REVIEW ARTICLE
J Mycol Infect 2023; 28(2): 28-34
pISSN:1226-4709, eISSN:2465-8278
https://dx.doi.org/10.17966/JMI.2023.28.2.28

JMI

Hepatitis C Infection and Chronic Renal Diseases: A Systematic Review

Tara Titian Maulidya[1†], Fauzio Nurul Khaira[2], Febi Ramdhani Rachman[3] and Reynold Harris Malingkas[4]

[1]Sariningsih Hospital, Bandung, Indonesia
[2]Balaraja Hospital, Banten, Indonesia
[3]Al Islam Bandung Hospital, Indonesia
[4]Kasih Bunda General Hospital, Cimahi Indonesia

A connection was reported between hepatitis C virus (HCV) and chronic kidney disease (CKD). A viral infection can be both a cause and a consequence of CKD. HCV infection is associated with a greater incidence of diabetes mellitus and CKD and a higher risk of systemic (particularly cardiovascular) effects because HCV infection increases the chance of illness developing. Although the fundamental symptom of HCV-induced glomerulonephritis has been well documented, the virus has been related to CKD in various ways, i.e., new evidence points to a connection between HCV infection and CKD onset, as well as the rapid advancement of CKD to end-stage renal disease, which calls for kidney transplantation or hemodialysis. An HCV infection dramatically increased a person's risk of developing CKD, which can lead to kidney failure. Compared with patients with HCV infection and existing CKD, those with HCV infection who had normal renal function had greater odds of renal progression. The administration of anti-hepatitis medication can result in variations in the estimated glomerular filtration rate, which can either lead to an improvement or a worsening of the patient's health, depending on which direction the variation goes.

Key Words: Chronic renal disease, End-stage renal disease, Hepatitis C, Interferon

INTRODUCTION

Globally, over 71 million people are infected with hepatitis C virus (HCV), resulting in over 399,000 deaths, primarily due to cirrhosis or hepatocellular cancer (HCC)[1,2]. As research mostly focuses on liver-associated consequences, especially cirrhosis and HCC, HCV-related mortality and morbidity are typically underestimated. Several patients with HCV have a broad spectrum of extrahepatic symptoms[3,4]. Included among these are mixed cryoglobulinemia/cryoglobulinemia vasculitis, B-cell non-Hodgkin's lymphoma, type 2 diabetes mellitus, glomerulonephritis, renal insufficiency, lichen planus, porphyria cutanea tarda, and cardiovascular disease events[5].

Since its discovery, HCV has been related to chronic kidney disease (CKD). A viral infection may be a cause or an effect of CKD[6]. HCV infection is related to a higher incidence of diabetes mellitus and CKD and a higher risk of systemic (particularly cardiovascular) consequences. The basic symptom of HCV-induced glomerulonephritis has been widely characterized; however, the virus has been associated with CKD in various other ways. Growing data indicate the link between HCV infection and initial CKD, as well as the rapid progression

Received: May 7, 2023 Revised: May 26, 2023 Accepted: June 19, 2023
†Corresponding: Tara Titian Maulidya, Sariningsih Hospital, Bandung, Indonesia.
e-mail: taratitian19@gmail.com

of CKD to end-stage renal disease (ESRD) requiring transplant or hemodialysis[6-10].

Fortunately, evidence suggests that >95% of patients with late-stage CKD and recipients of kidney transplantation can attain sustained virologic response. All patients with CKD and HCV infection should be considered for therapy with direct-acting antivirals (DAAs), prioritizing those with symptomatic cryoglobulinaemic vasculitis, severe liver fibrosis, and CKD stages 4~5, according to international guidelines. DAA therapy can be deferred until after transplantation for recipients whose transplant waiting time is drastically reduced by accepting an HCV-positive organ. The long-term renal safety of DAAs is a new concern that deserves reevaluation[7,11,12].

This study aimed to determine the association between HCV infection and chronic renal diseases.

METHODS

Protocol

This study was conducted in a manner that is compliant with the requirements outlined in the Preferred Reporting Items for Systematic Review and Meta-Analysis 2020 guidelines to ensure that the study findings are honest and accurate.

Criteria for eligibility

This literature review aimed to investigate and analyze the findings of previous studies about the connection between HCV infection and chronic renal disorders. Ongoing investigations have uncovered a serious obstacle to be addressed. Participation in the study requires meeting one or more of the following criteria: (1) For papers to be considered for publication, they must be written in English and discuss the association between HCV infection and CKDs. (2) The analysis takes into account articles that were published after 2018 but before the study period. Some examples include editorials, submissions without a DOI, published review articles, and duplicate journal entries.

Search strategy

The terms "hepatitis C" and "chronic kidney disease" were used. The search for studies eligible for inclusion in the systematic review was conducted from February 15, 2023, using the PubMed and SagePub databases by inputting the following keywords: ("hepatitis c, chronic" [MeSH Terms] OR "chronic hepatitis c" [All Fields] OR "hepatitis c chronic" [All Fields]) AND ("kidney diseases" [MeSH Terms] OR ("kidney" [All Fields] AND "diseases" [All Fields]) OR "kidney diseases" [All Fields] OR ("renal" [All Fields] AND "disease" [All Fields]) OR "renal disease" [All Fields]).

Data retrieval

After reviewing the titles and abstracts of other studies, the author decided to alter the criteria for inclusion. Additional resources for the research include specifics regarding the newly developed criteria. This highlighted how significant and intricate the issue is, indicating the need for additional research into the matter. Examining numerous studies that were all organized in the same way led to the discovery of this conclusion. In systematic reviews, eligible papers are limited to only those that satisfy all the inclusion criteria. This made it much simpler to zero in on significant specific items.

Our research team did not accept the study suggestions because they did not satisfy our established standards. As a result, the investigation certainly would be finished. During the investigation, names, authors, publication dates, locations, study activities, and parameters were collected. The following is a list of the various categories of products that can be purchased. If you practice using these talents, you will be able to improve at using them. The source of this information will possibly influence how it's portrayed here.

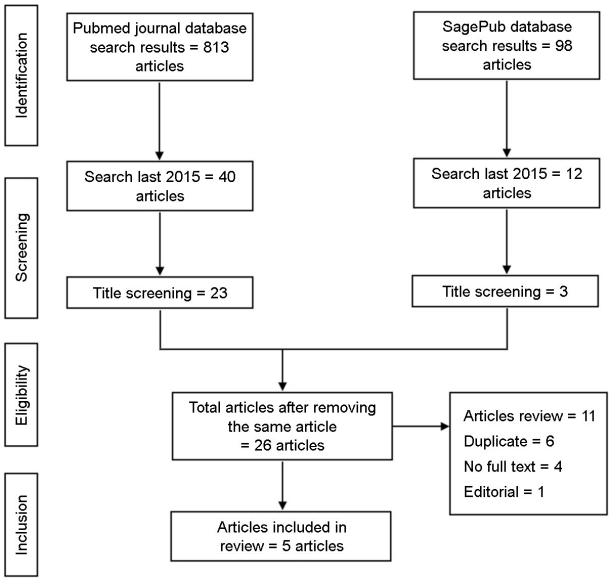

Fig. 1. Article search flowchart

Table 1. The litelature include in this study

Author	Origin	Method	Sample size	Result
Park, 2018[15]	USA	Retrospective cohort study	56,448 patients with HCV infection	The HCV group showed a 27% higher risk of CKD than the non-HCV group in a multivariable time-varying Cox regression model (HR 1.27; 95% CI 1.18~1.37). Individuals receiving the least effective HCV treatment for dual, triple, or all-oral therapy had a 30% lower risk of developing CKD (HR 0.70; 95% CI 0.55~0.88). Furthermore, compared with the non-HCV group, the HCV group had a twofold and nearly 17-fold increased incidence of MPGN (HR 2.23; 95% CI 1.84~2.71) and cryoglobulinemia (HR 16.91; 95% CI 12.00~23.81).
Zhang, 2019[13]	China	Cross-sectional study	2,435 study participants	Persistent HCV infection was significantly associated with CKD (odds ratio [OR] 1.33; 95% CI 1.06~1.66; $p = 0.013$), whereas no significant link was found between CKD and spontaneous HCV clearance (OR 1.23; 95% CI 0.79~1.90; $p = 0.364$), HBV infection (OR 0.73; 95% CI 0.44~1.19; $p = 0.201$), or HBV/HCV co-infection (OR 1.40; 95% CI 0.81~2.40; $p = 0.234$). Notably, after anti-HCV therapy, the serum creatinine concentration decreased significantly (76.0, 75.5~79.4 μmol/L) from the pretreatment level (95.0, 93.0~97.2 μmol/L), both in patients who showed an end-of-treatment virological response (ETVR) and those who did not ($p < 0.001$).
Liu, 2020[17]	Taiwan	Prospective cohort study	481 patients with compensated liver diseases and eGFR ≥30 mL/min/ 1.73 m^2	Patients receiving SOF-based DAA experienced a significant on-treatment decline in eGFR and a significant off-treatment improvement compared with patients receiving SOF-free DAAs. Multivariate analysis showed that age per 1-year increase, SOF-based DAAs, and CKD stage were independent factors that affect eGFR evolution from baseline to off-treatment week 24.
Sise, 2020[18]	USA	Retrospective observational cohort study	1,178 patients	In patients with eGFR < 60 mL/min per 1.73 m^2, the annual drop in eGFR in the 3 years before treatment was -5.98 mL/min (95% CI -7.30-[-4.67]) and improved to -1.32 (-4.50-1.88) following DAA therapy. In patients with eGFR of >60 mL/min per 1.73 m^2, the annual drop in eGFR in the 3 years before treatment was -1.43 mL/ min (95% CI -1.78-[-1.08]), and after DAA therapy, it was -2.32 (-3.36-[-1.03]).
Hsu, 2021[14]	Taiwan	Prospective cohort study	1,179 participants (946 without CKD and 233 with CKD)	In total, 111 of 233 (47.6%) patients with CKD and 167 of 946 (17.7%) without CKD had HCV infection. CKD occurs in 226.9 per 1000 person-years in the HCV group and 14.8 per 1000 person-years in the non-HCV group. The adjusted relative risk of HCV infection for incident CKD was 7.9 (95% CI 5.0~12.0). The HCV group with normal renal function independently had high risks of eGFR decrease at 1, 2, and 3 years. The risk remained substantial in models incorporating a 50% drop in eGFR at 3 years and other subgroup analyses. Among all patients with HCV infection and CKD, the increased risks of eGFR decrease were likewise well-known.

Quality assessment and data synthesis

Each author independently reviewed the studies based on their titles and abstracts before deciding which articles to analyze. Then, all papers that have the potential for inclusion in a systematic review were assessed. The articles that will be evaluated will be chosen based on our judgment, which was the basis for our selection of studies to review (Fig. 1). This makes the assessment of various articles simpler. Which previous studies can be incorporated into the review, and how can this be done?

RESULTS (Table 1)

Studies showed that persistent HCV infection was significantly associated with CKD [odds ratio (OR) 1.33; 95% confidence interval (CI) 1.06~1.66; $p = 0.013$], whereas no significant link was found between CKD and spontaneous HCV clearance (OR 1.23; 95% CI 0.79~1.90; $p = 0.364$), HBV infection (OR 0.73; 95% CI 0.44~1.19; $p = 0.201$), or HBV/HCV co-infection (OR 1.40; 95% CI 0.81~2.40; $p = 0.234$). After anti-HCV therapy, the serum creatinine concentration was significantly decreased (76.0, 75.5~79.4 μmol/L) from the pretreatment level (95.0, 93.0~97.2 μmol/L), both in patients who showed an end-of-treatment virological response (ETVR) and those who did not ($p < 0.001$). In both the ETVR and non-ETVR groups, the proportion of patients with an estimated glomerular filtration rate (eGFR) of ≥90 mL/min/1.73 m^2 increased significantly ($p < 0.001$), whereas the proportion of those with an eGFR of <60 mL/min/1.73 m^2 decreased significantly ($p < 0.001$)[13].

Hsu et al.[14] detected HCV in 111 of 233 (47.6%) patients with CKD and 167 of 946 (17.7%) patients without CKD. CKD occurs in 226.9 per 1000 person-years of patients with HCV infection and 14.8 per 1000 person-years in those without HCV infection. For incident CKD, the adjusted relative risk of HCV infection was 7.9 (95% CI 5.0~12.0). Patients with HCV infection and normal renal function had an increased risk of eGFR reduction at 1, 2, and 3 years. The risk associations remained significant in models that included a 50% decline in eGFR at 3 years and additional subgroup analyses. The higher risks of eGFR reduction were also well-known among all patients with both HCV infection and CKD.

In a multivariate time-varying Cox regression model conducted by Park[15], patients with HCV infection exhibited a 27% greater risk of CKD than those without HCV infection (hazard ratio [HR] 1.27; 95% CI 1.18~1.35). Those who had the least effective HCV treatment for dual, triple, or all-oral therapy had a 30% decreased risk of CKD development (HR 0.70; 95% CI 0.55~0.88). In addition, compared with the non-HCV group, the HCV group had a twofold and nearly 17-fold greater risk of membranoproliferative glomerulonephritis (MPGN) (HR 2.23; 95% CI 1.84~2.71) and cryoglobulinemia (HR 16.91; 95% CI 12.00~23.81), respectively.

Liu et al.[17] showed patients receiving sofosbuvir (SOF)-based direct-acting antiviral (DAA) treatment experienced a significant on-treatment decline in eGFR (adjusted slope coefficient difference: -1.24 mL/min/1.73 m^2/month; 95% CI -1.35 to -1.13; $p < 0.001$) and a significant off-treatment improvement (adjusted slope coefficient difference: 0.14 mL/min/1.73 m^2/month; 95% CI 0.08~0.21; $p = 0.004$) compared with patients receiving SOF-free DAAs. Multivariate analysis showed age per 1-year increase (adjusted slope coefficient difference: -0.05 mL/min/1.73 m^2/month; 95% CI -0.05 to -0.04; $p < 0.001$), SOF-based DAAs (adjusted slope coefficient difference: -0.33 mL/min/1.73 m^2/month; 95% CI -0.49 to -0.17; $p < 0.001$), and CKD stage (adjusted slope coefficient difference: -1.44 mL/min/1.73 m^2/month; 95% CI -1.58 to -1.30; $p < 0.001$ for stage 3 vs. 1, and -3.59 mL/min/1.73 m^2/month; 95% CI -3.88 to -3.30; $p < 0.001$ for stage 2 vs. 1) were independent factors that affect eGFR evolution from baseline to off-treatment week 24.

Chen et al.[15] showed that the CKD risk was considerably lower in the treated cohort than in the untreated group (7-year cumulative incidence, 2.6%; 95% CI 0.7~6.9%; $p = 0.001$), with an adjusted HR of 0.42 (95% CI 0.20~0.92; $p = 0.03$). The findings also remained true for the HCV group. At 7 years, 58 patients were treated to prevent one case of CKD. The risk reduction for CKD was the largest (0.35; 0.14~0.87; $p = 0.024$) among patients with HCV infection who received IFN-based therapy (IBT) for at least 6 months. Multivariable stratified analysis confirmed that individuals with HCV infection having hyperlipidemia, diabetes, and hypertension and those without coronary heart disease had a lower risk of CKD[16].

DISCUSSION

Both chronic renal disease and HCV infection are serious public health problems worldwide. HCV infection is linked to various extrahepatic symptoms that can occur in various organs, including the kidneys. It has recently come to light that a significant connection was found between HCV and chronic renal diseases. Hemodialysis is sadly a risk for HCV infection when it is used to assist patients who have reached the terminal stage of renal failure[20,21].

Despite significant treatment advancements, the frequency of HCV infection among patients receiving hemodialysis is still significantly greater than that of the general population. Patients on hemodialysis and recipients of kidney transplantation have a decreased chance of surviving if they have HCV infection[20,21].

A study showed the incidence of CKD related to HCV infection was greater (217.3 per 1000 person-years) than prior estimates. Differences in CKD classification, HCV prevalence, and viral genotyping variation may explain the disparities found among studies[14]. The increased risks of incident CKD and eGFR decrease associated with HCV infection, as identified in our analysis, were consistent with reports of some previous studies but inconsistent with others[14,15].

Some cross-sectional studies used eGFR cut-values from the Modification of Diet in Renal Disease or the CKD-EPI equation to define CKD, whereas other prospective studies used male-predominant participants or disease code-based registry claims data to determine renal outcomes rather than changes in serum creatinine or eGFR slopes. As a result, repeated measures of blood creatinine and urine protein decreased, potentially underestimating the true prevalence of CKD[22].

In individuals who have HCV infection, ESRD can have different causes. HCV infection can set off a chain reaction of immunological responses, which can then lead to kidney attacks and development of glomerulonephritis. In addition, HCV is linked to insulin resistance and dyslipidemia, all of which indirectly increase the risk of renal disease development[23].

Glomerulonephritis can develop in several years, if not decades, following an HCV infection. The mechanism for HCV-induced MPGN is thought to be immune-complex mediated (formation of antigen-antibody immune complexes from chronic infection), and these immune complexes activate the classical complement pathway, causing deposition of immunoglobulins, complement factors, and both kappa and lambda light chains in the mesangium and capillary walls. HCV-NS3 viral antigen deposits were found in kidney tissues of individuals with HCV RNA positivity and MPGN[15,24].

Cryoglobulins are immunoglobulins (Ig) that become insoluble at temperatures below the body temperature and rehydrate when rewarmed. These cryoglobulins are immunological complexes generated by monoclonal Ig M (typically IgM rheumatoid factor), polyclonal IgG, and HCV RNA that are deposited in small- and medium-sized capillaries of the skin, kidneys, and peripheral nerves in people with HCV infection[15,24].

Glomerulonephritis is caused by the accumulation of these immune complexes in the renal mesangium. Although proteinuria below the nephrotic range, microscopic hematuria, mild-to-moderate renal insufficiency, and arterial hypertension are typical clinical signs, 30% of patients with chronic HCV and cryoglobulinemia report nonspecific symptoms such as purpura, asthenia, and arthralgia. Vasculitis involving the kidney, skin, and nerves affects <10% of the population[15,24].

Nephritic disease, nephrotic syndrome, or isolated proteinuria can be the clinical manifestation of HCV-related kidney disorders. These diseases can occur with or without a reduction in renal function. MPGN, membranous glomerulopathy, IgA nephropathy, focal segmental glomerulosclerosis, mesangial proliferative glomerular nephritis, or tubulointerstitial nephritis are pathological abnormalities that can be seen on a renal biopsy[25].

The treatment of HCV in patients with ESRD with conventional or pegylated interferon (IFN) with or without ribavirin (RBV) continues to be a clinical challenge because of a low response rate, a high dropout rate due to poor tolerability, and a large number of unmet requirements. In patients with mild-to-moderate renal impairment and HCV infection, the introduction of novel DAA medicines for HCV treatment might bring about a significant shift in the treatment strategy. However, whether the most recent treatments for HCV are risk-free for those who have severe renal impairment has not yet been shown[20,26].

This nationwide cohort study found that patients with HCV infection who received IBT for ≥6 months and those with hyperlipidemia, diabetes, hypertension, and without coronary heart disease, had a lower chance of developing CKD than those with HCV infection who did not get IBT. These results show that HCV infection may play a pathogenic role in CKD development and may provide therapeutic guidance to explain the long-term usage and renal benefits of IBT in patients with HCV infection[16].

Antiviral therapy with IFN with RBV can enhance renal function and reverse CKD in individuals with HCV infection. Persistent HCV infection was independently linked with CKD[13,18]. Early therapy benefits patients with cirrhosis who are not candidates for kidney transplantation. The best time to treat patients with cirrhosis, including those with subclinical portal hypertension, who are kidney transplantation candidates will be determined by the policies of specific transplant facilities. HCV treatment standards must be revised regularly to reflect improvements. Hepatology and transplant nephrology must collaborate continuously to adjust transplant policy to this patient population[27].

Because IFN is mostly broken down in the kidneys, IFN treatment in individuals with renal disease may result in con-

siderable IFN buildup. PegIFN was developed, which attaches polyethylene glycol to the IFN molecule, making it more stable and having a longer half-life in the plasma. PegIFN requires only a weekly injection rather than thrice weekly injections of IFN. The two formulations of pegylated IFN are PegIFN-α2a and PegIFN-α2b[28].

The latter is weight based at 1.5 mcg/kg, whereas the dose of PegIFN-α2a is 180 mcg regardless of the body weight. PegIFN-α2a is metabolized in both the kidneys and liver, whereas PegIFN-α2b is only in the kidneys. The plasma concentration of PegIFN is significantly elevated in patients on hemodialysis; thus, PegIFN dose must be reduced. For patients with creatinine clearance of <30 mL/min and on hemodialysis, the PegIFN-α2a dose should be reduced from 180 mcg to 135 mcg weekly[28].

Urgent therapy with either elbasvir/grazoprevir or ombitasvir /dasabuvir/paritaprevir/ritonavir for G1 and G4 (without DSV) or G/P for G1-G6 should be considered for a kidney transplantation candidate with subclinical portal hypertension who may be accepted as a kidney transplantation candidate alone rather than a combined liver/kidney candidate with viral clearance and where extrahepatic manifestations of HCV, i.e., cryoglobulinemia, dictate urgency. It is an exciting period for HCV antiviral therapy and we are now seeing patients with concomitant ESRD benefit[27].

Other studies have shown the efficacy of sofosbuvir therapy. Little doubts remain on whether sofosbuvir is effective in treating HCV; nevertheless, findings of the drug's potential nephrotoxicity are up for debate. That is, the use of sofosbuvir led to a decline in kidney function during therapy but resulted in an improvement after stopping treatment. Before beginning DAA therapy in patients with HCV infection, our study leads us to believe that treating doctors should be aware of the risk factors for renal impairment as a precautionary measure[17].

CONCLUSION

Patients with HCV infection had a significantly increased probability of acquiring CKD. Individuals with HCV infection who had normal renal function had higher risks of renal disease progression compared with patients with HCV infection who had CKD. Anti-hepatitis treatment can cause variations in eGFR, leading to either an improvement or a worsening of the patient's condition.

CONFLICT OF INTEREST

In relation to this article, we declare that there is no conflict of interest.

ORCID

Tara Titian Maulidya: 0009-0007-8720-2578
Fauzio Nurul Khaira: 0000-0003-1881-8217
Febi Ramdhani Rachman: 0000-0003-2021-0497
Reynold Harris Malingkas: 0000-0001-5427-9391

REFERENCES

1. World Health Organization. Guidelines for the care and treatment of persons diagnosed with chronic hepatitis C virus infection. Geneva: World Health Organization; 2018
2. Veit O. Manson's tropical diseases 23rd edition. Travel Med Infect Dis 2015;13:117
3. Mohanty A, Salameh S, Butt AA. Impact of direct acting antiviral agent therapy upon extrahepatic manifestations of hepatitis C virus infection. Curr HIV/AIDS Rep 2019; 16:389-394
4. Stanaway JD, Flaxman AD, Naghavi M, Fitzmaurice C, Vos T, Abubakar I, et al. The global burden of viral hepatitis from 1990 to 2013: findings from the Global Burden of Disease Study 2013. Lancet (London, England) 2016; 388:1081-1088
5. Ferri C, Sebastiani M, Giuggioli D, Colaci M, Fallahi P, Piluso A, et al. Hepatitis C virus syndrome: A constellation of organ- and non-organ specific autoimmune disorders, B-cell non-Hodgkin's lymphoma, and cancer. World J Hepatol 2015;7:327-343
6. Ladino M, Pedraza F, Roth D. Hepatitis C virus infection in chronic kidney disease. J Am Soc Nephrol 2016;27: 2238-2246
7. Pol S, Parlati L, Jadoul M. Hepatitis C virus and the kidney. Nat Rev Nephrol 2019;15:73-86
8. Trinchet JC, Bourcier V, Chaffaut C, Ait Ahmed M, Allam S, Marcellin P, et al. Complications and competing risks of death in compensated viral cirrhosis (ANRS CO12 CirVir prospective cohort). Hepatology 2015;62:737-750
9. Mostafa A, Mohamed MK, Saeed M, Hasan A, Fontanet A, Godsland I, et al. Hepatitis C infection and clearance: impact on atherosclerosis and cardiometabolic risk factors. Gut 2010;59:1135-1140

10. Singhal A, Agrawal A, Ling J. Regulation of insulin resistance and type II diabetes by hepatitis C virus infection: A driver function of circulating miRNAs. J Cell Mol Med 2018;22:2071-2085
11. Saxena V, Khungar V, Verna EC, Levitsky J, Brown RS Jr, Hassan MA, et al. Safety and efficacy of current direct-acting antiviral regimens in kidney and liver transplant recipients with hepatitis C: Results from the HCV-TARGET study. Hepatology 2017;66:1090-1101
12. Maan R, Al Marzooqi SH, Klair JS, Karkada J, Cerocchi O, Kowgier M, et al. The frequency of acute kidney injury in patients with chronic hepatitis C virus infection treated with sofosbuvir-based regimens. Aliment Pharmacol Ther 2017;46:46-55
13. Zhang H, Xu H, Wu R, Yu G, Sun H, Lv J, et al. Association of hepatitis C and B virus infection with CKD and impact of hepatitis C treatment on CKD. Sci Rep 2019;9:1910
14. Hsu CK, Lai TS, Chen YT, Tseng YJ, Lee CC, Chen CY, et al. Renal function trajectories in hepatitis C infection: differences between renal healthy and chronic kidney disease individuals. Sci Rep 2021;11:17197
15. Park H, Chen C, Wang W, Henry L, Cook RL, Nelson DR. Chronic hepatitis C virus (HCV) increases the risk of chronic kidney disease (CKD) while effective HCV treatment decreases the incidence of CKD. Hepatology 2018; 67:492-504
16. Chen YC, Hwang SJ, Li CY, Wu CP, Lin LC. A Taiwanese nationwide cohort study shows interferon-based therapy for chronic hepatitis C reduces the risk of chronic kidney disease. Medicine (Baltimore) 2015;94:e1334
17. Liu CH, Lee MH, Lin JW, Liu CJ, Su TH, Tseng TC, et al. Evolution of eGFR in chronic HCV patients receiving sofosbuvir-based or sofosbuvir-free direct-acting antivirals. J Hepatol 2020;72:839-846
18. Sise ME, Chute DF, Oppong Y, Davis MI, Long JD, Silva ST, et al. Direct-acting antiviral therapy slows kidney function decline in patients with hepatitis C virus infection and chronic kidney disease. Kidney Int 2020;97:193-201
19. Chen H, Liu L, Qi X, He C, Wu F, Fan D, et al. Efficacy and safety of anticoagulation in more advanced portal vein thrombosis in patients with liver cirrhosis. Eur J Gastroenterol Hepatol 2016;28:82-89
20. Azmi AN, Tan SS, Mohamed R. Hepatitis C and kidney disease: An overview and approach to management. World J Hepatol 2015;7:78-92
21. Bonetto S, Fagoonee S, Battaglia E, Grassini M, Saracco GM, Pellicano R. Recent advances in the treatment of irritable bowel syndrome. Pol Arch Intern Med 2021; 131:709-715
22. Molnar MZ, Alhourani HM, Wall BM, Lu JL, Streja E, Kalantar-Zadeh K, et al. Association of hepatitis C viral infection with incidence and progression of chronic kidney disease in a large cohort of US veterans. Hepatology 2015;61:1495-1502
23. Dai CY, Yeh ML, Huang CF, Hou CH, Hsieh MY, Huang JF, et al. Chronic hepatitis C infection is associated with insulin resistance and lipid profiles. J Gastroenterol Hepatol 2015;30:879-884
24. Sethi S, Fervenza FC. Membranoproliferative glomerulonephritis-a new look at an old entity. N Engl J Med 2012;366:1119-1131
25. Ozkok A, Yildiz A. Hepatitis C virus associated glomerulopathies. World J Gastroenterol 2014;20:7544-7554
26. Azmi AN, Tan SS, Mohamed R. Hepatitis C and kidney disease: An overview and approach to management. World J Hepatol 2015;7:78-92
27. Angulo-Diaz V, Lim JK, Martin P, Liapakis A. Management of chronic hepatitis C in end-stage renal disease. J Clin Gastroenterol 2018;52:287-294
28. Gupta SK, Pittenger AL, Swan SK, Marbury TC, Tobillo E, Batra V, et al. Single-dose pharmacokinetics and safety of pegylated interferon-alpha2b in patients with chronic renal dysfunction. J Clin Pharmacol 2002;42:1109-1115