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Abstract

Cervical cancer is a common gynecological malignancy, particularly in developing countries, where it coexists with renal impairment in over one-third of patients. This disease typically presents acutely and progresses rapidly. Consequently, kidney replacement therapy, including hemodialysis (HD), is commonly required. To assess survival rates and associated factors, this retrospective cohort study analyzed the medical records of 252 cervical cancer patients who began HD across a three-month follow-up period. Kaplan–Meier analysis indicated a median short-term survival duration of 71.5 days (range: 7–90), with 1-, 2-, and 3-month survival rates of 56%, 51%, and 49%, respectively. Multivariate Cox regression identified post-HD systolic blood pressure <110 mmHg (hazard ratio [HR] 3.354; 95% confidence interval [CI]: 2.346–4.795; p-value <0.001) and interdialytic weight gain ≥5% (HR 1.685; 95% CI: 1.125–2.521; p-value <0.011) as significant predictors of decreased survival. Other variables, including age, urea, albumin, vascular access, baseline creatinine, and cancer stage, were not significantly associated with short-term survival. These findings underscore the critical role of salt and fluid management, adherence to dietary and dialysis regimens, and close monitoring of weight in improving outcomes. Interventions targeting modifiable factors may improve the survival of cervical cancer patients who require HD. Such approaches, therefore, warrant further investigation.

Keywords: cervical cancer, hemodialysis initiation, survival

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Introduction

Cervical cancer is the fourth leading cause of cancer-related mortality among women worldwide.[1] In Indonesia, its incidence has reached 23.4 per 100,000 people, making it the second most common cancer after breast cancer.[2] Despite being a preventable disease, cervical cancer continues to impose a substantial global health burden, with an estimated 660,000 new cases and 350,000 deaths reported in 2022. Nearly 94% of these deaths occurred in low- or middle-income countries.[3] This disproportionate death rate likely reflects disparities in education, access to health care, and implementation of preventive measures, such as HPV vaccination and routine screening.[4-5]

Renal impairment is a common complication of cervical cancer. A previous study indicate that over one-third of newly diagnosed patients present with some degree of kidney dysfunction.[3] This could be due to the tumor itself, which infiltrates surrounding tissues, including the ureters, causing inflammation or scarring and, consequently, obstructive nephropathy.[6] Renal function may be further compromised by the nephrotoxic effects of cancer-related treatments, including chemotherapy, radiotherapy, non-steroidal anti-inflammatory drugs and diagnostic contrast agents.[7] The resulting kidney injury is often acute and rapidly progressive, necessitating kidney replacement therapy, most commonly hemodialysis (HD), in many patients.[8]

HD can be temporary in cervical cancer patients with acute kidney injury, as interventions designed to treat renal obstruction, such as ureteral stenting or percutaneous nephrostomy, usually improve renal function. However, a study showed that about 26% of patients continued to require

HD to maintain renal function after such interventions.[9] The need for chronic dialysis can negatively affect patient survival, as patients with renal insufficiency require treatment modifications and dose adjustments, which can compromise the treatment of their cancer.[10] Another study reported a median survival of 33 days for patients requiring chronic HD. The prognosis is similarly poor, with a 3-month mortality rate of 77%.[11] Similarly, a recent cohort study from Ghana reported a median survival of 65.8 months among cervical cancer patients. However, the overall 5-year survival rate remained modest at 32.4%, reflecting the influence of disease stage and access to treatment on long-term outcomes.[12]

Factors such as age, cancer stage, and comorbidities are well-established predictors of cancer survival. Several studies have demonstrated that survival outcomes are significantly associated with age at diagnosis, with younger women consistently achieving better survival rates than older patients. Advanced cancer stage has also been strongly associated with worse survival outcomes.[13-16] In addition, the presence of comorbid conditions can significantly reduce survival, highlighting the negative impact of coexisting diseases on the overall prognosis of cervical cancer patients.[17]

Although cancer is one of the leading causes of death among patients on HD, detailed prognostic data on outcomes and HD-related clinical parameters in cancer populations are limited. Previous large cohort studies have primarily focused on general cancer populations or on incidence and mortality patterns within HD cohorts; they have not specifically examined how clinical aspects of HD influence survival among patients with specific cancer types.[18,19] To fill this gap, this study aimed to explore the influence of HD-related clinical factors on survival outcomes among cervical cancer patients who required kidney replacement therapy.

Method

This retrospective cohort study was conducted at the National Cancer Hospital in Indonesia. The study population comprised cervical cancer patients with histologically confirmed diagnoses, classified according to the International Federation of Gynecology and Obstetrics (FIGO) 2014 staging system, who required HD between July 1 and August 30, 2023. HD was initiated either (a) at the time of diagnosis in patients presenting with advanced renal impairment or (b) later during the disease course, following progression or treatment-related complications. Accordingly, the study population included both newly diagnosed cervical cancer patients and those with progressive or recurrent disease at the time of HD initiation, reflecting real-world clinical practice. Patients with incomplete medical records were excluded.

This single-cohort study included only cervical cancer patients who required HD, and no comparator group of cervical cancer patients without HD was included. Eligible patients were recruited using a consecutive sampling method: All cervical cancer patients who met the inclusion criteria during the study period were enrolled until the required sample size was achieved. The minimum required sample size was calculated using the formula for sample size estimation in survival analysis, assuming a two-sided significance level (α) of 0.05 and a statistical power of 80%. Based on this estimation, the minimum required sample size was 229 patients. To anticipate potential losses to follow-up, an additional 10% was added, resulting in a final minimum of 252 patients.

Data were collected from hospital medical records and included age, cancer stage, comorbidities, post-HD systolic blood pressure, type of vascular access, interdialytic weight gain (IDWG), and baseline laboratory values (urea, albumin, and creatinine). HD initiation was defined as the first documented HD session recorded in the medical record and prescribed for a diagnosis of acute kidney injury, acute-on-chronic kidney disease, or chronic kidney disease requiring kidney replacement therapy. The date of HD initiation was determined as the earliest documented HD procedure in the medical record.

Age was categorized into two groups: <55 and ≥ 55 years. The cutoff at 55 years was selected based on previous oncological and clinical studies that used 55 as a threshold for risk stratification, and because age-related declines in physiological reserve (including muscle mass and functional capacity) become more pronounced after approximately 50 years. This threshold has also been applied in studies evaluating survival outcomes in cervical and other gynecologic cancers.[20,21]

Disease staging was categorized into two groups: stage IV and stage <IV. The stage <IV group comprised patients with stage I, II, or III disease. Comorbidities included hypertension and/or diabetes mellitus, patients presenting with either or both of these conditions were categorized as having comorbidities ("yes"). Post-HD systolic blood pressure was measured immediately after each HD session and averaged across all post-HD measurements recorded during the three-month observation period for each patient. Post-HD systolic blood pressure was averaged over 3 months and classified as <110 mmHg or ≥110 mmHg.[22,23]

Urea, albumin, and creatinine values were classified based on normal reference values reported in previous studies.[24,25] Baseline urea and creatinine levels were defined as the most recent laboratory values recorded prior to the initiation of HD. Baseline serum albumin was defined as the last recorded value prior to HD initiation, reflecting patients' metabolic and nutritional status at the time they were determined to require renal replacement therapy. Baseline body weight (kg) before the first HD session was recorded and used to calculate IDWG, expressed as both an absolute (kg) and a relative (%) value.

The primary outcome was short-term survival, defined as survival status within 3 months of HD initiation. Patients were considered censored if they were alive at the end of the three-month observation period, lost to follow-up, transferred to another facility, or reported dead from causes unrelated to cervical cancer. Death from cervical cancer during the observation period was considered the event of interest. The three-month cutoff was selected to capture early mortality, as previous studies have shown that mortality is substantially elevated during the first months after dialysis initiation.[14,26]

Descriptive statistics were used to summarize clinical characteristics. The Chi-square test was used to compare the baseline characteristics of patients who survived ≥3 months with those of patients who died within the first 3 months. Survival analysis was performed using the Kaplan–Meier method, with the log-rank test used for group comparisons. The survival curve was analyzed using the Kaplan–Meier method. The Cox proportional hazard model was used for multivariate analysis of prognostic factors. Hazard ratios (HRs) and 95% confidence intervals (CIs) were calculated using the Cox proportional hazards model. Statistical analyses were conducted using licensed SPSS version 25.0, and p-values <0.05 were considered statistically significant.

Results

A total of 262 patients who met the inclusion criteria were identified; 10 were excluded due to incomplete medical records. The mean age at diagnosis was 49.5 (10.9) years, and the mean age at HD initiation was 50 (10.9) years. The median frequency of HD was 4 (2–9) episodes, with a median duration of 1 month. The baseline characteristics of the study participants are described in Table 1.

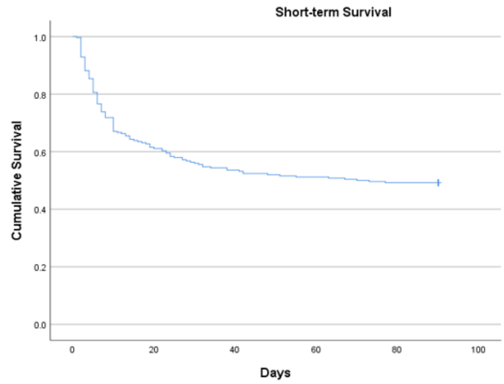
The patients were followed for 3 months after HD initiation. During the study period, 119 censored patients and 133 event patients were observed. The Kaplan–Meier analysis demonstrated a steep decline in survival during the first month of HD, with cumulative survival rates of 56%, 51%, and 49% at 30, 60, and 90 days, respectively.

Table 1. Patients Characteristics

Variable	Total (n = 252)
Age at HD initiation (years), mean (SD)	50 (10.9)
Age at diagnosis (years), median (IQR)	49 (16.0)
Age range (years), min–max	24–77
Age groups (n, %)	
<55 years	161 (63.9)
≥55 years	91 (36.1)
Cancer stage n (%)	
Stage IV	28 (11.1)
Stage III	218 (86.5)
Stage II	6 (2.4)
Comorbidities (hypertension and/or diabetes mellitus)	
Yes	55 (21.8)
No	197 (78.2)
Systolic blood pressure, median (IQR)	
<110 mmHg	43 (17.1)
≥110 mmHg	209 (82.9)
Vascular access	
CDL temporary	249 (98.8)
Cimino	3 (1.2)
Baseline body weight, mean (SD)	65.71 (11.9)
Interdialytic weight gain	
≥5%	87 (34.5)
<5%	165 (65.5)
Baseline creatinine, median (IQR)	8.40 (4.9–12.4)
>4.52 mg/dL (n,%)	203 (80.6)
≤4.52 mg/dL (n,%)	49 (19.4)
Baseline albumin, median (IQR)	2.9 (2.5–3.5)
≤3.5 g/dL (n,%)	192 (76.2)
>3.5 mg/dL (n,%)	60 (23.8)
Baseline urea, median (IQR)	184 (142–219)
<200 mg/dL (n,%)	84 (33.3)
≤200 mg/dL (n,%)	168 (66.7)

Notes: HD = hemodialysis, SD = standard deviation, IQR = interquartile range, CDL = catheter double lumen

The mean short-term survival time was 51.5 days (95% CI: 46.6–56.4) (Figure 1). Log rank analyses revealed no significant difference in short-term survival (STS) between age groups (p-value = 0.482), cancer stages (p-value = 0.174), comorbidities (p-value = 0.867), vascular access (p-value = 0.621), baseline creatinine (p-value = 0.463), baseline albumin (p-value = 0.227), or baseline urea (p-value = 0.380). The estimated mean STS for patients with IDWG of ≥5% was 27.6 days (95% CI: 46.6–56.4), while patients with IDWG of <5% had 64.1 days (95% CI: 58.6–69.7); p-value <0.001 (Figure 2). The mean STS for patients with average systolic blood pressure of <110 mmHg was 31.8 days (95% CI: 21.0–42.5), while for average systolic blood pressure of ≥110 mmHg was 55.6 days (95% CI: 46.6–56.4); p-value <0.001 (Figure 3).



Time (days)	Event	Cumulative Proportion (%)
0–30	110	56
31–60	13	51
61–90	5	49

Figure 1. Kaplan–Meier Estimates of Short-Term Survival

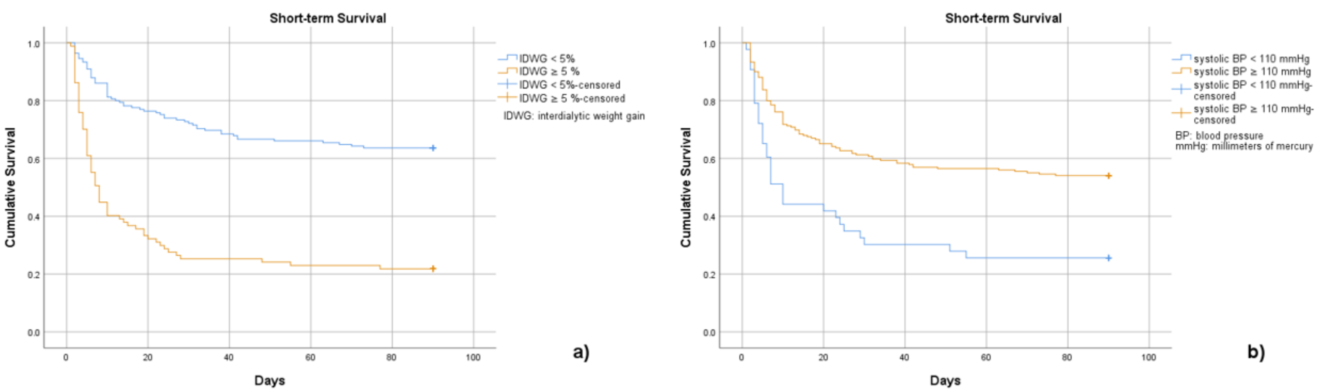


Figure 2. Kaplan–Meier Estimates of Short-Term Survival by Interdialytic Weight Gain and Systolic Blood Pressure

a) Kaplan–Meier shows that STS was significantly lower in patients with IDWG ≥5% compared to those with IDWG <5% (mean STS 27.6 vs 64.1 days; log-rank p-value <0.001)

b) Kaplan–Meier shows that STS was significantly lower in patients with average systolic blood pressure <110 mmHg compared to ≥110 mmHg (mean STS 31.8 vs 55.6 days; log-rank p-value <0.001).

Table 2. Baseline Characteristics According to 3-Month Survival Status

Variable	Short-Term Survival Status		p-value
	<3 months (n = 128)	≥3 months (n = 124)	
Age group			
≥55 years	43 (47.3)	48 (52.7)	0.475
<55 years	48 (52.7)	76 (47.2)	
Cancer stage			
Stage IV	11 (39.3)	17 (60.7)	0.275
Stage <IV	117 (52.2)	107 (47.8)	
Comorbidities (hypertension and/or diabetes mellitus)			
Yes	26 (47.3)	29 (52.7)	0.661
No	102 (51.8)	95 (48.2)	
Systolic blood pressure			
<110 mmHg	32 (74.4)	11 (25.6)	0.001*
≥110 mmHg	96 (45.9)	113 (54.1)	
Vascular access			
CDL temporary	127(51.0)	122 (49.0)	0.618
Cimino	1 (33.3)	2 (66.7)	
Interdialytic weight gain			
≥5%	68 (78.2)	19 (21.8)	<0.001*
<5%	60 (36.4)	105 (63.6)	
Baseline creatinine			
>4.52 mg/dL	100 (49.26)	103 (50.7)	0.406
≤4.52 mg/dL	28 (57.14)	21 (42.9)	
Baseline albumin			
≤3.5 g/dL	100 (52.1)	92 (47.92)	0.559
>3.5 mg/dL	28 (46.7)	32 (53.33)	
Baseline urea			
<200 mg/dL	44 (52.4)	40 (47.6)	0.824
≤200 mg/dL	84 (50.0)	84 (50.0)	

*Statistically associated with a p-value of <0.05

Notes: CDL = catheter double lumen

The baseline characteristics of patients who survived for at least 3 months and those who died within the first 3 months were comparable (Table 2). Patients who died within the first 3 months had significantly higher interdialytic weight gain and lower post-HD systolic blood pressure at baseline than those who survived 3 months or more (p-value <0.05). There were no significant differences in baseline characteristics, including age, cancer stage, comorbidities, vascular access, or baseline laboratory parameters.

Univariable Cox regression analysis indicated that systolic blood pressure and interdialytic weight gain were significantly associated with survival among cervical cancer patients undergoing HD (p-value <0.001 for both). In contrast, other variables, such as age group, cancer stage, comorbidities, type of vascular access, and baseline creatinine, albumin, and urea levels, did not show statistically significant associations with survival (p-value >0.05) (Table 3).

Table 3. Univariable Analysis of Prognostic Factors in Cervical Cancer Patients Undergoing Hemodialysis

Variable	Outcome		p-value	Crude HR (95% CI)
	Event (n = 128)	Censored (n = 124)		
Age group				
≥55 years	43 (47.3)	48 (52.7)	0.406	0.856 (0.593–1.235)
<55 years	48 (52.7)	76 (47.2)		Ref
Cancer stage				
Stage IV	11 (39.3)	17 (60.7)	0.254	0.698 (0.376–1.295)
Stage <IV	117 (52.2)	107 (47.8)		Ref
Comorbidities (hypertension and/or diabetes mellitus)				
Yes	26 (47.3)	29 (52.7)	0.698	0.918 (0.597–1.413)
No	102 (51.8)	95 (48.2)		Ref
Systolic blood pressure				
<110 mmHg	32 (74.4)	11 (25.6)	<0.001*	2.196 (1.469–3.282)
≥110 mmHg	96 (45.9)	113 (54.1)		Ref
Vascular access				
CDL temporary	127(51.0)	122 (49.0)	0.675	1.523 (0.213–10.898)
Cimino	1 (33.3)	2 (66.7)		Ref
Interdialytic weight gain				
≥5%	68 (78.2)	19 (21.8)	<0.001*	3.583 (2.519–5.097)
<5%	60 (36.4)	105 (63.6)		Ref
Baseline creatinine				
>4.52 mg/dL	100 (49.3)	103 (50.7)	0.334	0.813 (0.535–1.237)
≤4.52 mg/dL	28 (57.1)	21 (42.9)		Ref
Baseline albumin				
≤3.5 g/dL	100 (52.1)	92 (47.9)	0.369	1.212 (0.797–1.843)
>3.5 mg/dL	28 (46.7)	32 (53.3)		Ref
Baseline urea				
<200 mg/dL	44 (52.4)	40 (47.6)	0.729	1.066 (0.740–1.536)
≤200 mg/dL	84 (50.0)	84 (50.0)		Ref

*Statistically associated with a p-value of <0.05

Notes: HR = hazard ratio, CI = confidence interval, CDL = catheter double lumen

Table 4. Final Cox Regression Model of Hemodialysis-Related Survival Factors

Variable	p-value	Adjusted HR (95% CI)
Systolic blood pressure		
<110 mmHg	<0.001	1.685 (1.125–2.521)
≥110 mmHg		Ref
Interdialytic weight gain		
≥5%	<0.001	3.354 (2.346–4.795)
<5%		Ref

Notes: HR = hazard ratio, CI = confidence interval

Multivariate Cox regression analysis revealed that systolic blood pressure and interdialytic weight gain remained significantly associated with survival after adjusting for other variables. Patients with post-HD systolic blood pressure of <110 mmHg had a significantly higher risk of mortality, with an adjusted HR of 3.354 (95% CI: 2.346–4.795; p-value <0.001), indicating that these patients were more than three times likelier to experience mortality within the study period compared to those with systolic blood pressure ≥110 mmHg. Similarly, patients with interdialytic weight gain of ≥5% had an adjusted HR of 1.685 (95% CI: 1.125–2.521; p-value <0.001), indicating an approximately 1.7-fold higher risk of mortality than those with weight gain of <5% (Table 4).

Discussion

The STS outcomes observed among cervical cancer patients undergoing HD were notably lower than those reported in general cervical cancer populations. Whereas the 1-, 2-, and 3-month STS rates in this study were 56%, 51%, and 49%, respectively, previous studies in Ethiopia and Iran reported 1-year survival rates of 77% and 90%, respectively.[27,28] In China, the 3-year STS reached 84%.[29] These discrepancies emphasize the potential prognostic impact of renal impairment in cervical cancer patients.

Renal involvement in cervical cancer has long been recognized as a marker of poor prognosis, often indicating advanced disease stage and increased treatment complexity.[6] FIGO staging of cervical cancer assigns category IIIb to tumor invasion causing hydronephrosis or a non-functioning kidney.[30] A study in Brazil reported that cervical cancer patients who underwent HD had a 3-month mortality rate of 77%. Another study reported that in non-specific cancer patients requiring HD, 15.4% died within 3 months of HD initiation. Associated prognostic factors included age at diagnosis, body mass index, baseline albumin, and cancer stage at HD initiation.[11] Aside from indicating a more advanced cancer stage, kidney involvement can interfere with the administration of nephrotoxic cancer treatment, leading to a worse prognosis. Treatment associated with kidney involvement, such as ureteral stenting and percutaneous nephrostomy, can also affect morbidity.[6]

This study demonstrated that significant differences in interdialytic weight gain and baseline post-HD systolic blood pressure were associated with mortality. These results suggest that interdialytic weight gain and post-HD systolic blood pressure may serve as early clinical indicators of short-term survival among cervical cancer patients undergoing HD. Additionally, systolic blood pressure <110 mmHg and interdialytic weight gain≥5% were independently associated with poorer STS. While no studies have explored these factors in cervical cancer patients, these findings were consistent with research in general HD populations.

Miyasato *et al.* reported that IDWG ≥5% was associated with higher all-cause mortality, with an HR of 1.14 (95% CI: 1.06–1.22).[31] IDWG is a parameter for fluid and salt intake between two HD sessions. Excess IDWG can cause hemodynamic instability, potentially stressing the cardiovascular system.[32] The Guideline by Kidney Disease Outcomes Quality Initiative recommends IDWG <6% to reduce potential harm; thus, patient education on fluid and salt restriction, patient adherence to certain diets and dialysis schedules, and close monitoring of body weight become vital to ensuring optimal outcomes.[33]

Similarly, low blood pressure post-dialysis was associated with worse outcomes. This study found that among patients with pre-dialysis fluid overload, pre-dialysis systolic blood pressure <110 mmHg was independently associated with a higher risk of mortality (HR 1.52; 95% CI: 1.06–2.17).[22] Another study reported that patients with systolic blood pressure <110 mmHg had a significantly higher overall mortality risk than patients with systolic blood pressure 130–139 mmHg (HR 1.71; 95% CI: 1.32–2.20), discovering additional evidence of a J-curved relationship between blood pressure and poor cardiovascular outcomes.[23] Lower BP may increase the risk of end-organ hypoperfusion and signify the presence of comorbidities, such as heart failure or ischemic cardiomyopathy, which can influence mortality outcomes. While this relationship appears inverted compared to normal populations, cardiovascular disease associated with high BP—which typically takes a long time to emerge—may not have been observed due to the duration of this study.[34]

In this study, interdialytic weight gain and post-dialysis systolic blood pressure were independently associated with short-term survival among cervical cancer patients requiring HD. However, these associations may partly reflect underlying comorbidity burden and disease severity rather than stemming solely from dialysis. For instance, excessive fluid accumulation and blood pressure instability can indicate cardiovascular dysfunction, nutritional compromise, or progressive malignancy—all of which can confound the observed relationship between dialysis parameters and survival outcomes. Therefore, interdialytic weight gain ≥5% should be interpreted as a clinical marker of volume and systemic instability rather than as a definitive causal risk factor.

Although cancer stage traditionally plays a significant role in long-term oncologic outcomes, it was not a major factor in short-term survival in this study. Patients initiating HD are known to experience a high risk of death early after dialysis initiation, particularly within the first three months, as shown in incident HD cohorts in which early mortality was markedly elevated compared with later treatment periods. Clinical features present at dialysis initiation, such as advanced age, high comorbidity burden, and low serum albumin, have been identified as independent predictors of early mortality in incident dialysis patients. Furthermore, models developed to predict mortality within the first three months after HD initiation consistently highlight factors such as comorbidity and physiological vulnerability as major determinants of short-term survival, suggesting that systemic health status and physiological reserve may influence early survival more than disease-specific characteristics do during the initial dialysis period.[35-37] Post-HD hemodynamic parameters, including systolic blood pressure and interdialytic weight gain, may serve as immediate markers of physiological reserve and cardiovascular tolerance to dialysis-related stress, thereby exerting a stronger influence on short-term survival than oncological variables, such as cancer stage.

This study contributed to a relatively limited body of literature exploring the intersection between gynecologic malignancy and dialysis outcomes. By highlighting the prognostic value of specific HD-related parameters, the findings offered clinical relevance for early risk stratification and personalized management in this high-risk population. From a clinical perspective, these findings suggested several potential intervention strategies. Structured volume management, including regular reassessment of dry weight, individualized ultrafiltration targets, and close monitoring of interdialytic weight gain, may reduce volume-related hemodynamic stress. Additionally, optimizing post-HD blood pressure by carefully adjusting antihypertensive therapy, avoiding excessive ultrafiltration, and enhancing intradialytic blood pressure monitoring may further support cardiovascular stability. Identifying high-risk patients early and strengthening interdisciplinary collaboration between nephrology and oncology teams can facilitate coordinated treatment planning and proactive management of dialysis-related complications.

Additionally, these findings may influence clinical decisions regarding the initiation and management of dialysis in patients with advanced cervical cancer. Early assessment of hemodynamic stability and volume status after HD may support the creation of individualized dialysis prescriptions, including gradual ultrafiltration and closer monitoring during the initial dialysis period. For patients with limited physiological reserves, these parameters may contribute to prognostic stratification and shared decision-making regarding treatment goals, including integrating supportive and palliative care considerations when appropriate. Prospective cohort studies are warranted, particularly those evaluating structured volume management, blood pressure optimization, and interdisciplinary oncologic–nephrologic care to validate these findings. Furthermore, interventional studies targeting modifiable HD-related factors may help improve short-term survival outcomes among cervical cancer patients requiring HD.

This study had several limitations. Its single-center design may limit the generalizability of the findings to the broader cervical cancer population. This study was conducted within a specific dialysis infrastructure, clinical workflow, and level of interdisciplinary oncologic–nephrologic coordination, all of which may differ across healthcare systems. Variations in dialysis practices, resource availability, volume management strategies, and blood pressure targets may restrict the applicability of these findings to other settings. In higher-resource environments, more intensive volume monitoring and individualized ultrafiltration strategies may reduce the impact of post-HD hemodynamic instability on prognosis.

In contrast, in lower-resource settings with limited dialysis frequency or monitoring capacity, these parameters may exert a greater influence on short-term survival outcomes. Nevertheless, post-HD systolic blood pressure and interdialytic weight gain represent fundamental physiological markers of cardiovascular stability and volume regulation that are likely relevant across HD populations. In addition, the relatively small sample size may have reduced the study's statistical power, as indicated by the wide confidence intervals observed for several variables, particularly those without significant associations. This imprecision suggested that certain true associations may not have been detected. Furthermore, this study only included patients who progressed to dialysis dependence, which may have introduced selection bias and limited generalizability to cervical cancer patients with preserved renal function. The heterogeneity in cancer status at the time of HD initiation, including both newly diagnosed and progressive or recurrent cases, may have contributed to the variability in prognosis.

Beyond these issues, several analytical limitations should be considered. Unmeasured confounding cannot be excluded, as factors such as cardiac function and nutritional status were not determinable based on the available data and may have influenced the associations between dialysis parameters and survival. Multicollinearity among covariates, particularly between interdialytic weight gain and post-HD systolic blood pressure, was not formally assessed and may have led to overlapping effects among volume-related variables. Stratified or sensitivity analyses by cancer stage or vascular access type were not performed due to the limited sample size, as further stratification would substantially reduce the study's statistical power. Although the frequency and duration of HD were reported descriptively, these figures were not incorporated into the Cox regression analysis because of sample homogeneity and incomplete data. The inability to separate hypertension and diabetes mellitus into distinct categories represented a limitation of this study. Nevertheless, their combined inclusion reflects their overlapping contribution to kidney function decline, which is central to the clinical course of patients requiring HD. Due to the retrospective design, causal relationships between interdialytic weight gain, post-HD systolic blood pressure, and mortality could not be established. Future multicenter studies with larger cohorts and prospective designs are recommended to provide more robust estimates and minimize the potential bias inherent in retrospective analyses.

Conclusion

Lower STS was observed in cervical cancer patients undergoing HD than in patients with cervical cancer in general. These findings underscore the impact of kidney involvement as a marker of poor prognosis, one that reflects advanced cancer stages and increased treatment complexity. IDWG and systolic blood pressure are modifiable clinical factors associated with worse survival outcomes. Future studies are warranted to validate these findings and explore strategies that may improve prognosis in cervical cancer patients undergoing HD.

Abbreviations

HD: hemodialysis; FIGO: International Federation of Gynecology and Obstetrics; IDWG: interdialytic weight gain; HR: hazard ratio; CI: confidence interval; STS: short-term survival; KDOQI: kidney disease outcomes quality initiative.

Ethics Approval and Consent to Participate

This study conforms to the principles outlined in the 1964 Declaration of Helsinki and its subsequent amendments. Ethical approval was granted by the Ethics Committee of Dharmais Cancer Hospital (research protocol number: 284/KEPK/VIII/2023). All data used in this study were fully anonymized prior to analysis. Due to the retrospective nature of the research and the use of secondary data, the requirement for informed consent was waived by the ethics committee.

Competing Interests

The authors declare no competing interests that could be perceived as influencing the results and/or discussion reported in this paper.

Availability of Data and Materials

The datasets used during the current study are available from the corresponding author upon request.

Authors' Contributions

MTB contributed to the conceptualization and methodology of the study, collected data, and conducted formal data analysis. MBHM performed data curation, contributed to the interpretation of results, and drafted the manuscript. WR was involved in conceptualization and methodology design. IR provided senior supervision and oversight of administration, and HS contributed to manuscript visualization and critical revisions. DLP supported data acquisition and visualization. DM supervised and provided review and editing of the final manuscript. PN assisted in methodology development and ensured data validity. SK and PS were involved in revising and editing the final manuscript. All authors reviewed and approved the final version of the manuscript.

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Declaration on the Use of Artificial Intelligence

The authors declare that artificial intelligence (AI) tools were utilized solely for language editing and grammatical refinement to improve the clarity and readability of the manuscript. The specific AI tool used was DeepL. AI was not involved in content generation, data analysis, interpretation, or any decision-making processes. All scientific content, interpretations, conclusions, and responsibilities related to the manuscript rest solely with the authors.

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