J Nephropharmacol. 2025; 14(x): e12745.

https://jnephropharmacology.com DOI: 10.34172/npj.2025.12745

Journal of Nephropharmacology

Complications of remdesivir in COVID-19 patients with kidney disease: a retrospective cohort study

Neda Najafi[1], Houshang Sanadgol[1*], Hounaz Akbari[1], Asal Sadat Karimi[2], Negin Sanadgol[2], Atra Ajdari[2], Mohsen Vahedi[3]

[1]Department of Nephrology, Hasheminejad Kidney Center, School of Medicine, Iran University of Medical Sciences, Tehran, Iran
[2]Research Committee, School of Medicine, Iran University of Medical Sciences, Tehran, Iran
[3]Department of Biostatistics, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran

ARTICLE INFO

Article Type:
Original

Article History:
Received: 29 Aug. 2024
Revised: 21 Oct. 2024
Accepted: 8 Apr. 2025
ePublished: 30 Jun. 2025

Keywords:
COVID-19
Remdesivir
Kidney impairment
Liver function
Inflammatory markers

ABSTRACT

Introduction: The COVID-19 pandemic has highlighted the vulnerability of patients with chronic kidney disease (CKD) to severe complications from the virus. Remdesivir, an antiviral drug initially developed for Ebola, has emerged as a treatment option for COVID-19, yet its safety and efficacy in patients with kidney disease remain under investigation.

Objectives: This study aims to evaluate the complications associated with remdesivir in COVID-19 patients who have pre-existing kidney conditions.

Patients and Methods: This retrospective cohort study involved 230 COVID-19 patients who were referred to Hasheminejad hospital in Tehran between October 2021 and July 2022, all of whom received a minimum of 100 mg of remdesivir. Participants were categorized based on their history of kidney disease into groups comprising those with CKD, end-stage renal disease (ESRD), and kidney transplant (KT) recipients as well as patients without a history of kidney disease including those with consistently normal kidney function. The study assessed demographic data and laboratory parameters related to liver function, specifically measuring alanine aminotransferase (ALT) and aspartate aminotransferase (AST), along with lactate dehydrogenase (LDH) levels, as well as inflammatory markers, including C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR), at both baseline and post-treatment intervals. Data were compared between groups using analytical tests.

Results: Out of 230 included patients, 145 showed no kidney impairment, while 30 had CKD, 35 had undergone KT, and 20 were ESRD. The results indicated that there were no significant differences in liver enzyme levels (including AST and ALT), inflammatory markers (including CRP and ESR), and LDH, from pre- to post-administration of remdesivir between patients with kidney impairment and those without. Additionally, no differences were found among different kidney impairment groups such as CKD, KT, and ESRD. However, LDH and ESR levels were significantly higher in KT patients compared to those without kidney impairment, raising potential concerns for this population.

Conclusion: The findings suggest that remdesivir-related complications concerning liver function, inflammatory markers, and LDH levels did not show significant differences between patients with or without kidney impairment, particular attention should be given to KT recipients due to observed significant increases in LDH and ESR, which may indicate a higher risk of adverse outcomes in this vulnerable population.

Implication for health policy/practice/research/medical education:
In this cohort study, we found that remdesivir does not significantly affect liver function, inflammation level, or lactate dehydrogenase in patients with kidney impairment, suggesting its safety in this population. However, the significantly higher levels of with lactate dehydrogenase (LDH) and erythrocyte sedimentation rate (ESR) observed in kidney transplant patients compared to those without kidney impairment highlight a potential vulnerability that necessitates closer monitoring and tailored management strategies for this group. Overall, remdesivir appears safe regarding liver function and inflammatory responses, the findings warrant further investigation into the implications for kidney transplant patients receiving this antiviral therapy..

Please cite this paper as: Najafi N, Sanadgol H, Akbari H, Karimi AS, Sanadgol N, Ajdari A, Vahedi M. Complications of remdesivir in COVID-19 patients with kidney disease: a retrospective cohort study. J Nephropharmacol. 2025;14(2):e12745. DOI: 10.34172/npj.2025.12745.

***Corresponding author**: Houshang Sanadgol, Email: sanadgol@yahoo.com, sanadgol.H@iums.ac.ir

Original

Introduction

COVID-19 began in December 2019 in Wuhan, Hubei province, China, where the first cases were linked to a seafood market. The causative agent, identified as SARS-CoV-2, is a novel coronavirus closely related to bat coronaviruses, indicating zoonotic origins with potential intermediate hosts. This outbreak rapidly escalated into a global health crisis, leading the World Health Organization to declare it a public health emergency of international concern on January 30, 2020, and later a pandemic on March 11, 2020 (1). Until May 2023, the COVID-19 pandemic has resulted in over 676 million confirmed cases and 6.8 million deaths globally (2).

Kidney damage due to COVID-19 has emerged as a significant complication, with studies indicating that acute kidney injury (AKI) occurs in a notable percentage of hospitalized patients, particularly those with severe illness. The mechanisms behind kidney injury may include direct viral invasion of renal epithelial cells, systemic inflammation, and microvascular thrombosis, which can lead to disrupted kidney function. Research has shown that patients with pre-existing chronic kidney disease (CKD) are at higher risk for worse outcomes, and AKI in COVID-19 patients is associated with increased mortality rates (3,4). Additionally, long-term follow-up studies suggest that even after recovery from acute illness, some patients may experience persistent renal impairment, highlighting the need for ongoing monitoring and management of kidney health in COVID-19 survivors (5).

Remdesivir has emerged as a significant antiviral treatment for COVID-19, particularly for hospitalized patients, due to its ability to inhibit the replication of the SARS-CoV-2 virus. Studies indicate that remdesivir can lead to faster recovery times and reduced duration of hospitalization, although its effect on mortality rates remains debated (6,7). A systematic review highlighted that when remdesivir administered in combination with other therapies, such as convalescent plasma, this drug was associated with a significantly lower risk of death in hospitalized patients (8). Furthermore, recent analysis has examined its efficacy across various patient populations, including those with specific health conditions, underscoring the importance of tailoring treatment approaches (9). Despite some concerns regarding the drug's side effects, it continues to be a key component of COVID-19 management protocols worldwide (10).

While remdesivir has demonstrated efficacy in shortening recovery time and reducing mortality in COVID-19 patients, its use in those with renal impairment is complicated by concerns over nephrotoxicity due to the drug's metabolites and its vehicle, particularly in individuals with an estimated glomerular filtration rate (eGFR) below 30 mL/min (11). Previous studies indicated that patients with CKD may experience a higher risk of severe COVID-19 outcomes; however, the safety profile of remdesivir in this population remains uncertain due to their exclusion from large clinical trials (12). A prior review study also highlighted that despite a high mortality rate among CKD patients with COVID-19, no significant increase in adverse effects was reported from remdesivir administration, suggesting that careful patient selection and monitoring could allow for its use in certain cases (13). However, further research is necessary to establish clear guidelines for safely administering remdesivir in CKD patients (14). This study aimed to evaluate the safety and efficacy of remdesivir in patients with pre-existing kidney disease who are hospitalized due to COVID-19.

Objectives

The objective of this study is to evaluate the complications associated with remdesivir treatment in patients with COVID-19 who have a history of kidney disease. Specifically, the study aims to compare the incidence of liver dysfunction and inflammatory disorders between patients with and without pre-existing kidney conditions. By analyzing clinical outcomes and laboratory data, this research seeks to provide insights into the safety and efficacy of remdesivir in this vulnerable population, eventually informing clinical decision-making and treatment protocols.

Patients and Methods

Study design and participants

The STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) Guidelines were used to conduct this retrospective cohort study (15). This study included 230 patients with confirmed SARS-CoV-2 infection, diagnosed through either chest computed tomography (CT) scans or reverse transcription polymerase chain reaction (RT-PCR), who were admitted to the Hasheminejad kidney center between October 2021 and July 2022 and received at least 100 mg of remdesivir. The study analyzed the medical records of these hospitalized COVID-19 patients to evaluate complications, particularly focusing on liver dysfunction and inflammatory disorders. Patients were divided into two groups based on their history of kidney disease; those with CKD defined as a GFR of less than 60 mL/min for more than three months, end-stage renal disease (ESRD) characterized by a GFR of less than 15 mL/min requiring hemodialysis or peritoneal dialysis, and kidney transplant (KT) recipients. Patients without a history of kidney disease included those with consistently normal kidney function, defined as a GFR greater than 60 mL/min.

Inclusion and Exclusion criteria

Inclusion criteria for this study comprised adults aged 18 years and older who had a confirmed diagnosis of COVID-19 based on either a lung CT scan or RT-PCR test and who received at least one dose of remdesivir (100 mg). Patients who were receiving other antiviral treatments concurrently were excluded from the study.

Data collection

Data collection for this study involved gathering detailed demographic, clinical, and laboratory information from participants. Demographic data included age, sex, and comorbidities such as diabetes mellitus (DM), hypertension (HTN), and ischemic heart disease (IHD). Clinical variables focused on the dosage of remdesivir administered to each patient. Laboratory parameters assessed liver function through measurements of alanine aminotransferase (ALT), aspartate aminotransferase (AST), and lactate dehydrogenase (LDH) at both baseline and post-treatment. Additionally, inflammatory markers were evaluated using C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR), while renal function was monitored through serum creatinine levels and eGFR.

Outcomes

The primary outcome of this study is to evaluate changes in liver enzymes, inflammatory markers, and LDH before and after remdesivir administration in patients with and without renal impairment. Additionally, the study aims to compare these changes among three subgroups of patients with renal impairment: those with CKD, ESRD, and KT recipients. By analyzing these parameters, the study seeks to identify potential differences in the impact of remdesivir on liver function and inflammation across these patient populations.

Statistical analysis

Data analysis was performed using the Statistical Package for Social Sciences (SPSS) software (IBM Corp, USA) to process the collected information. The normality of the data was evaluated with the Kolmogorov-Smirnov test. To compare qualitative and quantitative variables between the control and case groups, the chi-square or Fishers' exact tests and one-way ANOVA were utilized. Furthermore, the post hoc least significant difference (LSD) test was applied to assess mean differences among the groups. A *P* value of less than 0.05 was deemed statistically significant, indicating meaningful differences in the analyzed variables.

Results

Among the 230 patients included in the study, 145 did not have kidney impairment, while 30 were diagnosed with CKD, 35 were KT recipients, and 20 had ESRD. The analysis revealed no statistically significant differences in the frequency distribution of key demographic and clinical characteristics, including age, gender, DM, HTN, and IHD, among patients with kidney impairment (CKD, kidney transplantation and ESRD) and those without kidney impairment. These findings suggest comparable baseline profiles across all groups, implying that factors such as age, sex, and common comorbidities did not disproportionately influence the observed outcomes in this cohort (Table 1).

The results indicated that the frequency distribution of laboratory findings, including AST, ALT, LDH, ESR), and CRP, at baseline before remdesivir administration did not show statistically significant differences between patients with kidney impairment (CKD, kidney transplantation and ESRD) and those without kidney impairment. Following remdesivir treatment, the mean values for AST, ALT, ESR, and CRP also remained statistically non-significant across these groups; however, LDH levels were found to be significant. Furthermore, the changes observed in AST, ALT, and CRP from pre- to post-administration of remdesivir did not yield statistically significant differences between the groups, while changes in ESR and LDH were statistically significant (Table 2).

The results demonstrated that the changes in liver

Table 1. Frequency distribution of demographic characteristics among patients without and with kidney impairment across three distinct groups

Variable		Group								*P* value
		No kidney impairment (n = 145)		CKD (n = 30)		KT (n = 35)		ESRD (n = 20)		
		N	%	N	%	N	%	N	%	
Gender	Male (n= 139)	82	59	20	14.4	23	16.5	14	10.1	0.462*
	Female (n=91)	63	69.2	10	11	12	13.2	6	6.6	
DM	No (n= 171)	112	65.5	19	11.1	25	14.6	15	8.8	0.439*
	Yes (n= 59)	33	55.9	11	18.6	10	16.9	5	8.6	
HTN	No (n= 136)	93	68.4	13	9.6	21	15.4	9	6.6	0.099*
	Yes (n= 94)	52	55.3	17	18.1	14	14.9	11	11.7	
IHD	No (n= 204)	127	62.3	27	13.2	32	15.7	18	8.8	0.969**
	Yes (n= 26)	18	69.3	3	11.5	3	11.5	2	7.7	
Variable		**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	***P* value**
Age (year)		55.39	16.00	60.83	13.69	53.31	13.34	59.00	16.77	0.176***
Remdesivir dosage (mg)		582.75	156.50	600.0	155.36	622.85	181.63	525.00	209.94	0.196***

CKD, Chronic kidney disease; KT, Kidney transplantation; ESRD, End-stage renal disease; SD, Standard deviation; HTN, Hypertension; DM, Diabetes mellitus; IHD, Ischemic heart diseases.
*Chi-square; **Fishers' exact test; ***ANOVA.

Table 2. Frequency distribution of laboratory findings among patients without and with kidney impairment across three distinct groups

Variable		Group								*P* value*
		No kidney impairment (n = 145)		CKD (n = 30)		KT (n = 35)		ESRD (n = 20)		
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	
AST (U/L)	Baseline	58.87	47.77	57.26	53.74	61.45	89.21	32.77	25.05	0.451
	After treatment	70.49	65.58	78.81	76.76	85.13	116.54	44.31	24.41	0.419
	Changes	11.62	38.93	21.52	57.34	23.68	72.18	11.54	11.85	0.559
ALT (U/L)	Baseline	58.47	57.88	50.42	46.38	38.75	27.66	28.08	15.15	0.085
	After treatment	72.06	74.55	66.69	59.06	66.58	98.31	38.18	15.59	0.565
	Changes	13.72	37.27	16.42	45.37	27.26	85.08	9.00	12.54	0.570
LDH (U/L)	Baseline	607.79	300.12	577.12	319.19	661.31	418.04	455.38	170.56	0.287
	After treatment	619.69	367.37	772.36	869.20	1309.9	1927.5	843.92	1148.3	0.022
	Changes	11.90	294.65	203.33	697.16	648.65	1719.1	338.54	1150.2	0.012
CRP (mg/L)	Baseline	68.30	51.80	50.25	39.07	56.36	37.40	44.69	30.31	0.305
	After treatment	35.53	47.63	27.39	46.48	22.08	21.41	35.76	21.82	0.627
	Changes	32.77	57.07	22.85	62.95	34.28	31.20	8.93	21.48	0.602
ESR (mm/h)	Baseline	44.13	24.82	72.33	37.31	60.70	35.24	57.25	44.43	0.062
	After treatment	36.00	25.83	57.87	42.06	22.70	21.48	60.20	65.12	0.053
	Changes	8.38	23.39	14.47	28.27	38.00	22.36	2.95	63.56	0.021

CKD, Chronic kidney disease; KT, Kidney transplant; ESRD, End-stage renal disease; SD, Standard deviation; ALT, Alanine aminotransferase; AST, Aspartate aminotransferase; LDH, Lactate dehydrogenase; CRP, C-reactive protein; ESR, Erythrocyte sedimentation rate.
* ANOVA.

enzymes, specifically AST and ALT, as well as LDH levels, from pre- to post-administration of remdesivir did not significantly differ between patients with kidney impairment and those without. Additionally, comparisons among various kidney impairment groups, including CKD, kidney transplantation and ESRD patients, revealed no significant differences in these enzyme levels. However, a notable exception was observed in LDH levels, which were significantly higher in kidney transplantation compared to those without kidney impairment, indicating a potential area of concern for this specific patient population (Table 3).

The results indicated that the changes in inflammatory markers, specifically CRP and ESR, from pre- to post-remdesivir administration did not show significant differences between patients with kidney impairment and those without, nor among the various kidney impairment groups, including CKD, kidney transplantation and ESRD patients. However, a significant difference was noted in ESR levels, with KT patients exhibiting markedly higher values compared to those without kidney impairment, highlighting a potential concern for this particular group (Table 4).

Discussion

Our findings suggest that remdesivir does not significantly impact liver function, inflammation levels, or LDH in patients with kidney impairment, supporting its safety within this population. However, KT patients demonstrated significantly higher LDH and ESR levels compared to individuals without kidney impairment. This highlights a potential vulnerability in KT recipients, emphasizing the need for closer monitoring and individualized management strategies to mitigate any associated risks during remdesivir treatment. This finding aligns with previous studies that have also reported the drug's safety profile in similar populations; in a study by Chang et al, remdesivir was found to be well-tolerated among hospitalized COVID-19 patients, irrespective of their renal function. They stated that these findings reinforce the recent guidelines recommending the administration of remdesivir in individuals with severe renal impairment, suggesting that its benefits can be safely extended to this high-risk group (16). In another study, Biancalana et al found that remdesivir does not affect eGFR in a group of elderly patients with COVID-19 (17). In a clinical trial by Sise et al, the authors concluded that remdesivir is a safe treatment option for patients with COVID-19 and severe kidney impairment, addressing prior concerns about its use in this high-risk population (18).

In contrast with our study, the study by Chang et al demonstrated that hospitalized COVID-19 patients with severe renal impairment who were treated with remdesivir faced a higher risk of developing AKI, increased hospital mortality, and greater progression of COVID-19 compared to those without severe renal impairment (11). In a retrospective study by Pettit et al, 20 subjects of 135 patients who received remdesivir had GFR of less than 30 mL/min. Serum creatinine elevation was more frequent in groups with kidney dysfunction compared to those without kidney dysfunction. However, it was challenging to ascertain whether the observed elevations in liver functional tests or serum creatinine levels were attributable to the SARS-CoV-2 infection or to remdesivir

Table 3. Comparison analysis of changes observed in Liver enzymes and LDH from pre- to post-administration of remdesivir between patients with kidney impairment (CKD, kidney transplantation and ESRD) and those without kidney impairment

First group			Second group	Mean difference	*P* value*
Liver enzymes and LDH	AST	No kidney impairment	CKD	9.89	0.343
			KT	12.05	0.224
			ESRD	0.08	0.995
		CKD	KT	2.15	0.865
			ESRD	9.98	0.541
		KT	ESRD	12.13	0.448
	ALT	No kidney impairment	CKD	2.70	0.805
			KT	13.53	0.186
			ESRD	4.72	0.765
		CKD	KT	10.83	0.414
			ESRD	7.42	0.679
		KT	ESRD	18.25	0.297
	LDH	No kidney impairment	CKD	191.42	0.343
			KT	636.74	0.001
			ESRD	376.63	0.148
		CKD	KT	445.32	0.073
			ESRD	185.20	0.537
		KT	ESRD	260.11	0.380

CKD, Chronic kidney disease; KT, Kidney transplant; ESRD, End-stage renal disease; ALT, Alanine aminotransferase; AST, Aspartate aminotransferase; LDH, Lactate dehydrogenase.
* ANOVA and post hoc LSD test.

Table 4. Comparison analysis of changes observed in inflammatory indicators from pre- to post-administration of remdesivir between patients with kidney impairment (CKD, kidney transplantation and ESRD) and those without kidney impairment

First group			Second group	Mean difference	*P* value*
Inflammatory indicators	CRP	No kidney impairment	CKD	9.91	0.509
			KT	1.51	0.911
			ESRD	23.84	0.229
		CKD	KT	11.43	0.535
			ESRD	13.92	0.551
		KT	ESRD	25.35	0.261
	ESR	No kidney impairment	CKD	6.09	0.555
			KT	29.62	0.004
			ESRD	11.32	0.439
		CKD	KT	23.53	0.069
			ESRD	17.41	0.299
		KT	ESRD	40.95	0.015

CKD, Chronic kidney disease; KT, Kidney transplant; ESRD, End-stage renal disease; CRP, C-reactive protein; ESR, Erythrocyte sedimentation rate.
* ANOVA and post hoc LSD test.

treatment (19).

The findings suggest that remdesivir is a generally safe antiviral treatment for COVID-19 patients with kidney impairment, as no significant complications were observed in this population. This is an important insight, given the initial concerns surrounding the use of remdesivir in individuals with compromised renal function due to its potential nephrotoxic effects. The absence of major adverse effects in this group supports the broader applicability of remdesivir in managing COVID-19 among patients with varying degrees of kidney dysfunction. However, the findings also highlight the need for special caution when using remdesivir in KT recipients. This subgroup may face unique risks, possibly due to interactions with immunosuppressive therapies or heightened vulnerability to drug-induced nephrotoxicity. These potential risks underscore the importance of individualized risk-benefit assessments and close monitoring when prescribing remdesivir to transplant patients. In conclusion, while remdesivir appears to be a viable treatment option for most COVID-19 patients with kidney impairment, clinicians should exercise heightened vigilance in KT recipients. Further research is warranted to better understand the specific risks and mechanisms affecting this subgroup, as well as to optimize treatment protocols for these vulnerable patients.

Conclusion

The findings of this study provide valuable insights into the safety profile of remdesivir in patients with varying degrees of kidney impairment. Notably, the absence of significant differences in liver enzyme levels (AST and ALT), inflammatory markers (CRP and ESR), and LDH from pre- to post-administration of remdesivir suggests that the drug does not exacerbate liver function or inflammatory responses in this patient population. This is particularly encouraging given the concerns surrounding the use of antiviral therapies in individuals with pre-existing renal conditions. However, the observation that LDH and ESR levels were significantly higher in KT patients compared to those without kidney impairment raises important considerations for clinical practice. This finding indicates a potential vulnerability within the KT population, which may necessitate closer monitoring and tailored management strategies when administering remdesivir. In conclusion, while remdesivir appears to be safe regarding liver enzyme and inflammatory marker levels across different kidney impairment groups, the elevated LDH and ESR in KT patients warrant further investigation. Future studies should focus on understanding the implications of these findings to ensure optimal treatment protocols for COVID-19 patients with kidney disease, particularly those who have undergone transplantation.

Limitations of the study

First of all, the retrospective design inherently limits the ability to establish causality between remdesivir treatment and observed complications, as it relies on previously collected data that may not capture all relevant variables. Second, the study's reliance on medical records may introduce biases related to data completeness and accuracy, particularly regarding laboratory results and patient histories. Additionally, the sample size, while adequate, may not fully represent the broader population of COVID-19 patients with kidney disease, potentially limiting the generalizability of the findings. The exclusion of patients receiving concurrent antiviral treatments could also skew results, as these individuals may have different outcomes compared to those treated solely with remdesivir. These limitations highlight the need for further prospective studies to validate the findings and better understand the implications of remdesivir in this vulnerable patient population.

Acknowledgments

The authors would like to express their heartfelt appreciation to the staff and administration of Hasheminejad Hospital in Tehran for their support and collaboration throughout this study.

Authors' contribution

Conceptualization: Neda Najafi and Houshang Sanadgol.
Data curation: Neda Najafi and Atra Ajdari.
Formal analysis: Asal Sadat Karimi and Hounaz Akbari.
Investigation: Mohsen Vahedi and Negin Sanadgol.
Methodology: Hounaz Akbari and Asal Sadat Karimi.
Project Management: Houshang Sanadgol.
Resources: All authors.
Supervision: Neda Najafi.
Validation: Asal Sadat Karimi and Negin Sanadgol.
Writing–original draft: All authors.
Writing–reviewing and editing: All authors.

Conflicts of interest

The authors declare no conflict of interest.

Ethical issues

The research was conducted in accordance with the Declaration of Helsinki. This study resulted from the research project (No. 22308), with the Ethical code (IR.IUMS.FMD.REC.1401.159; https://ethics.research.ac.ir/EthicsProposalView.php?id=262908), approved by the Iran University of Medical Sciences, Tehran, Iran. Prior to any intervention, all participants provided written informed consent. Besides, the authors have ultimately observed ethical issues (including plagiarism, data fabrication, and double publication).

Funding/Support

The funding was supported by the Iran University of Medical Sciences (Grant #22308).

References

1. Berekaa MM. Insights into the COVID-19 pandemic: origin, pathogenesis, diagnosis, and therapeutic interventions. Front Biosci (Elite Ed). 2021;13:117-39. doi: 10.2741/874.
2. Lin CF, Chang SH. Advanced mobile communication techniques in the fight against the COVID-19 pandemic era and beyond: an overview of 5G/B5G/6G. Sensors (Basel). 2023;23:7817. doi: 10.3390/s23187817.
3. Pal M, Nawn D, Lahiri P, Das D, Paul RR, Chakraborty D. Malignant potentiality assessment of oral submucous fibrosis through semi-quantitative approach. J Oral Maxillofac Pathol. 2020;24:188. doi: 10.4103/jomfp.JOMFP_297_19.
4. Zhen T, Cao Y, Ren G, Zhao L, Hyde RK, Lopez G, et al. RUNX1 and CBFβ-SMMHC transactivate target genes together in abnormal myeloid progenitors for leukemia development. Blood. 2020;136:2373-85. doi: 10.1182/blood.2020007747.
5. Zeng L, Li C, Jiang H, Chen Y, Li Z, Xu F, et al. Total saponins from *Nigella glandulifera* seeds ameliorate adjuvant-induced rheumatoid arthritis in rats by inhibition of an inflammatory response and bone erosion. Biomed Res Int. 2021;2021:6613527. doi: 10.1155/2021/6613527.
6. Allen R, Turner M, deSouza IS. Remdesivir for the treatment of COVID-19. Am Fam Physician. 2022;105:131-2.
7. Qomara WF, Primanissa DN, Amalia SH, Purwadi FV, Zakiyah N. Effectiveness of remdesivir, lopinavir/ritonavir, and favipiravir for COVID-19 treatment: a systematic

review. Int J Gen Med. 2021;14:8557-71. doi: 10.2147/ijgm.S332458.
8. Franchini M, Focosi D, Cruciani M, Joyner MJ, Pirofski LA, Senefeld JW, et al. Safety and efficacy of convalescent plasma combined with other pharmaceutical agents for treatment of COVID-19 in hospitalized patients: a systematic review and meta-analysis. Diseases. 2024;12:41. doi: 10.3390/diseases12030041.
9. Chen C, Fang J, Chen S, Rajaofera MJN, Li X, Wang B, et al. The efficacy and safety of remdesivir alone and in combination with other drugs for the treatment of COVID-19: a systematic review and meta-analysis. BMC Infect Dis. 2023;23:672. doi: 10.1186/s12879-023-08525-0.
10. Ansems K, Grundeis F, Dahms K, Mikolajewska A, Thieme V, Piechotta V, et al. Remdesivir for the treatment of COVID-19. Cochrane Database Syst Rev. 2021;8:CD014962. doi: 10.1002/14651858.Cd014962.
11. Chang HY, Hsu CC, Hu LF, Chou CY, Chang YL, Lu CC, et al. Safety and effectiveness of remdesivir in hospitalized patients with COVID-19 and severe renal impairment: experience at a large medical center. Ann Med. 2024;56:2361843. doi: 10.1080/07853890.2024.2361843.
12. Adamsick ML, Gandhi RG, Bidell MR, Elshaboury RH, Bhattacharyya RP, Kim AY, et al. Remdesivir in patients with acute or chronic kidney disease and COVID-19. J Am Soc Nephrol. 2020;31:1384-6. doi: 10.1681/asn.2020050589.
13. Al Bishawi A, Abdel Hadi H, Elmekaty E, Al Samawi M, Nair A, Abou Kamar M, et al. Remdesivir for COVID-19 pneumonia in patients with severe chronic kidney disease: a case series and review of the literature. Clin Case Rep. 2022;10:e05467. doi: 10.1002/ccr3.5467.
14. Huang W, Li B, Jiang N, Zhang F, Shi W, Zuo L, et al. Impact of the COVID-19 pandemic on patients with chronic kidney disease: a narrative review. Medicine (Baltimore). 2022;101:e29362. doi: 10.1097/md.0000000000029362.
15. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. BMJ. 2007;335:806-8. doi: 10.1136/bmj.39335.541782.AD.
16. Chang MC, Wu PF, Ho YC, Lin WY, Wu CY, Liu SY, et al. Clinical outcomes and safety of remdesivir in hospitalized individuals with COVID-19, with or without severe renal impairment. J Infect Public Health. 2024;17:102460. doi: 10.1016/j.jiph.2024.05.048.
17. Biancalana E, Chiriacò M, Sciarrone P, Mengozzi A, Mechelli S, Taddei S, et al. Remdesivir, renal function and short-term clinical outcomes in elderly COVID-19 pneumonia patients: a single-centre study. Clin Interv Aging. 2021;16:1037-46. doi: 10.2147/cia.S313028.
18. Sise ME, Santos JR, Goldman JD, Tuttle KR, Teixeira JP, Seibert AF, et al. Efficacy and safety of remdesivir in people with impaired kidney function hospitalized for COVID-19 pneumonia: a randomized clinical trial. Clin Infect Dis. 2024;79:1172-81. doi: 10.1093/cid/ciae333.
19. Pettit NN, Pisano J, Nguyen CT, Lew AK, Hazra A, Sherer R, et al. Remdesivir use in the setting of severe renal impairment: a theoretical concern or real risk? Clin Infect Dis. 2021;73:e3990-5. doi: 10.1093/cid/ciaa1851.