Cardiac imaging in congenital heart disease during the coronavirus disease-2019 pandemic: recommendations from the Working Group on Congenital Heart Disease of the Italian Society of Cardiology

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The recent outbreak of 2019 severe acute respiratory syndrome coronavirus-2 is having major repercussions on healthcare services provision in Italy and worldwide. Data suggest the virus has a strong impact on the cardiovascular system, and cardiac imaging will play an important role in patients affected by coronavirus disease-2019. Although paediatric patients are mildly affected, they represent a clear accelerator in spreading the virus, and healthcare workers are at higher risk of infection. The aim of this position paper is to provide clinical recommendation regarding the execution of imaging investigations for the cardiac diagnostic work-up of paediatric patients with suspected or confirmed infection.

Introduction
The 2019 severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) that is responsible for coronavirus disease-2019 (COVID-19) has been recently declared a pandemic by WHO and is critically affecting the provision of healthcare services.1 Among Western countries, Italy was the first to be deeply affected by SARS-CoV-2, currently being the one with the largest number of infected people after China, and the country with the highest number of deaths.

Evidence suggest that, compared with adult patients, clinical manifestations of children’s COVID-19 may be less severe. However, young children, particularly infants, are vulnerable to infection and, furthermore, they may play a pivotal role in interfamilial and human-to-human virus transmission.2,3

Furthermore, SARS-CoV-2 is thought to infect host cells through ACE2 to cause COVID-19, and to provoke direct damage to the myocardium resulting in virus-related myocarditis.4–6 This will turn into multiple requests for transthoracic echocardiograms and/or cardiac diagnostic work-up of positive patients.

Healthcare workers are at higher risk of infection especially in the event of close contact with suspected or confirmed cases, such as during physical examination and investigations (i.e. echocardiographic studies). According to statistics from the Italian Report of Istituto Superiore di Sanità (ISS) of 19 March 2020, 3559 (10%) out of 35 731 SARS-CoV-2-infected patients were healthcare workers.7 Sonographers, nurses, and physicians involved in the Paediatric Echo Lab and in performing echocardiographic exams have to reduce their own risk of infection and prevent the spread of the disease.

The aim of this position paper is to provide recommendations on how to manage challenges faced by the different cardiac imaging modalities in the evaluation of patients with congenital heart disease (CHD), during the pandemic. However, these indications must be
considered as expert opinion because of the lack of evidence-based scientific data on this subject.

**Indications for echocardiography**

In suspected or confirmed paediatric COVID-19 cases, echocardiography should only be performed if there is a strong clinical indication, and the result may provide a clear benefit or may have a crucial impact on clinical management. In particular, the Echo-Lab leading team along with referring physicians should identify all those investigations that have an urgent/emergent indication and reschedule all the elective ones, especially for patients at higher risk of infection and low priority for echocardiogram.  

**High priority**

(1) First echocardiographic study in a newborn/infant with a strong clinical suspicion of CHD (cyanosis, cardiac murmur, cardiomegaly at chest X-ray, abnormal arterial pulses, respiratory distress not otherwise explained, failure to thrive) or with an antenatal diagnosis of critical CHD, who is likely to require a surgical/interventional procedure in the near future (e.g. D-Transposition of Great Arteries, Tetralogy of Fallot, pulmonary atresia, aortic coarctation, univentricular hearts, pulmonary or aortic valve critical stenosis).

(2) Known CHD patients (e.g. Fontan circulation, Eisenmenger syndrome) or patients with known cardiomyopathy (e.g. hypertrophic, dilated, restrictive), presenting to the emergency department with signs and/or symptoms suggesting hemodynamic deterioration and/or worsening of their underlining cardiac condition.

(3) Patients presenting to the emergency department or referred by a local paediatrician with a high suspicion of cardiovascular disease based on history, physical examination, electrocardiogram, chest X-ray (e.g. myocarditis, dilated cardiomyopathy, hypertrophic cardiomyopathy, infective endocarditis, left or right heart obstruction, aortic arch disease).

**Medium priority**

(1) Scheduled echocardiogram in a patient with known CHD who underwent recent surgical/interventional procedure and/or medical therapy modification, but is otherwise clinically stable.

(2) Scheduled echocardiogram in known CHD patient whose cardiac status has changed from previous ultrasound investigation but is otherwise clinically stable.

**Low priority**

(1) Scheduled outpatient echocardiogram in a known CHD patient without a clear change in clinical status from previous ultrasound investigation.

(2) Scheduled outpatient echocardiogram, requested after incidental murmur detection in a child otherwise clinically stable.

Transesophageal echocardiogram (TEE) deserves special consideration in determining when and whether it should be performed. In fact, TEEs carry a higher risk of the SARS-CoV-2 infection’s spread, as they can cause the aerosolization of droplets containing virus. In addition, especially in children or young adults, the transthoracic acoustic window is generally good for minimizing the need for TEE. Therefore, TEEs should be postponed or canceled if they are unlikely to change the clinical management, and/or if an alternative imaging modality (e.g. ultrasound enhancing agent with TTE, cardiac computed tomography (CT) or cardiac magnetic resonance (CMR)) can provide the necessary information (see below in Guidance for advanced imaging).

**Special cases**

(1) Adult patients with CHD (ACHD) should be managed according to SIECVI recommendation.  

(2) Fetal echocardiography screening and follow-up, if indicated, should be pursued according to local guidelines without exceptions or delays, even during the pandemic. However, in the circumstances of pregnant women with suspected or confirmed COVID-19 infection, all the precautions regarding personal protection (see below) should be followed in order to minimize the contagion. It would be appropriate to counsel the parent using technologies allowing a reduction in the time spent in physical proximity to the patient (e.g. video conferencing, phone calls).

**Suggested echocardiographic scan protocol**

**Echocardiogram execution**

Echocardiographic studies performed on paediatric patients with suspected or confirmed COVID-19 should be as focused as necessary to be of any diagnostic value. Each exam should be planned in advance after review of images from past exams and/or other imaging modalities. In fact, prolonged scanning time can expose the operator to added risk. However, thorough investigation may be necessary in some circumstances (e.g. first scan in a newborn). In order to minimize the scanning time, these exams should be executed by experienced sonographers and measurements should be performed offline.

Echocardiogram should take place inside an isolated room with dedicated machine whenever possible. The echo machine must be covered with special protections in order to avoid/minimize contamination. Non-touch screen systems should be preferred as the touching system once covered is less efficient, thus increasing the scanning time. Sterile single-use ultrasound gel packets are preferable to nonsterile gel. Unless crucial, ECG leads should not be used.
Ideally, the child should be placed in the left lateral position with the operator positioned on the right side of the bench, in this manner the distance patient-to-imager would increase, minimizing the exposition of the operator to droplets. However, changing the preferred patient position should be balanced against potential tradeoffs in lower image quality and longer scanning time.

The number of personnel involved in the exam execution should be reduced to a minimum. Restriction should be applied to all students, residents, fellows and practicing physicians who are not essential to scan performance and interpretation. Only one caregiver should be allowed to stay in the room during the scan.

Outpatient setting
In the outpatient setting, the child and one caregiver should be triaged by phone the day before the appointment and triaged verbally on the day of the exam to check for any symptoms of infection or close contact with infected people. Among those who have criteria for suspected COVID-19 infection, the elective studies must be deferred. In case of a nondeferrable patient, this should be screened and tested for infection according to local protocols and methods for quarantine. Before accessing the outpatient department, the patient and the caregiver would undergo temperature measurement. In addition, they would be invited to wash their hands and wear a surgical facemask.

Inpatient setting
In the case of an echocardiogram in a suspected or confirmed COVID-19 hospital inpatient, a bedside investigation with a portable machine in the isolated room should be preferred, avoiding moving patients within the clinic or hospital. The echo machine should undergo a comprehensive cleaning protocol with specific products before next use. For each COVID-19 ward a dedicated echo machine should be identified and must not be moved from that location. The identification of the optimal location for the echocardiographic study should also take into account the monitoring capabilities and staffing of different locations.

Only one caregiver should be allowed for every patient, and she/he should be always the same during the whole hospital stay. All caregivers and patients (when applicable) should be invited to wear a facemask and wash their hands frequently. In some institutions (e.g. University Hospital of Padua) patients and caregivers, regardless of symptoms and infection risk, would undergo a nasopharyngeal swab test the day before the admission.

Personal protection of healthcare workers
As a general protocol, all healthcare workers should undergo a temperature check before starting their working day. They should frequently and meticulously wash/sanitize their hands during their working time. Furthermore, they should always wear a surgical facemask inside the hospital and respect the social distancing, except during physical examination or medical procedures.

Guidance on personal protective equipment (PPE) to manage patients with low risk of infection:

1. Wash hands
2. Wear disposable gown
3. Put on nonsterile gloves and surgical face mask

Guidance on donning PPE to manage COVID-19 suspected or confirmed patients:

1. Put on special work clothes and work shoes
2. Wash hands
3. Put on disposable surgical cap
4. Put on medical protective mask (FFP2 or FFP3)
5. Put on inner disposable nitrite/latex gloves
6. Put on goggles and protective clothing (including waterproof boot covers, disposable isolation gown and face shield)
7. Put on outer disposable latex gloves

Guidance on removing PPE to manage COVID-19 suspected or confirmed patients:

1. Wash hands and remove visible bodily fluids/blood contaminants on the outer surfaces of both hands
2. Wash hands and replace outer gloves with new gloves
3. Remove full-face shield
4. Wash hands and remove disposable gowns along with outer gloves
5. Wash hands and put on new outer gloves
6. Remove protective clothing along with outer gloves (for gloves and protective clothing, turn inside out, while rolling them down) and remove the waterproof boot covers
7. Wash hands and remove goggles
8. Wash hands and remove facemask
9. Wash hands and remove cap
10. Wash hands and remove inner disposable latex gloves
11. Wash hands and leave removal area

Echocardiographic machine protection and cleaning
Whenever possible it would be ideal to set a machine for use with suspected or confirmed patients. After donning of the operator and before entering the room, probes and machine consoles should be covered with disposable plastic. After the echocardiogram, the machine and probes should be thoroughly cleaned, ideally in the
patient’s room and again outside. All the surfaces of objects should be wiped with 1000 mg/l chlorine-containing disinfectant or wipes with effective chlorine; after 30 min, they should be rinsed with clean water. However, before initiating the cleaning process, the operator should consult vendors’ disinfecting guidelines available online, as procedures vary and could affect the functionality of machines and probes. Smaller, laptop-sized portable machines should be preferred as they are more easily cleaned; however, the operator should take into account the inferior image quality and functionality compared with conventional machines.

**Guidance for advanced imaging (cardiac CT and CMR)**

Chest CT is a key component of the diagnostic work-up for patients with suspected infection with SARS-CoV-2, even though it is rarely performed in the paediatric population because of the less severe lung involvement and for safety reasons.

If a patient with an underlying heart condition and suspected/confirmed COVID-19 needs additional anatomical cardiac assessment (most likely presurgical and postsurgical assessment, newborn with nonconclusive echocardiographic diagnosis, coronary assessment, suspected pulmonary embolism), cardiac CT can be an option.

The evaluation can be performed either as a targeted cardiovascular study, or as a combined cardiothoracic assessment if lung information is required because of respiratory impairment. CT equipment to perform a comprehensive cardiac examination must include a multitrow detector CT scanner, ECG cardiac synchronization and iodinate contrast injector system.

Apart from the urgent scans (presurgical/postsurgical, new diagnosis, recent hemodynamic deterioration), all the elective exams planned in clinically stable subjects should be postponed.

Cardiac Magnetic Resonance (CMR) is rarely a mandatory exam, so in suspected or confirmed SARS-CoV-2 infection, CMR can almost always be delayed, and all the elective studies should be re-scheduled.

The most likely clinical scenario where CMR can be considered is in case of suspected myocarditis. In this setting (suspected/confirmed COVID-19 and signs of myocarditis), CMR can be performed, considering the risk/benefit ratio according to the patient’s hemodynamic status and exam’s therapeutic impact. Other less common possible CMR indications in this setting might be advanced presurgical hemodynamic assessment in patients with complex CHD (e.g. complex intracardiac shunt assessment, borderline ventricle assessment), and subjects with recent diagnosis of myocardial mass.

Both for cardiac CT and CMR, all the nonurgent scans planned as outpatients, even in patients with no suspicion of infection, should be postponed in accordance with the referring physician because of the risk of infection in the hospital setting.

If the exam (CT or CMR) is indicated, the number of people involved in the procedure execution should be reduced to a minimum, limiting access to all those who are not essential for scan performance and interpretation. All the people involved (physicians, nurses, technicians) should wear protective equipment including respiratory protection with use of a medical mask, disposable isolation gown with fluid-resistant characteristics, disposable gloves with coverage over gown cuffs, eye protection with goggles and probably a face mask over goggles. Patients should wear a surgical mask during transport to and from the department. CT and MR machine gantries, and reporting stations (monitor, mouse and keyboards) should be sanitized after every contact with suspected patients.

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**Conflicts of interest**

There are no conflicts of interest.

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