefited little from systematic pelvic/para-aortic lymph node dissection during surgery, which may attribute to the difficulties in identifying the patients with pelvic/para-aortic lymph node metastases (LNM) preoperatively. Unfortunately, risk factors predicting the pelvic/para-aortic LNM in OC patients are lacking now. The purpose of this study was to investigate preoperative risk factors of predicting OC patients at high risk of pelvic/para-aortic LNM and preventing OC patients at low risk of LNM from receiving unnecessary lymphadenectomy.

Methods

Patients diagnosed with OC between January 2012 and May 2020 from Tongji Hospital, Chongqing Cancer Hospital, and Tumor Hospital of Henan, were retrospectively reviewed. Demographics, pathology, and preoperative laboratory features were extracted from Electronic-Medical Records. The correlation between factors and LNM was assessed by chi-square test and multivariate logistic regression analysis.

Results

A total of 827 patients were included in this study. Univariate analysis indicated 23 preoperative features were significantly associated with LNM. Multivariate analysis showed that BMI ≥ 23.23 kg/m^2 (odds ratio [OR], 2.082; 95% confidence interval [CI], 1.448–2.995), ascites (OR, 3.022, 95% CI, 2.058–4.438), CA125 ≥ 432.15 U/ml (OR, 4.665, 95% CI, 3.158–6.891), neutrophil count ≥ 2.965*10^9/L (OR, 2.882, 95% CI, 1.606–5.172), lymphocyte count < 1.30*10^9/L (OR, 1.554, 95% CI, 1.086–2.223), and monocyte count ≥ 0.415*10^9/L (OR, 1.506, 95% CI, 1.047–2.166) were independent risk factors in predicting LNM. The area under the curve (AUC) of predicting LNM by combining these factors was 0.836 (95% CI 0.808–0.864). The predicting performance of this model was also promising in OC patients with early-stage (stage I-II) (AUC, 0.809, 95% CI, 0.619–1.000) and advanced-stage (stage III-IV) (AUC, 0.764, 95% CI, 0.723–0.805). Furthermore, patients with 0–3 risk factors had significantly lower LNM rates than those of patients with 4–6 risk factors (15.40% vs 58.92%, $p < 0.001$).

Conclusions

Preoperative BMI, ascites, CA125 level, neutrophil count, lymphocyte count, and monocyte count can predict the risk of LNM and facilitate decision-making of systematic lymphadenectomy in OC patients, which could avoid unnecessary lymphadenectomy.

1. Introduction

Ovarian cancer (OC) is the deadliest gynecologic cancer. Though the morbidity is not within the top ten of female cancers, OC may cause 22,950 deaths, which ranked 5th of cancer mortality for women in the United States in 2021(1). In China, there were 52,100 new cases diagnosed with OC and 22,500 patients died from it during 2015 (2). Since a 5-year overall survival was 92.1% in OC patients with International Federation of Gynecology and Obstetrics (FIGO) stage I compared with 25% in patients with FIGO stage III and IV (3), the poor prognosis of OC was mainly attributed to the advanced stage at diagnosis and the asymptomatic progression at an early stage (4).

The primary surgical cytoreduction and followed platinum-based chemotherapy were the fundamental therapeutic strategies in OC (3). However, systematic pelvic/para-aortic lymph node dissection during surgery remains controversial, especially in advanced OC (5–7). Though lymph node metastases (LNM) had a great impact on the staging and prognosis of OC patients (8, 9), systematic retroperitoneal lymphadenectomy increased the surgically related complications and cost, prolonged the operative time and hospitalization time (10), which was chilly for patients without LNM. Studies indicated that the rate of LNM ranged 13.6–30.3% in OC patients regardless of stage and 6.1–29.6% in patients with stage I–II OC(11–13). It means that nearly 70% of OC patients without LNM are unnecessary to go through lymphadenectomy and could have avoided the side effects of lymphadenectomy. However, the investigations to search for the risk factors of predicting pelvic/para-aortic LNM based on preoperative demographics and laboratory tests are limited.

Here, we aimed to screen the risk factors associated with pelvic/para-aortic LNM based on preoperative demographics and laboratory tests to identify OC patients at high risk of LNM to receive systematic pelvic/para-aortic lymphadenectomy and prevent OC patients at low risk of LNM from receiving unnecessary lymphadenectomy.

2. Methods

2.1 Patients

From January 2012 to May 2020, all patients diagnosed with OC from three hospitals (Tongji Hospital, Chongqing Cancer Hospital, and Tumor Hospital of Henan) in China were retrospectively reviewed. Patients who had received staging surgery and pelvic or para-aortic lymphadenectomy were included in this study with accessible preoperative targeted clinical features. The exclusion criteria were as follows: (1) patients with other concomitant cancers, (2) patients who received neoadjuvant chemotherapy, (3) patients with missing data > 20%. This study was approved by the Research Ethics Commission of Tongji Medical College, Huazhong University of Science and Technology with waived informed consent by the Ethics Commission mentioned above (No. S201).

2.2 Data extraction

The clinical information about preoperative demographics, laboratory tests (including tumor markers, routine blood tests, blood biochemical examination, and fibrinogen), and postoperative pathology were

extracted from Electronic Medical Records. Body mass index (BMI) was calculated based on the height and weight of patients. The data missing in more than 20% of the patients in each hospital was eliminated in further analysis. The rest missing data was imputed by the missForest algorithm in each center respectively with R (version 3.6.2) (14).

2.3 Statistical analysis

The endpoint of this study was pelvic/para-aortic LNM confirmed by pathologists after staging surgery. The differences of variables between OC patients with and without LNM were evaluated in univariate analysis with Chi-square test. The optimal cut-off values of continuous variables were determined by the receiver operating characteristic (ROC) curve. The risk factors associated with LNM in univariate analysis were further confirmed by a multiple logistic regression analysis. To make a preoperative prediction, histology and FIGO stage which could only be confirmed postoperatively were not included in the multiple logistic regression analysis. Odds ratios (OR) and 95% confidence interval (CI) were calculated for each factor in both univariate analysis and multivariate analysis. The area under the curve (AUC) of predicting pelvic/para-aortic LNM was drawn based on the prediction probability calculated by logistic regression model. A p-value < 0.05 was considered significant in all analyses. All data analyses were carried out with the SPSS statistical software, version 23.0 (IBM Corporation; Armonk, NY, USA).

3. Results

A total of 827 patients meeting the inclusion criteria were finally included in this study. The median number of dissected lymph nodes was 26 (interquartile range [IQR], 19–26). 264 (31.92%) patients were detected pelvic or para-aortic LNM among the 827 patients. Of the 264 patients with positive lymph nodes, 125 (47.35%) patients with pelvic LNM, 87 (32.95%) patients with para-aortic LNM, and 52 (19.70%) patients with pelvic and para-aortic LNM were detected. The median number of positive lymph nodes was 4 (IQR, 1–8). The median age was 50.5 years (IQR, 45–57 years). 511 (61.8%) of 827 patients were diagnosed with serous carcinoma. There were 182 (22.0%) patients at stage I, 144 (17.4%) patients at stage II, 442 (53.4%) patients at stage III, and 59 (7.2%) patients at stage IV. Other demographic and clinicopathologic characteristics of these 827 patients were presented in Table 1.

Table 1. The demographic and pathological characteristics of OC patients with and without pelvic/para-aortic LNM.

Parameters	Total (N=827)	Pelvic/para-aortic LNM. N=264	No pelvic/para-aortic LNM. (N=563)	OR (95% CI)	*p* value
Age, years, *n (%)*					
<60	673 (81.4)	210 (79.5)	463 (82.2)	0.84 (0.58–1.22)	0.354
≥60	154 (18.6)	54 (20.5)	100 (17.8)		
Histology, *n (%)*					
Serous	511 (61.8)	215 (81.4)	296 (52.6)	3.96 (2.79–5.63)	<0.001
Non–Serous	316 (38.2)	49 (18.6)	267 (47.4)		
FIGO Stage, *n (%)*					
I	182 (22.0)	0 (0.0)	182 (32.3)		<0.001
II	144 (17.4)	8 (3.0)	136 (24.2)		
III	442 (53.4)	224 (84.8)	218 (38.7)		
IV	59 (7.2)	32 (12.1)	27 (4.8)		
Ascites, *n (%)*					
Yes	427 (51.6)	208 (78.8)	219 (38.9)	5.83 (4.15–8.20)	<0.001
No	400 (48.4)	56 (21.2)	344 (61.1)		
BMI, *n (%)*					
≥23.23	265 (32.0)	114 (43.2)	151 (26.8)	2.07 (1.53–2.82)	<0.001
<23.23	562 (68.0)	150 (56.8)	412 (73.2)		

Abbreviations: OC ovarian cancer, OR odds ratios, CI confidence interval, BMI body mass index, LNM lymph node metastases,

The status of ascites was determined by ultrasonography or computed tomography (CT). Thus, 427 (51.6%) patients were accompanied by ascites. The optimal cut-off values of continuous variables were determined by the ROC curve. We found 23 features that could be obtained before surgery were significantly associated with LNM in univariate analysis (Table 1 and Table 2). In the clinical features, ascites (OR, 5.83, 95% CI, 4.15–8.20, $p<0.001$) and BMI≥23.23 kg/m^2 (OR, 2.07, 95% CI, 1.53–2.82, $p<0.001$) were risk factors of LNM. Among the tumor markers, CA125≥432.15 U/ml (OR, 8.43, 95% CI, 5.89–12.05, $p<0.001$) was a risk predictor for LNM. However, CEA≥2.46 ng/ml (OR, 0.63, 95% CI, 0.44–0.90, $p=0.011$) and CA199≥28.31 U/ml (OR, 0.61, 95% CI, 0.44–0.86, $p=0.005$) were protective factors of LNM. Among the routine blood tests, neutrophil count≥2.965*10^9/L (OR, 4.01, 95% CI, 2.47–6.51, $p<0.001$), lymphocyte count<1.30*10^9/L (OR, 2.22, 95% CI, 1.64–2.94, $p<0.001$), monocyte count≥0.415*10^9/L (OR, 2.40, 95% CI, 1.78–3.24, $p<0.001$), platelet count≥284.5*10^9/L (OR, 2.14, 95% CI, 1.59–2.89, $p<0.001$), and thrombocytocrit≥0.285% (OR, 2.18, 95% CI, 1.62–2.94, $p<0.001$) increased the probability of LNM. Additionally, mean corpuscular volume (MCV) ≥91.85 fl (OR, 0.63, 95% CI, 0.45–0.89, $p=0.008$), mean corpuscular hemoglobin (MCH)≥29.35 pg (OR, 0.56, 95% CI, 0.42–0.76, $p<0.001$), coefficient of variation of RBC distribution width (RDW-CV)≥12.65% (OR, 0.63, 95% CI, 0.46–0.86, $p=0.004$), platelet distribution width (PDW)≥12.75 fl (OR, 0.71, 95% CI, 0.53–0.96, $p=0.024$), and mean platelet volume (MPV)≥9.75 fl (OR, 0.63, 95% CI, 0.45–0.87, $p=0.005$) decreased the probability of LNM. Patients with aspartate aminotransferase (AST)≥18.95 U/L (OR, 1.94, 95% CI, 1.43–2.62, $p<0.001$) or blood glucose≥5.175 mmol/L (OR, 1.36, 95% CI, 1.01–1.83, $p=0.043$) were inclined to have LNM. Furthermore patients with albumin (ALB)≥38.22 g/L (OR, 0.47, 95% CI, 0.35–0.63, $p<0.001$), total bilirubin (TBIL)≥9.29 umol/L (OR, 0.68, 95% CI, 0.51–0.92, $p=0.012$), Na^+≥138.825 mmol/L (OR, 0.64, 95% CI, 0.46–0.90, $p=0.010$), Cl^-≥100.39 mmol/L (OR, 0.52, 95% CI, 0.36–0.73, $p<0.001$), or Ca^{2+}≥2.31 mmol/L (OR, 0.70, 95% CI, 0.51–0.96, $p=0.028$) were not inclined to have LNM. Fibrinogen≥3.805 g/L (OR, 1.71, 95% CI, 1.23–2.30, $p<0.001$) also indicated a high risk of LNM. Other features which were not related to LNM in univariate analysis were shown in additional file 1.

Table 2. The factors associated with pelvic/para-aortic LNM in univariate analysis.

Parameters	Total (N=827)	Pelvic/para-aortic LNM N=264	No pelvic/para-aortic LNM (N=563)	OR (95% CI)	*p* value
CA125≥432.15 U/ml, *n (%)*	412 (49.8)	216 (81.8)	196 (34.8)	8.43 (5.89–12.05)	<0.001
CEA≥2.46 ng/ml, *n (%)*	199 (24.1)	49 (18.6)	150 (26.6)	0.63 (0.44–0.90)	0.011
CA199≥28.31 U/ml, *n (%)*	235 (28.4)	58 (22.0)	177 (31.4)	0.61 (0.44–0.86)	0.005
Neutrophil count ≥2.965*10^9/L, *n (%)*	661 (79.9)	243 (92.0)	418 (74.2)	4.01 (2.47–6.51)	<0.001
Lymphocyte count <1.30*10^9/L, *n (%)*	288 (34.8)	125 (47.3)	163 (29.0)	2.22 (1.64–2.94)	<0.001
Monocyte count ≥0.415*10^9/L, *n (%)*	383 (46.3)	161 (61.0)	222 (39.4)	2.40 (1.78–3.24)	<0.001
MCV≥91.85 fl, *n (%)*	232 (28.1)	58 (22.0)	174 (30.9)	0.63 (0.45–0.89)	0.008
MCH≥29.35 pg, *n (%)*	363 (43.9)	91 (34.5)	272 (48.3)	0.56 (0.42–0.76)	<0.001
RDW-CV ≥12.65%, *n (%)*	579 (70.0)	167 (63.3)	412 (73.2)	0.63 (0.46–0.86)	0.004
PLT≥284.5*10^9/L, *n (%)*	349 (42.2)	145 (54.9)	204 (36.2)	2.14 (1.59–2.89)	<0.001
PDW≥12.75 fl, *n (%)*	414 (50.1)	117 (44.3)	297 (52.8)	0.71 (0.53–0.96)	0.024
MPV≥9.75 fl, *n (%)*	618 (74.7)	181 (68.6)	437 (77.6)	0.63 (0.45–0.87)	0.005
Thrombocytocrit ≥0.285%, *n (%)*	368 (44.5)	152 (57.6)	216 (38.4)	2.18 (1.62–2.94)	<0.001

AST≥18.95 U/L, *n (%)*	452 (54.7)	173 (65.5)	279 (49.6)	1.94 (1.43–2.62)	<0.001
ALB≥38.22 g/L, *n (%)*	504 (60.9)	128 (48.5)	376 (66.8)	0.47 (0.35–0.63)	<0.001
TBIL≥9.29 umol/L, *n (%)*	359 (43.4)	98 (37.1)	261 (46.4)	0.68 (0.51–0.92)	0.012
Na^+≥138.825 mmol/L, *n (%)*	646 (78.1)	192 (72.7)	454 (80.6)	0.64 (0.46–0.90)	0.010
Cl^-≥100.39 mmol/L, *n (%)*	659 (79.7)	190 (72.0)	469 (83.3)	0.52 (0.36–0.73)	<0.001
Ca^{2+}≥2.31 mmol/L, *n (%)*	285 (34.5)	77 (29.2)	208 (36.9)	0.70 (0.51–0.96)	0.028
Glucose ≥5.175 mmol/L, *n (%)*	328 (39.7)	118 (44.7)	210 (37.3)	1.36 (1.01–1.83)	0.043
Fibrinogen ≥3.805 g/L, *n (%)*	376 (45.5)	144 (54.5)	232 (41.2)	1.71 (1.23–2.30)	<0.001

Abbreviations: OR odds ratios, CI confidence interval, MCV mean corpuscular volume, MCH mean corpuscular hemoglobin, RDW-CV coefficient of variation of RBC distribution width, PLT platelet, PDW platelet distribution width, MPV mean platelet volume, AST aspartate aminotransferase, ALB albumin; TBIL total bilirubin, LNM lymph node metastases,

In this study, we aimed to predict the risk of LNM in OC patients before surgery. Thus, we only enrolled the significant factors which could be obtained preoperatively into multivariate logistic regression analysis. According to the multivariate analysis, we found ascites (OR, 3.022, 95% CI, 2.058–4.438, p<0.001), BMI≥23.23 kg/m^2 (OR, 2.082, 95% CI, 1.448–2.995, p<0.001), CA125≥432.15 U/ml (OR, 4.665, 95% CI, 3.158–6.891, p<0.001), neutrophil count≥2.965*10^9/L (OR, 2.882, 95% CI, 1.606–5.172, p<0.001), lymphocyte count<1.30*10^9/L (OR, 1.554, 95% CI, 1.086–2.223, p=0.016) , and monocyte count≥0.415*10^9/L (OR, 1.506, 95% CI, 1.047–2.166, p=0.027) were independent risk factors of LNM (Table 3).

Table 3. Multivariate logistic regression analysis of risk factors for pelvic/para-aortic LNM in OC patients.

Parameters	B	SE(B)	Wald	OR (95% CI)	*p* value
BMI≥23.23 kg/m^2	0.734	0.185	15.645	2.082 (1.448–2.995)	<0.001
Ascites	1.106	0.196	31.308	3.022 (2.058–4.438)	<0.001
CA125≥432.15 U/ml	1.540	0.199	59.882	4.665 (3.158–6.891)	<0.001
Neutrophil count ≥2.965*10^9/L	1.058	0.298	12.585	2.882 (1.606–5.172)	<0.001
Lymphocyte count <1.30*10^9/L	0.441	0.183	5.827	1.554 (1.086–2.223)	0.016
Monocyte count ≥0.415*10^9/L	0.410	0.185	4.875	1.506 (1.047–2.166)	0.027

Abbreviations: OC ovarian cancer, OR odds ratios, CI confidence interval, BMI body mass index, SE standard error,

Through integrating the six risk factors above, the AUC of predicting LNM in OC patients was 0.836 (95% CI, 0.808–0.864) (Fig.1a). The performance of this regression model was also promising in predicting LNM in OC patients with early-stage (stage I-II) (AUC, 0.809, 95% CI, 0.619–1.000) and advanced-stage (stage III-IV) (AUC, 0.764, 95% CI, 0.723–0.805) (Fig.1b-1c). The LNM rates for OC patients with 0, 1, 2, 3, 4, 5, and 6 risk factors were 0, 4.13%, 12.88%, 28.34%, 50.30%, 65.25%, and 77.78% respectively (p<0.001) (Table 4) (Fig.2). Patients with 0–3 risk factors had significantly lower LNM rates than those of patients with 4–6 risk factors (15.40% vs 58.92%, p<0.001).

Table 4. Distribution of OC patients with pelvic/para-aortic LNM in different risk groups.

Number of risk factors	N (%)	Pelvic/para-aortic LNM, n (%)	No pelvic/para-aortic LNM, n (%)	*p* value
0	42 (5.08)	42 (100.00)	0 (0.00)	<0.001
1	121 (14.63)	116 (95.87)	5 (4.13)	
2	163 (19.71)	142 (87.12)	21 (12.88)	
3	187 (22.61)	134 (71.66)	53 (28.34)	
4	169 (20.44)	84 (49.70)	85 (50.30)	
5	118 (14.27)	39 (33.05)	79 (65.25)	
6	27 (3.26)	6 (22.22)	21 (77.78)	

Abbreviations: OC ovarian cancer, LNM lymph node metastases

4. Discussion

Though LNM had a great impact on the prognosis of OC patients (9), systematic pelvic/para-aortic lymph node dissection during surgery is still controversial, especially in advanced OC (6, 7). It was mainly attributed to the fact that predicting the status of lymph nodes before surgery was difficult. Clinical trials and reviews revealed that the rate of LNM ranged 13.6%–30.3% in OC patients and 6.1%–29.6% in patients with stage I–II (11-13). Thus, identifying patients at high risk of LNM and performing systematic lymphadenectomy accordingly could prevent nearly 70% of patients from relevant complications. As medical imaging technologies develop, swollen lymph nodes could be detected through radiological methods, including computed tomography scan (CT) and magnetic resonance imaging (MRI). However, the accuracy of these methods to predict LNM was unsatisfactory (15). Though investigations in researching the relationship between clinicopathological factors and pelvic/para-aortic LNM in OC had been carried out (16, 17), few studies were revealing the relevance of preoperative clinical features to pelvic/para-aortic LNM.

In this multicenter study, we first systematically screened the capability of 35 features (including demographics, tumor markers, routine blood tests, blood biochemical examination, and fibrinogen) in predicting pelvic/para-aortic LNM. To make a preoperative prediction, all the enrolled 35 features were obtained before surgery. Finally, six independent risk factors including BMI≥23.23 kg/m^2, ascites, CA125≥432.15 U/ml, neutrophil count≥2.965*10^9/L, lymphocyte count<1.30*10^9/L, and monocyte count≥0.415*10^9/L associated with LNM were recognized. The AUC of the integrating six risk factors was 0.836. This study could help clinicians to timely identify OC patients at high risk of LNM more precisely and avoid performing lymphadenectomy in patients at low risk of LNM.

In this multi-center retrospective study, the preoperative BMI, ascites, the level of neutrophil count, lymphocyte count, and monocyte count were first identified as the factors associated with LNM in OC patients. CA125, a reported risk factor of LNM, was also validated in our study. However, the cut-off values of CA125 varied across studies (16-19). It may be due to the various sample sizes and FIGO stages in different studies. Besides in OC, increased CA125 was regarded as a risk factor of LNM in endometrial cancer (20, 21). Nevertheless, we confirmed the role of CA125 in prediction of LNM in gynecological tumors. Obesity was reported to be a risk factor of LNM in prostate cancer and breast cancer (22, 23). However, its role in predicting LNM in gynecological tumors was unclear. It is the first time to uncover that BMI≥23.23 kg/m^2 was significantly associated with LNM in OC patients. The underlying mechanism might be explained by the theory that obesity could promote tumor metastasis (24, 25). In a retrospective study with a small sample size of advanced serous OC, Szymon et al. did not find a significant association between the status of ascites and LNM (17). The contradictory conclusion compared to the current study might be attributed to the different sample sizes and different inclusion criteria. In this study, we did not consider the pathology and the stage of OC patients for the aim that we want to make a prediction before surgery. The systemic inflammatory markers, especially neutrophil, lymphocyte, and monocyte, played an important role in the progression of several cancers (26, 27). These factors may be partly involved in LNM. Studies indicated increased neutrophil-to-lymphocyte ratio

portended a higher probability of LNM in thyroid carcinoma (28, 29). Here, we first validated that the preoperative increased neutrophil count and monocyte count, decreased lymphocyte count were independent risk factors of LNM in OC. And in addition, we further calculated the optimal cut-off values of these factors.

There were several advantages of this study. First, our study provided possibility of preoperatively predicting LNM in OC, which could avoid unnecessary lymphadenectomy for OC patients at low risk of LNM. Unlike previous studies, we did not enroll pathology and FIGO stage which could only be obtained after surgery in the establishment of regression model (16, 17). All six risk factors identified in this study could be easily obtained before surgery. Second, five of the six indicators for LNM in OC were identified for the first time in our study. In addition, the AUC of predicting the LNM by integrating the six factors achieved 0.836, which was a promising performance in this multi-center retrospective study.

The current study still had some limitations. First, the data missing in less than 20% of patients were imputed by algorithms, and the data missing in ≥20% of patients were abandoned, which might result in buried information due to the retrospective nature of the study. Second, not all the patients received both systematic pelvic and para-aortic lymphadenectomy, which had potential impact on the status of LNM.

5. Conclusions

In summary, our study provided a promising model to predict LNM before surgery in OC patients by involving preoperative BMI, the status of ascites, CA125, neutrophil count, lymphocyte count, and monocyte count, which might improve the therapeutic efficacy of systematic lymphadenectomy and avoid unnecessary lymphadenectomy.

6. Abbreviations

OC: Ovarian cancer; LNM: lymph node metastases; CI: confidence interval; OR: odds ratio; BMI: body mass index; AUC: area under the curve; FIGO: International Federation of Gynecology and Obstetrics; ROC: receiver operating characteristic.

Declarations

Ethics approval and consent to participate

This study was approved by the Research Ethics Commission of Tongji Medical College, Huazhong University of Science and Technology with waived informed consent by the Ethics Commission mentioned above (No. S201).

Availability of data and materials

The data analyzed in this study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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None.

Authors' contributions

Xiaoming Xiong: Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing–original draft, review & editing. **Yue Gao:** Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Resources, Supervision, Validation, Visualization. **Mengjie Wang, Jianhua Chi, Xiaofei Jiao, and Shaoqing Zeng:** Data curation, Validation, Investigation. **Lingxi Chen:** Methodology. **Qi Zhou, Li Wang, Yu Xia, Yong Fang, and Wei Zhang:** Data curation, Writing–review & editing. **Qinglei Gao:** Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing–review & editing.

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Figures

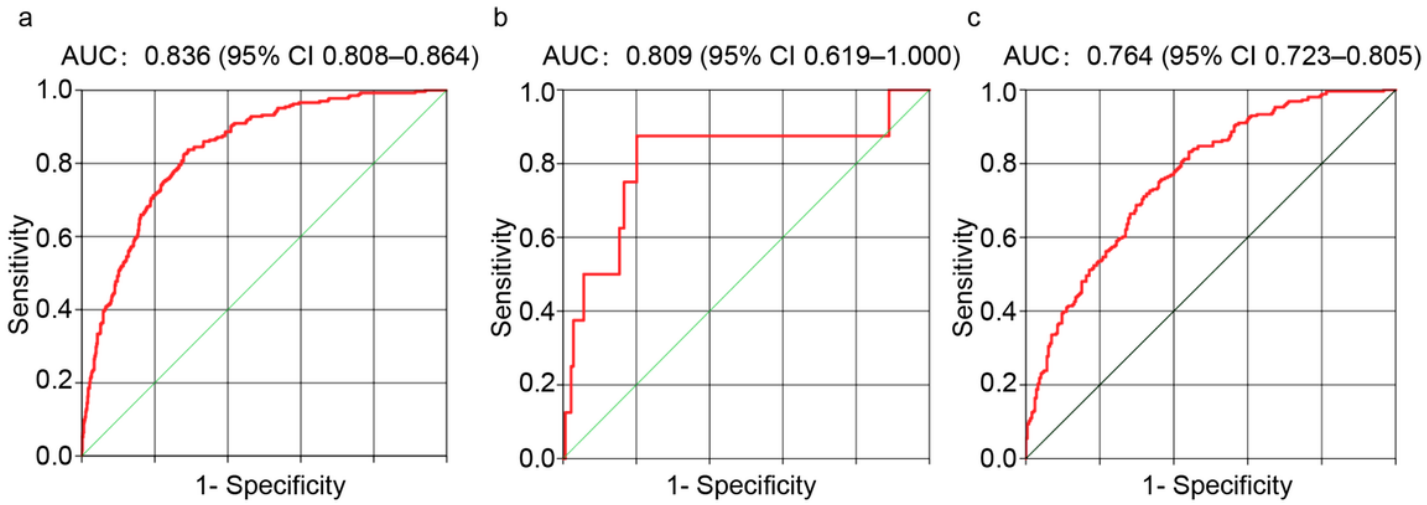

Figure 1

The performance of predicting the pelvic/para-aortic LNM in OC patients by combined six risk factors. The AUC of predicting the pelvic/para-aortic LNM in total OC patients (**a**), in patients with FIGO stage I-II (**b**), and patients with FIGO stage III-IV (**c**).

Abbreviation: LNM lymph node metastases, OC ovarian cancer, BMI body mass index, AUC area under the curve,

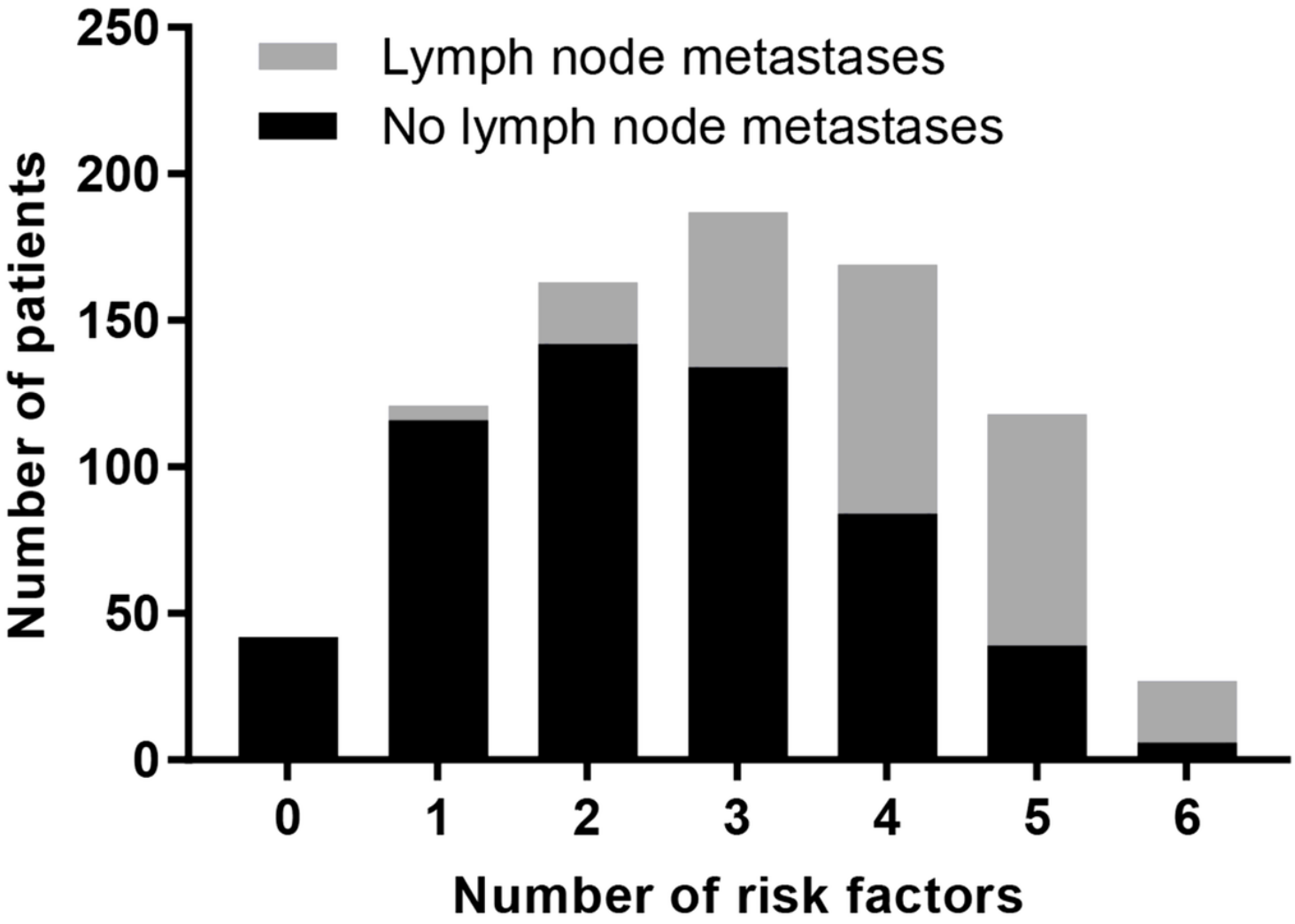

Figure 2

Distribution of OC patients with LNM in different risk groups.

Abbreviation: OC ovarian cancer, LNM lymph node metastases,

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