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Original Article

The correlation between clinical and pathological features of renal cancer patients with survival after surgical intervention

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Abstract

Background: Renal cell carcinoma (RCC) is a prevalent malignancy with a steadily increasing incidence. This study examined the association between clinical and pathological factors and RCC patient survival outcomes.

Methods: This retrospective cohort study enrolled patients diagnosed with malignant renal tumors who underwent surgical resection at Urmia Imam Khomeini Hospital between April 2017 and March 2022. Eligible patients were identified through a review of medical records and recruited using a convenience sampling method. Demographic, clinical, and pathological data were collected for each patient.

Results: Of the 171 patients, 104 were males and 67 were females with a mean age of 57.9 years (SD±14.5). The one-, three, and five-year overall survival rates were 84.7%, 72.4%, and 70.5%, respectively. Univariate regression analysis revealed that five-year mortality following surgical intervention was strongly associated with moderate-to-severe anemia HR: 6.495, 95%CI: 3.618-11.660, p<0.001), elevated ESR (HR: 6.690, 95%CI: 3.122-14.335, p<0.001), presence of necrosis (HR 13.216, 95% CI 5.213-33.509, p < 0.001), and lymphovascular invasion (HR 7.988, 95% CI 4.184-15.251, p < 0.001). Multivariate regression analysis identified moderate-to-severe anemia, lymphovascular invasion, and stage III &IV, high ESR and eGFR<45 as strong predictors of five-year mortality.

Conclusion: These findings highlight the importance of considering clinical and pathological features in the management and prognosis of RCC patients.

Keywords: Survival analysis, Nephrectomy, Renal cell carcinoma, Clinical and pathological features.

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Renal cell carcinoma (RCC) represents the most prevalent form of kidney cancer among adults (1). Notably, RCC exhibits a significantly higher annual mortality-to-incidence ratio compared to other common urological malignancies (2). The incidence of RCC is more pronounced in males, typically peaking between the ages of 60 and 70 (3). A substantial proportion of patients, approximately 20-30%, present with metastatic disease at diagnosis (4). Unfortunately, one-third of diagnosed patients succumb to the disease due to metastatic progression (5). While the overall incidence of renal cancer has been increasing, recent years have witnessed a stabilization in incidence rates, coupled with a significant decline in mortality rates (6). Renal cell carcinoma (RCC) is a pathologically heterogeneous disease characterized by distinct histopathologic subtypes with divergent natural histories (7). Clear cell carcinoma predominates, representing 75–80% of cases, followed by papillary (10–15%) and chromophobe (5%) subtypes (8). Rare variants like collecting duct carcinoma comprise <1% of cases (9).

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Prognosis is significantly influenced by histological subtype, tumor stage, and grade (10), though conflicting evidence exists regarding prognostic stratification: some studies suggest histology better predicts outcomes in advanced/high-grade tumors, while others indicate greater utility in low-stage disease (11). Crucially, both histological subtype and tumor grade strongly correlate with five-year cancer-specific survival after radical nephrectomy (12). Notably, sarcomatoid differentiation present in 5% of RCC cases across all subtypes is classified as a high-grade component (designated grade 4) rather than a distinct entity, reflecting its association with poor differentiation (13, 14).

Research has indicated that the treatment outcomes for advanced renal cancer remain unsatisfactory (15). Advanced RCC presents a significant healthcare challenge due to its increasing incidence and complexity (16). Despite advancements in understanding its pathophysiology and identifying risk factors, early detection is necessary for effective treatment and improved outcomes (17).While nephrectomy is considered the standard treatment for localized renal cancer, its efficacy in controlling disease progression and improving patient survival compared to alternative therapies is under ongoing investigation (18). Surgical intervention, particularly nephrectomy, remains the primary recommended treatment for renal tumors, including RCC, offering the potential for long-term survival (19). Early detection and treatment of renal cancer are crucial for improving overall survival (OS) that measures how long patients live after a specific treatment or diagnosis (20). Traditional tumor staging and grading systems, although effective predictors for various cancers (21), do not fully account for the biological heterogeneity of patients and the impact of socioeconomic factors (22).

While several clinical and pathological factors have been proposed as prognostic indicators of RCC, there remains a paucity of comprehensive data evaluating the interplay between clinical parameters (such as sex, presenting symptoms, and tumor size) and pathological features (including histological type, Fuhrman grade, pathological stage, nodal involvement, and lymphovascular invasion) in predicting progression-free survival among RCC patients. Most existing studies are limited by small sample sizes, single-center designs, or lack detailed correlation analyses between these variables. Given this knowledge gap, the present study aimed to systematically investigate the association between key clinical and pathological parameters and progression-free oncological survival in a well-defined cohort of RCC patients who underwent surgical treatment at Urmia Imam Khomeini Hospital over a five-year period. By clarifying these relationships, our findings may contribute to improved risk stratification and personalized management strategies for individuals diagnosed with RCC.

Methods

This retrospective cohort study included patients diagnosed with malignant renal tumors who underwent surgical intervention at Imam Khomeini Hospital, affiliated with Urmia University of Medical Sciences, between April 2017 and March 2022. The study protocol was approved by the Ethics Committee of Urmia University of Medical Sciences (code: IR.UMSU.REC.1400.034). All study procedures were conducted in accordance with the ethical principles outlined in the latest version of the Declaration of Helsinki. Eligible patients were identified and included in the study through a retrospective review of medical records. Complete medical records are defined as patient files that contain all of the following essential data elements including demographic Information, clinical data, pathological data, treatment details, follow-up data, and oncological outcomes. Inclusion criteria included: age ≥18 years, histopathologically confirmed renal neoplasm staged according to the 2022 World Health Organization Classification of Tumors of the Urinary System and Male Genital Organs, availability of pre-operative laboratory data, and complete medical records. In total, 171 patients with renal tumors included in the study.

The hospital records of the patients were reviewed and the data on demographic, clinical, and pathological data were collected for each patient, including: age, sex, family history of renal cell carcinoma, body mass index (BMI), tobacco use, presence of palpable mass, flank pain, hematuria, pre-operative hemoglobin, platelet count, erythrocyte sedimentation rate (ESR), creatinine, glomerular filtration rate (GFR), neutrophil-to-lymphocyte ratio (NLR), tumor histology, tumor stage (according to the TNM staging system), tumor grade (according to the Fuhrman grading system), tumor size, lymph node involvement, sarcomatoid differentiation, surgical margin status, lymphovascular invasion, necrosis, survival status, and cause of death. The researcher reviewed the medical records and extracted the studied information. All patients were followed-up every 6 months in the first three years after surgery through a telephone call and direct contact with patients or their families. We could not find six patients (censored data). Information regarding the date and cause of death was obtained for patients who died during or after hospitalization by interview with family members, and hospital records. Moreover, it should be acknowledged that

family interviewees may engage in self-presentation bias, altering their responses to portray themselves or the family in a socially desirable manner. Additionally, retrospective accounts are susceptible to memory distortion, including omissions, exaggerations, or unintentional or intentional inaccuracies, as recollections may be influenced by the passage of time and subjective reinterpretation of past events.

Statistical analysis: We used mean (standard deviation) and frequency (%) to describe the distribution of continuous and categorical data, respectively. To estimate glomerular filtration rate (eGFR), the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation was employed as follows :

$eGFRcr = 142 \times \min(Scr/\kappa, 1)^{\alpha} \times \max(Scr/\kappa, 1)^{-1.200} \times 0.9938^{AGEc} \times 1.012$ (if female)

where AGEc is age in years, Scr is the serum creatinine (mg/dl), K for men and women were 0.7 and 0.9, respectively, and αfor men and women were -0.241 and -0.302, respectively. Then we classified the patients into two groups <45 and ≥45 mL/min/1.73m^2. The optimal cut-off value for the neutrophil-to-lymphocyte ratio (NLR) and platelet level was determined using receiver operating characteristic (ROC) curve analysis for event prediction and the Youden Index. Youden Index shows the maximum difference between the true positive rate (sensitivity) and the false positive rate (1-specificity), and calculated as: Sensitivity + Specificity - 1. We classified ESR level as Low (<29 in women and <22 in men), and high (≥29 in women and (≥22 in men) based on a previous study (23). For anemia, the levels of Hb in men and women were categorized as follows: non-anemic (Hb>12 in women and Hb>13 in men), mild anemia (Hb 10 to 12 in women and 11 to 13 in men) and moderate to severe anemia (Hb <10 in women and <11 in men).

Kaplan-Meier survival analysis was utilized to assess one-, three-, and five-year cancer-specific survival rates. The log-rank test was applied to compare survival curves between different groups. Univariate and multivariate Cox regression analyses were conducted to identify factors associated with overall survival. A hazard ratio (HR) greater than 1 indicated an increased risk of mortality. Backward stepwise selection was used to determine the final multivariate model.Statistical analyses were performed using SPSS software Version 20 (IBM Corp., Armonk, NY, USA). A p-value of less than 0.05 was considered statistically significant.

Results

The study cohort comprised 171 patients, of whom 104 (60.8%) were males and 67 (39.2%) were females. The mean age of the participants was 57.9±14.5 years (range: 25–92 years), with a median age at diagnosis of 58.1 years. The median follow-up duration was 46.8 months. A comprehensive summary of demographic, clinical, laboratory, and histopathological characteristics is provided in table 1.

Table 1. Patient's and disease demographic, clinical, laboratory and histopathologic features

Demographics and history		no	%
Gender	Male	104	60.8
	female	67	39.2
BMI	<25	54	31.6
	≥25	117	68.4
Family history of renal cancer	Yes	5	2.9
	no	166	97.1
Smoker	Yes	70	40.9
	no	101	59.1
Type of Surgical procedure	Radical nephrectomy	98	57.3
	Partial nephrectomy[1]	73	42.7
Clinical factors			
Palpable mass	Yes	70	40.9
	no	101	59.1
Flank pain	Yes	129	75.4
	no	42	24.6
Preoperative hematuria	Yes	71	41.5
	no	100	58.5

Laboratory factors			
Anemia[2]	non-anemic	99	56.3
	Mild anemia	46	26.1
	Moderate to severe anemia	31	17.6
Platelet count (× 10^9/L)	≤227	83	48.5
	>227	88	51.5
Neutrophil to lymphocyte ratio[3]	low	127	74.3
	high	44	25.7
Erythrocyte sedimentation rate (mm/hour) [4]	low	87	51.5
	high	82	48.5
Serum creatinine (mg/dL)	≤1.2	105	61.4
	>1.2	66	38.6
Glomerular filtration rate	≥45	136	79.5
	<45	35	20.5
Histopathological factors			
Cell type	Chromophobe	7	4.0
	Clear cell	138	78.9
	Papillary	23	13.1
	Other	7	4.0
Grade of tumor	I	37	21.8
	II	77	45.3
	III	32	18.8
	IV	24	14.1
Stage of tumor	I	69	40.4
	II	31	18.1
	III	61	35.7
	IV	10	5.8
Size of tumor	≤6 cm	78	45.1
	>6cm	95	54.9
Surgical margin	Yes	51	29.8
	no	120	70.2
Lymphovascular invasion	Yes	55	32.2
	no	116	67.8
Lymph node involvement	Yes	33	19.3
	no	138	80.7
Sarcomatoid feature	Yes	37	20.9
	no	140	79.1
Tumor necrosis	Yes	78	45.6
	no	93	54.4

[1]Nephron Sparing Surgery
[2]We established three categories for classification of anemia: non-anemic (Hb>12 in women and Hb>13 in men), mild anemia (Hb 10 to 12 in women and 11 to 13 in men) and moderate to severe anemia (Hb <10 in women and <11 in men)
[3]Low if NLR was ≤3.3 showed by ROC curve and high ifNLR was >3.3 showed by ROC curve
[4] We classified ESR as: Low (<29 in women and <22 in men), high (≥29 in women and (≥22 in men).

Patient follow-up continued until March 2022, with a median follow-up duration of 46.8 months. Of the 171 patients, six patients lost to follow-up, and 49 (28.7%) died during the follow-up period. Renal cell carcinoma was the underlying cause of death in 47 patients, while two patients died from other causes. A significant proportion of deaths

(26/47, 55.3%) occurred within the first year of diagnosis. An additional 19 deaths were observed by the end of the third year (16 in the second year and 3 in the third year). Two more deaths occurred in the fourth year.The one-, three-, and five-year overall survival rates were 84.7% (95% CI: 79.2-90.2), 72.4% (95% CI: 65.5-79.3), and 70.5% (95% CI: 63.2-77.8), respectively (table 2). Figure 1 depicts the five-year cumulative survival curve for renal cell carcinoma patients following surgical treatment. With regard to demographic factors, a significant positive association was found between younger age (≤60 years; p = 0.045, 0.002, 0.002, respectively) and higher body mass index (BMI > 25 kg/m²; P = 0.04, 0.016, 0.004, respectively) and improved one-, three-, and five-year survival rates.

Conversely, patient survival was not significantly influenced by gender (p > 0.36) or smoking status (p > 0.59) (figure 2). According to clinical and laboratory features, the presence of a palpable mass was associated with significantly lower three- and five-year survival (p < 0.001). While flank pain did not significantly impact patient survival (p > 0.08), the presence of preoperative hematuria was inversely associated with three- and five-year survival (P = 0.039 and 0.018, respectively). Preoperative anemia was significantly associated with lower one-, three-, and five-year survival (p < 0.001).

Table 2. Cumulative incidence of death and survival of one-, three- and five years of renal cancer patients

Year	Number of patients at the beginning of the period	Death due to renal cancer	Death due to other causes	Cumulative incidence of death	Cumulative survival	95% CI of cumulative survival
1-year	171	26	1	15.3	84.7	79.2-90.2
3-year	144	19	0	27.6	72.4	65.5-79.3
5 -year	129	2	1	29.5	70.5	63.2-77.8

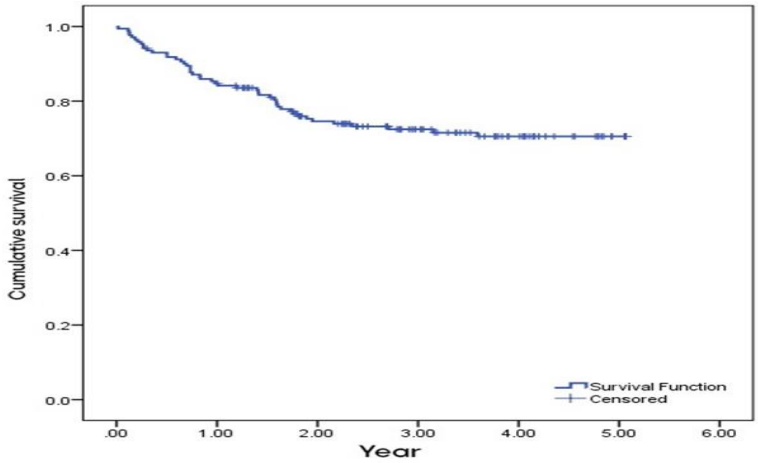

Figure 1. Five-year cumulative survival of renal cancer patients

Additionally, patients with a platelet count greater than 227,000/mL exhibited significantly lower three- and five-year survival compared to those with a lower platelet count (P= 0.019). Significant reductions in one-, three-, and five-year survival rates were observed in patients with a high neutrophil-to-lymphocyte ratio (p < 0.001), elevated erythrocyte sedimentation rate (ESR; p < 0.001), elevated serum creatinine levels (≥1.2 mg/dL; P = 0.009, p < 0.001, and p < 0.001, respectively), and low glomerular filtration rate (<45 mL/min/1.73 m²; p ≤ 0.001). In histopathological analysis, lower patient survival was significantly associated with higher tumor grade, higher tumor stage (p < 0.001), and larger tumor size (>7 cm; p < 0.001). However, tumor cell type did not significantly impact survival (p > 0.696) (figure 4). Among the remaining histopathological variables examined, including surgical margin status, lymphovascular invasion, lymph node involvement, sarcomatoid features, and tumor necrosis, all were significantly associated with increased mortality and decreased survival (p < 0.001 for all factors) (figure 5).

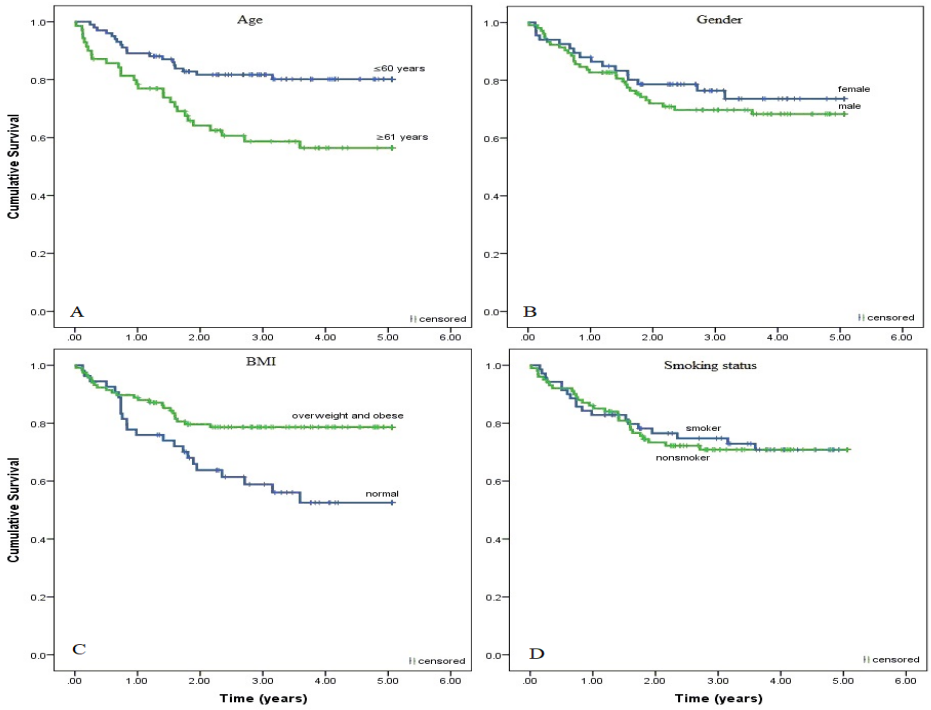

Figure 2. 5-year survival of renal cancer patients according to individual features. A) age, B) gender, C) body mass index, D) smoking status.

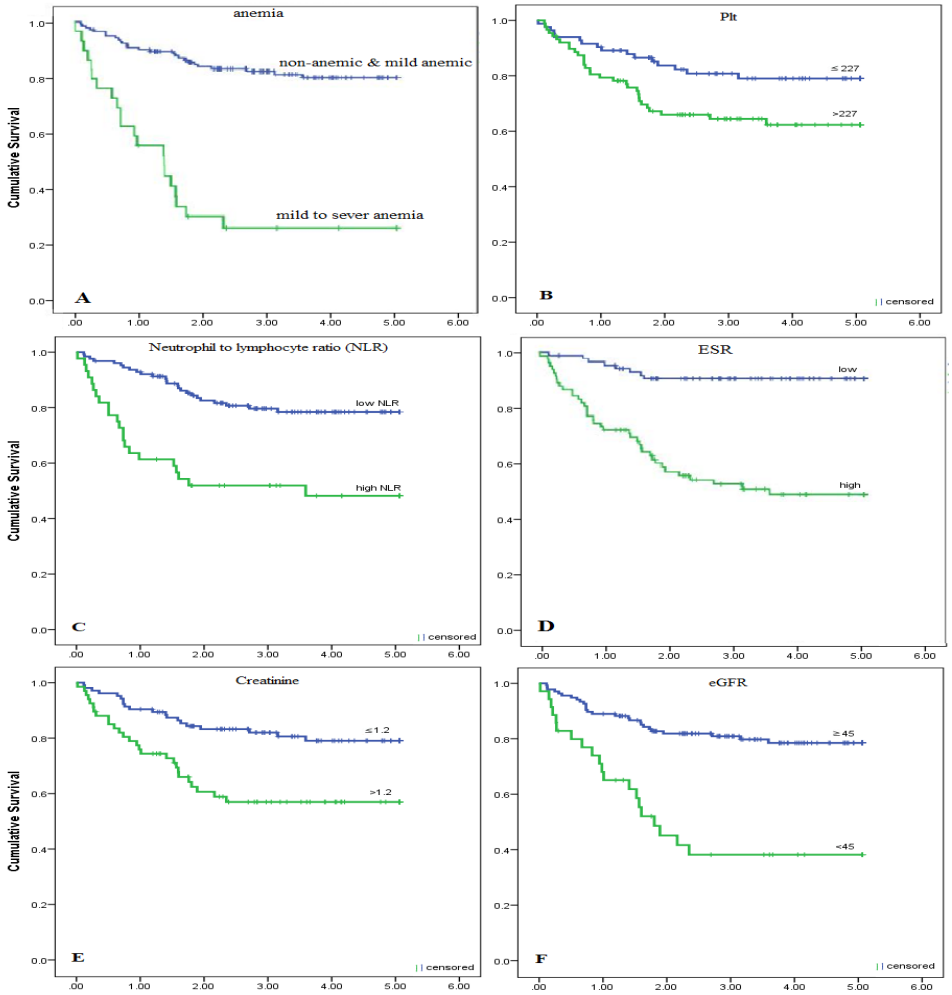

Figure 3. 5-year survival of renal cancer patients according to laboratory features. A) Anemia, B) Platelet level, C) Neutrophil to lymphocyte ratio, D) ESR, E) Creatinine level and F) Glomerular filtration rate

Univariate Cox regression analysis revealed that five-year mortality following surgical intervention was strongly associated with moderate-to-severe anemia (HR: 6.495, 95%CI: 3.618-11.660, p<0.001), elevated ESR (HR: 6.690, 95%CI: 3.122-14.335, p<0.001), presence of necrosis (HR: 13.216, 95%CI: 5.213-33.509, p<0.001), and lymphovascular invasion (HR: 7.988, 95% CI 4.184-15.251, p < 0.001). These factors were identified as significant negative prognostic indicators for five-year survival (table 3). Multivariate Cox regression analysis identified moderate-to-severe anemia, lymphovascular invasion, ESR, GFR and stage III & IV of cancer as independent predictors of five-year mortality from renal cell carcinoma (table 4). Conversely, being non-anemia or mild anemia, the absence of lymphovascular invasion, low level of ESR and GFR, and stage I & II were associated with a reduced risk of mortality and improved survival.

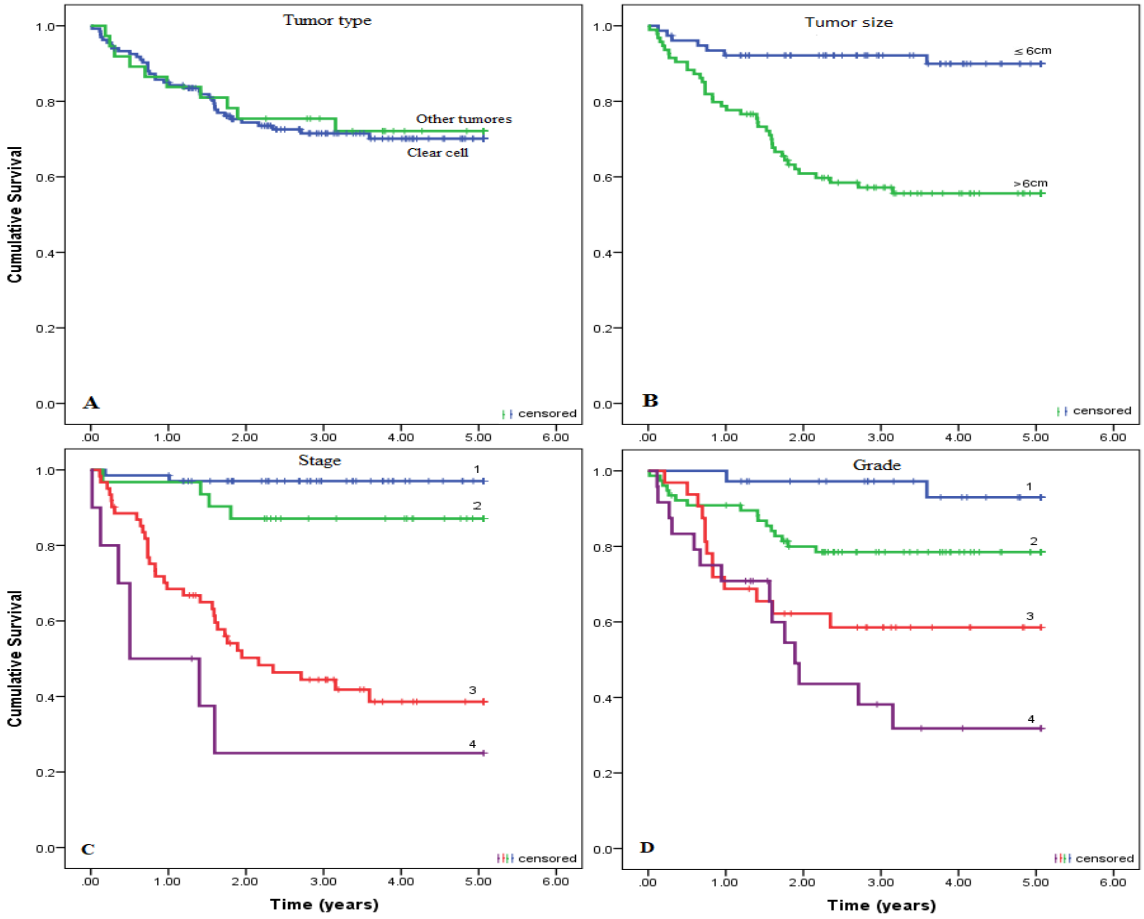

Figure 4. Five-year survival of renal cancer patients according to the features of tumor. A) tumor type, B) tumor size, C) tumor stage, D) tumor grade

Table 3. Results of univariate Cox regression analysis for various factors of patient's and disease in renal cancer patients.

Feature	Groups	Hazard ratio	95% CI	P-value
Age	<60	1		
	≥ 60	2.488	1.389-4.457	0.002
BMI	≥ 25	1		
	<25	2.244	1.266-3.979	0.006
Flank pain	No	1		
	Yes	2.005	0.898-4.477	0.090
Anemia	No/mild anemia	1		
	Moderate to severe	6.495	3.618-11.660	<0.001

Feature	Groups	Hazard ratio	95% CI	P-value
Platelet count	≤ 227	1		
	>227	2.031	1.110-3.715	0.021
NLR[1]	Low	1	-	-
	High	3.346	1.884-5.943	<0.001
ESR[2]	low	1		
	high	6.690	3.122-14.335	<0.001
Serum creatinine	≤1.2	1		
	>1.2	2.564	1.436-4.578	<0.001
GFR [3]	≥ 45	1		
	<45	3.927	2.196-7.023	<0.001
Size of tumor	≤6 cm	**1**		
	>6 cm	5.442	2.436-12.156	<0.001
Stage of tumor	I, II	1		
	III, IV	4.021	5.933-33.133	<0.001
Grade of tumor	I, II	1		
	III, IV	3.880	2.130-7.067	<0.001
Lymph node involvement	No	1		
	Yes	4.157	2.316-7.463	<0.001
Lymphovascular invasion	No	1		
	Yes	7.988	4.184-15.251	<0.001
Surgical margin	No	1		
	Yes	6.142	3.332-11.319	<0.001
Sarcomatoid feature	No	1		
	Yes	4.309	2.422-7.665	<0.001
Tumor necrosis	No	1		
	Yes	13.216	5.213-33.509	<0.001

[1]Neutrophil to Lymphocyte Ratio. [2] Erythrocyte Sedimentation Rate: We classified ESR as: Low (<29 in women and <22 in men), high (≥29 in women and (≥22 in men). [3]GlomerularFiltrationRate

Table 4. Factors affecting five-year mortality of renal cancer in multivariate Cox regression analysis

Feature		Hazard ratio	95% CI	P-value
Anemia	No/ mild	1		
	moderato to severer	3.425	1.760-6.662	<0.001
ESR[1]	Low	1		
	High	2.959	1.283-6.826	0.011
GFR[2]	≤ 45	1		
	>45	1.987	1.085-3.640	0.026
Lymphovascular invasion	NO	1		
	Yes	2.852	1.315-6.184	0.008
stage	I & II	1		
	III & IV	5.188	1.913-14.066	0.001

[1] Erythrocyte Sedimentation Rate: We classified ESR as: Low (<29 in women and <22 in men), high (≥29 in women and (≥22 in men)
[2] Glomerular Filtration Rate
Hazard ration of 1 shows reference group.

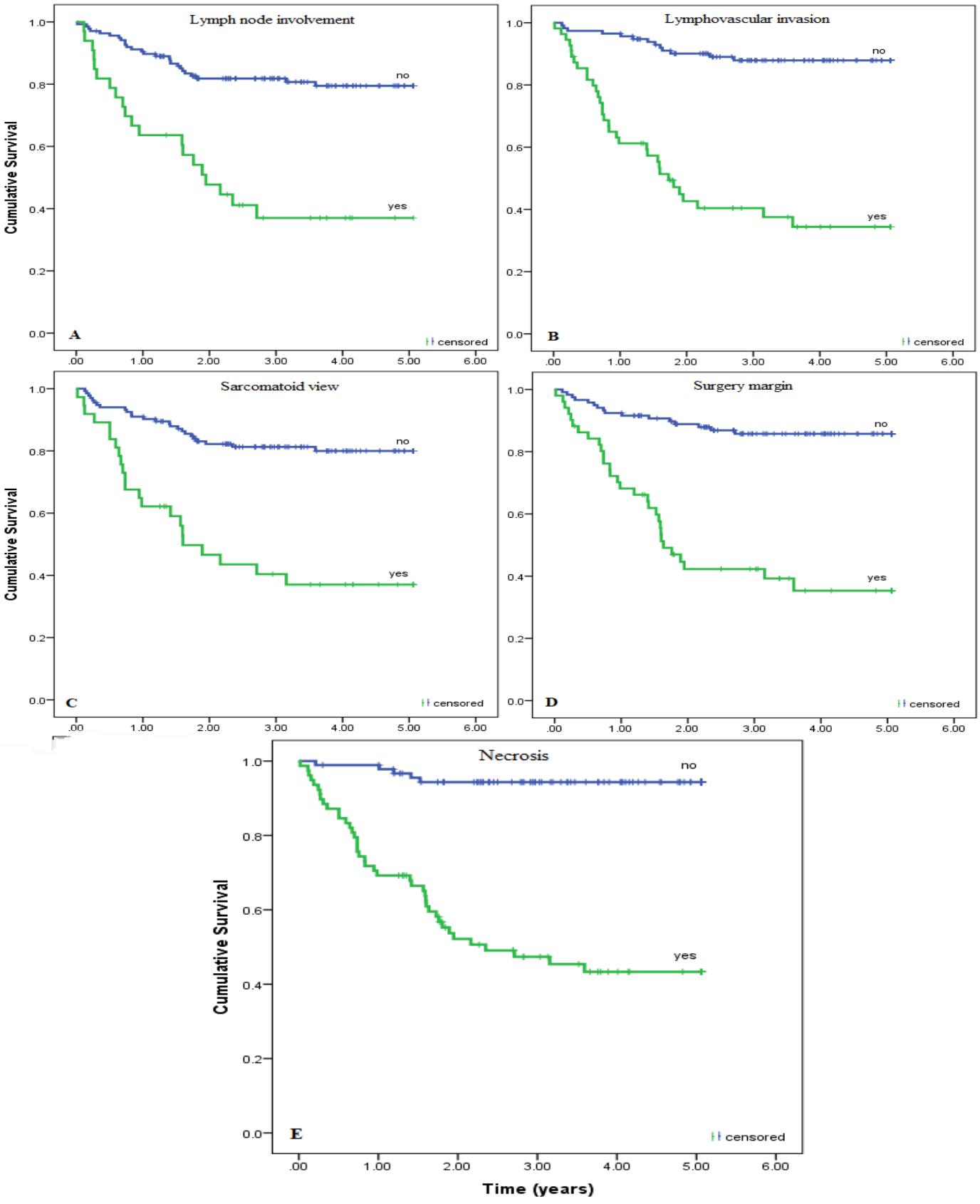

Figure 5. 5-year survival of renal cancer patients according to the histological features of tumors. A) lymph node involvement, B) lymphovascular invasion, C) having a sarcomatoid appearance, D) surgical margin, E necrosis

Discussion

Kidney cancer constitutes 2.2% of the global cancer burden (9), with a higher incidence in developed compared to less developed countries (24). In Iran, kidney cancer has a relatively low incidence rate of approximately 1.94 per 100,000 individuals, with a slight male predominance, totaling around 1,641 reported cases (25). This study aimed to investigate the correlation between clinical and pathological parameters and progression-free oncological survival in patients with RCC. The estimated incidence of RCC increases with advancing age, and incidence rates are significantly higher in males compared to females across all age groups (26). In line with these observations, our study also demonstrated a higher prevalence of RCC in males. While hormonal factors (e.g., estrogen) and occupational exposures to chemicals have been implicated, the underlying reasons for this gender disparity remain unclear (27, 28). This study demonstrated a significant positive association between younger age and improved survival. Previous studies have indicated that increased age is correlated with poorer survival outcomes for RCC patients (29). Taccoen et al. (30) demonstrated that younger patients, defined as those ≤ 40 years old, had significantly better 5-year survival rates compared to older patients (90.8% vs 78.3%; P= 0.005). There exists some debate regarding potential gender disparities in survival outcomes for RCC patients. Certain Western studies have suggested that women exhibit a significantly higher proportion of incidentally detected RCC, which has been linked to improved survival outcomes and attributed to greater utilization of healthcare services by women (31, 32). However, our study did not reveal a significant association between gender and patient survival, which diverges from the findings reported by Zhang et al. (33).

Interestingly, in univariate analysis we observed a positive association between higher BMI (BMI ≥25) and improved survival, supporting the concept of an "obesity paradox" in RCC patients treated with targeted therapy (34). The relationship between BMI and survival outcomes in various cancers is complex and controversial. While some studies, such as a meta-analysis on lung cancer, have reported a lower mortality and longer overall survival among patients with higher BMI (35), others, including meta-analyses on breast, colorectal, and ovarian cancers, have suggested worse survival and increased mortality in obese patients (36). In the context of RCC, evidence suggests that obese patients may have a lower risk of death compared to non-obese patients (37). Additionally, a study has shown that RCC patients with higher BMI who underwent nephrectomy experienced significantly improved overall and recurrence-free survival (38). Smoking at diagnosis has been identified as an independent predictor of cancer-specific survival, with both current and former smokers exhibiting an elevated risk of kidney cancer-related mortality compared to never-smokers (39). While this study observed a 40.9% increase in RCC risk among smokers compared to never-smokers, no statistically significant correlation was found between smoking and survival. This lack of association may be attributed to the retrospective nature of the study and its relatively small sample size.However, recent epidemiological studies have suggested a link between smoking and worse survival outcomes in RCC patients (40).

In this study, hematuria (41.5%) and flank pain (75.4%) were the most common presenting symptoms. Patients with localized disease may present with a broad spectrum of symptoms, laboratory abnormalities, or may be incidentally diagnosed. While flank pain was not associated with patient survival, the presence of preoperative hematuria was inversely correlated with three- and five-year survival. Previous research has primarily focused on hydronephrosis as a predictive factor for clinical outcomes in transitional cell carcinoma (TCC), with hematuria and flank pain being the most common symptoms of RCC (2). Gu et al. (41) identified flank pain and weight loss as novel adverse predictors of survival in a preoperative model, demonstrating significantly shorter survival times in the "flank pain" group compared to other groups. In our study, the presence of a palpable mass was associated with lower three- and five-year survival. Clear cell type was the most common histopathologic type, accounting for 78.4% of cases. These findings align with previous reports by Majidova and Demirag, who reported similar frequencies of clear cell (60-70%), papillary (5-15%), chromophobe and oncocytic (5-10%), and collecting duct (<1%) RCC subtypes (42). In our study, the prevalence of preoperative mild and moderate-to-severe anemia was 26.1% and 17.6%, respectively, lower than the 40% reported in other studies (43). Preoperative anemia was significantly associated with poorer one-, three-, and five-year survival, aligning with the findings of Deng et al. (44). Additionally, patients with platelet counts exceeding 227,000/mL exhibited significantly lower three- and five-year survival compared to those with lower platelet counts (P=0.019).While the prognostic significance of platelet counts in RCC has been explored in limited studies (45), it is hypothesized that elevated platelet levels may impair immune system clearance of circulating tumor cells (45).

Patients with high serum creatinine levels and low glomerular filtration rate exhibited significantly decreased

one-, three-, and five-year survival rates (Fig 3, E and F). GFR, a measure of kidney function, is typically calculated from blood creatinine measurements (46). Park et al. analyzed over 10,000 kidney cancer cases in the Korean population and reported an 18% increased risk in individuals with eGFR ≤30 mL/minute/1.73 m² compared to those with normal eGFR (47). Other studies have reported a 2- to 3-fold increase in the risk of RCC in individuals with chronic kidney disease (CKD) (48).

Patients with a high NLR and elevated erythrocyte sedimentation rate (ESR) exhibited significantly decreased one-, three-, and five-year survival rates (Fig 3, C and D). Pichler et al. confirmed that an increased NLR in patients with renal clear cell carcinoma is an independent risk factor for overall survival, potentially reflecting a higher risk of severe disease (49). NLR is a crucial inflammatory parameter, and patients with low inflammatory cell infiltration and high peripheral blood NLR have been shown to have a significantly worse prognosis compared to those with high inflammatory cell infiltration and low peripheral blood NLR (50).Furthermore, patients with preoperative high ESR levels had a 2.10-fold higher risk of dying from RCC compared to those with low ESR levels (38). These findings suggest a significant association between ESR and cancer survival, highlighting the important role of inflammation in RCC progression (38).

Our study revealed a significant association between lower survival rates and higher tumor grade, advanced tumor stage, and larger tumor size (>6 cm). In the limited literature on pediatric RCC, tumor grade has also been shown to impact survival. Survival rates for stage I and II RCC remain relatively high, but decline significantly for stage III and IV tumors (51). Tumor stage, in both adult and pediatric RCC, appears to be the most robust prognostic indicator of survival (52).A previous study reported the greatest absolute increase in kidney cancer mortality among patients with lesions exceeding 7 cm. While cancer-specific mortality rates also increased in patients with tumors <2 cm, 2-4 cm, and 4-7 cm, the magnitude of increase was less pronounced compared to those with lesions >7 cm (53).

Among the remaining five histopathological variables examined (surgical margin status, lymphovascular invasion, lymph node involvement, sarcomatoid features, and tumor necrosis), all were significantly associated with increased mortality and decreased survival. Lymphovascular invasion has been recognized as a crucial factor in defining aggressive disease across various urological and non-urological malignancies. However, the association between LVI in RCC and adverse patient outcomes has been subject to conflicting reports (54). Lymph node metastasis has long been established as a poor prognostic factor in kidney cancer (55). Notably, lymph node status remains an important prognostic indicator even in the presence of distant metastatic disease. Significantly, surgical margin status was associated with a more than twofold increase in the risk of recurrence, aligning with existing literature that identifies surgical margin as a critical prognostic indicator (56). Previous studies have reported a high risk of recurrence in patients with positive surgical margins following partial nephrectomy (57), consistent with our findings. Additionally, sarcomatoid features and tumor necrosis were associated with higher mortality and lower survival rates in RCC patients.Sarcomatoid RCC, a specific subtype of RCC, remains poorly characterized and is considered a highly lethal form of kidney cancer (58). Despite accounting for only approximately 5% of all RCC cases, its aggressive nature and advanced stage at presentation make it relatively common among patients with metastatic disease (59).

The prognostic significance of tumor necrosis in RCC is well-established. Our study confirmed this association, demonstrating that tumor necrosis was linked to higher mortality and decreased survival. Early studies suggested that necrosis in RCC could predict adverse outcomes (60). This notion has been further substantiated by larger modern studies, which have consistently identified necrosis as an adverse prognostic factor (61). In clear cell and chromophobe RCC, necrosis ranks alongside tumor type, nuclear grade, and TNM stage as an independent predictor of poor prognosis. The study's limitations include its single-center design, relatively small sample size, lack of external validation, and retrospective nature. Additionally, the study's statistical power may be limited, necessitating larger, multicenter studies and meta-analyses for a more comprehensive evaluation of risk factors and validation of these findings.Moreover, convenience sampling could be a limitation that limits the generalizability of the study results. This study identified several factors significantly associated with survival outcomes in RCC patients' post-surgery. Factors such as younger age, higher BMI, and absence of specific clinical and laboratory markers were linked to improved survival. Conversely, factors like anemia, elevated ESR, necrosis, and lymphovascular invasion were associated with poorer outcomes. Multivariate analysis confirmed the independent prognostic significance of anemia, lymphovascular invasion, and large tumor size. These findings can aid clinicians in identifying high-risk patients and tailoring appropriate management strategies. Future research should validate these findings and explore targeted therapies for high-risk RCC.

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