Original Article

OPEN ACCESS

Effects of Ophthalmic Intravitreal Injection of Anti-VEGF on Renal Function in Diabetes Mellitus Patients

Amena Masrur[1], Jais Kumar Karmani[2], Furqan Ahmad Khan[3], Armughan Ahmad[4], Fatima Amjad[5], Ali Tayyab[6]

[1,3]Associate Professor Ophthalmology, [2]Professor of Nephrology, [6]Professor of Ophthalmology, (Akbar Niazi Teaching Hospital/IMDC, Islamabad)

[4]Consultant/Physician, Federal Government Services Hospital/Polyclinic, Islamabad.

[5]Consultant Hera General Hospital, Makkah, KSA

Author`s Contribution

[1,2]Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Final approval of the version to be published

[3,4,6]Drafting the work or revising it critically for important intellectual content, [5]Active participation in active methodology

Funding Source: None

Conflict of Interest: None

Received: Dec 19, 2024

Revised: Mar 27, 2025

Accepted: April 23, 2025

Address of Correspondent

Dr. Amena Masrur

Associate Professor

Ophthalmology

Akbar Niazi Teaching Hospital/IMDC, Islamabad

ABSTRACT

Objective: To investigate the effects of ophthalmic intravitreal injection of anti-VEGF treatment on renal function in DM2 patients.

Methodology: This observation retrospective study was carried out in the Ophthalmology and Nephrology departments of Akbar Niazi Teaching Hospital, Islamabad, from February 2022 to February 2024. Total 100 patients of DM2, 50 patients received anti-VEGF treatment were included, both with and without chronic kidney disease (CKD). The progression of renal function was analyzed after the initiation of anti-VEGF treatment and in comparison, to a control group.

Results: The patients mean age was 69.3±9.6 years (ranging 51–85 years). The ratio of males to females was 1:1.3, with 56% (n=28) being males and 44% (n=22) being females. At 12-month mark, 75% of patients had CKD, mean decrease in estimated glomerular filtration rate (eGFR) of 20%. 26% of patients (n=13) experienced a reduction in eGFR of > 25%, while 10% of patients (n=5) had a reduction in eGFR of > 50%. By the 24-month mark, 85% of patients had developed CKD, with an average reduction in eGFR of 33.3%. The eGFR mean decline rate among patients underwent anti-VEGF was 10 ml/min/year, significant high than the 1.5 ml/min/year observed in the control group ($p < 0.05$). Following initial management, renal replacement was required for 20% of patients in the CKD group (n=6) in the follow up period (average duration of 21±11 months). The primary risk factors for dialysis requirement were age, baseline proteinuria, and the presence of preexisting CKD.

Conclusion: Ophthalmic anti-VEGF intravitreal for treatment is linked with an increased risk of CKD and accelerated progressive end stage kidney disease in individuals with preexisting CKD. Understanding the administration of these drugs is critical for managing progressive CKD and appropriately limiting their administration in specific patient populations.

Keywords: Diabetes mellitus; Intravitreal injections; Vascular endothelial growth factor A.

Cite this article as: Masrur A, Karmani JK, Khan FA, Ahmad A, Amjad F, Tayyab A. Effects of Ophthalmic Intravitreal Injection of Anti-VEGF on Renal Function in Diabetes Mellitus Patients. Ann Pak Inst Med Sci.2025;21(2):463-468. Doi.10.48036/apims.v21i2.1524.

Introduction

The prevalence of diabetes mellitus (DM) is steadily rising in our population. In recent decades, the incidence of DM has increased sharply due to DM2.[1] Nearly, 35% patients of diabetes develop diabetic retinopathy, and up to 80% of these also have diabetic renal disease. The preferred treatment for diabetic retinopathy is the intravitreal delivery of anti-VEGF.[2]

Recently, intravitreal anti-VEGF agents have altered the treatment of numerous retinal conditions, including diabetic macular edema, age related macular

degeneration, proliferative diabetic retinopathy, and central retinal vein blockage.[3] Ophthalmic intravitreal anti-VEGF is demonstrated to stop disease progression and enhance vision in patients receiving treatment, leading to its exponential increase in use within the discipline of ophthalmology currently.[4]

The kidney damage caused by systemic anti-VEGF administration is well-documented, encompassing a variety of kidney lesions such as arterial hypertension, increased proteinuria, thrombotic microangiopathy, and various glomerular diseases.[5-7] Recently, pharmacological studies have indicated that intravitreal is systemically absorbed and may lead to renal damage.[8,9] Nevertheless, limited information of this agent is in literature regarding the renal effects.[10] Recently, isolated case series have reported kidney involvement following intravitreal anti-VEGF administration.[11] Given the increasing use of these drugs, larger studies are required to clarify their negative effects and ensure their safer use.[12]

The objective of the study was to investigate the effects of ophthalmic intravitreal injection of anti-VEGF on renal function in DM patients, their impact on kidney disease progression, changes in other factors including blood pressure and additional negative effects.

Methodology

This observation retrospective (case-control) study was carried out in the Ophthalmology and Nephrology departments of Akbar Niazi Teaching Hospital, Islamabad, from February 2022 to February 2024. This single-centre study focused on patients of diabetes, regardless of CKD status, who administered ophthalmic intravitreal injections of anti-VEGF, and a follow up period of 24 months. The patients included in the study were diabetic individuals who visited the hospital's ophthalmology clinic and were diagnosed with macular edema or diabetic retinopathy, necessitating treated with intravitreal injections of anti-VEGF. The study control group consisted of DM2 patients, both CKD or non-CKD, who were not underwent anti-VEGF and had same baseline parameters. This study received approval from hospital's ethics committee ref no 680/IMDC/IREB-2022.

The patients' demographics details, including age, gender, and BMI were assessed. The study documented various clinical factors, including arterial hypertension (AHT) (previous diagnosed AHT, BP >140/90 mmHg, and those on antihypertensive therapy); DM duration; retinopathy type; preexisting CKD (albuminuria, eGFR <60 ml/min, and CKD stage of 3 or higher according to classification of KDIGO; Kidney Disease Improving Global Outcomes); the usage of renin angiotensin aldosterone system (RAS) blockers; insulin; and oral antidiabetics. Additionally, analytical factors were recorded, such as glycated hemoglobin, glycemia, serum creatinine, albuminuria (albumin to creatinine ratio [ACR], mg/g), and estimated GFR (determined by equation of Epidemiological Collaboration for CKD). Additional parameters included type of anti-VEGF treatment, doses given, and any other negative effects were documented. Data were gathered on progression of treated patients over a 12 months period before given ophthalmic intravitreal injection of anti-VEGF to 24-months afterward. Data of control group were gathered over the same duration.

Quantitative parameters were stated as mean ± SD. The analysis was conducted using an independent t test. Qualitative parameters were presented as proportional frequencies and were compared using chi square. The correlation among parameters was determined using Pearson's correlation test. The Kaplan-Meier survival analysis was employed and compared by log rank model. The multivariate analysis by cox regression was conducted, such as all parameters with clinical importance. It was considered p-values ≤ 0.05 to be significant. The analysis was conducted by SPSS v 25.

Results

The study encompassed 100 patients in total, and baseline characteristics of patients in both groups are presented in Table I. Fifty patients received anti-VEGF treatment, 56% were male. Mean age was 69.3±9.6 years, and mean duration of DM was 15 years. 90% had hypertension, and 60% had CKD previously diagnosed.

Among CKD treated patients, 96.7% had hypertension (89.7% of them were RAS blocker treated). In the group without CKD, 90% had hypertension (80% of them were RAS blocker treated). No difference was observed among CKD and non-CKD patients about the hypertension and RAS blocker treatment frequency. Regarding metabolic control, majority patients had glycated hemoglobin (HbA1c) mean of 7.3±1.2. Non-CKD patients had worse control, with a mean HbA1c of 8.0±1.1, compared to a mean HbA1c of 6.7±1.1 in CKD patients. This difference was significant. Additionally, 65% of non-CKD patients were receiving insulin at baseline, in contrast to 70% of CKD patients, with no difference among the groups. In

terms of oral antidiabetics, 90% of non-CKD patients were receiving oral antidiabetic drugs, compared to 76.7% in CKD group. In terms of BMI, CKD patients had a BMI of 30.2±4.7 kg/m², which was not different from the BMI of non-CKD patients, who had a BMI of 30 kg/m². In 86% of patients, anti-VEGF was started for macular edema. 24% patients were age related macular degeneration, had no difference among those CKD and non-CKD. Mean number of doses given was 12.6±6.8, ranging 1–24 (Table II). 50 patients in control group were assessed. The mean age was 70.1±9.2 years, with 52% being male. All the patients had a history of AHT, and 94% were on treatment of RAS blocker. All the patients were taking oral antidiabetics, and 30% were on insulin. The BMI mean was 30.0±4.5 kg/m².

Table I: Overall baseline characteristic details.

Variables	Anti-VEGF (n = 50)	Control (n = 50)	p-value
Ages (yr)	69.9±9.3	70.1±9.2	1.00
Gender (male)	28 (56%)	26 (52%)	.891
Insulin	35 (70%)	15 (30%)	.001
AHT	45 (90%)	50 (100%)	.524
Oral antibiotics	40 (80%)	50 (100%)	.001
RAS blocker	45 (90%)	47 (94%)	.882
BMI	30.2±4.7	30.0±4.5	.974
Diabetic macular edema	43 (86%)	-	-
Macular degeneration	12 (24%)	-	-
Glycated Hb (g/dl)	7.3±1.2	7.4±1.2	.985
Creatinine baseline (mg/dl)	1.8±1.1	1.2±1.1	.001
eGFR baseline (ml/min)	44.3±11.4	53.8±12.2	.002
ACR baseline (mg/g)	256±30.7	221±31.3	.002

The eGFR mean at baseline was 44.3±11.4 ml/min for anti-VEGF treatment patients, compared to 53.8±12.2 ml/min for control group. Additionally, albumin to creatinine ratio mean was 256±30.7 mg/g in the anti-VEGF group vs 221±31.3 mg/g in control group. The eGFR mean at 6 months was 36.0±8.4 ml/min for anti-VEGF treatment patients, indicating a decrease of 8.3 ml/min, while eGFR mean was 49.1±8.3 ml/min for control group, showing a reduction of 4.7 ml/min ($p < 0.001$). The eGFR mean at 12 months was 33.4±8.2 ml/min, compared to 51.1±8.2 ml/min in control group, representing a reduction of 10.9 ml/min vs 2.7 ml/min ($p < 0.0001$). The eGFR mean at 24-month of anti-VEGF group was 29.4±7.1 ml/min, a reduction of 14.9 ml/min. In contrast, control group eGFR mean was 48.0±7.3 ml/min, a reduction of 5.8 ml/min ($p < 0.001$). Figure 1

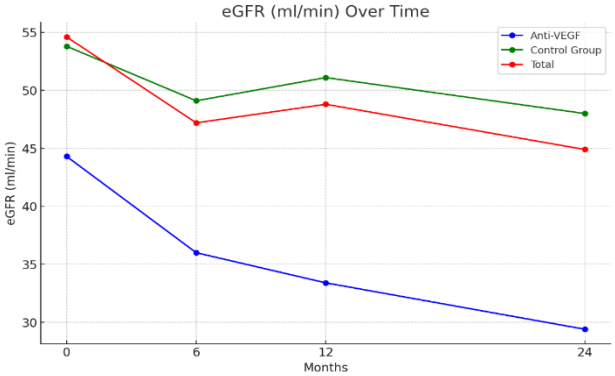

Figure 1: Overall changes in renal function.

In patients underwent anti-VEGF treatment, the decline in eGFR exceeded 25% in 16% of cases at 6-month, 26% of cases at 12-month, and 30% of cases at 24-month of follow up period. Additionally, a 50% decrease was observed in 10% of cases at 12-month and 16% of cases at 24-month. Table IV

In total, 60% (n = 30) of patients had CKD with a GFR < 60 ml/min at initiation of anti-VEGF therapy, by eGFR mean of 31.6±8.2 ml/min. The remaining patients non-CKD had GFR mean of 80.4±14.7 ml/min. Among CKD

Table II: Patients characteristics at baseline who underwent anti-VEGF treatment.

Variables	Total (n = 50)	CKD (n = 30)	Non-CKD (n = 20)	p-value
Ages (yr)	69.9±9.3	69.7±9.1	70.1±9.2	.880
Gender (male)	28 (56%)	18 (60%)	8 (40%)	.091
Insulin	35 (70%)	21 (70%)	13 (65%)	.523
AHT	45 (90%)	29 (96.7%)	18 (90%)	.571
Oral antibiotics	40 (80%)	23 (76.7%)	18 (90%)	.001
RAS blocker	33 (66%)	26 (89.7%)	16 (80%)	.486
BMI	30.2±4.7	30.2±4.7	30.9±4.5	.913
Diabetic macular edema	43 (86%)	23 (76.7%)	17 (85%)	.425
Macular degeneration	12 (24%)	8 (26.7%)	3 (15%)	.414
Glycated Hb (g/dl)	7.3±1.2	6.7±1.1	8.0±1.1	.001
Creatinine baseline (mg/dl)	1.7±1.1	1.9±1.1	0.7±0.2	.001
eGFR baseline (ml/min)	44.3±11.4	31.6±9.3	80.4±14.7	.001
ACR baseline (mg/g)	256±30.7	637±32.4	162±30.1	.001

Table III: Changes in eGFR pre- and post-anti-VEGF treatment.

	12 mo previous	Baseline	6 mo	12 mo	24 mo
Total					
eGFR (ml/min)	50.2±12.7	44.3±11.4	36.1±8.2	33.4±8.3	29.6±8.1
Decrease eGFR	-	5.9	8.2	10.9	14.7
p value vs 12 mo	-	.074	.071	.039	.028
CKD					
eGFR	36.0±8.4	30.5±6.1	24.7±6.0	19.8±5.3	19.8±5.3
Decrease eGFR	-	5.5	5.8	10.7	10.7
p value vs 12 mo	-	.074	.071	.039	.028
Non-CKD					
eGFR	83.7±11.4	80.4±14.7	70.3±10.4	61.8±7.4	58.5±7.3
Decrease eGFR	-	3.3	10.1	18.6	21.9
p value vs 12 mo	-	.074	.001	.001	.001

Table IV: eGFR percentage decrease in CKD and non-CKD treated patients

	Total, f (%)	CKD, f (%)	Non-CKD, f (%)	p-value
Reduction of eGFR >25%				
Baseline	2 (4%)	2 (6.7%)	0	.038
6 months	8 (16%)	6 (20%)	2 (10%)	.001
12 months	13 (26%)	8 (26.7%)	4 (20%)	.031
24 months	15 (30%)	10 (33.3%)	6 (30%)	.031
Reduction of eGFR >50%				
Baseline	0	0	0	-
6 months	0	0	0	-
12 months	5 (10%)	2 (6.7%)	1 (5%)	.039
24 months	8 (16%)	4 (13.3%)	2 (10%)	.038

patients, the eGFR mean in 12 months before starting the medication was 36.0±8.4 ml/min. At beginning of intervention, the GFR mean was 30.5±6.1 ml/min, decreasing to eGFR mean of 24.7±6.0 ml/min at 6-month, and further to eGFR mean of 19.8±5.3 ml/min at 12-month and 24-month into the intervention. Consequently, a decrease in eGFR mean of 5.8 ml/min was noted at 6-month, followed by a reduction mean of 10.7 ml/min at 12-month and 24-month.

Among patients non-CKD, GFR mean in preceding 12-month was 83.7±11.4 ml/min. The eGFR mean was 80.4±14.7 ml/min at baseline, 70.3±10.4 ml/min at 6 months, 61.8±7.4 ml/min at 12-month, and 58.5±7.3 ml/min at conclusion of 24-month follow up. A decrease in eGFR mean of 10.1 ml/min in 6-month, 18.6 ml/min in 12-month, and 21.9 ml/min in 24-month was noted (Table III). The decline in eGFR was notably more pronounced at 12-month and 24-month following anti-VEGF treatment compared to the 12-month before the initiation of the drug in both patient groups.

Table IV displays a decline in eGFR among CKD and non-CKD patients. In CKD patients, a decrease was observed in eGFR exceeding 25% in 20%, 26.7%, and 33.3% of cases at 6-month, 12-month, and 24-month, respectively. Among non-CKD patients, a reduction in eGFR exceeding 25% was observed in 10%, 20%, and 30% of cases, respectively. In CKD patients, a 50% decrease was seen in 6.7% and 13.3% of cases at 12-month and 24-month, respectively, compared to 5% and 10% in non-CKD patients.

In interventional group, 6 patients (20%) of CKD needed renal replacement therapy (RRT) during follow up period, with a mean time of 21.2±11.4 months after receiving the initial dose. The progression risk to end stage CKD patients showed in figure 2. The mean age of this group at beginning was significant high than overall average age of 69 years, with a mean eGFR of < 32 ml/min at beginning of intervention and ACR exceeding 1000 mg/g at beginning of follow up. None of the patients in the control group required RRT.

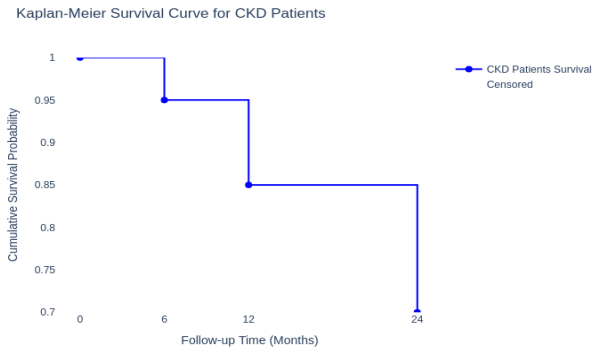

Figure. 2. ESRD risk in CKD treated patients.

Discussion

The main results of this study were that DM patients, both CKD and non-CKD, experienced significant kidney function decline following intravitreal anti-VEGF usage. The impact of systemic anti-VEGF administration on worsening AHT, increasing proteinuria, and declining kidney function is well-documented.[13] VEGF inhibitors are now the preferred treatment for various retinal diseases.[14] This ophthalmologic drug relies on local administration; however, studies indicate that some of these medications are absorbed into the bloodstream, leading to negative effects.[15] Growing evidence in literature suggests that intravitreal usage of these medications may lead to proteinuria and AHT, particularly in DM patients who frequently already have proteinuria, CKD, and hypertension.[16]

In contrast, studies by Diabetic Retinopathy Clinical Research Committee have questioned the impact of intravitreal antiangiogenic drugs on renal damage. These studies examined ACR in patients treated with bevacizumab, aflibercept, or ranibizumab over 52 weeks follow up. On average, patients administered 9 to 10 injections throughout the treatment. Across all interventional groups, over 77% of patients persisted proteinuria levels near baseline. Alternatively, 10% and 16% of patients showed a deterioration in ACR during follow up.[17] This study showed that these medications did not have a harmful impact on the control of proteinuria in patients.

In our cohort of treated patients, 75% experienced increased proteinuria during follow up, with this increase being significant greater at 24-month among both groups, including subgroup without prior CKD. The primary identified risk factors for progression to ESRD included older age, baseline albuminuria, and pre-existing CKD. This aligns with published data, which suggests that the risks associated with inhibition of anti-VEGF may be approximately 14% for progression of hypertension and 14% to 45% for the worsening of proteinuria.[18]

In this study, 57% patients received anti-VEGF exhibited significant decline in kidney function (defined as a reduction of more than 25% from baseline eGFR), while control group demonstrated significant more stable eGFR levels, though a decline remained noted. This decline was significant more pronounced in CKD group. At the end of the 24-month follow up, proteinuria raised in 75% patients who received treatment. Nevertheless, a significant raise in proteinuria was also observed among patients with CKD of control group at 12-month, although the raise was less significant. During the follow up period after first dose, 6 (20%) patients in CKD group needed renal replacement. These patients were significant older, had eGFR of less than 30 ml/min, and exhibited high proteinuria at baseline, compared to patients who received treatment and did not require renal replacement.

In terms of visual outcomes, this study found that 2/3 patients exhibited unchanged or enhanced visual acuity, along with enhanced optical coherence tomography measurements throughout the follow up. Conversely, 1/3 patients did not demonstrate any enhancement in their visual acuity. Significantly, 40% CKD patients experienced visual enhancement or maintenance. This considerable proportion of visual enhancement complicates the choice to halt anti-VEGF in CKD individuals, especially given the decline in eGFR at 24 months in this specific group and the relatively low incidence of kidney replacement, despite it not being absent. These results emphasize the necessity for studies involving larger patient populations to reach definitive conclusions.

The study limitations are noteworthy and include the following; study was retrospective, single centre with a limited patient population. Nevertheless, one of its strengths is that it reflects practical clinical setting, incorporating patients both CKD and non-CKD alongside a comparable control group.

Conclusion

In CKD patients of DM undergoing intravitreal injection of anti-VEGF, it is essential to closely monitor proteinuria, renal function, and blood pressure following administration. This approach will facilitate the early detection of effects of these medications on kidney function and may even allow for the contraindication of their usage in high-risk patients for the progression or exacerbation of CKD. Prospective studies are necessary to generate additional evidence to support these findings.

References

1. McBenedict B, Hauwanga W, Lizarazo JF, Djeagou A, Akram I. Diabetes Mellitus Mortality Trends in Brazil From 2000 to 2021: An In-Depth Joinpoint Analysis. Cureus. 2024;16(1):e51632. https://doi.org/10.7759/cureus.51632
2. Arrigo A, Aragona E, Bandello F. VEGF-targeting drugs for the treatment of retinal neovascularization in diabetic retinopathy. Ann Med. 2022;54(1):1089-1111. https://doi.org/10.1080/07853890.2022.2064541

3. Grzybowski A, Markeviciute A, Zemaitiene R. Treatment of macular edema in vascular retinal diseases: a 2021 update. J Clin Med. 2021;10(22):5300. https://doi.org/10.3390/jcm10225300
4. Gupta A. Bench-to-Bedside Research in Ophthalmology. Biomedical Translational Research: From Disease Diagnosis to Treatment. 2022:67-124. https://doi.org/10.1007/978-981-16-8845-4_5
5. Rosner MH, Jhaveri KD, McMahon BA, Perazella MA. Onconephrology: the intersections between the kidney and cancer. CA: Cancer J Clin. 2021;71(1):47-77. https://doi.org/10.3322/caac.21636
6. Shah AR, Van Horn AN, Verchinina L, Wichorek M, Su L, Markel D, et al. Blood pressure is associated with receiving intravitreal anti-vascular endothelial growth factor treatment in patients with diabetes. Ophthalmol Retina. 2019;3(5):410-416. https://doi.org/10.1016/j.oret.2019.01.019
7. Russo G, Barbieri MA, Sorbara EE, Cicala G, Franchina T, Santarpia M, et al. Renal Disorders with Oral Tyrosine Kinase Inhibitors in Metastatic Colorectal Cancer: An Analysis from the FDA Adverse Event Reporting System Database. Biomedicines. 2023;11(8):2311. https://doi.org/10.3390/biomedicines11082311
8. Hanna RM, Barsoum M, Arman F, Selamet U, Hasnain H, Kurtz I. Nephrotoxicity induced by intravitreal vascular endothelial growth factor inhibitors: emerging evidence. Kidney Int. 2019;96(3):572-580. https://doi.org/10.1016/j.kint.2019.02.042
9. Melincovici CS, Boşca AB, Şuşman S, Marginean M, Mihu C, Istrate M, et al. Vascular endothelial growth factor (VEGF)-key factor in normal and pathological angiogenesis. Rom J Morphol Embryol. 2018;59(2):455-467.
10. Phadke G, Hanna RM, Ferrey A, Torres EA, Singla A, Kaushal A, et al. Review of intravitreal VEGF inhibitor toxicity and report of collapsing FSGS with TMA in a patient with age-related macular degeneration. Clin Kidney J. 2021;14(10):2158-2165. https://doi.org/10.1093/ckj/sfab066
11. Hanna RM, Lopez EA, Hasnain H, Selamet U, Wilson J, Youssef PN, et al. Three patients with injection of intravitreal vascular endothelial growth factor inhibitors and subsequent exacerbation of chronic proteinuria and hypertension. Clin Kidney J. 2019;12(1):92-100. https://doi.org/10.1093/ckj/sfy060
12. O'Neill RA, Gallagher P, Douglas T, Little JA, Maxwell AP, Silvestri G, et al. Evaluation of long-term intravitreal anti-vascular endothelial growth factor injections on renal function in patients with and without diabetic kidney disease. BMC Nephrol. 2019;20:1-7. https://doi.org/10.1186/s12882-019-1650-1
13. van Dorst DC, Kabadayi S, Oomen-de Hoop E, Danser AJ, Mathijssen RH, Versmissen J. Treatment and Implications of vascular endothelial growth factor inhibitor-induced blood pressure rise: a clinical Cohort Study. J Am Heart Assoc. 2023;12(1):e028050. https://doi.org/10.1161/JAHA.122.028050
14. Shye M, Hanna RM, Patel SS, Tram-Tran N, Hou J, Mccannel C, et al. Worsening proteinuria and renal function after intravitreal vascular endothelial growth factor blockade for diabetic proliferative retinopathy. Clin Kidney J. 2020;13(6):969-980. https://doi.org/10.1093/ckj/sfaa049
15. Hanna RM, Lopez E, Wilson J, Barathan S, Cohen AH. Minimal change disease onset observed after bevacizumab administration. Clin Kidney J. 2016;9(2):239-244. https://doi.org/10.1093/ckj/sfv139
16. Zafar S, Walder A, Virani S, Biggerstaff K, Orengo-Nania S, Chang J, et al. Systemic adverse events among patients with diabetes treated with intravitreal anti-vascular endothelial growth factor injections. JAMA Ophthalmol. 2023;141(7):658-666. https://doi.org/10.1001/jamaophthalmol.2023.2098
17. Rivero M, Fernández-Vidal M, Sandino J, Rico RB, Moliz C, Ruiz-Cabello JE, et al. Effect of Intravitreal Anti-Endothelial Growth Factor Agents on Renal Function in Patients with Diabetes Mellitus. Kidney Int Rep. 2024;9(5):1397-1405. https://doi.org/10.1016/j.ekir.2024.02.003
18. Chebotareva N, Grechukhina K, Mcdonnell V, Zhukova L, Krasnova T. Early biomarkers of nephrotoxicity associated with the use of anti VEGF drugs. Biomed. Rep. 2022;16(6):1-10. https://doi.org/10.3892/br.2022.1529