COVID-19 Specificity Advanced Imaging

Subjects: Others

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Advanced cardiac imaging may play a role in discriminating the broad spectrum of differential diagnoses. The easiest tools are represented by the advanced imaging techniques in echocardiography. Among them, the most important one is the myocardial strain evaluation using the speckle-tracking analysis. Similarly, other useful tools are the cardiac magnetic resonance (CMR) and the positron-emission tomography (PET) that, however, are both more difficult to use in acute patients. Finally, there is no specific advanced imaging useful to differentiate or help in arrhythmias' management. Nevertheless, being the latter issue an essential prospective, additional studies are needed to further investigate this topic.

Keywords: cardiovascular involvement ; cardiovascular magnetic resonance ; coronavirus disease 2019 ; echocardiography ; emergency ; heart computerized tomography ; intensive care ; lung ultrasound ; nuclear imaging ; point-of-care ultrasonography

1. Echocardiography Longitudinal Strain

TTE may be empowered by advanced imaging techniques. The longitudinal strain (LS) measured by two-dimensional speckle-tracking echocardiography (2D-STE). It is a recent method able to perform a more accurate and sensitive indicator of cardiac function in a variety of cardiovascular diseases [1][2] and a prognostic tool in different clinical settings [3][4]. RV LS (RVLS) is an evolution of the technique used in COVID-19 patients.

Xie et al. [5] investigated biventricular LS in COVID-19 patients as prognostic tool. They found that patients with cardiac injury had higher levels of inflammatory and coagulopathy markers, more mechanical ventilation therapies, higher incidence of complications, and higher mortality. Heart involved patients were characterized by decreased of both LV and RV strain. These results were correlated with higher biomarkers of cardiac injury and inflammation as well as by the presence of pericardial effusion [5][6]. Moreover, patients who died were afflicted by impaired LS, an independent predictor of mortality in a Cox analysis. Therefore, at 3-month follow-up visit after discharge in survivors, a significant improvement was observed in both right and left LS [5]. However, RVLS worsened in patients who experienced hospitalization due to their clinical conditions, especially if they had severe pneumonia [6].

Furthermore, RVLS is useful to evaluate patients who received ventilation. Abnormal LS was found in about 66% of patients ventilated in ICU, and it was associated with higher lung compliance, lower airway plateau pressures, lower tidal volume ventilation and reduced LV function [7]. RV LS is not related to abnormal lung mechanics or ventilatory pressures [7]. A recent systematic review on LS both of LV and RV in COVID-19 patients showed that lower LV-GLS and RV-LS were associated with poor outcome [8]. Authors evaluated clinical trials that analysed as outcome a composite of mortality and severe COVID-19. Their meta-analysis included 7 studies and 612 patients. They found that each 1% decrease in LV-GLS was associated with 1.4 increased risk of poor outcome, while each 1% decrease in RV-LS was associated with 1.3 increased risk of poor outcome [8].

2. Heart Computerized Tomography

Computerized tomography (CT) emerged as one of the primary imaging modalities in the COVID era. CT can be used to evaluate chest pain, LV dysfunction, new onset of heart failure or cardiomyopathy, and evaluation of patients with possible angina and new arrhythmias [9]. Cardiac CT also allows the have a comprehensive assessment of pulmonary parenchyma and vessels as well as an evaluation of coronary arteries. Cardiac CT use become the preferred tool in acute atrial arrhythmias to evaluate LA before to cardioversion, to evaluate of LA appendage closure and during atrial fibrillation ablation [9]. Endocarditis evaluation changed to incorporate multiphase cardiac CT instead of the TEE for patients with low-risk echocardiography findings who presents ongoing clinical suspicion because a persistent bacteraemia. For patients requiring surgical intervention for endocarditis, cardiac CT is preferred to both pre-operative TEE and cardiac catheterization which were routinely deferred when possible. In fact, cardiac CT is able to perform an evaluation of perivalvular complications and coronary anatomy in patients without known coronary disease. However, it is limited to expert centres and it is not routinely used.

3. Cardiovascular Magnetic Resonance

In COVID-19 patients is not clear the role of cardiovascular magnetic resonance (CMR). Advances in multi-parametric CMR now allow having a detailed tissue characterization including scar, diffuse fibrosis, oedema and quantitative ischaemia assessment. During the COVID-19 pandemic, CMR has not been widely considered, as for the necessary limitations due to the strain put upon the healthcare system [10]. Accepted diagnostic indications for CMR should be considered appropriate in COVID 19 patients, but only if it is clinically necessary and after other suited imaging techniques were assessed. Special attention should be given to the use of gadolinium enhanced CMR in patients with COVID-19. Kidney function is often decreased and might contradict a clinically urgent CMR scan. In these patients, the importance of enhanced adrenergic stimulation, systemic inflammation and renal failure in more advanced cases should be recognised. Details of CMR are rather limited but it is useful to provide a diagnosis in patient with elevated troponin from unclear aetiology [11]. Whenever feasible, CMR can allow a non-invasive diagnosis of clinically suspected myocarditis, while a definite diagnosis and proof of SARS-CoV-2 infection and inflammation would require endomyocardial biopsy. The suspicion of acute myocarditis might be one indication for a CMR, especially if typical symptoms, elevated troponins, ventricular dysfunction and/or severe arrhythmias cannot be explained by other diagnostics and imaging methods.

Esposito et al. reported a series of eight patients with elevated troponin and electrocardiography alterations whose CMR findings fulfilled the 2018 Lake Louise Criteria for the diagnosis of myocarditis [12]. Despite that all patients included had no remarkable previous history of cardiovascular disease, CMR showed diffuse intense myocardial oedema, increased T1 and T2 mapping and a mild pericardial effusion in 75% of them [13]. However, other reports suggest that CMR patterns are heterogeneous but similar to other typical form of active myocardial inflammation characterized by diffuse oedema. Late gadolinium enhancement (LGE) seems to be less-frequently observed in these patients [12], indicating a myocyte necrosis is limited at acute phase [13]. In fact, LGE has a non-ischemic pattern and it is predominantly located in the inferior and inferior-lateral segments [14].

CMR may be helpful to evaluate the presence of a myocardial injury. In this setting, patients may present a decreased LV ejection fraction, increased LV volumes, and raised native T1 and T2. Wang et al. [15] confirmed these results in a small cohort of patients evaluated with CMR three months after recovery: LGE was found in 30% of them. These patients had significantly decreased LV peak global circumferential strain (GCS), RV peak both GCS and GLS as compared to non-LGE patients. In contrast, no difference was found between healthy controls and non-LGE patients. Lesions were located in the mid myocardium and/or sub-epicardium with a scattered distribution [15]. In the so far largest prospective observational cohort study, Puntmann et al. [16] has described abnormal CMR findings, including raised myocardial native T1, raised myocardial native T2, myocardial LGE or pericardial enhancement. A small but significant difference between patients who recovered at home vs. hospital for native T1 but not for native T2 mapping was described. Native T1 and T2 mapping is significantly correlated to high-sensitivity troponin T and it is independent of pre-existing conditions, severity and overall course of the acute illness [16].

4. Other Advanced Tools in COVID-19 Imaging

Cardiac evaluation of metabolic pattern should be assessed using [18F]-2-Fluoro-2-deoxy-D-glucose (FDG) positron emission tomography (PET) [17]. It is a sensitive and quantitative technique to detect inflammatory process. Few cases are reported on the use of FDG-PET in COVID-19 patients [18][19][20]. Recently, Dietz et al. [21] using FDG-PET assessed the inflammatory status at the presumed peak of the inflammatory phase in non-critically ill patients. Next to lung inflammation, all patients demonstrated increased mediastinal lymph nodes glucose uptake. The worthy finding is that they described also a myocardial up-take related to SARS-CoV-2 infection [21]. Despite the fascinating perspectives, larger forthcoming studies are needed to evaluate FDG-PET utility for COVID-19 myocardial damage.

An additional type of imaging is the coronary angiography (CAG): it is the gold standard to evaluate the coronary artery lumen, and it is recommended only in patients with ST-segment elevation on EKG or with new left bundle-branch block. In clinically suspected STEMI, coronary angiography should be performed whenever possible, since COVID-19 can trigger acute coronary syndromes. At the same time, alternative causes of troponin elevation must be investigated, if STEMI is excluded.

Artificial intelligence (AI) is a brand new tool rising in helping the daily medical practice and clinical imaging [22]. The use of AI has been also proposed for COVID-19 [23][24] treatment. In CT, CMR and ultrasound modalities, AI has been applied for data retrieval, segmentation of medical organs and diagnosis for COVID-19 [25]. However, AI is far from being routinely used in daily practice or in acute settings.

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