BR 2024; 6 (2): e530
DOI: 10.53238/br_20247_530

IMPACT OF COVID-19 PANDEMIC ON SEPTIC ARTHRITIS MANAGEMENT: A MONOCENTRIC RETROSPECTIVE STUDY

S. ZEMRANI, B. AMINE, I. ELBINOUNE, S. ROSTOM, R. BAHIRI

• • •

[1]Department of Rheumatology A, El Ayachi Hospital, University Hospital Center Ibn Sina, Rabat-Sale, Morocco

Corresponding Author
Salma Zemrani, MD; e-mail: medsalma3@gmail.com

ABSTRACT – ***Objective:*** This study aimed to assess the impact of COVID-19 pandemic on the incidence and management of septic arthritis in a tertiary rheumatology department.

Patients and Methods: This retrospective monocentric study included patients hospitalized for septic arthritis between January 2018 and December 2021. Patients were divided into two groups: G1 (patients hospitalized before the pandemic: 2018-2019), and G2 (patients hospitalized during the COVID-19 pandemic: 2020-2021). Septic arthritis incidence was calculated for both groups, risk factors, clinical, paraclinical, therapeutic data were compared between the two periods. Patients who developed COVID-19 in G1 were identified.

Results: Twenty-two patients with septic arthritis were included: G1 (n = 7), G2 (n = 15). The incidence rate of septic arthritis was significantly higher during the COVID-19: 3.8/100 patient-years [0.87-3.06] IC 95% *vs*. 1.8/100 patient-years [0.87-3.06] IC 95%. No significant differences were observed in comorbidities or risk factors for septic arthritis between the two groups. During the pandemic, diagnosis delay and prior use of antibiotics were more significant: 15 [7-30] *vs.* 5 [3-7] days (p = 0.04) and 60% *vs.* 14.3% (p = 0.04). However, hospital Length of Stay and duration of antibiotic therapy were statistically comparable. Only G2 reported synovectomy and were transferred to intensive care unit (ICU). COVID-19 was detected only in two patients from G1.

Conclusions: The higher incidence of septic arthritis in Group 2 suggests a potential impact of the pandemic on immunity. However, this hypothesis still requires confirmation. Additionally, significant diagnosis delay and prior use of antibiotics during the era of COVID-19 suggest that patients with septic arthritis encountered difficulties in accessing healthcare services during the lockdown.

KEYWORDS: Septic arthritis, COVID-19, Pandemic.

LIST OF ABBREVIATIONS: SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus 2; WHO: World Health Organization; SA: Septic arthritis; Intensive Care Unit: ICU.

INTRODUCTION

Coronavirus Disease 2019 was caused by a virus from the CORONAVIRIDAE family. It was first identified in China in December 2019 and named SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus 2) due to its genetic similarity to SARS-CoV, which caused the SARS epidemic in 2003[1]. The infection has quickly spread globally. On March 11, 2020, the World Health Organization (WHO) classified Coronavirus disease 2019 as a global pandemic. Healthcare professionals faced considerable challenges in managing this emergency.

The practice of rheumatology has been affected by COVID-19 health measures. Lockdowns, quarantines, and curfews, implemented to prevent the virus's spread, have made it challenging to provide follow-up care for patients with rheumatic diseases. This group of patients had to face a significant problem regarding the risk of exposure due to their potential immunosuppression and vulnerability, weighed against the necessity of ongoing medical attention and regular follow-up. Several studies have examined the characteristics of COVID-19 infection in patients with inflammatory rheumatic diseases and assessed the pandemic's impact on their follow-up care[2]. Although the public health emergency declared by the WHO[3] ended on May 5, 2023, discussions about the possibility of future pandemics persist. Therefore, it is crucial to analyze how this crisis has affected daily rheumatology medical practice to derive lessons.

Septic arthritis (SA) is a rheumatological emergency that occurs when an infectious agent invades a joint, causing inflammation and potentially leading to significant joint damage. Early diagnosis and treatment are crucial to preserve joint function and prevent increased morbidity and mortality[4].

Recently, there has been discussion among some authors about an increased risk of SA during the COVID-19 pandemic. However, these claims are based on limited data from case reports and case series and are not sufficient to draw definitive conclusions about the exact mechanisms[5]. Research has shown that COVID-19 infection can cause immune dysregulation, which may persist in severe cases[6]. Additionally, some authors have suggested that certain practices during lockdown, such as social distancing, could have a detrimental effect on the immune system by limiting exposure to pathogens[7]. This may result in a lack of immune stimulation, as described by the immunity debt theory[7]. Therefore, we hypothesize that the immune dysregulation that occurs during the pandemic could potentially lead to a period of immunosuppression. This could make patients more susceptible to other microorganisms and infections, including SA.

From another perspective, similar to inflammatory rheumatic diseases, lockdown interventions could impact the management of SA, particularly in rural and socioeconomically disadvantaged regions. This may pose challenges such as constrained healthcare access and subsequent diagnostic delays. However, there is presently insufficient high-quality literature to substantiate this hypothesis.

This study aims to describe a tertiary rheumatology center's experience in managing SA during the COVID-19 pandemic. The primary objective is to estimate the incidence rate of SA during this period, while the secondary objective is to evaluate the pandemic's impact on management.

PATIENTS AND METHODS

Patients

This monocentric retrospective study was conducted at the Rheumatology Department A of El Ayachi Hospital. The study included hospitalized patients diagnosed with SA between January 2018 and December 2021. The diagnosis was confirmed by bacterial growth on culture or presumptive criteria based on a combination of clinical and laboratory arguments, such as fever, synovial fluid white blood cell counts greater than 50,000 cells/mm^3, and high inflammatory markers. The study recorded data on socio-demographic features, comorbidities, clinical and biological characteristics of SA, risk factors, antibiotic treatment, length of hospitalization, use of surgical intervention, and intensive care.

Ethics approval and written informed consent

The study was approved by the Ethics Committee for Biomedical Research Mohammed V University - Faculty of Medicine and Pharmacy (Rabat, Morocco; approval number: J/23). Patients' information remained anonymous and written informed consent was signed by each patient involved in the study.

Methods

The surveys conducted from January 1, 2018, to December 31, 2019, were categorized as the pre-pandemic group (Group 1), while those conducted from January 1, 2020, to December 31, 2021, were considered as the pandemic group (Group 2). The incidence rate of SA was calculated by dividing the total number of SA admissions by the total number of hospitalizations in each time period. A comparison of socio-demographic characteristics, risk factors, clinical and paraclinical data, and therapeutic approaches was conducted between the two groups. Patients who developed COVID-19 in G2 were identified.

Statistical Analysis

Statistical analysis was performed using SPSS software, version 13.0 (SPSS Inc., Chicago, IL, USA). Normally distributed parameters were presented as mean± standard deviation (SD), and asymmetric parameters were expressed as median± interquartile range (IQR defend as 25–75th percentiles). Qualitative data were presented as frequencies (number and percentage). The comparisons between Group 1 and Group 2 were examined using the T Student and Mann-Whitney tests for quantitative variables and using the Chi-squared test or Fischer's exact test for qualitative variables. *P*-values less than 0.05 were considered statistically significant.

RESULTS

A total of twenty-two patients with SA were included in the study, consisting of 7 patients in the pre-COVID-19 period and 15 patients in the COVID-19 pandemic period. The incidence rate of SA before the COVID-19 period was 1.8/100 patient-years [0.87-3.06] IC 95%, while the incidence rate in the COVID-19 period was 3.8/100 patient-years [0.87-3.06] IC 95%.

The mean age in group 1 and group 2 was 54.29±21.81 and 54.60±12.25-year-old, respectively. There were no statistically significant differences in gender, sociodemographic characteristics, comorbidities, or risk factors for SA between the two groups (Table 1).

Table 1. Demographic characteristics, comorbidities and risk factors.

	Pre-pandemic group (G1) (7 patients)	Pandemic group (G2) (15 patients)	*p*-value
Age (years)[1]	54.29±21.81	54.6±12.25	0,2
Sex, male[2]	3 (42.9)	10 (66.7)	0.29
Diabetis[2]	2 (28.6)	4(26.,7)	0.92
Hypertension[2]	2 (28.6)	5(33.3)	0.82
Pre-existing arthropathy[2]	2(28.6)	8(53.3)	0.27
Inflammatory rheumatic desiase[2]	2(28.6)	5 (33.3)	0.27
Oral corticosteroid[2]	2(28.6)	4 (26.,7)	0.92
Biothérapy[2]	0	3 (20)	0.20
Traumatism[2]	0	1 (6.7)	0.48

[1]Mean and standard deviation; [2]Number and percentage; [3]Median and IQR.

During the pandemic, delay in diagnosis and prior use of antibiotic therapy was more significant: 15 [7-30] *vs*. 5 [3-7] days (p = 0.04) and 60% *vs.* 14.3% (p = 0.04). The knee was the most common localization in both groups, but other joints were involved in Group 2: shoulder (n = 2), hip (n = 1) and sacroiliac joint (n = 1). Germs were identified in 42.9% of group 1 and 46.7% of group 2, and the most common was Staphylococcus aureus (Table 2).

Hospital Length of Stay and duration of antibiotic therapy before and during the pandemic were statistically comparable: 26.07±9.12 *vs.* 27.43±10.87 days (p=0.76), and 50±10 *vs.* 48±25.79 days (p=0.83), respectively. In group 1, all patients responded to medical treatment, whereas in group 2, synovectomy was required in three patients (20%), one of whom was also admitted to ICU for septic shock. Two of these three patients were on immunomodulatory treatment for rheumatoid arthritis, but no one of them had a history of COVID-19 infection. The latter was noted only in two patients in Group 2, six month and one year before first symptoms of SA, and it was about non-severe forms. In addition, 33.3% of Group 2 were vaccinated against COVID-19 (Table 2).

Table 2. Clinical and paraclinical characteristics.

	Pre-pandemic group (G1) (7 patients)	Pandemic group (G2) (15 patients)	*p*-value
Diagnosis delay (days)[3]	5 [3-7]	15 [7-30]	0.04
Prior use of antibiotic treatment[2]	1 (14.3)	9 (60)	0.04
Infectious Entry point[2]	1 (14.3)	5 (33.3)	0.35
Joint affected			
• **Knee**	7 (100)	11 (73.3)	0.26
• **Shoulder**	0	2	
• **Hip**	0	1	
• **Sacroiliac**	0	1	
Synovial biopsy[2]	2 (28.6)	5 (33.3)	0.82
Germe identification[2]	3 (42.9)	7 (46.7)	0.86
Positive blood culture[2]	0	5 (33.,3)	0.08
Length of hospitalization (days)[1]	27.43±10.87	26.07±9.12	0.76
Duration of antibiotic therapy (days)[1]	48±25.79	50±10	0.83
Transfer to ICU[2]	0	1 (6.7)	0.48
Surgery[2]	0	3 (20)	0.70

[1]Mean and standard deviation; [2]Number and percentage; [3]Median and IQR.

DISCUSSION

COVID-19 infection is mostly associated with pulmonary involvement; however, it can also affect other organs, such as heart, kidney, liver, and nervous system[8]. Furthermore, there have been reports of musculoskeletal manifestations[5]. In addition to arthralgia and myalgia[9,10], other musculoskeletal conditions may manifest in the weeks or months following the disease. These conditions may include reactive arthritis, vasculitis, myositis, connective tissue diseases, and SA[11-14].

The risk of bacterial infections during or after the acute phase of SARS-CoV-2 has been described[15]. A systematic review reported 33 cases of active pulmonary tuberculosis following recovery from COVID-19 across 13 countries[16]. Secondary pneumococcal infection was also described[17], and some authors[18] reported that 50% of patients with COVID-19 acquire secondary hospital bacterial infections. SA that occurs during or after recovery from SARS-Cov 2 is an interesting entity that has recently been discussed. However, drawing conclusions is currently challenging due to limited data, which is mostly based on case reports. A 28-year-old patient was diagnosed with bilateral shoulder SA a few days after being discharged from mechanical ventilation during hospitalization for a severe form of COVID-19 infection[19]. An 18-year-old man who had fully recovered from COVID-19 also reported meningococcal arthritis[20]. In India, authors have reported cases of musculoskeletal infections in patients with a history of COVID-19, including SA, soft-tissue abscess, and postoperative infection[21]. Five cases of hip S with salmonella and coagulase-negative staphylococci infection were described after full recovery from COVID-19[22]. Finally, a case of hip SA was reported 3 months after COVID-19[23].

The mechanism by which SARS-CoV-2 may contribute to SA is currently unclear. Studies have shown that COVID-19 disrupts the immune system, leading to uncontrolled inflammatory responses, lymphopenia, lymphocyte dysfunction, and high cytokine levels[6,24]. These immune abnormalities may persist in the long term after infection resolution, particularly in severe cases, and this phenomenon is known as long COVID or post-COVID syndrome[25-27]. This immunocompromised state could potentially increase patients' susceptibility to other infections, including SA. Additionally, COVID-19 can cause secondary complications such as pneumonia, which can lead to bacteremia, providing a pathway for bacteria to enter joints. It is important to note that corticosteroids and tocilizumab, which are used to manage

COVID-19, may worsen the immunosuppressed condition, thereby increasing the risk of SA[21]. According to an alternative theory, the SARS-CoV-2 virus may cause harm to joints by infecting and damaging cells in the synovial membrane that lines them[28].

Our study found a higher incidence of SA during the pandemic, which may support the immunocompromised theory. However, SARS-Cov2 infection was only detected in two patients, 6 months and 1 year before the initial symptoms of SA, and these were non-severe cases. Moreover, the literature has only reported anecdotal cases of SA occurring during or after COVID-19 infection[19-21], and there is a lack of high-quality studies on this topic. Therefore, it is challenging to make conclusions regarding our hypothesis.

From a different perspective, some authors have suggested that immune dysfunction during this pandemic is not only due to the virus, but also to several confounding factors[7]. Various measures imposed by the authorities to limit the spread of infection, such as confinement at home, social distancing, disinfection and face masks, may have important consequences on the immunity by limiting interaction with the environment and exposure to pathogens, resulting in a lack of immune stimulation as described by the immunity debt theory[29-32]. In addition, the economic situation caused by this crisis, mental health problems and anxiety, malnutrition and sedentary lifestyle could also potentially harm the immune system[33-35]. This pandemic-induced reduction in immunity, with its multifactorial origins, could be considered as a potential risk factor for contracting other infectious diseases. However, this hypothesis still requires confirmation.

This paper presents data on the impact of the COVID-19 pandemic on the management of SA. Our results demonstrate that diagnosis delay and the prior use of antibiotics without medical prescription were more significant during the pandemic. This suggests inadequate and difficult access to health services during the lockdown. Although there is a lack of similar studies in the literature, certain case reports have highlighted this diagnosis delay. SA of the shoulder was diagnosed in a 59-year-old man four weeks after symptom onset. The delay was due to the patient's difficulty in visiting a healthcare provider in person. Instead, the patient opted for a virtual clinic visit[36]. Boussaidane et al[37] reported a case of infectious sacroiliitis in a 66-year-old patient, which is relatively rare[37]. The diagnosis was delayed due to the circuit of suspected COVID-19 patients imposed by the health authorities. Additionally, the non-specific clinical presentation made diagnosis difficult and often overlooked[38]. Our series identified a significant delay in diagnosis in the pandemic group, especially in two cases of atypical shoulder and sacroiliac SA, with delays of 90 and 45 days, respectively.

Despite the diagnosis delay observed in our series, neither the length of hospital stays, nor the duration of antibiotic treatment were impacted and were comparable in both groups. However, three patients required surgical intervention and were transferred to the ICU due to septic shock during the pandemic. This finding aligns with a prospective study conducted at a leading trauma center between 28th March 2020 and 31st June 2020, involving six patients hospitalized for SA of their native joints. They were treated with aspiration and antibiotic therapy, and of these patients, four required surgical intervention due to either clinical or biological deterioration. However, it was not possible to determinate the COVID-19 status of these patients[39]. In our data, none of the three patients had a history of COVID-19 infection, but two of them are immunocompromised with rheumatoid arthritis and use of immunomodulatory treatments such as methotrexate and biotherapy.

To the best of our knowledge, this is the first study to analyze SA incidence and management during the COVID-19 pandemic and comparing it with the same time period in 2018-2019. However, it has several limitations. First, it was conducted on a small population. Second, all variables were obtained retrospectively, which inherently restricts this type of research. Thirdly, our study provides hypotheses explaining the recrudescence of SA in our department during the COVID-19 period but cannot establish a definitive causal relationship between the pandemic and this increase in incidence.

CONCLUSIONS

These findings illustrate a higher incidence of SA in our department during the COVID-19 pandemic. The immune dysfunction induced by SARS-CoV-2 infection as well as the possible negative impact of confinement on the immune system have been suggested to explain this recrudescence, but our results and literature data are insufficient to reach a definitive conclusion. Therefore, larger studies are needed to confirm these hypotheses.

From another perspective, our study suggests that delayed diagnosis and prior antibiotic therapy were more significant during the COVID-19 era. Additionally, surgical management and transfer to intensive care were observed only during this pandemic. This is probably attributed to inadequate and difficult access to health service due to measures implemented by authorities, which might indirectly lead to increased morbidity and mortality.

While world health organization declared on May 5, 2023, the end of COVID-19 as a public health emergency, newly emerging variants are continuously posing high global public health concerns. Studies on the impact of COVID-19 pandemic on SA are lacking in the literature. Therefore, our data could improve our understanding of this issue and allow us to be better prepared for a possible new pandemic.

Authors Contributions:

Salma Zemrani drafted this manuscript, collected the data and reviewed the literature. Bouchra Amine and Imane Elbinoune participated in article writing and reviewed critically the manuscript; Samira Rostom and Rachid Bahiri reviewed critically the manuscript. All authors read and approved the manuscript.

Availability of data and material:

Available from the corresponding author on reasonable request.

Conflict of interests:

The authors declare that they have no conflict of interest to disclose.

Consent for publication:

Consent for publication was obtained from the patients.

Ethics approval:

The study was approved by the Ethics Committee for Biomedical Research Mohammed V University - Faculty of Medicine and Pharmacy (Rabat, Morocco; approval number: J/23).

Funding:

No funding is declared for this article.

Informed consent:

Patients' information remained anonymous and written informed consent was signed by each patient involved in the study.

REFERENCES

1. Sharma A, Ahmad Farouk I, Lal SK. COVID-19: A Review on the Novel Coronavirus Disease Evolution, Transmission, Detection, Control and Prevention. Viruses 2021; 13: 202.
2. Ziadé N, El Kibbi L, Hmamouchi I, Abdulateef N, Halabi H, Hamdi W, Abutiban F, El Rakawi M, Eissa M, Masri B. Impact of the COVID-19 pandemic on patients with chronic rheumatic diseases: A study in 15 Arab countries. Int J Rheum Dis 2020; 23: 1550-1557.
3. World Health Organization. WHO Director-General's Opening Remarks at the Media Briefing on COVID-19–11 March 2020. Available online: https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefingon-covid-19---11-march-2020(accessed on 17 May 2020).
4. Ross JJ. Septic Arthritis of Native Joints. Infect Dis Clin North Am 2017; 31: 203-218.
5. Pires RE, Reis IGN, Waldolato GS, Diego D. Pires DD, Bidolegui F, Giordano V. What Do We Need to Know About Musculoskeletal Manifestations of COVID-19? A Systematic Review. JBJS Rev 2022; 3: 10.
6. Davitt E, Davitt C, Mazer M B, Areti SS, Hotchkiss RS, Remyb KE. COVID-19 disease and immune dysregulation. Best Pract Res Clin Haematol 2022; 35: 101401.
7. Ghanemi A, Yoshioka M, St-Amand J. Coronavirus Disease 2019 (COVID-19) Crisis: Losing Our Immunity When We Need It the Most. Biology (Basel) 2021; 10: 545
8. Gupta A, Madhavan MV, Sehgal K, Nair N, Mahajan S, Sehrawat TS, Bikdeli B, Ahluwalia N, Ausiello JC, Wan EY, Freedberg DE, Kirtane AJ, Parikh SA, Maurer MS, Nordvig AS, Accili D, Bathon JM, Mohan S, Bauer KA, Leon MB, Krumholz HM, Uriel N, Mehra MR, Elkind MSV, Stone GW, Schwartz A, Ho DD, Bilezikian JP, Landry DW. Extrapulmonary manifestations of COVID-19. Nat Med 2020; 26: 1017-1032.
9. Widyadharma IPE, Sari NNSP, Pradnyaswari KE, Yuwana KT, Adikarya IPGD, Tertia C, Wijayanti IAS, Indrayani IAS, Utami DKI. Pain as clinical manifestations of COVID-19 infection and its management in the pandemic era: a literature review. Egypt J Neurol Psychiatr Neurosurg 2020; 56: 121.
10. Garg M, Maralakunte M, Garg S, Dhooria S, Sehgal I, Bhalla AS, Vijayvergiya R, Grover S, Bhatia V, Jagia P, Bhalla A, Suri V, Goyal M, Agarwal R, Puri GD, Sandhu MS. The Conundrum of 'Long-COVID-19': A Narrative Review. Int J Gen Med 2021; 14: 2491-2506.
11. Migliorini F, Bell A, Vaishya R, Eschweiler J, Hildebrand F, Mafulli N. Reactive arthritis following COVID-19 current evidence, diagnosis, and management strategies. J Orthop Surg Res 2023; 18: 205.

12. Morris D, Patel K, Rahimi O, Sanyurah O, Iardino A, Khan N. ANCA vasculitis: A manifestation of post-Covid-19 Syndrome. Respir Med Case Rep 2021; 34: 101549.
13. Shahidi Dadras M, Rakhshan A, Ahmadzadeh A, Hosseini SA, Diab R, Safari Giv T, Abdollahimajd F. Dermatomyositis-lupus overlap syndrome complicated with cardiomyopathy after SARS-CoV-2 infection: A new potential trigger for musculoskeletal autoimmune disease development. Clin Case Rep 2021; 9: e04931.
14. Drosos AA, Pelechas E, Voulgari PV. Seronegative Erosive Arthritis Following SARSCoV-2 Infection. Rheumatol Ther 2022; 9: 295-301.
15. Bahceci I, Yildiz IE, Duran OF, Soztanaci US, Harbawi ZK, Senol FF, Demiral G. Bacterial co-infection and secondary infection in patients with COVID-19: a living rapid review and meta-analysis. Clin Microbiol Infect 2020; 26: 1622-1629.
16. Alemu A, Bitew ZW, Seid G, Diriba G, Gashu E, Berhe N, Mariam SH, Gumi B. Tuberculosis in individuals who recovered from COVID-1917: A systematic review of case reports. PLoS One 2022; 17: e0277807.
17. Golbets E, Kaplan A, Shafat T, Yagel Y, Jotkowitz A, Awesat J, Barski L. Secondary organizing pneumonia after recovery of mild COVID-19 infection. J Med Virol 2022; 94: 417-423.
18. Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, Xiang J, Wang Y, Song B, Gu X, Guan L, Wei Y, Li H, Wu X, Xu J, Tu S, Zhang Y, Chen H, Cao B. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet 2020; 395: 1054-1062.
19. Neves TR, Lourenço AL, Alves P, Teiga C, Caetano AP. Bilateral shoulder arthritis in COVID-19 patient after prolonged mechanical ventilation assist: a case report. Radiol Case Rep 2021; 16: 2894-2898.
20. Ducatez N, Chancel M, Douadi Y, Dayen C, Suguenot R, Lecuyer E, Brihaye B, Bentayeb H. Primary meningococcal arthritis in a COVID-19 18-year-old man: a case report and review of the literature. BMC Infect Dis 2021; 21: 499.
21. Bagaria V. Usual and Unusual Musculoskeletal Sequalae of COVID 19! Indian J Orthop 2021; 55: 518-519.
22. Ardakani MV, Parviz S, Ghadimi E, Zamani Z, Salehi M, Ayati Firoozabadi M, Mortazavi SMJ. Concomitant septic arthritis of the hip joint and femoral head avascular necrosis in patients with recent covid-19 infection: A cautionary report. J Orthop Surg Res 2022; 17: 302.
23. Vijayamohan S, Gopal VS. Sphingomonas paucimobilis Septic Arthritis Post COVID-Case Report. Asian J Orthop Res 2022; 7: 29-32.
24. Wong LYR, Perlman S. Immune dysregulation and immunopathology induced by SARS-CoV-2 and related coronaviruses — are we our own worst enemy? Nat Rev Immunol 2022; 22: 47-56.
25. Garg M, Maralakunte M, Garg S, Dhooria S, Sehgal I, Bhalla AS, Vijayvergiya R, Grover S, Bhatia V, Jagia P, Bhalla A, Suri V, Goyal M, Agarwal R, Puri GD, Sandhu MS. The Conundrum of 'Long-COVID-19': A Narrative Review. Int J Gen Med 2021; 14: 2491-2506.
26. Anaya JM, Rojas M, Salinas ML, Rodríguez Y, Roa G, Lozano M, Rodríguez-Jiménez M, Montoya N, Zapata E, Post-COVID study group, Monsalve DM, Acosta-Ampudia Y, Ramírez-Santana C. Post-COVID syndrome. A case series and comprehensive review. Autoimmun Rev 2021; 20: 102947.
27. Phetsouphanh C, Darley DR, Wilson DB, Howe A, Munier CML, Patel SK, Juno JA, Burrell LM, Kent SJ, Dore GJ, Kelleher AD, Matthews GV. Immunological dysfunction persists for 8 months following initial mild-to-moderate SARS-CoV-2 infection. Nat Immunol 2022; 23: 210-216.
28. Silva F, Rosado MM, Simões IG, Correia BL. Septic Sternoclavicular Arthritis: An Uncommon Manifestation in the Context of Immunosuppression Following SARS-CoV-2 Infection. Cureus 2023; 15: e49609.
29. Ponomarev SA, Sadova AA, Rykova MP, Orlova KD, Vlasova DD, Shulgina SM, Antropova EN, Kutko OV, Germanov NS, Galina VS, Shmarov VA. The impact of short-term confinement on human innate immunity. Sci Rep 2022; 12: 8372.
30. Akira S, Uematsu S, Takeuchi O. Pathogen recognition and innate immunity. Cell 2006; 124: 783-801.
31. Medzhitov R. Recognition of microorganisms and activation of the immune response. Nature 2007; 449: 819-826.
32. Alexandre-Silva GM, Brito-Souza PA, Oliveira ACS, Cerni FA, Zottich U, Pucca MB. The hygiene hypothesis at a glance: Early exposures, immune mechanism and novel therapies. Acta Trop 2018; 188: 16-26.
33. Niles MT, Bertmann F, Belarmino EH, Wentworth T, Biehl E, Neff R. The Early Food Insecurity Impacts of COVID-19. Nutrients 2020; 12: 96.
34. Vasile C. Mental health and immunity (Review). Exp Ther Med 2020; 20: 211.
35. Belchior-Bezerra M, Lima RS, Medeiros NI, Gomes JAS. COVID-19, obesity, and immune response 2 years after the pandemic: A timeline of scientific advances. Obes Rev 2022; 23: e13496.
36. Driver L, McFadden K, Al Jalbout N, Shokoohi H. Delayed Diagnosis of Shoulder Septic Arthritis and Osteomyelitis During the COVID-19 Pandemic: The Role of Point-of-Care Ultrasound. Cureus 2023; 15: e35460.
37. Hodgson BF. Pyogenic sacroiliac joint infection. Clin Orthop 1989; 246: 146-149.
38. Colatutto D, Sonaglia A, Zabotti A, Cereser L, Girometti R, Quartuccio L. post-COVID-19 Arthritis and Sacroiliitis: Natural History with Longitudinal Magnetic Resonance Imaging Study in Two Cases and Review of the Literature. Viruses 2021; 13: 1558.
39. Piper D, Smith G, Archer JE, Woffenden H, Woffenden H, Bose D. Management of Native Joint Septic Arthritis, Serial Aspiration vs. Arthroscopic Washout During the COVID-19 Pandemic. Cureus 2020; 12: e11391.