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.

Trends in Cardiovascular Medicine 31 (2021) 17–19

Contents lists available at ScienceDirect

Trends in Cardiovascular Medicine

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

Editorial commentary: Cardiovascular imaging in COVID-19: Focus on safety, value, and clinical relevance ☆

Sourbha S. Dani [a], Shiv Bagga [a], Sarju Ganatra [a,b,*]

[a] Department of Cardiovascular Medicine, Lahey Hospital and Medical Center, Beth Israel Lahey Health, Burlington, MA, 01805, USA
[b] Cardio-Oncology Program, Department of Cardiovascular Medicine, Lahey Hospital and Medical Center, Beth Israel Lahey Health, Burlington, MA, 01805, USA

ARTICLE INFO

Keywords:
COVID-19
Cardiovascular disease
Multimodality imaging
Echocardiogram
Cardiac MRI

The novel coronavirus disease 2019 (COVID-19) pandemic caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) has disrupted the global order. The disease has affected the health of millions and has disrupted billions of lives due to its social, economic, and psychological impact. COVID-19 and cardiovascular diseases have shown a bidirectional relationship. Underlying pre-existing cardiovascular risk factors and disease appear to be at an increased susceptibility and severity of COVID-19 [1,2]. In addition, *de-novo* cardiovascular involvement in various forms (type II myocardial infarction, arrhythmia, myocarditis, heart failure, and venous thromboembolism) is reported in a high proportion of patients with severe COVID-19, which is also associated with adverse outcomes [3–5]. While the exact mechanisms of cardiovascular involvement with COVID-19 are not well understood, several potential mechanisms such as direct toxicity through the myocardial viral invasion (myocarditis), angiotensin-converting enzyme-2 (ACE-2) receptor-mediated myocardial and endothelial injury, microvascular dysfunction and thrombosis as well as cytokine release syndrome (mainly IL-6 mediated) and stress cardiomyopathy due to the imbalance in myocardial supply and demand have been implicated [6,7].

While several studies have shown myocardial injury in patients with severe COVID-19, based upon elevation in myocardial necrosis biomarker [1,6,8], performing an extensive cardiac workup in patients with COVID-19 is challenging not just because of their clinical status but also due to the need of limiting exposure of health care personnel [9]. Non-invasive imaging remains the backbone for the diagnosis and risk stratification as well as to guide the management of cardiovascular disease [8,10,11]. The review by Citro et al. [12] in this issue of the Journal describes the role of various imaging modalities for the identification of various COVID-19 associated cardiovascular manifestations as well as how to efficiently utilize these tests during the pandemic to minimize the risk of infection transmission to healthcare workers and patients.

The authors provide a concise summary of practically useful recommendations based upon the evolving knowledge of COVID-19 as well as the mechanisms of cardiovascular system involvement and its implications. While the review article by Citro et al. [12] has mainly focused on cardiovascular imaging in patients with COVID-19, cardiovascular imaging amidst the pandemic, even in patients without COVID-19, needs thoughtful consideration and special attention [5]. The role of multimodality imaging in the context of COVID-19 is important on several fronts i) for diagnosis and risk stratification as well as to guide management of acute COVID-19 associated cardiovascular issues, ii) for assessment of non-COVID associated cardiovascular problems during the pandemic, iii) to study the long-term cardiovascular consequences of those affected with COVID-19, iv) screening and surveillance imaging of the high-risk patient population, e.g., patients with cancer undergoing potentially cardiotoxic chemotherapy for guideline-recommended surveillance [13]. Various societal guidelines and position papers have outlined the critical role of imaging and have laid out management pathways concerning cardiovascular care [13-15].

The authors describe that in COVID-19 patients with abnormal cardiac biomarkers or cardiovascular symptoms, a 2-Dimensional transthoracic echocardiogram (2D-TTE) used as a point of contact ultrasound (POCUS) is the first-line imaging modality given that it is an easily available, portable, and high-value, low-cost inter-

☆ Disclaimers: None.

* Corresponding author.
E-mail address: sarju.ganatra@lahey.org (S. Ganatra).

https://doi.org/10.1016/j.tcm.2020.10.015

vention [12,15]. A dedicated team of sonographers and machines in the emergency room and COVID-19 designated units can help diagnose and differentiate various common cardiovascular conditions in patients with COVID-19 such as acute coronary syndrome (ACS) with wall motion abnormalities, type II myocardial infarction due to supply-demand mismatch, or stress cardiomyopathy [5]. It can also be utilized to assess left ventricular function and differentiate non-cardiogenic shocks from cardiogenic. Acute pulmonary embolism, which is reported in a significant proportion of critically ill patients with COVID-19, may lead to right ventricular dysfunction, and TTE may help prompt diagnosis as well as prognostication [11].

A recent multicenter study showed that among patients with myocardial injury as noted by elevated cardiac troponin (cTn) during COVID-19 illness, any cardiac structural abnormality such as left ventricular wall motion abnormalities, global left ventricular dysfunction, left ventricular diastolic dysfunction, right ventricular dysfunction, and pericardial effusions noted on TTE was associated with a significantly elevated risk of in-hospital mortality [8]. These findings would argue about routine testing of cardiac biomarkers as well as cardiovascular imaging, at least TTE in all patients with an elevated cardiac biomarker. However, given the rapidly increasing number of COVID-19 associated hospitalizations, the healthcare infrastructure is facing an unprecedented burden on available resources. Additionally, elevated cTn in most critically ill patients is secondary to supply-demand mismatch, and they may have underlying pre-existing cardiovascular disease, which may represent adverse prognosis. Cardiac imaging under these circumstances may not provide any additional actionable information [16]. Universal imaging with TTE or other modalities, while may be tempting, is neither practical nor necessary. Judicious utilization, focused rather than detailed echocardiographic examination, and utilization of appropriate personal protective equipment (PPE) are crucial in minimizing infection transmission from proven or suspected cases of COVID-19, thus balancing patient care and safety [17].

Trans-esophageal echocardiogram (TEE) is a potentially aerosol-generating procedure that necessitates full PPE, and should be avoided without a compelling indication in suspected or proven COVID-19 cases [14]. Alternative imaging modalities should be considered when appropriate. For example, cardiac computed tomography (CT) scan could replace the need for TEE in cases of atrial fibrillation requiring cardioversion for ruling out left atrial appendage clot. While hyperinflammatory response seen with COVID-19 may lead to coronary plaque destabilization and thrombosis leading to ACS, as alluded to above; more often, cTn elevation in COVID-19 patients is secondary to supply-demand ischemia [16]. Coronary computed tomography (CT) angiography has a high negative predictive value to rule out obstructive coronary artery disease. Instead of invasive cardiac catheterization, it could be considered as its rapid acquisition time helps minimize exposure to COVID-19(5). In fact, chest CT (with different sequencings) can be used as a one-stop-shop to evaluate pneumonia, pleural effusions, pulmonary embolism, and even obstructive coronary artery disease.

A prospective study by Puntmann et al. [18] from Germany showed that a significant proportion of patients (60%) had myocardial inflammation detected by cardiac magnetic resonance imaging (CMR) likely due to myocarditis. However, the clinical implication of this remains unknown. Due to its high accuracy for LVEF assessment and the ability for myocardial tissue characterization, including identification of inflammation, fibrosis, and scar burden, CMR is typically a necessary diagnostic test in patients with suspected myocarditis [19]. However, despite the relatively high prevalence of possible myocarditis in one study, in the context of COVID-19, it should be used cautiously and as clinically indicated rather than for screening purposes in all-comers. When needed, abbreviated exams tailored to the specific clinical question should be performed due to decreased exposure time and required down-time of the scanner in between studies for decontamination [20]. When unavailable or difficult to obtain, a cardiac CT scan with myocardial late iodine enhancement (LIE) to detect areas of myocardial fibrosis, inflammation, or diffuse ischemia can be considered, which may help to avoid the need for time-consuming CMR.

Multimodality cardiovascular imaging will remain instrumental in the deceleration phase of this pandemic as well. Cardiovascular imaging will play a pivotal role to better understand the long-term cardiovascular consequences of COVID-19, particularly in those who may have had COVID-19 associated myocarditis, have residual cardiovascular manifestations, and potentially for those who need to resume high-intensity activity, such as professional athletes.

Many non-urgent but required cardiovascular imaging tests for non-COVID-19 associated cardiovascular issues have been significantly delayed due to the pandemic, which may have a long-term adverse impact. As we "re-open", we will have to identify and prioritize high-risk patients so the limited resources can be utilized wisely. One such group is patients undergoing potentially cardiotoxic anti-neoplastic therapy where cardiac surveillance imaging is typically required [21,22]. We will also have to learn to utilize other markers of cardiotoxicity, such as cardiac biomarkers, in case of limited imaging-resource availability. Vigilant follow-up and thorough clinical examination would also likely limit the need for repeat imaging in only selected cases. Additionally, stringent protective measures such as universal testing for SARS-CoV-2 in all patients before any invasive or aerosol-generating procedure regardless of symptoms, masking policy for everyone including patients at all times while in health care facilities, hand hygiene, and use of appropriate PPE by healthcare providers should be continually followed.

Over time, we have relied increasingly on non-invasive imaging tests, which has revolutionized cardiovascular care by enabling us to make a timely diagnosis and individualize the management. While this is helpful in most instances, we as a medical community have also overused such diagnostic testing leading to a plethora of incidental findings of undetermined significance [23]. Amidst the pandemic, it is now more critical than ever before to judiciously and rightfully use these tests to avoid under and over-diagnosis and minimize the risk of bidirectional infection transmission.

References

[1] Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. The Lancet 2020.
[2] Guan WJ, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX, et al. Clinical characteristics of coronavirus disease 2019 in China. N Engl J Med 2020.
[3] Guo T, Fan Y, Chen M, Wu X, Zhang L, He T, et al. Cardiovascular implications of fatal outcomes of patients with coronavirus disease 2019 (COVID-19). JAMA Cardiol 2020.
[4] Ganatra S, Hammond SP, Nohria A. The novel coronavirus disease (COVID-19) threat for patients with cardiovascular disease and cancer. JACC: CardioOncology 2020;80.
[5] Ganatra S, Dani SS, Shah S, Asnani A, Neilan TG, Lenihan D, et al. Management of cardiovascular disease during coronavirus disease (COVID-19) pandemic. Trends Cardiovasc Med 2020.
[6] Zheng Y-Y, Ma Y-T, Zhang J-Y, Xie X. COVID-19, and the cardiovascular system. Nat Rev Cardiol 2020.
[7] Nicin L, Abplanalp WT, Mellentin H, Kattih B, Tombor L, John D, et al. Cell type-specific expression of the putative SARS-CoV-2 receptor ACE2 in human hearts. Eu Heart J 2020.
[8] Lala A, Johnson KW, Januzzi JL, Russak AJ, Paranjpe I, Richter F, et al. Prevalence and impact of myocardial injury in patients hospitalized with COVID-19 infection. J Am Coll Cardiol 2020;76(5):533–46.
[9] Lavie CJ, Sanchis-Gomar F, Lippi G. Cardiac injury in COVID-19–echoing prognostication[*]. J Am College Cardiol 2020;76(18):2056–9.
[10] Giustino G, Croft LB, Stefanini GG, Bragato R, Silbiger JJ, Vicenzi M, et al. Characterization of myocardial injury in patients with COVID-19. J Am College Cardiol 2020;76(18):2043–55.

[11] Li Y, Li H, Zhu S, Xie Y, Wang B, He L, et al. Prognostic value of right ventricular longitudinal strain in patients with COVID-19. JACC: Cardiovas Imaging;0(0).
[12] Citro R, Pontone G, Bellino M, Silverio A, Iuliano G, Baggiano A, et al. Role of multimodality imaging in evaluation of cardiovascular involvement in COVID-19. Trends Cardiovasc Med 2020.
[13] Lenihan D, Carver J, Porter C, Liu JE, Dent S, Thavendiranathan P, et al. Cardio-oncology care in the era of the coronavirus (COVID-19) pandemic: an international cardio-oncology society (ICOS) statement on cardiac safety in a new treatment paradigm. CA Cancer J Clin 2020 In Press.
[14] Rudski L, Januzzi JL, Rigolin VH, Bohula EA, Blankstein R, Patel AR, et al. Multimodality imaging in evaluation of cardiovascular complications in patients with COVID-19: JACC scientific expert panel. J Am Coll Cardiol 2020;76(11):1345–57.
[15] Kirkpatrick JN, Mitchell, Taub C, Kort C, Hung S, Swaminathan M J. ASE statement on protection of patients and echocardiography service providers during the 2019 novel coronavirus outbreak: endorsed by the American college of cardiology. J Am Soc Echocardiogr 2020;33(6):648–53.
[16] Sandoval Y, Januzzi JL Jr, Jaffe AS. Cardiac troponin for assessment of myocardial injury in COVID-19: JACC review topic of the week. J Am Coll Cardiol 2020;76(10):1244–58.
[17] ASE Statement on Point-of-Care Ultrasound (POCUS) During the 2019 Novel Coronavirus Pandemic. Available at: https://www.asecho.org/wp-content/uploads/2020/04/POCUS-COVID_FINAL2_web.pdf. Accessed April 20, 2020.
[18] Puntmann VO, Carerj ML, Wieters I, Fahim M, Arendt C, Hoffmann J, et al. Outcomes of cardiovascular magnetic resonance imaging in patients recently recovered from coronavirus disease 2019 (COVID-19). JAMA Cardiol 2020.
[19] Friedrich MG, Sechtem U, Schulz-Menger J, Holmvang G, Alakija P, Cooper LT, et al. Cardiovascular magnetic resonance in myocarditis: a JACC white paper. J Am Coll Cardiol 2009;53(17):1475–87.
[20] Kelle S, Bucciarelli-Ducci C, Judd RM, Kwong RY, Simonetti O, Plein S, et al. Society for cardiovascular magnetic resonance (SCMR) recommended CMR protocols for scanning patients with active or convalescent phase COVID-19 infection. J Cardiovasc Magn Reson 2020;22(1):61.
[21] Lenihan D, Carver J, Porter C, Liu JE, Dent S, Thavendiranathan P, et al. Cardio-oncology care in the era of the coronavirus disease 2019 (COVID-19) pandemic: an international cardio-oncology society (ICOS) statement. CA: A Cancer J Clinicians;n/a(n/a).
[22] Ganatra S, Dani S, Redd R, Rieger-Christ K, Patel R, Parikh R, et al. Outcomes of the novel coronavirus disease 2019 in patients with a history of cancer and co-morbid cardiovascular disease. J Natl Compr Canc Netw 2020;Nov 3:1-10. PMID: 33142266 In this issue https://jnccn.org/view/journals/jnccn/aop/article-10.6004-jnccn.2020.7658/article-10.6004-jnccn.2020.7658.xml. doi:10.6004/jnccn.2020.7658.
[23] Roth AR, Lazris A, Ganatra S. Overuse of cardiac testing. Am Fam Physician 2018;98(10):561–3.