Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

International Journal of Cardiology 339 (2021) 243–245

Contents lists available at ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

Editorial

Multimodality evaluation of cardiac injury in COVID-19: Getting to the heart of the matter☆

ARTICLE INFO

Keywords
COVID-19
SARS-CoV-2
Cardiovascular disease
Cardiovascular imaging
Multimodality
Pandemic

More than a year after its emergence in Wuhan (China), severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection has reached a global pandemic status and changed the collective perception of medicine and society permanently [1–4]. At the time of this writing, the global death toll from coronavirus disease-19 (COVID-19) has exceeded 4 million as SARS-CoV-2 infections crossed 185 million cases worldwide. Although initially believed to be a respiratory syndrome characterized solely by acute lung injury and respiratory failure, this infectious pathology commonly and adversely affects cardiovascular system. Cardiac injury in COVID-19 patients can be triggered by a multitude of causes, including direct cytopathic damage of cardiomyocytes and indirect injury secondary to systemic inflammation, endothelial activation, and microvascular thrombosis [1–6]. In addition, the risk of coronary thrombosis due to atherosclerotic plaque rupture/erosion appears to increase during SARS-CoV-2 infection [1,4–7].

Nearly two-thirds of patients hospitalized for COVID-19 have evidence of cardiac injury, which has been reported to be associated with more severe illness, greater need for intensive care, and worse prognosis [1,8–11]. Previous studies have mainly examined myocardial injury based on abnormal laboratory findings (i.e., rise and/or fall of cardiac troponin on admission or during hospitalization), offering limited evidence on the prevalence and implications of concomitant structural or functional cardiac abnormalities at electrocardiographic and imaging analysis [9,12]. Yet, whether elevated circulating levels of myocardial necrosis biomarkers "in isolation" confers a higher risk of adverse events remains controversial. Giustino et al. recently reported that COVID-19 patients with increased cardiac troponins more frequently have electrocardiographic and echocardiographic abnormalities than those with normal troponin values [8]. They showed that serum troponin elevation was independently associated with an increased risk of in-hospital mortality, but interestingly this effect was confined to patients with concomitant cardiac structural abnormalities at transthoracic echocardiography (resulting neutral otherwise). These findings underline the importance of a comprehensive cardiac evaluation in the case of confirmed SARS-CoV-2 infection – integrating clinical, laboratory, electrocardiographic, and imaging data – to properly risk stratify and manage these patients [1,8–13]. However, performing an extensive cardiac workup in the setting of COVID-19 is logistically challenging due to patients' clinical liability and the need for limiting healthcare personnel exposure. Therefore, studies addressing SARS-CoV-2-related cardiac injury by multiple diagnostic modalities (the so-called "multimodality approach") remain desirable to better inform in- and out-of-hospital pathways and optimize cardiovascular care in the current pandemic.

In this issue of the *International Journal of Cardiology*, Maestrini and colleagues, on behalf of the Policlinico Umberto I COVID-19 Group, reported the results of a study aiming at comprehensively characterizing cardiac involvement and its clinical implications in hospitalized patients with SARS-CoV-2 infection [14]. The study enrolled 152 consecutive COVID-19 patients who underwent multimodality cardiovascular evaluation during hospitalization and at 1 month (with 1-year telephone follow-up). The prospective inclusion of unselected patients receiving systematic and serial cardiac examination is a strength of this study compared with previous reports, which often included retrospective data of non-consecutive patients limited to the in-hospital stay period [1].

The heart can be affected in diverse ways by SARS-CoV-2 infection, which is entirely in line with the data offered by the authors [14]. About 30% of patients presented with new cardiovascular conditions encompassing a broad spectrum of manifestations – namely, left or biventricular myocarditis, myocardial infarction, Takotsubo syndrome, pulmonary embolism with right ventricular dysfunction, and

☆ All authors take responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

https://doi.org/10.1016/j.ijcard.2021.07.031
Received 12 July 2021; Accepted 14 July 2021
Available online 21 July 2021

pericarditis. Consistently with previous reports [1,8], the presence of cardiovascular disease was independently associated with 3-fold increase in the risk of mortality [14]. Maestrini et al. demonstrated that the adoption of a uniform and straightforward diagnostic algorithm – including routine implementation of troponin testing, 12-lead ECG, and focus cardiac ultrasound, with optional cardiac magnetic resonance, coronary angiography, and computed tomography pulmonary angiography, if clinically indicated – is feasible and allows an accurate definition of cardiac involvement in the majority of COVID-19 patients. Cardiac troponin is recommended by Professional Societies to detect and quantify myocardial injury, irrespective of its origin, and carries relevant diagnostic and prognostic implications in SARS-CoV-2 infection [1]. Standard ECG represents a valuable tool to identify the two main patterns of myocardial injury in COVID-19: diffuse ST-segment deviation (mainly reflecting diffuse myocardial inflammation) and regional ST-segment deviation (possibly indicating ischemic damage due to coronary/microvascular thrombosis). In the Policlinico Umberto I experience, laboratory and electrocardiographic findings were routinely integrated with imaging data to more precisely evaluate the causes and extension of myocardial injury, confirm or redirect initial diagnostic hypothesis, and guide therapeutic decisions. Follow-up data remarked the importance of early defining cardiovascular status in COVID-19. In general, patients with cardiac involvement on admission reported symptoms resolution and improved cardiac function at 30 days, with no cardiovascular recurrences or new hospitalization [14]. Among those without cardiac involvement on admission, two developed acute pericarditis and started anti-inflammatory therapy at 30-day visit. These data reinforce the conviction that timely diagnosis of COVID-19-related cardiovascular abnormalities and strict follow-up are critical to establish an appropriate treatment and improve short-term outcomes. The long-term cardiac consequences of COVID-19 were less clearly addressed in this study since 1-year follow-up was limited to phone contact exploring re-hospitalization and symptom status only.

Cardiac involvement plays a key role in the management and prognostication of patients with SARS-CoV-2 infection. Based on available evidence, we endorse a systematic (yet stepwise) cardiovascular evaluation including clinical, laboratory, electrocardiographic, and (focus) echocardiographic data in the totality of patients hospitalized for COVID-19, reserving more advanced techniques to selected cases in whom additional information is needed for diagnostic and therapeutic purposes (Fig. 1).

We congratulate the Policlinico Umberto I COVID-19 Group for the important data presented in the *Journal*. Despite the limitations of a relatively small number of participants (n = 152) and single-center

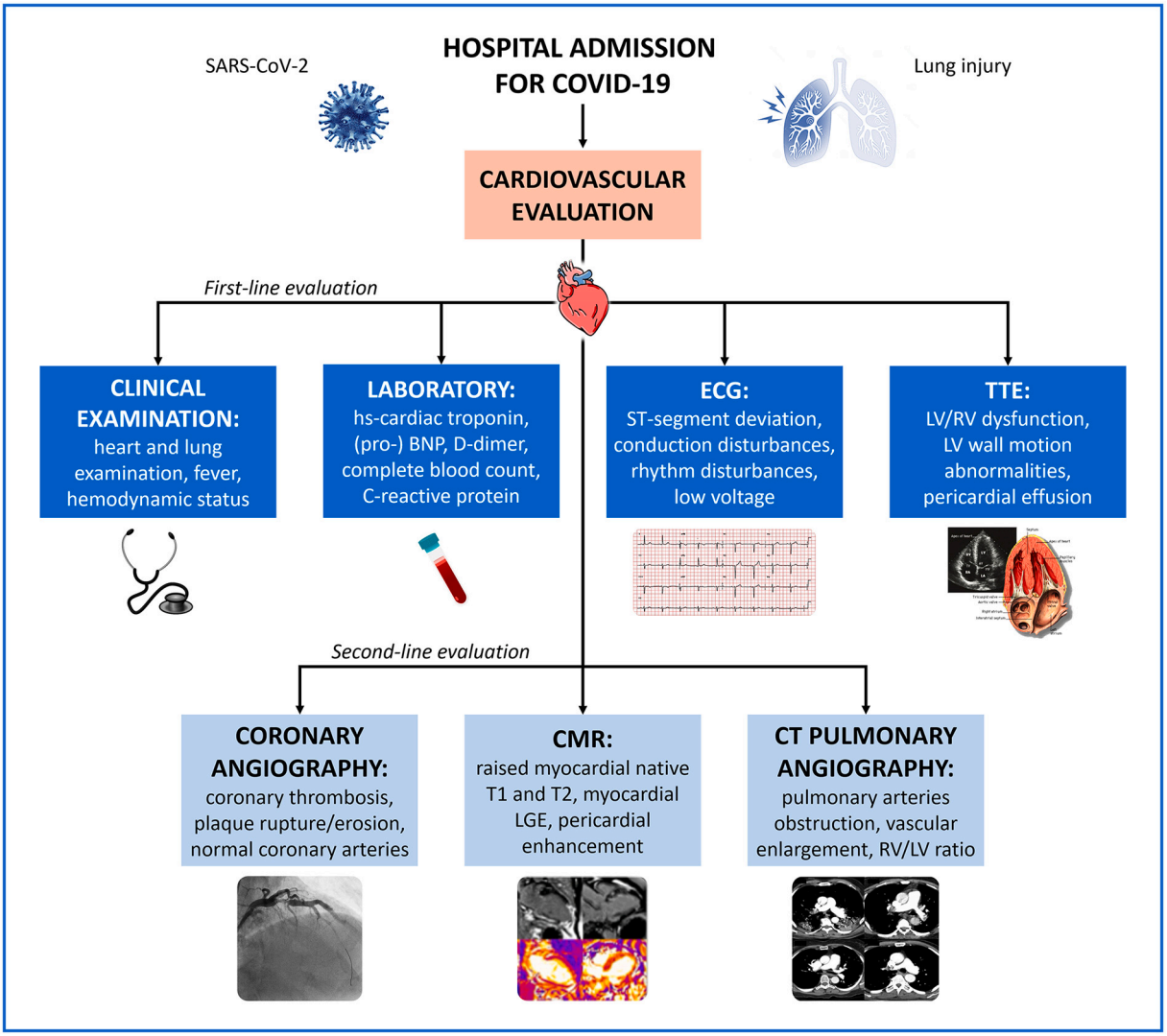

Fig. 1. Cardiovascular evaluation algorithm in COVID-19 patients.
BNP: Brain Natriuretic Peptide; CMR: Cardiac Magnetic Resonance; COVID-19: Coronavirus Disease-19; LGE: Late Gadolinium Enhancement; LV: hs: High Sensitivity; Left Ventricle; RV: Right Ventricle; SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus 2; TTE: Transthoracic Echocardiography.

design, which may limit the generalizability of the results, this real-world experience offers practical evidence to refine cardiovascular management of COVID-19 patients.

Long-term cardiovascular data of patients who have recovered from SARS-CoV-2 infection are now urgently required to inform and improve clinical practice in the pandemic (and post-pandemic) world.

Authors' contributions

All authors contributed to the conception, writing, and critical revision of the manuscript, and they approved the final version submitted to the Journal.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declarations of interest

None.

Acknowledgements

None.

References

[1] G. Giustino, S.P. Pinney, A. Lala, et al., Coronavirus and cardiovascular disease, myocardial injury, and arrhythmia: JACC focus seminar, J. Am. Coll. Cardiol. 76 (2020) 2011–2023, https://doi.org/10.1016/j.jacc.2020.08.059.

[2] J. Sabatino, S. Moscatelli, Y. Rustamova, et al., Pink international young academy of cardiology. Women's perspective on the COVID-19 pandemic: walking into a post-peak phase, Int. J. Cardiol. 323 (2021) 29–33, https://doi.org/10.1016/j.ijcard.2020.08.025.

[3] W. Tan, J. Aboulhosn, The cardiovascular burden of coronavirus disease 2019 (COVID-19) with a focus on congenital heart disease, Int. J. Cardiol. 309 (2020) 70–77, https://doi.org/10.1016/j.ijcard.2020.03.063.

[4] S. De Rosa, C. Spaccarotella, C. Basso, et al., Società Italiana di Cardiologia and the CCU academy investigators group. Reduction of hospitalizations for myocardial infarction in Italy in the COVID-19 era, Eur. Heart J. 41 (2020) 2083–2088, https://doi.org/10.1093/eurheartj/ehaa409.

[5] O. Scudiero, B. Lombardo, M. Brancaccio, et al., Exercise, immune system, nutrition, respiratory and cardiovascular diseases during COVID-19: a complex combination, Int. J. Environ. Res. Public Health 18 (2021) 904, https://doi.org/10.3390/ijerph18030904.

[6] G. Patti, V. Lio, I. Cavallari, et al., Italian study group on atherosclerosis, thrombosis. Questions and answers on practical thrombotic issues in SARS-CoV-2 infection: a guidance document from the Italian working group on atherosclerosis, thrombosis and vascular biology, Am. J. Cardiovasc. Drugs 20 (2020) 559–570, https://doi.org/10.1007/s40256-020-00446-6.

[7] G. Patti, V. Lio, I. Cavallari, et al., Antithrombotic treatments in patients with SARS-CoV-2 infection: from current evidence to reasonable recommendations - a position paper from the Italian working group on atherosclerosis, thrombosis and vascular biology, G Ital. Cardiol. (Rome) 21 (2020) 489–501, https://doi.org/10.1714/3386.33634.

[8] G. Giustino, L.B. Croft, G.G. Stefanini, et al., Characterization of myocardial injury in patients with COVID-19, J. Am. Coll. Cardiol. 76 (2020) 2043–2055, https://doi.org/10.1016/j.jacc.2020.08.069.

[9] A. Maino, E. Di Stasio, M.C. Grimaldi, et al., Prevalence and characteristics of myocardial injury during COVID-19 pandemic: a new role for high-sensitive troponin, Int. J. Cardiol. (2021), https://doi.org/10.1016/j.ijcard.2021.06.028. S0167-5273(21)01026–3.

[10] C. Bleakley, S. Singh, B. Garfield, et al., Right ventricular dysfunction in critically ill COVID-19 ARDS, Int. J. Cardiol. 327 (2021) 251–258, https://doi.org/10.1016/j.ijcard.2020.11.043.

[11] Q. Deng, B. Hu, Y. Zhang, et al., Suspected myocardial injury in patients with COVID-19: evidence from front-line clinical observation in Wuhan, China, Int. J. Cardiol. 311 (2020) 116–121, https://doi.org/10.1016/j.ijcard.2020.03.087.

[12] C. Yang, F. Liu, W. Liu, et al., Myocardial injury and risk factors for mortality in patients with COVID-19 pneumonia, Int. J. Cardiol. 326 (2021) 230–236, https://doi.org/10.1016/j.ijcard.2020.09.048.

[13] S. Leonardi, F. Gragnano, G. Carrara, et al., Prognostic implications of declining hemoglobin content in patients hospitalized with acute coronary syndromes, J. Am. Coll. Cardiol. 77 (2021) 375–388, https://doi.org/10.1016/j.jacc.2020.11.046.

[14] V. Maestrini, L.I. Birtolo, M. Francone, et al., Policlinico Umberto I COVID-19 group. Cardiac involvement in consecutive unselected hospitalized COVID-19 population: in-hospital evaluation and one-year follow-up, Int. J. Cardiol. (2021), https://doi.org/10.1016/j.ijcard.2021.06.056. S0167-5273(21)01094–9.

Felice Gragnano[a,b], Arturo Cesaro[a,b], Francesco Pelliccia[c], Paolo Calabrò[a,b,*]

[a] *Department of Translational Medical Sciences, University of Campania "Luigi Vanvitelli", Naples, Italy*

[b] *Division of Cardiology, A.O.R.N. "Sant'Anna e San Sebastiano", Caserta, Italy*

[c] *Department of Cardiovascular Sciences, Sapienza University, Rome, Italy*

[*] Corresponding author at: Division of Clinical Cardiology, A.O.R.N. Sant'Anna e San Sebastiano, F. Palasciano 1, Caserta 81100, Italy.

E-mail addresses: arturo.cesaro@unicampania.it (A. Cesaro), md4151@mclink.it (F. Pelliccia), paolo.calabro@unicampania.it (P. Calabrò).