Clinical Journal of Gastroenterology
https://doi.org/10.1007/s12328-023-01794-x

CASE REPORT

Corticosteroid-refractory autoimmune hepatitis after COVID-19 vaccination: a case report and literature review

Masayuki Ueno[1,2] · Hiroyuki Takabatake[1] · Junya Itakura[3] · Rio Fujita[1,4] · Takahisa Kayahara[1] · Youichi Morimoto[1] · Kenji Notohara[3] · Motowo Mizuno[1]

Received: 30 January 2023 / Accepted: 27 March 2023

Abstract

Several vaccines have been developed for coronavirus disease 2019 (COVID-19) and are used worldwide. Here we report a case of severe acute hepatitis induced by COVID-19 vaccination. A 54-year-old woman received two doses of the Pfizer-BioNTech COVID-19 mRNA vaccine and an additional dose of the Moderna COVID-19 mRNA vaccine. Seven days after the third dose, she noticed fatigue, appetite loss and dark urine. Laboratory tests were consistent with severe liver injury and jaundice. Anti-smooth muscle antibody and HLA-DR4 were positive; thus, we suspected that she had autoimmune hepatitis (AIH). Intravenous methylprednisolone followed by oral prednisolone were administered. Because remission was not achieved, we performed percutaneous liver biopsy. Histologically, pan-lobular inflammation with moderate infiltration of lymphocytes and macrophages, interface hepatitis, and rosette formation were present. We regarded these findings as confirmation of the diagnosis of AIH. As she had not responded to corticosteroids, we added azathioprine. Liver biochemistry tests gradually improved, and prednisolone could be tapered without relapse of AIH. Dozens of cases of AIH after COVID-19 vaccination have been reported. Corticosteroids were effective in most cases, but some patients have died from liver failure after vaccination. This case illustrates the efficacy of azathioprine for steroid-refractory AIH induced by COVID-19 vaccination.

Keywords Autoimmune hepatitis · Azathioprine · SARS-Cov-2 · Vaccines · Adverse drug reactions

Introduction

The viral cause of coronavirus disease 2019 (COVID-19), i.e., severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is characterized by rapid mutation and transmission and has caused a global pandemic of more than 660 million cases and millions of deaths [1, 2]. Several vaccines have been developed and introduced into national vaccination programs, among which mRNA vaccines are most widely used [3–5]. The toxicity of these vaccines is generally acceptable; however, they can sometimes induce autoimmune disorders, including autoimmune hepatitis (AIH) [6]. Herein, we present a new case of AIH after COVID-19 vaccination. Unlike reported cases [7], remission was not achieved with corticosteroids alone, but addition of azathioprine was effective. This case report was prepared according to the CARE guidelines [8].

Case report

A 54-year-old woman presented to the emergency department with fatigue, appetite loss, and dark urine. She had no past medical history other than mild hypertension, and no laboratory abnormalities had been detected by annual check-ups. She was taking no drugs, herbs, or supplements, and she drank < 20 g alcohol /day. She received two doses of the Pfizer-BioNTech COVID-19 mRNA vaccine in June 2021 and a dose of Moderna COVID-19 mRNA vaccine in February 2022. Seven days after the third dose, she noticed

✉ Masayuki Ueno
masayukiu@kuhp.kyoto-u.ac.jp

1 Department of Gastroenterology and Hepatology, Kurashiki Central Hospital, 1-1-1 Miwa, Kurashiki, Okayama 710-8602, Japan

2 Department of Gastroenterology and Hepatology, Graduate School of Medicine, Kyoto University, Kyoto, Japan

3 Department of Anatomic Pathology, Kurashiki Central Hospital, Okayama, Japan

4 Department of Gastroenterology, Okayama City Hospital, Okayama, Japan

Published online: 07 April 2023

fatigue, appetite loss, and dark urine. She was afebrile, and physical examination revealed apparent jaundice. Laboratory tests were consistent with severe liver injury: bilirubin 11.1 mg/dL [normal range, 0.4–1.5], aspartate aminotransferase 2001 U/L [13–30], alanine aminotransferase (ALT) 2472 U/L [7–23], alkaline phosphatase 352 U/L [38–113], gamma-glutamyl transferase 416 U/L [9–32], albumin 4.0 g/dL [4.1–5.1], and prothrombin time-international normalized ratio 1.03 [0.9–1.1]. Serology was negative for hepatitis A, B, C and E, Epstein-Barr virus, cytomegalovirus, and herpes simplex virus. The polymerase chain reaction test for COVID-19 was also negative. Anti-smooth muscle antibody (1:40) and HLA-DR4 were positive. Antinuclear, anti-liver-kidney microsomal, anti-mitochondrial, and anti-neutrophil cytoplasmic antibodies were negative. The serum ceruloplasmin and immunoglobulins (Ig) levels were normal: IgG 1358 mg/dL [861–1747], IgA 216 mg/dL [93–393], and IgM 162 mg/dL [50–269]. Ultrasonography and contrast-enhanced computed tomography revealed no apparent abnormalities in the liver and biliary tracts (Fig. 1). Based on these findings, AIH was suspected.

She was admitted, and we started intravenous administration of methylprednisolone (500 mg/day, 3 days). Liver enzymes decreased initially but worsened after oral prednisolone (40 mg/day) replaced the intravenous methylprednisolone (Fig. 2). We then resumed intravenous methylprednisolone (250 mg/day, 3 days) followed by higher dose of oral prednisolone (60 mg/day). Even on these therapies, serum ALT levels exceeded 2000 U/L, so we performed percutaneous liver biopsy. Histologically, pan-lobular inflammation with moderate infiltration of lymphocytes and macrophages, interface hepatitis, and rosette formation were present (Fig. 3), whereas no fibrosis was seen. Thus, we assumed the patient had an acute onset of liver injury. These findings were consistent with previous reports of AIH induced by COVID-19 vaccines [9]. According to the revised International Autoimmune Hepatitis Group criteria [10], the patient's pre-treatment score was 16 (definite diagnosis of AIH), on the basis that there was no history of using hepatotoxic drugs. Since there had been several reports of AIH induced by COVID-19 vaccination, we suspected a causal

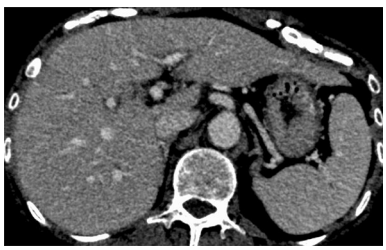

Fig. 1 Radiological findings. No abnormalities are present in the contrast-enhanced CT (portal phase)

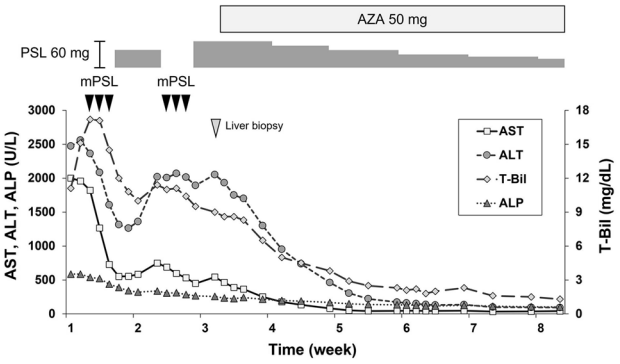

Fig. 2 Clinical course. *mPSL* methylprednisolone; *PSL* prednisolone; *AZA* azathioprine

relationship between COVID-19 vaccination and AIH. According to the DDW-Japan 2004 workshop scoring for drug-induced liver injury (DILI) [11], the score was 3 (possible diagnosis of DILI).

Because the patient had not responded to corticosteroids, we added azathioprine (50 mg/day) after verifying that she carried no risk allele in nudix hydrolase 15 gene (*NUDT15*). Liver biochemistry test then gradually improved (Fig. 2). We tapered the prednisolone dose while continuing azathioprine according to a standard treatment for AIH [12]. Liver enzymes normalized in May 2022, and prednisolone and azathioprine were discontinued in July 2022 and September

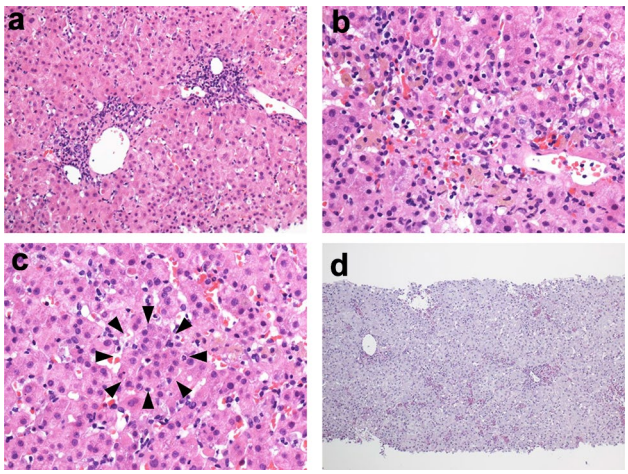

Fig. 3 Histological findings. **a** Mild infiltration of inflammatory cells with interface hepatitis are present in the periportal area. Infiltrating cells are mainly lymphocytes and macrophages. No apparent fibrosis is present (hematoxylin and eosin staining, ×20). **b** Moderate inflammation is present around the central vein (hematoxylin and eosin staining, ×40). **c** Rosette formation of hepatocytes is present (arrowheads) (hematoxylin and eosin staining, ×40). **d** Pan-lobular infiltration of macrophages containing diastase-resistant particles are present (periodic acid-Schiff-diastase staining, ×10)

2022, respectively. At the time of this writing (January 2023), no relapse of liver injury has been observed.

Discussion

Here we reported a case of severe acute hepatitis after COVID-19 vaccination. This report also first described the efficacy of azathioprine in the treatment of vaccine-induced hepatitis refractory to corticosteroid therapy. The patient's clinicopathological findings were typical for AIH, and definitive diagnosis of AIH was made according to the revised International Autoimmune Hepatitis Group criteria [10]. Her symptoms started immediately after the vaccination, and liver fibrosis was nearly absent in the liver biopsy. Thus, acute liver injury caused by COVID-19 vaccination was suspected.

Azathioprine is commonly used for treating AIH, often in combination with corticosteroids, which has been superior to either alone [13]. The American and the European guidelines recommend combination of these drugs as first-line treatment of AIH [14, 15]. In mild cases, azathioprine is often added two weeks after the initiation of corticosteroids to assess the response to steroid therapy alone and to learn the results of *NUDT15* analysis [15]. In severe cases, withholding azathioprine until cholestasis is resolved is recommended [14, 15]. On the other hand, the Japanese guidelines recommend azathioprine for cases with incomplete response, treatment intolerance, or relapse with steroid treatment [16], and its efficacy has been reported is such cases [17]. Other immunosuppressive agents, such as mycophenolate mofetil and tacrolimus, are also mentioned in the American and the European guidelines, but their use is not approved in Japan by national health insurance. Based on this background, we initially treated the patient with corticosteroids alone and added azathioprine after a poor response to steroids was established.

Bril F, et al. firstly reported a case of AIH after COVID-19 vaccine, in April 2021 [18]. Since then, dozens of similar cases have been reported worldwide. We have summarized the treatment in 39 cases of new-onset or exacerbation of liver injury after COVID-19 vaccination (Table 1); details of each case are presented in Table S1 [6, 18–55]. As first-line treatment, corticosteroids were used in 34 patients (75.6%), and they were effective in 31 patients (91.2%). In the three patients who did not improve with corticosteroid treatment, one patient recovered with N-acetylcysteine, but two died from liver failure. Azathioprine was used in ten patients as initial or maintenance therapy. In a most recent case series of 87 cases, which was not included in the table, one patient who did not respond to corticosteroids required liver transplantation [7]. Thus, we should appreciate that COVID-19 vaccine-induced hepatitis can be fatal and learn how to manage this adverse event when it is refractory to corticosteroids. Among the reports mentioned above, there was no report of the efficacy of azathioprine for corticosteroid-refractory liver injury. Our experience suggests that addition of azathioprine is a promising treatment option in cases refractory to steroid therapy. Although continuation of immunosuppressive treatment after achieving remission is recommended in the Japanese AIH guidelines [16], we finally discontinued both prednisolone and azathioprine. In

Table 1 Summary of treatment in previous case reports ($N=45$)

Parameters	Values
Number of vaccine doses before liver injury	
One	28 (62.2%)
Two	15 (33.3%)
Three	2 (4.4%)
Type of vaccine	
Pfizer-BioNTech BNT162b2	24 (53.3%)
Moderna mRNA-1273 vaccine	12 (26.7%)
ChAdOx1 nCoV-19 vaccine	6 (13.3%)
Sinovac CoronaVac (inactivated vaccine)	2 (4.4%)
Sinopharm COVID-19 vaccine (inactivated vaccine)	1 (2.2%)
Initial therapy	
Prednisolone	22 (48.9%)
Methylprednisolone	3 (6.7%)
Budesonide	2 (4.4%)
Steroids (details not available)	2 (4.4%)
Steroids and azathioprine	2 (4.4%)
Steroids and IVIg	2 (4.4%)
Other treatment	6 (13.3%)
No treatment	5 (11.1%)
NA	1 (2.2%)
Response to initial therapy	
Present	34 (75.6%)
Absent	4 (8.9%)
NA	7 (15.6%)
Additional therapy in refractory cases	
Methylprednisolone	1 (2.2%)
N-acetylcysteine	1 (2.2%)
Plasma exchange	1 (2.2%)
None	1 (2.2%)
Additional therapy for maintenance	
Azathioprine	8 (17.8%)
Steroids (e.g., prednisolone after methylprednisolone)	5 (11.1%)
None	34 (75.6%)
NA	1 (2.2%)
Outcome	
Improved	41 (91.1%)
Death from liver failure	3 (6.7%)
NA	1 (2.2%)

IVIg intravenous immunoglobulin; *NA* not available

case of COVID-19 vaccine-induced hepatitis, immunosuppressive therapy can be safely discontinued in some patients, while relapse after discontinuation has been also reported [56]. Therefore, we should carefully determine whether to and when to discontinue these therapies.mRNA vaccines strongly stimulate innate immune cells and lead to production of type I interferon and other proinflammatory cytokines [57]. In addition, Boettler T, et al. showed that activation of acquired immunity could also contribute to acute hepatitis after COVID-19 vaccination [48]. Whereas molecular mimicry is most likely responsible for the activation of acquired immunity, epitope spreading or bystander activation may also be involved [6]. Heterogeneity in the degree and pathway of immune-system activation may be the reason that corticosteroids are not always effective for treatment of vaccine-induced hepatitis. It will need further discussion for the appropriate term for this phenomenon, AIH, DILI, or other terms, while it has been often dealt as AIH in past reports. Chow KW, et al. used the term "AIH-like syndrome following COVID-19 vaccination" in their systematic review, in which fulfilling the AIH criteria was not required [9].

We emphasize that our aim of this case report is not to discourage clinicians from promoting COVID-19 vaccination. According to a recent large-scale study, the risk of liver injury after COVID-19 vaccines is extremely low [58]. Therefore, we believe that the benefits of vaccination overweigh the risks of adverse effects, and vaccination to prevent spreading of COVID-19 should be promoted.

In conclusion, clinicians should be aware that COVID-19 vaccines can induce acute-onset liver injury. Azathioprine appears to be an effective treatment for steroid-refractory AIH after COVID-19 vaccination.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s12328-023-01794-x.

Acknowledgements The authors thank Dr. William R Brown, director of the International Medical Editing Service, LLC, USA, for the English language review. The authors also thank Dr. Ken Takahashi for kind advice on an earlier version of this paper.

Author contributions MU and HT contributed to the study conception and design. The patient was managed by MU, HT, RF, TK, and YM Pathological evaluation was conducted by JI and KN Data collection and analysis were performed by MU The first draft of the manuscript was written by MU and HT, with advice from MM. All authors read and approved the final manuscript.

Declarations

Conflict of interest All authors declare that they have no conflict of interest.

Ethics statement This study has been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its subsequent amendments. According to the protocol of the Medical Ethics Committee of Kurashiki Central Hospital, ethics review was not required.

References

1. Hu B, Guo H, Zhou P, et al. Characteristics of SARS-CoV-2 and COVID-19. Nat Rev Microbiol. 2021;19:141–54.
2. WHO Coronavirus (COVID-19) Dashboard. Available at: https://covid19.who.int. Accessed 26 Jan 2023.
3. Thomas SJ, Moreira ED, Kitchin N, et al. Safety and efficacy of the BNT162b2 mRNA Covid-19 vaccine through 6 months. N Engl J Med. 2021;385:1761–73.
4. Baden LR, El Sahly HM, Essink B, et al. Efficacy and safety of the mRNA-1273 SARS-CoV-2 vaccine. N Engl J Med. 2021;384:403–16.
5. Voysey M, Clemens SAC, Madhi SA, et al. Safety and efficacy of the ChAdOx1 nCoV-19 vaccine (AZD1222) against SARS-CoV-2: an interim analysis of four randomised controlled trials in Brazil, South Africa, and the UK. Lancet. 2021;397:99–111.
6. Camacho-Domínguez L, Rodríguez Y, Polo F, et al. COVID-19 vaccine and autoimmunity. A new case of autoimmune hepatitis and review of the literature. J Transl Autoimmun. 2022;5:100140.
7. Efe C, Kulkarni AV, Terziroli Beretta-Piccoli B, et al. Liver injury after SARS-CoV-2 vaccination: features of immune-mediated hepatitis, role of corticosteroid therapy and outcome. Hepatology. 2022;76:1576–86.
8. Gagnier JJ, Kienle G, Altman DG, et al. The CARE guidelines: consensus-based clinical case report guideline development. J Clin Epidemiol. 2014;67:46–51.
9. Chow KW, Pham NV, Ibrahim BM, et al. Autoimmune hepatitis-like syndrome following COVID-19 vaccination: a systematic review of the literature. Dig Dis Sci. 2022;67:4574–80.
10. Alvarez F, Berg PA, Bianchi FB, et al. International autoimmune hepatitis group report: review of criteria for diagnosis of autoimmune hepatitis. J Hepatol. 1999;31:929–38.
11. Takikawa H, Onji M. A proposal of the diagnostic scale of drug-induced liver injury. Hepatol Res. 2005;32:250–1.
12. Vierling JM. Autoimmune hepatitis and overlap syndromes: diagnosis and management. Clin Gastroenterol Hepatol. 2015;13:2088–108.
13. Lamers MM, van Oijen MG, Pronk M, et al. Treatment options for autoimmune hepatitis: a systematic review of randomized controlled trials. J Hepatol. 2010;53:191–8.
14. European Association for the Study of the Liver. EASL clinical practice guidelines: autoimmune hepatitis. J Hepatol. 2015;63:971–1004.
15. Mack CL, Adams D, Assis DN, et al. Diagnosis and management of autoimmune hepatitis in adults and children: 2019 practice guidance and guidelines from the American association for the study of liver diseases. Hepatology. 2020;72:671–722.
16. Ohira H, Takahashi A, Zeniya M, et al. Clinical practice guidelines for autoimmune hepatitis. Hepatol Res. 2022;52:571–85.
17. Takenami T, Sakaguchi K, Nishimura M, et al. Therapeutic effects of azathioprine in combination with low-dose prednisolone in patients with intractable autoimmune hepatitis type 1. Acta Med Okayama. 2001;55:341–7.
18. Bril F, al Diffalha S, Dean M, et al. Autoimmune hepatitis developing after coronavirus disease 2019 (COVID-19) vaccine: Causality or casualty? J Hepatol. 2021;75:222–4.
19. Mann R, Sekhon S, Sekhon S. Drug-induced liver injury after COVID-19 vaccine. Cureus. 2021;13: e16491.
20. Hines A, Shen JG, Olazagasti C, et al. Immune thrombocytopenic purpura and acute liver injury after COVID-19 vaccine. BMJ Case Rep. 2021;14: e242678.
21. Lensen R, Netea MG, Rosendaal FR. Hepatitis C virus reactivation following COVID-19 vaccination: a case report. Int Med Case Rep J. 2021;14:573–6.

22. Ghielmetti M, Schaufelberger HD, Mieli-Vergani G, et al. Acute autoimmune-like hepatitis with atypical anti-mitochondrial antibody after mRNA COVID-19 vaccination: a novel clinical entity? J Autoimmun. 2021;123: 102706.
23. Vuille-Lessard É, Montani M, Bosch J, et al. Autoimmune hepatitis triggered by SARS-CoV-2 vaccination. J Autoimmun. 2021;123: 102710.
24. Rocco A, Sgamato C, Compare D, et al. Autoimmune hepatitis following SARS-CoV-2 vaccine: may not be a casuality. J Hepatol. 2021;75:728–9.
25. Rela M, Jothimani D, Vij M, et al. Auto-immune hepatitis following COVID vaccination. J Autoimmun. 2021;123: 102688.
26. Wong CY, Rios EJ. Cutaneous hypersensitivity reaction with acute hepatitis following COVID-19 vaccine. JAAD Case Rep. 2021;16:44–6.
27. Clayton-Chubb D, Schneider D, Freeman E, et al. Autoimmune hepatitis developing after the ChAdOx1 nCoV-19 (Oxford-AstraZeneca) vaccine. J Hepatol. 2021;75:1249–50.
28. Londoño MC, Gratacós-Ginès J, Sáez-Peñataro J. Another case of autoimmune hepatitis after SARS-CoV-2 vaccination: still casualty? J Hepatol. 2021;75:1248–9.
29. Tan CK, Wong YJ, Wang LM, et al. Autoimmune hepatitis following COVID-19 vaccination: true causality or mere association? J Hepatol. 2021;75:1250–2.
30. Lodato F, Larocca A, D'Errico A, et al. An unusual case of acute cholestatic hepatitis after m-RNABNT162b2 (Comirnaty) SARS-CoV-2 vaccine: coincidence, autoimmunity or drug-related liver injury. J Hepatol. 2021;75:1254–6.
31. Garrido I, Lopes S, Simões MS, et al. Autoimmune hepatitis after COVID-19 vaccine: more than a coincidence. J Autoimmun. 2021;125: 102741.
32. Avci E, Abasiyanik F. Autoimmune hepatitis after SARS-CoV-2 vaccine: new-onset or flare-up? J Autoimmun. 2021;125: 102745.
33. Mahalingham A, Duckworth A, Griffiths WJH. First report of post-transplant autoimmune hepatitis recurrence following SARS-CoV-2 mRNA vaccination. Transpl Immunol. 2022;72: 101600.
34. Dumortier J. Liver injury after mRNA-based SARS-CoV-2 vaccination in a liver transplant recipient. Clin Res Hepatol Gastroenterol. 2022;46:101743.
35. Zhou T, Fronhoffs F, Dold L, et al. New-onset autoimmune hepatitis following mRNA COVID-19 vaccination in a 36-year-old woman with primary sclerosing cholangitis: should we be more vigilant? J Hepatol. 2022;76:218–20.
36. Goulas A, Kafiri G, Kranidioti H, et al. A typical autoimmune hepatitis (AIH) case following Covid-19 mRNA vaccination. More than a coincidence? Liver Int. 2022;42:254–5.
37. Kawasaki Y, Matsubara K, Hori M, et al. Liver injury and cytopenia after BNT162b2 COVID-19 vaccination in an adolescent. Pediatr Int. 2022;64:e15178.
38. Hasegawa N, Matsuoka R, Ishikawa N, et al. Autoimmune hepatitis with history of HCV treatment triggered by COVID-19 vaccination: case report and literature review. Clin J Gastroenterol. 2022;15:791–5.
39. Lasagna A, Lenti MV, Cassaniti I, et al. Development of hepatitis triggered by SARS-CoV-2 vaccination in patient with cancer during immunotherapy: a case report. Immunotherapy. 2022;14:915–25.
40. Palla P, Vergadis C, Sakellariou S, et al. Letter to the editor: autoimmune hepatitis after COVID-19 vaccination: a rare adverse effect? Hepatology. 2022;75:489–90.
41. Erard D, Villeret F, Lavrut PM, et al. Autoimmune hepatitis developing after COVID 19 vaccine: presumed guilty? Clin Res Hepatol Gastroenterol. 2022;46:101841.
42. Zin Tun GS, Gleeson D, Al-Joudeh A, et al. Immune-mediated hepatitis with the Moderna vaccine, no longer a coincidence but confirmed. J Hepatol. 2022;76:747–9.
43. Ghorbani H, Rouhi T, Vosough Z, et al. Drug-induced hepatitis after Sinopharm COVID-19 vaccination: a case study of a 62-year-old patient. Int J Surg Case Rep. 2022;93:106926.
44. Nyein CM, Liew ZHS, Leow WQ, et al. Severe de novo liver injury after Moderna vaccination: not always autoimmune hepatitis. J Hepatol. 2022;77:556–8.
45. Kang SH, Kim MY, Cho MY, et al. Autoimmune hepatitis following vaccination for SARS-CoV-2 in Korea: coincidence or autoimmunity? J Korean Med Sci. 2022;37:e116.
46. Pinazo-Bandera JM, Hernández-Albújar A, García-Salguero AI, et al. Acute hepatitis with autoimmune features after COVID-19 vaccine: coincidence or vaccine-induced phenomenon? Gastroenterol Rep. 2022;10:goac014.
47. López Romero-Salazar F, Veras Lista M, Gómez-Domínguez E, et al. SARS-CoV-2 vaccine, a new autoimmune hepatitis trigger? Rev Esp Enferm Dig. 2022;114:567–8.
48. Boettler T, Csernalabics B, Salié H, et al. SARS-CoV-2 vaccination can elicit a CD8 T-cell dominant hepatitis. J Hepatol. 2022;77:653–9.
49. Hermida Pérez B, Robles Gaitero S, García LR. AMA-positive hepatitis induced by the SARS-CoV-2 vaccine. Rev Esp Enferm Dig. 2022;114:297–8.
50. Cao Z, Gui H, Sheng Z, et al. Letter to the editor: exacerbation of autoimmune hepatitis after COVID-19 vaccination. Hepatology. 2022;75:757–9.
51. Suzuki Y, Kakisaka K, Takikawa Y. Letter to the editor: autoimmune hepatitis after COVID-19 vaccination: Need for population-based epidemiological study. Hepatology. 2022;75:759–60.
52. Fimiano F, D'Amato D, Gambella A, et al. Autoimmune hepatitis or drug-induced autoimmune hepatitis following Covid-19 vaccination? Liver Int. 2022;42:1204–5.
53. Brubaker JED, Casaccio CL, Brazeau MJ. Recurrence of autoimmune hepatitis after COVID-19 vaccination. Cureus. 2022;14:e25339.
54. Mekritthikrai K, Jaru-Ampornpan P, Komolmit P, et al. Autoimmune hepatitis triggered by COVID-19 vaccine: the first case from inactivated vaccine. ACG Case Rep J. 2022;9:e00811.
55. Barary M, Sharifi-Razavi A, Rakhshani N, et al. Fulminant hepatitis following COVID-19 vaccination: a case report. Clin Case Rep. 2022;10:e6066.
56. Codoni G, Kirchner T, Engel B, et al. Histological and serological features of acute liver injury after SARS-CoV-2 vaccination. JHEP Rep. 2022;5:100605.
57. Teijaro JR, Farber DL. COVID-19 vaccines: modes of immune activation and future challenges. Nat Rev Immunol. 2021;21:195–7.
58. Wong CKH, Mak LY, Au ICH, et al. Risk of acute liver injury following the mRNA (BNT162b2) and inactivated (CoronaVac) COVID-19 vaccines. J Hepatol. 2022;77:1339–48.