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Evaluation of Psoas Muscle Index for Prognosis Prediction in Patients with Ovarian Cancer: A Retrospective 2-Center Cohort Study

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Abstract

Background: Ovarian cancer is a leading cause of death among gynecological cancers. The prognosis depends mainly on the diagnosis stage. Sarcopenia, characterized by muscle wasting, significantly impacts cancer prognosis. This study aimed to examine the importance of the psoas muscle index in predicting outcomes for ovarian cancer patients.

Methods: We conducted a retrospective cohort study with 73 patients treated between 2011 and 2021 at Akbarabadi Obstetrics and Gynecology Hospital and Rasool-Akram General Hospital in Tehran, Iran. The psoas muscle index was calculated from the sectional area of the psoas muscle at the third lumbar vertebra using computed tomography (CT) and magnetic resonance imaging (MRI) scans. Data collection included demographic information, cancer stage, pathology, and treatment outcomes. Statistical analyses, including logistic and Cox regressions, evaluated the association between the psoas muscle index and patient outcomes.

Results: The psoas muscle index was significantly higher in patients without treatment failure (173 ± 28.94) compared with those with treatment failure (149.75 ± 20.39) (P = 0.016). Logistic regression analysis indicated that an increased psoas muscle index was an independent predictor for better survival outcomes (odds ratio [OR], 0.891 [95% CI, 0.786-1.01]).

Conclusion: The findings highlight the importance of sarcopenia in the prognosis of ovarian cancer. This study supports the potential of the psoas muscle index as a noninvasive and accessible prognostic tool in clinical practice.

Keywords: Ovarian Cancer, Psoas Muscle Index, Prognosis, Cancer Survival

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Introduction

Ovarian cancer is a significant cause of female mortality globally, especially among gynecological malignancies. Despite advancements in treatment, it has the highest mortality rate (1-3). In women over 40 years, particularly in developed countries, ovarian cancer is the second most common malignancy after breast cancer (4, 5). Overall, it ranks eighth in prevalence and is the fifth leading cause of cancer-related death among women (5).

Even though ovarian cancer awareness is increasing, cure rates and survival have not significantly improved due to the difficulty of early diagnosis (5). The prognosis for women who develop ovarian cancer depends directly on the stage of the disease at the time of diagnosis (5, 6). Women diagnosed with stage I have a very high 5-year survival rate

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↑What is "already known" in this topic:
Ovarian cancer is a significant cause of mortality among gynecological cancers. The psoas muscle index (PMI), derived from imaging studies, has been evaluated as an indicator of sarcopenia and is associated with outcomes in various cancers.

→What this article adds:
This study highlights the prognostic value of PMI specifically in ovarian cancer patients. It found that higher PMI is significantly associated with better treatment outcomes. The research supports the potential of PMI as a noninvasive prognostic tool. The use of PMI in clinical practice could aid in patient stratification and treatment personalization, potentially improving survival rates and quality of life for patients with ovarian cancer.

exceeding 90%; however, this rate progressively declines with advanced stages (5, 6). For localized spread, the 5-year survival rate drops to around 80%, and it further decreases to 25% for metastatic disease (5, 6).

Ovarian cancer often lacks specific symptoms and has no reliable screening test, leading to late-stage diagnoses (2, 6-9). Advanced-stage epithelial ovarian cancer can cause systemic inflammation, large tumors, and ascites. This leads to malnutrition in up to 68% of patients due to reduced oral intake and bowel dysfunction, resulting in muscle wasting and cachexia, a syndrome linked to higher mortality (1, 9, 10).

Sarcopenia—the progressive loss of muscle mass and strength—is a critical feature of cancer cachexia and a key prognostic indicator. This syndrome reflects overall weight loss and specific muscle wasting, weakening cancer patients. Sarcopenia is a key physiological change during cancer cachexia and the most clinically relevant indicator of this debilitating condition. (1, 2, 4, 9, 10). Sarcopenia, identified through routine computed tomography (CT) scans, is associated with poorer outcomes in cancer patients. These scans could therefore serve as valuable tools for assessing muscle wasting and predicting patient prognosis (8, 9). Studies have demonstrated that tissue analysis at the third lumbar vertebra (L3) strongly correlates with total body fat and muscle mass. Consequently, this method is widely used to assess body composition in cancer patients (1-3, 6). However, research indicates that changes in the psoas muscle area do not accurately reflect overall muscle changes, making them unsuitable for predicting survival in patients with ovarian cancer undergoing this treatment (3). Research suggests that psoas muscle mass, assessed using the psoas muscle index (PMI), is an independent predictor of worse overall survival in patients with epithelial ovarian cancer. The PMI is calculated by dividing the cross-sectional area of the psoas muscle at the fifth lumbar vertebra by the height squared (9). However, larger studies are needed to confirm this finding.

This study aimed to investigate the association between the prognosis of ovarian cancer patients and their muscle mass. Muscle mass is measured by the PMI, derived from the psoas muscle area at the third lumbar vertebra using CT and magnetic resonance imaging (MRI) scans before treatment.

Methods

Study Design

This study utilized a retrospective diagnostic cohort design to investigate the association between PMI and survival outcomes in patients with ovarian cancer. Data were collected from 2 medical centers located in Tehran, Iran—Akbarabadi Obstetrics and Gynecology Hospital and Rasool-Akram General Hospital—from 2011 to 2021.

Participants

The study population consisted of patients diagnosed with ovarian cancer who received treatment at the 2 study hospitals during the study period. All eligible patients were enrolled. The inclusion criteria included a diagnosis of ovarian cancer and consent to participate. The exclusion criterion was the absence of PMI data in the patient's health records. All participants signed informed consent for the anonymous use of their information in the research at the time of admission.

Data Collection

Data collection involved retrieving pertinent information from patients' medical records. A researcher-made questionnaire was used to gather demographic data (eg, age and body mass index [BMI]), cancer-related variables (eg, cancer stage, cancer type, and presence of metastasis), and treatment outcomes (eg, readmission, metastasis, and survival). Between March 2023 and April 2024, telephone interviews with patients and/or their first-degree family members (in case of death or disability) were conducted to obtain the outcomes and also additional verbal informed consent.

Outcome Assessment

The study outcome was defined as treatment failure both in case of disease recurrence or death due to malignancy. In addition to treatment consequences, pulmonary thromboembolism (PTE), deep vein thrombosis (DVT), and recurrent ascites were asked through a phone interview.

Clinical and Paraclinical Variables

CT scans and MRI images were used to calculate the PMI. A radiologist assessed the muscle area of the psoas major at the third lumbar vertebra using these images. The psoas major muscle surface area was divided by the square of the patient's height (mm^2/m^2). A surgeon determined and documented the cancer stage in patients' files. Moreover, tumor markers were evaluated alongside the PMI.

Statistical Analysis

Patients with and without treatment failure were compared for clinical characteristics—including age at diagnosis, BMI, length of follow-up, and PMI—using an independent t test or the Mann-Whitney U test. Logistic analysis was employed to determine the association of the PMI with the success of the treatment and time to treatment failure, adjusting for potential confounders such as metastasis, readmission, patients' BMI, and time intervals related to these events. Furthermore, Cox regression analysis was utilized to assess the relationship between PMI and time to treatment failure outcome. Statistical analysis was performed using SPSS software Version 22 (IBM), with the significance level set at 0.05.

Potential Bias

The main potential bias of the study was the possible censoring of patients who experienced events. We were unable to follow 6 patients from the included cases, and they were therefore excluded from the analysis. In addition, the results of distant metastasis and lymph node pathology reports for 20 patients were lost and not included in the multivariate analysis. The censoring of these data was independent of the study event. Another limitation was selection bias, as the PMI was measured only in patients with

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available CT and/or MRI scans who were patients with a higher risk of high-stage tumors.

Results

The study included 73 patients with malignant ovarian cancer and their PMI was calculated. The mean (SD) age at diagnosis was 56.84 (9.94) years (Table 1). The mean (SD) BMI was 24.15 kg/m^2 (2.92). The mean (SD) gravidity was 3.46 (2.1), and the parity was 2.87 (1.88). The mean (SD) number of abortions was 0.62 (0.89) (Table 1). A family history of cancer was reported in 27% of patients. Seven cases (12.5%) of patients had a previous history of ovarian cysts, and 8 cases (14.3%) had a history of menstrual disorders. The study found that the most common type of pathology was serous carcinoma, which occurred in 65 patients (89%) (Table 1).

From the 73 included patients, the information on distant metastasis and lymph node involvement was available for 53 patients. Distant metastasis was reported in 16 patients and lymph node involvement in 13 patients. Due to the retrospective nature of the study, tumor markers were not calculated for all patients. Several tumor markers were analyzed—including HE4, ROMA, LDH, CEA, CA125, and APF (Table 1). The mean levels of these biomarkers are presented in Table 1. Fourteen patients (26.42%) received adjuvant chemotherapy, 8 patients (15.09%) received neoadjuvant therapy (all received chemotherapy), and 31 patients (58.49%) underwent surgery. The study also found that 8 patients (10.96%) experienced treatment failure: 6 patients (8.22%) experienced recurrence, and 2 patients (2.74%) died (Table 1).

Patients who experienced treatment failure had a mean age of diagnosis of 57.86 ± 9.55 years, compared with 54.73 ± 10.17 years, for patients who did not experience treatment failure ($P = 0.43$) (Table 2). The study also found that patients who experienced treatment failure had a mean BMI of 23.16 ± 1.85 kg/m^2, compared with 24.25 ± 3.04 kg/m^2, for patients who did not experience treatment failure (P = 0.36). The PMI in the group without treatment failure was 173 ± 28.94 and in the group with treatment failure was 149.75 ± 20.39, which showed a significant difference ($P = 0.016$) (Table 2). All cases of treatment failure were associated with high-grade serous carcinoma, as reported in the pathologic laboratory reports.

The median (range) of the follow-up period was 517 days (117-2187 days) for patients who did not experience treatment failure and 671 days (132-1258 days) for patients who experienced treatment failure; however, this difference was not statistically significant ($P = 0.67$) (Table 2).

The study found a statistically significant correlation between PMI and BMI, with a correlation coefficient of 0.55 and $P < 0.001$ (Table 3). However, the age at diagnosis was not significantly correlated with PMI ($P = 0.996$).

Table 1. Patient Clinical Characteristics

Variable	N	Mean/frequency	SD / %
Age	73	56.84	9.94
Age Of Diagnosis	73	54.94	10.08
Gravidity	73	3.46	2.1
Parity	73	2.87	1.88
Abortions	73	0.62	0.89
BMI	73	24.15	2.92
Pathology	73		
Serous		65	89
Granulosa Cell		2	2.7
Papillary Serous		2	2.7
Clear Cell		1	1.4
Endometrioid		1	1.4
Immature Cystic		1	1.4
Mixed Serous And Clear Cell		1	1.4
Laterality	73		
Bilateral		33	45.2
Left		17	23.3
Right		23	31.5
PMI	73	170.64	29.3
Tumor markers			
HE	14	176.91	128.87
ROMA	10	38.43	25.43
LDH	10	399.4	208.35
CEA	7310	3.39	3.96
CA	37	388.53	1297.55
APF	6	4.21	4.12
Metastasis	46	16	30.19
Lymph node involvement	53	13	24.53
Treatment	53		
Adjuvant	Adjuvant	14	26.42
Neo Adjuvant	therapy	8	15.09
Surgery	Surgery	31	58.49
Treatment failure	73	8	10.96
Recurrence		6	8.22
Death		2	2.74

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Table 2. Comparison of Patient's Clinical Characteristics between Two Groups of with and without Treatment Failure

Treatment Failure		No	Yes	*P*-value
Age of Diagnosis*		54.73(10.17)	57.86(9.55)	0.43
BMI*		24.25(3.04)	23.16(1.85)	0.36
PMI*		173(28.94)	149.75(20.39)	0.016
Hb*		10.4(1.2)	9.3(0.61)	0.025
Follow Up (days)**		517.5(577)	671.5(870)	0.67
Metastasis***		16(34.8%)	7(87.5%)	0.005
Treatment***	Adjuvant therapy	4 (50%)	10 (21.7%)	0.127
	Neo adjuvant therapy	2 (25%)	7 (15.2%)	
	Surgery	2 (25%)	29 (63%)	

*Data are reported as mean (SD) and analyzed using student t-test
**Data are reported as median (IQR) analyzed using U Mann Wnitneu
***Data are reported as frequency (percent) analyzed using chi square/ fisher exact test

Table 3. Logistic Regression Model for Treatment Success

Variable	OR	95% C.I for OR		P-value
		Lower	Upper	
Age of Diagnosis	1.072	.943	1.218	.290
BMI	1.228	.563	2.675	.606
PMI	.891	.786	1.010	.072
Metastasis	3325.3	3.325	3325825	.021
Treatment				0.059
Surgery	Ref	Ref	Ref	
Neo Adjuvant therapy	2374	3.859	1460266	.018
Adjuvant therapy	204.8	.035	1193096	.229

BMI: Body mass index, PMI: Psoas Muscle Index

Table 4. Cox Regression Model for Treatment Success

Variable	OR	95% C.I for OR		Sig.
		Lower	Upper	
Age of incidence	1.034	.929	1.150	.544
BMI	1.094	.541	2.211	.803
PMI	.941	.878	1.009	.086
Metastasis	19.23	1.73	201	.016
Treatment				0.052
Surgery	Ref	Ref	Ref	
Neo Adjuvant therapy	2148	3.621	1381347	.023
Adjuvant therapy	192	0.042	1214136	0.195

BMI: Body mass index, PMI: Psoas Muscle Index

The logistic regression model for treatment failure includes outcome and potentially confounder factors—including PMI, age at diagnosis, BMI, metastasis, and treatment that the patients received. Logistic regression analysis showed that the relapse odds ratio for the PMI index adjusted for the presence of metastasis and the type of treatment was equal to 0.891, meaning that with each unit increase in PMI, the chance of recurrence would be reduced by 10.09% (Table 3). Similar results were obtained from Cox regression, adjusting for the time of treatment failure (Table 4, Figure 1).

Discussion

Sarcopenia is often observed in chronic debilitating diseases like cancer. It has recently been studied as a predictive factor for survival across various cancer types. Indicators such as PMI, SMI, SMM, and PV have been evaluated for their role in assessing sarcopenia and predicting survival in ovarian cancer patients. In this study, the mean PMI in the group without treatment failure (65 patients) was significantly higher than in the group with treatment failure (8 patients) ($P = 0.016$). Logistic and Cox regression analyses indicated that increasing PMI was associated with a lower likelihood of treatment failure. Furthermore, metastasis emerged as a statistically significant predictor of treatment failure in both models. The use of neoadjuvant therapy was also linked to an elevated risk of treatment failure.

Numerous studies have explored the impact of PMI on survival prediction in cancers such as lung, gastrointestinal, kidney, liver, and breast (11-15). Several studies have also highlighted PMI and SMI as crucial prognostic factors for ovarian cancer survival. For instance, Yoshikawa's study found an association between PMI and overall survival in patients with ovarian cancer, confirmed by 2 independent

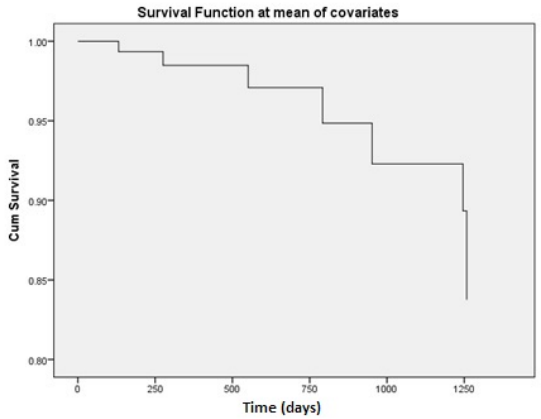

Figure 1. The Cox regression describes the adjusted time to treatment failure for the patients.

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multivariate analyses (9). Conrad et al reported that preoperative PMI at the lumbar L4 level was not linked to poor prognosis, but PMI combined with hypoalbuminemia indicated a poor prognosis in advanced ovarian cancer (16). Matsubara et al investigated the prognostic roles of SMA, PA, and PV in ovarian cancer. They found that low PV was significantly associated with poorer PFS and overall survival compared with high PV, with PV outperforming SMA and PA in prognosis prediction (4).

Yoshikawa's study identified PMI at the fifth lumbar vertebra as an independent risk factor for developing peripheral neuropathy in patients receiving Taxotere and cyclophosphamide treatment for ovarian cancer (17). A moderate correlation between PMI and BMI was also observed. Aust et al in 2015 reported that skeletal muscle wasting is a significant predictor of ovarian cancer prognosis. They evaluated muscle body composition measurement (BCMs), nutritional and inflammatory markers, and clinicopathological parameters in 140 patients with **epithelial ovarian cancer (**EOC), concluding that muscle wasting is an independent prognostic factor for survival (18).

Tomita et al found low PMI to be a poor prognostic factor in Japanese patients with epithelial ovarian cancer (19). Ataseven et al demonstrated that muscle wasting is a valuable indicator for risk classification post- primary debulking surgery (PDS) and correlates with poor survival, especially in patients with residual tumors post-PDS (20). Another study showed that women with ovarian cancer who maintained skeletal muscle mass during treatment had better prognoses than those who experienced muscle loss (21). Chae's study measured skeletal muscle index (SMI) before and after chemotherapy, revealing a strong association of presurgery sarcopenia (SMI $\leq$38.7 cm^2/m^2) with both overall survival and disease free survival (DFS). Sarcopenic patients had nearly half the median overall survival compared with nonsarcopenic patients (6).

In a 2023 meta-analysis by Jin et al, low SMI in patients with ovarian cancer was associated with poor PFS, 5-year survival, low BMI, and advanced International Federation of Gynecology and Obstetrics stage. This meta-analysis included only studies measuring SMI at the lumbar L3 level by CT scan, creating a homogeneous cohort. However, the prevalence of sarcopenia varied across studies due to differing SMI cutoffs, and all studies were retrospective (2).

Some researchers dispute the prognostic value of sarcopenia in ovarian cancer. In a meta-analysis, Jorne Ubachs et al reported that although sarcopenia is linked to ovarian cancer survival, the poor quality and retrospective nature of the data prevent definitive conclusions (22). Rutten et al found that measuring the psoas muscle, whether via software or manually, is not a reliable indicator for overall survival prognosis and sarcopenia in patients with ovarian cancer (3). McSharry's 2020 meta-analysis also found no association between sarcopenia and 5-year survival in EOC patients (10). Similarly, a United States cohort study reported no link between sarcopenia and poor survival outcomes in patients with EOC (23). The psoas region is typically measured at the L3 or L4 vertebrae. Previous studies have focused on sarcopenia assessed by total skeletal muscle mass area at the third lumbar vertebra. Despite being recognized as an important prognostic factor, sarcopenia's optimal index and cutoff values remain subjects of debate.

Study Limitations

Due to the retrospective nature of this study, it was not possible to retrieve all variables and potential confounding factors for all patients. The CT and MRI scans were not available for all patients before treatment initiation, which led to the exclusion of large cases. Furthermore, we were unable to calculate both overall and progression-free survival separately because the sample size with available imaging data was too small.

Conclusion

Our findings indicated that PMI in the group without treatment failure was significantly higher than in the group with treatment failure. Logistic regression analyses also demonstrated that an increase in PMI is associated with a lower likelihood of patient relapse. The use of PMI in clinical practice could enhance the ability to stratify patients more effectively, potentially improving survival rates and quality of life for patients with ovarian cancer. Future studies with larger sample sizes are needed to further validate these findings and refine the use of PMI in clinical settings.

Authors' Contributions

Mahdiss Mohamadianamiri: study Conception and design, supervision, preparation of the manuscript Mohammadreza Babaei: acquision of data, administrative, edit of the manuscript Arash Mohazzab: study Conception and design, data analysis and interpretation, preparation of the manuscript Fahimeh Zeinalkhani: acquision of data Peyman Kamali Hakim: acquision of data Somayeh Ebadi Soflo: acquision of data Fatemeh Jayervand, acquision of data Maryam Noroozi: Study Conception and design, administrative, preparation of the manuscript, acquision of data.

Ethical Considerations

This study was conducted in compliance with the ethical standards outlined in the Declaration of Helsinki. Institutional review board approval was obtained from the respective hospitals and The Ethics Board of Iran University of Medical Sciences with registration code 1401.083.IR.IUMS.FMD.REC. Informed consent was obtained from all participants or their legal guardians.

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Conflict of Interests

The authors declare that they have no competing interests.

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