

## Myocarditis: A complication of COVID-19 and long-COVID-19 syndrome as a serious threat in modern cardiology

Lukasz Szarpak<sup>1,2,3</sup> , Michal Pruc<sup>3</sup> , Krzysztof J. Filipiak<sup>1</sup> , Julia Popieluch<sup>4</sup>, Andrzej Bielski<sup>3,5</sup> , Milosz J. Jaguszewski<sup>6</sup> , Natasza Gilis-Malinowska<sup>6</sup> , Francesco Chirico<sup>7,8</sup> , Zubaid Rafique<sup>9</sup> , Frank W. Peacock<sup>9</sup>

<sup>1</sup>Institute of Outcomes Research, Maria Skłodowska-Curie Medical Academy, Warsaw, Poland

<sup>2</sup>Research Institute, Maria Skłodowska-Curie Białystok Oncology Center, Białystok, Poland

<sup>3</sup>Research Unit, Polish Society of Disaster Medicine, Warsaw, Poland

<sup>4</sup>Students Research Club, Maria Skłodowska-Curie Medical Academy, Warsaw, Poland

<sup>5</sup>Polonia University, Czestochowa, Poland

<sup>6</sup>1<sup>st</sup> Chair and Department of Cardiology, Medical University of Gdansk, Poland

<sup>7</sup>Post-graduate School of Occupational Health, Università Cattolica del Sacro Cuore, Rome, Italy

<sup>8</sup>Health Service Department, Italian State Police, Milan, Italy

<sup>9</sup>Henry JN Taub Department of Emergency Medicine, Baylor College of Medicine, Houston, TX, United States

**This paper was guest edited by Prof. Togay Evrin**

Myocarditis is the inflammation of the heart muscle and is usually a consequence of a viral infection [1]. Because this disease can cause the destruction of myocytes, it may result in cardiomyopathy, heart failure, and sudden cardiac death. Cardiovascular complications from coronavirus disease 2019 (COVID-19) are emerging [2], especially during hospitalization, and myocarditis has been identified as a cause of death in some COVID-19 patients [3]. In the current epidemiological situation of a very large number of hospitalized patients, we must consider the long-term effects of myocarditis caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Initial reports based on magnetic resonance imaging studies showed 78% of patients with myocardial abnormalities and 60% with ongoing myocarditis 2 to 3 months after COVID-19 infection. High blood troponin concentrations were also found in 76% of patients, although their heart function was preserved [4]. In

other studies, about 10 weeks after SARS-CoV-2 infection, 37% of patients were also diagnosed with myocarditis, despite only half of the respondents having symptoms of COVID-19 infection [5]. In contrast, the most recent reports that analyzed data for a fifth of the United States (US) population showed that males between 12 and 17 years of age most likely developed myocarditis within 3 months of SARS-CoV-2 infection, with an incidence of approximately 450 per million infections. The most recent CDC reports, indicating the number of infected teenagers in the US is the highest in all age groups, suggest that myocarditis will become a significant burden [6]. The reports also estimate a 16 times higher risk in patients with COVID-19 compared to the general population, with an incidence of COVID-19-associated myocarditis of approximately 150 cases per 100,000 [7].

In light of these numbers, cardiac complications both during and after the SARS-CoV-2 infec-

**Address for correspondence:** Lukasz Szarpak, Assoc. Prof., PhD, DPH, MBA, DBA, LLM, Institute of Outcomes Research, Maria Skłodowska-Curie Medical Academy, ul. Solidarności 12, 03–411 Warszawa, Poland, e-mail: lukasz.szarpak@gmail.com

Received: 10.09.2021

Accepted: 14.11.2021

Early publication date: 19.11.2021

This article is available in open access under Creative Commons Attribution-Non-Commercial-No Derivatives 4.0 International (CC BY-NC-ND 4.0) license, allowing to download articles and share them with others as long as they credit the authors and the publisher, but without permission to change them in any way or use them commercially.

tion will become a significant burden. Currently, the only effective method of preventing COVID-19 complications is vaccination, which reduces not only the risk of infection and mortality but also its long-term complications, i.e., long-COVID-19. In a study of 971,504 fully vaccinated people, only 0.2% developed COVID-19 symptoms, and only 31 developed long-COVID-19. On the other hand, the rate of COVID-19 infections was 11% in the unvaccinated group [8].

There is a lesser need to focus on myocarditis following mRNA vaccination [9]. This is because the infection and hospitalization rates are 17 times lower when compared to the unvaccinated group [10]. In summary, it is necessary to vaccinate the whole of society as soon as possible, perform further research on myocarditis in long-COVID-19 syndrome, create effective screening systems, and provide care for people suffering from long-COVID-19 syndrome before it leads to more serious complications.

### Acknowledgments

The study was supported by the ERC Research Net and by the Polish Society of Disaster Medicine.

**Conflict of interest:** None declared

### References

- Pollack A, Kontorovich AR, Fuster V, et al. Viral myocarditis—diagnosis, treatment options, and current controversies. *Nat Rev Cardiol.* 2015; 12(11): 670–680, doi: [10.1038/nrcardio.2015.108](https://doi.org/10.1038/nrcardio.2015.108), indexed in Pubmed: [26194549](https://pubmed.ncbi.nlm.nih.gov/26194549/).
- Robak O, Dudek M, Ladny JR, et al. Cardiac tamponade as a cause of COVID-19. *Cardiol J.* 2020; 27(6): 900–901, doi: [10.5603/CJ.2020.0175](https://doi.org/10.5603/CJ.2020.0175), indexed in Pubmed: [33432570](https://pubmed.ncbi.nlm.nih.gov/33432570/).
- Ruan Q, Yang K, Wang W, et al. Clinical predictors of mortality due to COVID-19 based on an analysis of data of 150 patients from Wuhan, China. *Intensive Care Med.* 2020; 46(6): 1294–1297, doi: [10.1007/s00134-020-06028-z](https://doi.org/10.1007/s00134-020-06028-z), indexed in Pubmed: [32253449](https://pubmed.ncbi.nlm.nih.gov/32253449/).
- Puntmann VO, Carerj ML, Wieters I, et al. Outcomes of cardiovascular magnetic resonance imaging in patients recently recovered from coronavirus disease 2019 (COVID-19). *JAMA Cardiol.* 2020; 5(11): 1265–1273, doi: [10.1001/jamacardio.2020.3557](https://doi.org/10.1001/jamacardio.2020.3557), indexed in Pubmed: [32730619](https://pubmed.ncbi.nlm.nih.gov/32730619/).
- Eiros R, Barreiro-Perez M, Martin-Garcia A, et al. Pericarditis and myocarditis long after SARS-CoV-2 infection: a cross-sectional descriptive study in health-care workers. *medRxiv.* 2020, doi: [10.1101/2020.07.12.20151316](https://doi.org/10.1101/2020.07.12.20151316).
- Singer ME, Taub IB, Kaelber DC. Risk of Myocarditis from COVID-19 Infection in People Under Age 20: A Population-Based Analysis. *medRxiv.* 2021, doi: [10.1101/2021.07.23.21260998](https://doi.org/10.1101/2021.07.23.21260998), indexed in Pubmed: [34341797](https://pubmed.ncbi.nlm.nih.gov/34341797/).
- Boehmer TK, Kompaniyets L, Lavery AM, et al. Association Between COVID-19 and Myocarditis Using Hospital-Based Administrative Data — United States, March 2020–January 2021. *MMWR Morb Mortal Wkly Rep.* 2021; 70(35): 1228–1232, doi: [10.15585/mmwr.mm7035e5](https://doi.org/10.15585/mmwr.mm7035e5), indexed in Pubmed: [34473684](https://pubmed.ncbi.nlm.nih.gov/34473684/).
- Antonelli M, Penfold RS, Merino J, et al. Risk factors and disease profile of post-vaccination SARS-CoV-2 infection in UK users of the COVID Symptom Study app: a prospective, community-based, nested, case-control study. *Lancet Infect Dis.* 2021 [Epub ahead of print], doi: [10.1016/S1473-3099\(21\)00460-6](https://doi.org/10.1016/S1473-3099(21)00460-6), indexed in Pubmed: [34480857](https://pubmed.ncbi.nlm.nih.gov/34480857/).
- Diaz GA, Parsons GT, Gering SK, et al. Myocarditis and pericarditis after vaccination for COVID-19. *JAMA.* 2021; 326(12): 1210–1212, doi: [10.1001/jama.2021.13443](https://doi.org/10.1001/jama.2021.13443), indexed in Pubmed: [34347001](https://pubmed.ncbi.nlm.nih.gov/34347001/).
- Delahoy MJ, Ujamaa D, Whitaker M, et al. Hospitalizations Associated with COVID-19 Among Children and Adolescents — COVID-NET, 14 States, March 1, 2020–August 14, 2021. *MMWR Morb Mortal Wkly Rep.* 2021; 70(36): 1255–1260, doi: [10.15585/mmwr.mm7036e2](https://doi.org/10.15585/mmwr.mm7036e2), indexed in Pubmed: [34499627](https://pubmed.ncbi.nlm.nih.gov/34499627/).

