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Cardiovascular Symptom Burden and Associated Factors in Cancer Patients Receiving Bevacizumab Therapy: A Cross-Sectional Study

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Research Article

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Abstract

Background

Bevacizumab is widely used in cancer treatment but is associated with cardiovascular adverse events, particularly hypertension and vascular complications. This study aimed to determine the frequency of cardiovascular symptoms and identify factors associated with cardiovascular-related hospitalization in cancer patients receiving bevacizumab.

Methods

This descriptive, cross-sectional study included 100 adult cancer patients receiving bevacizumab-containing therapy at a university hospital between June 2025 and August 2026. Data were collected through face-to-face interviews and clinical records. Blood pressure was assessed before the first and a subsequent bevacizumab treatment. Multiple linear regression with bootstrap resampling was used to identify predictors of cardiovascular-related hospitalization.

Results

The mean age was 60.61 ± 12.81 years and BMI was 26.38 ± 5.20 kg/m². Colon cancer was the most common malignancy (42.0%). Hypertension, arrhythmia, and coronary artery disease were present in 43.0%, 14.0%, and 18.0% of patients, respectively, and 22.0% experienced cardiovascular-related hospitalization. Systolic blood pressure increased from 120.38 ± 11.66 to 125.79 ± 15.89 mmHg (P = 0.008), while diastolic blood pressure increased from 74.28 ± 11.14 to 78.83 ± 9.53 mmHg (P = 0.002). Urinary protein level was the strongest independent predictor of cardiovascular-related hospitalization (β = 0.658, P < 0.001) and remained significant after bootstrap resampling (P = 0.001; 95% CI, 0.002–0.005).

Conclusions

Cardiovascular symptoms and blood pressure elevations are important concerns during bevacizumab therapy. Urinary protein may be a practical marker for identifying patients at increased risk of cardiovascular-related hospitalization. Regular monitoring of blood pressure and proteinuria may improve patient safety and support treatment continuity.

1. Introduction

Bevacizumab is a monoclonal antibody that targets tumor angiogenesis and has become one of the cornerstones of anti-angiogenic therapy applied across various cancer types today. However, therapies targeting the vascular endothelial growth factor (VEGF) pathway are associated with a broad spectrum

of cardiovascular adverse events (CVAEs), a phenomenon that can adversely affect treatment efficacy and patient outcomes (Bair et al., 2013; Tocchetti et al., 2013; Touyz & Herrmann, 2018).

VEGF signaling is critical not only for tumor vascularization but also for normal cardiovascular homeostasis. Inhibitors of the VEGF pathway can affect endothelial function, coronary perfusion, and myocardial stress response, leading to CVAEs such as hypertension, left ventricular (LV) dysfunction, thromboembolism, and, rarely, arrhythmias. Bevacizumab in particular carries a notable risk profile with respect to hypertension and vascular complications, while LV dysfunction and thrombotic events are also among the toxicities frequently reported across the VEGF inhibitor class. For this reason, a cardio-oncology-based approach and risk-focused monitoring programs stand out as an integral part of clinical practice (Bair et al., 2013; Dobbin et al., 2021; Tocchetti et al., 2013; Touyz & Herrmann, 2018). Cumulative dose and combination therapies can also modify the likelihood and severity of these toxicities; patient-specific factors (comorbidities, baseline cardiovascular risk, tumor type and stage) play a determining role in treatment decisions (Dobbin et al., 2021; Mihalcea et al., 2023; Touyz & Herrmann, 2018).

Among patients receiving bevacizumab and other VEGF inhibitors, hypertension, LV dysfunction, and heart failure stand out as the leading CVAEs; findings regarding arterial and venous thromboembolism, ischemia-related events, and an increased risk of arrhythmia have also been reported. Because of variability in study designs and patient populations, the precise incidence rates specific to bevacizumab may differ across sources; nevertheless, the literature generally emphasizes that hypertension and LV dysfunction are the most prominent findings. These risks interact with factors such as age, pre-existing cardiovascular disease, combination therapies, and treatment intensity (Bair et al., 2013; Dobbin et al., 2021; Mihalcea et al., 2023; Touyz & Herrmann, 2018).

Cardiovascular toxicity associated with VEGF inhibitors encompasses a broad clinical spectrum, including hypertension, ischemia, LV systolic dysfunction, arrhythmias, and pericardial involvement. Early detection may directly influence decisions regarding treatment continuation, modification, or discontinuation, highlighting the importance of active screening and multilevel cardio-oncology monitoring (Chen et al., 2023; Dobbin et al., 2021; Tocchetti et al., 2013; Touyz & Herrmann, 2018). Baseline cardiovascular risk assessment and regular monitoring are essential to minimize CVAEs while preserving oncologic benefit (Chen et al., 2023; Kim et al., 2018; Samuel et al., 2023).

The risk of bevacizumab-associated CVAEs is influenced by pre-existing cardiovascular disease, age, sex, tumor characteristics, treatment intensity, and concomitant cardiotoxic therapies. Biomarkers and imaging findings may further contribute to risk stratification, supporting individualized cardiovascular assessment, monitoring, and preventive strategies (Dobbin et al., 2021; Kim et al., 2018; Mihalcea et al., 2023; Samuel et al., 2023; Touyz & Herrmann, 2018). Although greater caution may be warranted in older patients, quantitative evidence regarding age-related differences in bevacizumab-specific toxicity remains inconsistent (Accordino et al., 2014; Samuel et al., 2023).

In the literature, the mechanisms, clinical findings, and risk factors related to the cardiovascular toxicity profile of bevacizumab have largely been established through review-type studies, and there remains an ongoing need for current, continuous, patient-level data that jointly evaluate the frequency of symptoms in real clinical populations and the factors influencing this frequency. Building on this knowledge gap, the present study aimed to determine the frequency of cardiovascular symptoms among cancer patients receiving bevacizumab therapy and to examine, through a cross-sectional design, the sociodemographic, clinical, and treatment-related factors influencing the occurrence of these symptoms.

2. Methods

2.1. Study Design and Setting

This study was designed as a descriptive, cross-sectional study aiming to determine the frequency of cardiovascular symptoms and the factors influencing these symptoms among cancer patients receiving bevacizumab therapy. The research was conducted among patients undergoing a bevacizumab-containing treatment protocol at the Medical Oncology and outpatient Chemotherapy Unit of a university hospital located in Istanbul, between June 2025 and August 2026. The cross-sectional design allowed data collection to be carried out within a single time frame and enabled the simultaneous assessment of current cardiovascular symptom status together with potentially associated factors.

2.2. Sample and Participants

The study population consisted of cancer patients followed and treated with a bevacizumab-containing chemotherapy protocol at the relevant center. The sample was determined either through an approach aiming to reach the entire population or through consecutive sampling, a non-probabilistic sampling method. The required sample size was calculated by power analysis, taking into account the expected symptom prevalence, the confidence interval (95%), and the acceptable margin of error (± 5%); a certain proportion was added to the calculated number to account for the possibility of data loss.

Inclusion criteria were defined as follows: (i) being 18 years of age or older, (ii) having a histopathologically confirmed cancer diagnosis, (iii) having received at least one cycle of bevacizumab therapy, (iv) agreeing to participate in the study and signing the informed consent form, and (v) having the cognitive and physical capacity required for communication.

Exclusion criteria were defined as follows: (i) patients with a history of advanced, decompensated cardiac disease prior to bevacizumab therapy who were therefore unable to complete the assessment forms, (ii) patients unable to participate in the data collection process due to severe cognitive impairment or psychiatric illness, and (iii) patients who declined to participate in the study or withdrew their consent during the process.

2.3. Data Collection

Data were collected through face-to-face interviews during patients' routine oncology outpatient clinic/chemotherapy unit visits. Interviews were conducted by researchers specifically trained for the study, following a standardized protocol that lasted an average of 15–20 minutes. Clinical and laboratory data were transferred to the form based on the most recently recorded measurements closest to the date of data collection.

2.4. Data Collection Tools

Data were collected using a multi-part data collection form developed by the researchers in line with the relevant literature and finalized with expert opinion. The form consisted of two main sections:

Sociodemographic and Clinical Information Form: This section included variables such as age, sex, tumor type and stage, comorbidities (hypertension, diabetes, coronary artery disease, etc.), smoking/alcohol use, body mass index, number of bevacizumab treatment cycles, cumulative dose, and concomitant antineoplastic/combination therapies.

Cardiovascular Symptom Assessment Form: This section recorded hypertension (blood pressure measurements), coronary artery disease, hyperlipidemia, diabetes mellitus, cardiovascular problems, palpitations, blood pressure measurements when available, and biomarker results such as electrocardiography (ECG) findings, obtained from patient records. Blood pressure measurements: Patients' blood pressure values were assessed at two different time points. The first measurement was taken on the day the patient first started bevacizumab treatment, before the start of treatment. The second measurement was taken in the morning before the start of treatment on one of the subsequent bevacizumab treatments. Both measurements were taken before treatment administration. Systolic and diastolic blood pressure values were recorded, and the change between the two measurements was evaluated.

2.5. Ethical Considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki, and approval was obtained from the xxx University Non-Interventional Clinical Research Ethics Committee prior to data collection (Approval No: xxx). The necessary institutional permissions were also obtained from the institution where the study was conducted. All participants were informed about the purpose and scope of the study, the voluntary nature of participation, and the confidentiality of the data, and written informed consent was obtained from patients who agreed to participate. The collected data were coded and stored in accordance with personal data protection legislation and were used solely for research purposes. The principles of the Declaration of Helsinki were adhered to throughout the research process.

2.6. Data Analysis

All statistical analyses were conducted using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were examined using descriptive and graphical approaches to evaluate their distribution and were presented as mean ± standard deviation (SD). Categorical variables were

summarized using frequencies and percentages. Given the marked dispersion observed in urinary protein measurements, the median value was also reported for this variable.

Within-patient changes in systolic and diastolic blood pressure between the two assessment points were examined using paired-samples t tests. For each comparison, the mean change and corresponding 95% confidence interval (CI) were calculated. Statistical significance was evaluated using a two-sided p value threshold of < 0.05.

A multiple regression model was subsequently constructed to investigate factors associated with cardiovascular-related hospitalization. Bevacizumab dose, urinary protein level, number of treatment cycles, and treatment regimen were included as explanatory variables based on their clinical relevance. Cardiovascular-related hospitalization was specified as the dependent variable. Model performance was assessed using R, R^2, adjusted R^2, and the overall F statistic. For each predictor, unstandardized coefficients (B), standard errors (SE), standardized coefficients (β), t values, p values, and 95% CIs were reported. The Durbin–Watson statistic was also examined to evaluate the independence of residuals.

Bootstrap resampling was used to further evaluate the stability of the regression estimates. Bootstrap p values and 95% bootstrap confidence intervals were obtained for the regression coefficients. A two-sided p value < 0.05 was considered statistically significant throughout the analyses.

3. Results

A total of 100 patients receiving bevacizumab were included in the study. The mean age of the patients was 60.61 ± 12.81 years, and the mean BMI was 26.38 ± 5.20 kg/m². Colon cancer was the most frequently represented malignancy (42.0%), followed by ovarian cancer (19.0%) and brain tumors (18.0%). Hepatocellular carcinoma accounted for 11.0% of the diagnoses, whereas rectal, lung/bronchial, pancreatic, cervical, and breast cancers each constituted 2.0% of the sample. Regarding treatment regimens, 60.0% of patients received bevacizumab in combination with chemotherapy, while 29.0% received bevacizumab alone and 11.0% received bevacizumab with another systemic therapy.

Among the assessed chronic disease and lifestyle-related characteristics, smoking was reported by 45.0% of the patients, whereas hyperlipidemia and diabetes mellitus were present in 20.0% and 16.0%, respectively. Alcohol use was reported by 17.0% of the participants. Previous radiotherapy had been received by 30.0% of the patients (Table 1).

Table 1
Sociodemographic and clinical characteristics of patients receiving Bevacizumab (n = 100)

Variables	**Mean ± SD**	
Age (years)	60.61 ± 12.81	
BMI (kg/m²)	26.38 ± 5.20	
Cancer diagnosis	**n**	**%**
Colon cancer	42	42.0
Ovarian cancer	19	19.0
Brain tumor	18	18.0
Hepatocellular carcinoma	11	11.0
Rectal tumor	2	2.0
Lung/bronchial cancer	2	2.0
Pancreatic cancer	2	2.0
Cervical cancer	2	2.0
Breast cancer	2	2.0
Treatment regimen*		
Bevacizumab alone	29	29.0
Bevacizumab + chemotherapy	60	60.0
Bevacizumab + Immunotherapy / other systemic treatment	11	11.0
Other Chronic Disease		
Diabetes mellitus	16	16.0
Hyperlipidemia	20	20.0
Smoking	45	45.0
Alcohol use	17	17.0
Previous radiotherapy	30	30.0

*Treatments containing atezolizumab were evaluated in the Bevacizumab + Immunotherapy / other systemic treatment group. Treatments using only chemotherapy agents in combination with Bevacizumab were evaluated in the Bevacizumab + Chemotherapy group.

The mean systolic and diastolic blood pressure values at the first assessment were 120.38 ± 11.66 mmHg and 74.28 ± 11.14 mmHg, respectively. At the second assessment, these values increased to 125.79 ± 15.89 mmHg and 78.83 ± 9.53 mmHg, respectively. The mean heart rate was 78.57 ± 13.35

beats/min. Urinary protein levels showed considerable variability, with a mean value of 68.85 ± 94.43 mg/dL and a median of 30.00 mg/dL. The mean bevacizumab dose was 551.36 ± 254.97, and patients received a mean of 14.08 ± 12.82 treatment cycles. The mean ejection fraction was 54.59 ± 12.65%.

Echocardiographic evaluation revealed that 61.0% of the patients had no echocardiographic examination recorded. Among patients with available echocardiographic findings, degenerative valvular/heart disease or degenerative valvular changes were observed in 12.0%, while 15.0% had normal findings. Diastolic dysfunction was identified in 3.0% of patients, and mild aortic insufficiency was also observed in 3.0%. Mild valvular insufficiency was present in 2.0% of the patients. Mild valvular disorder and mild insufficiency were each reported in 1.0% and 3.0% of the patients, respectively (Table 2).

Table 2
Cardiovascular characteristics and bevacizumab treatment-related variables (n = 100)

Variable	**Mean ± SD**	
Systolic BP 1 (mmHg)	120.38 ± 11.66	
Diastolic BP 1 (mmHg)	74.28 ± 11.14	
Systolic BP 2 (mmHg)	125.79 ± 15.89	
Diastolic BP 2 (mmHg)	78.83 ± 9.53	
Heart rate (beats/min)	78.57 ± 13.35	
Urinary protein (mg/dL)	68.846 ± 94.43 (Median = 30.00)	
Bevacizumab dose	551.36 ± 254.97	
Number of bevacizumab cycles	14.08 ± 12.82	
Ejection fraction (%)	54,592 ± 12.651	
Echocardiography	**n**	**%**
No echocardiography	61	61.0
Degenerative valvular/heart disease or degenerative valvular changes	12	12.0
Mild valvular insufficiency	2	2.0
Normal	15	15.0
Mild valvular disorder	1	1.0
Diastolic dysfunction	3	3.0
Mild aortic insufficiency	3	3.0
Mild insufficiency	3	3.0
Cardiovascular-related hospitalization	**n**	**%**
No	78	78.0
Yes	22	22.0
Hypertension		
No	57	57.0
Yes	43	43.0
Arrhythmia		
No	86	86.0

Variable	Mean ± SD	
Yes	14	14.0
Coronary artery disease		
No	82	82.0
Yes	18	18.0

Overall, the cardiovascular profile demonstrated a modest increase in both systolic and diastolic blood pressure between the first and second assessments. In addition, the presence of proteinuria and various echocardiographic abnormalities in a subset of patients highlights the occurrence of cardiovascular and renal parameters that warrant monitoring during bevacizumab therapy.

Cardiovascular-related hospitalization occurred in 22.0% of the patients receiving bevacizumab, whereas 78.0% did not require hospitalization for a cardiovascular-related event. Hypertension was identified in 43.0% of the patients. Arrhythmia was present in 14.0% of the study population, while coronary artery disease was reported in 18.0% of patients (Table 2).

A statistically significant increase in blood pressure was observed between the first and second assessments. Mean systolic blood pressure increased from 120.38 ± 11.66 mmHg at the first assessment to 125.79 ± 15.89 mmHg at the second assessment, corresponding to a mean increase of 5.41 mmHg (95% CI: 1.43–9.39; t = − 2.70, p = 0.008). Similarly, mean diastolic blood pressure increased from 74.28 ± 11.14 mmHg to 78.83 ± 9.53 mmHg, with a mean difference of 4.55 mmHg (95% CI: 1.67–7.43; t = − 3.14, p = 0.002) (Table 3).

Table 3
Comparison of systolic and diastolic blood pressure measurements between the first and second assessments (n = 100)

Variable	First measurement, Mean ± SD	Second measurement, Mean ± SD	Mean difference*	95% CI	t	p
Systolic blood pressure (mmHg)	120.38 ± 11.66	125.79 ± 15.89	5.41	1.43–9.39	−2.70	**0.008**
Diastolic blood pressure (mmHg)	74.28 ± 11.14	78.83 ± 9.53	4.55	1.67–7.43	−3.14	**0.002**

*Mean difference represents the absolute change from the first to the second measurement (second measurement − first measurement). The paired-samples t-test in SPSS was calculated as first measurement − second measurement; therefore, the reported t values are negative.

Thus, both systolic and diastolic blood pressure measurements demonstrated statistically significant increases between the two assessment points. The magnitude of change was greater for systolic blood pressure in absolute terms, although both parameters showed significant within-patient changes.

A multiple linear regression analysis was performed to examine the variables associated with cardiovascular-related hospitalization. The overall regression model was statistically significant ($R = 0.719$, $R^2 = 0.516$, adjusted $R^2 = 0.459$, $F = 9.073$, $p < 0.001$), indicating that the variables included in the model collectively explained 51.6% of the variance in cardiovascular-related hospitalization. The Durbin–Watson statistic was 1.940, suggesting no substantial concern regarding autocorrelation of the residuals.

Among the variables entered into the model, urinary protein was the only statistically significant independent predictor of cardiovascular-related hospitalization. Higher urinary protein levels were associated with a greater likelihood of cardiovascular-related hospitalization ($B = 0.003$, $SE = 0.001$, $\beta = 0.658$, $t = 4.946$, $p < 0.001$). The conventional 95% confidence interval for the regression coefficient ranged from 0.002 to 0.005, and the bootstrap analysis confirmed the robustness of this association (bootstrap $p = 0.001$; bootstrap 95% CI: 0.002–0.005).

In contrast, bevacizumab dose was not significantly associated with cardiovascular-related hospitalization in the conventional regression analysis ($\beta = -0.157$, $p = 0.212$), and the corresponding bootstrap analysis did not demonstrate a statistically significant association (bootstrap $p = 0.081$). Similarly, the number of bevacizumab treatment cycles was not a significant predictor ($\beta = 0.064$, $p = 0.627$; bootstrap $p = 0.648$). Treatment type was also not statistically significant in the conventional model ($\beta = 0.193$, $p = 0.125$); however, its bootstrap confidence interval remained positive (bootstrap $p = 0.040$; bootstrap 95% CI: 0.025–0.358), suggesting a potentially relevant association that warrants cautious interpretation (Table 4).

Table 4
Multiple regression analysis of the variables associated with cardiovascular-related hospitalization (n = 100)

Variables	B	SE	Standard Beta (β)	t	p	95% CI	Bootstrap p	Bootstrap 95% CI
Constant	0.055	0.199	—	0.278	0.782	-0.349 to 0.460	0.695	-0.245 to 0.380
Bevacizumab dose	< 0.001	< 0.001	-0.157	-1.272	0.212	-0.001 to < 0.001	0.081	-0.001 to -0.00001
Urinary protein	**0.003**	**0.001**	**0.658**	**4.946**	**< 0.001**	**0.002 to 0.005**	**0.001**	**0.002 to 0.005**
Bevacizumab treatment cycles	0.002	0.004	0.064	0.490	0.627	-0.006 to 0.010	0.648	-0.007 to 0.010
Treatment	0.180	0.114	0.193	1.575	0.125	-0.052 to 0.411	**0.040**	**0.025 to 0.358**
Dependent variable: Cardiovascular-related hospitalization $R = 0.719$; $R^2=0.516$; Adjusted $R^2=0.459$; $F = 9.073$; $p < 0.001$; Durbin–Watson = 1.940								

Overall, the findings indicate that urinary protein was the most prominent variable associated with cardiovascular-related hospitalization in the multivariable model. Notably, the association remained statistically significant after bootstrap resampling, supporting the stability of this finding.

4. Discussion

The findings obtained in this cross-sectional study are largely consistent with the current literature, which supports the notion that cardiovascular monitoring should be an integral part of treatment decisions in cancer patients receiving bevacizumab therapy. Below, the main findings of the study are interpreted in light of recent sources, and their implications for clinical practice are discussed.

In our study, the first measurement reflects blood pressure values before bevacizumab therapy was initiated, while the second measurement reflects values after treatment had begun; therefore, the increase observed between the two measurements can be attributed more to treatment exposure than to the spontaneous course of the disease. This pattern is consistent with the pathophysiological model based on the role of the VEGF pathway in regulating systemic vascular tone: blockade by bevacizumab of the vasodilatory effect mediated by VEGF-induced activation of endothelial nitric oxide synthase leads to increased peripheral vascular resistance and elevated blood pressure (Touyz & Herrmann, 2018; Bair et al., 2013). A reduction in capillary bed density (rarefaction) and VEGF inhibition-related impairment of

renal sodium excretion are also cited as complementary mechanisms contributing to this process (Dobbin et al., 2021). Recent reviews report that a considerable degree of blood pressure elevation from baseline is observed in the vast majority of patients treated with VEGF pathway inhibitors, and that new-onset or worsening hypertension affects a substantial proportion of patients; this characterizes hypertension as a toxicity specific to VEGF inhibitors that is largely mechanism-dependent and predictable (Palaskas et al., 2026; Camarda et al., 2022). Our findings provide additional real-world evidence confirming this broad clinical picture and point to the importance of baseline blood pressure assessment before treatment and regular monitoring throughout the course of therapy.

The fact that urinary protein level was the variable most strongly and consistently associated with cardiovascular-related hospitalization in our model supports the view that the cardiovascular and renal toxicities of VEGF inhibition share a common underlying mechanism. Fundamental studies demonstrating that the loss of local VEGF expression in podocytes leads to glomerular microvascular damage and thrombotic microangiopathy indicate that proteinuria is not merely an isolated renal side effect but may also represent a marker of systemic vascular injury (Eremina et al., 2008). Recent real-world cohorts also support this relationship, reporting that uncontrolled systolic blood pressure is an independent risk factor for the development of bevacizumab-associated proteinuria, and that blood pressure control may reduce the risk of proteinuria (Kiyomi et al., 2023; Nihei et al., 2024). Within this framework, the blood pressure increase observed in our study and the association between proteinuria and hospitalization can be regarded as complementary findings; however, due to the nature of the cross-sectional design, the direction and causality of this relationship cannot be clarified. Current nephrology-based recommendations emphasize that regular urinary protein screening and strict monitoring of blood pressure targets in patients receiving VEGF inhibitors play a key role in preventing both renal and cardiovascular complications (Rashidi et al., 2023).

The lack of a significant association between bevacizumab dose or the number of administered cycles and hospitalization is a notable finding, yet it is not inconsistent with the literature. Although some studies have reported a dose-dependent relationship between cumulative dose and the risk of hypertension, this relationship has generally been demonstrated in larger, prospectively followed cohorts; the failure to statistically detect such dose–response effects in our single-center, cross-sectional study with a relatively limited sample size may be explained more by the small sample size than by the true absence of an association. In contrast, although the treatment regimen variable did not reach significance in the conventional regression model, it showed a significant and positive association in the bootstrap resampling analysis; this should be regarded as a signal, warranting cautious interpretation, that is consistent with the literature suggesting that combination therapies (particularly the concurrent use of bevacizumab with additional systemic agents) may increase cardiovascular risk. Real-world case series reporting that adverse events such as hypertension and proteinuria are more frequently observed in combination regimens compared with single-agent therapy support this finding.

The absence of a recorded echocardiographic assessment in 61% of patients in our study reflects the known gap between international recommendations in the field of cardio-oncology and current clinical

practice. The 2022 European Society of Cardiology (ESC) Cardio-Oncology Guidelines strongly recommend a baseline assessment based on cardiovascular risk classification, along with transthoracic echocardiography in high-risk patients, prior to initiating VEGF inhibitor therapy (Lyon et al., 2022). In contrast, multicenter real-world surveys show that echocardiographic monitoring lags behind recommended standards, and that this gap becomes even more pronounced in centers without cardio-oncology expertise (Barbieri et al., 2024). Our findings suggest that this international observation may also apply within the context of our own country and support the need to integrate a structured, risk-based cardiovascular monitoring protocol into oncology clinics.

In conclusion, the findings of this study underscore that systematic monitoring of blood pressure during bevacizumab treatment and the evaluation of urinary protein level as a simple yet valuable marker of cardiovascular risk deserve emphasis. A structured cardio-oncology monitoring approach that includes baseline assessment prior to treatment and regular follow-up of blood pressure and proteinuria during treatment is considered likely to enhance both the sustainability of treatment and patient safety. Nevertheless, multicenter, prospective, and longitudinal studies are needed to clarify the causal structure of these relationships and the impact of clinical monitoring strategies on treatment outcomes.

5. Limitations

Owing to the nature of the cross-sectional design, a causal relationship cannot be established between cardiovascular symptoms and the factors examined; only associative inferences can be drawn. Because the study was conducted at a single center, the generalizability of the findings may be limited; furthermore, the assessment of some symptoms based on patient self-report carries a risk of recall bias.

6. Conclusion

This cross-sectional study demonstrates that cardiovascular symptoms are common in cancer patients receiving bevacizumab, with hypertension, increased blood pressure, and cardiovascular-related hospitalization being the most salient findings. Urinary protein level was the strongest and most consistent independent predictor of hospitalization, remaining robust after bootstrap validation, whereas bevacizumab dose and treatment cycles were not independently associated with hospitalization. These findings support the link between VEGF inhibition and cardiovascular–renal toxicity and highlight blood pressure and proteinuria as practical parameters for routine monitoring. A structured, risk-based cardio-oncology protocol incorporating baseline cardiovascular assessment, regular blood pressure and proteinuria monitoring, and echocardiography for high-risk patients may therefore be warranted. Prospective multicenter studies are needed to confirm these associations and determine whether structured monitoring improves long-term outcomes.

Abbreviations

CAD: Coronary artery disease

CI: Confidence interval

CVAE: cardiovascular adverse events

OR: Odds ratio

PMI: Platelet mass index

SD: Standard deviation

VEGF: vascular endothelial growth factor

Declarations

Conflict of Interest Statement

The authors declare that there is no conflict of interests.We have no funding sources to declare.

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Declarations

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Declaration of competing interest

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

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Code availability: N/A

Constent to participate: Informed consent was obtained from all individual participants included in the study.

AUTHOR CONTRIBUTIONS

Elif Değirmenci Aktaş: Conceptualization (equal); data curation(equal); formal analysis (equal); funding acquisition (equal); project administration (equal); methodology (equal); software (equal); visuali-zation (equal); writing – original draft (equal); writing– review and editing (equal).

Dilek Yildirim: Conceptualization (equal); funding acquisition(equal); project administration (equal); resources (equal); supervision (equal); writing – original draft (equal); writing – review and editing (equal).

Ethical Considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki, and approval was obtained from the Koç University Non-Interventional Clinical Research Ethics Committee prior to data collection (Approval No: 2025.060.IRB1.010). The necessary institutional permissions were also obtained from the institution where the study was conducted. All participants were informed about the purpose and scope of the study, the voluntary nature of participation, and the confidentiality of the data, and written informed consent was obtained from patients who agreed to participate. The collected data were coded and stored in accordance with personal data protection legislation and were used solely for research purposes. The principles of the Declaration of Helsinki were adhered to throughout the research process.

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