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COVID -19 pandemic and cardiac imaging. EACVI recommendations on precautions, indications, prioritisation and protection for patients and healthcare personnel.

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Abstract:	<p>The coronavirus disease 2019 (COVID-19) pandemic is affecting most hospitals around the world and has created new and unpredictable challenges for modern medicine and health care systems. Common challenges faced by all cardiac imaging modalities during the pandemic include limited expert staff availability (sickness or redeployment in prioritised areas, such as intensive care units) and the risk of peri-procedural transmission of SARS-CoV-2 between patients and staff. The indication for any cardiac imaging test should be carefully considered, and only those tests considered essential to patient care performed. The scope of these EACVI recommendations is to summarise how these challenges may be addressed during the pandemic. In particular we focus upon bold prioritisation and provide specific indications and recommendations on how to perform an echocardiogram during the pandemic whilst safeguarding both patient and staff safety.</p>

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Introduction:

The coronavirus disease 2019 (COVID-19) pandemic has created new and unpredictable challenges for modern medicine and health care systems. Preliminary reports have demonstrated that older age, previous cardiovascular disease, diabetes and hypertension are risk factors for increased mortality.¹ Data on the cardiac affinity of the virus and its potential and mechanisms to harm the cardiovascular system are sparse.² ³A systemic infection generally increases demand on the heart, and can exacerbate underlying cardiac conditions. When the lungs are heavily involved, as seen in COVID-19 patients, this may have a major impact on cardiac function, particularly that of the right ventricle. Finally, COVID-19 may have direct effects on the heart as may some drugs being used in its treatment.

The severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) is responsible for COVID-19 and is transmitted by droplets from person to person.⁴ Echocardiographers in particular, and cardiac imagers more generally, are in close contact with patients and therefore likely to have high a risk of being infected. To decrease the risk of patient to patient-, patient to imager- and imager to patient-contamination, the indication for any cardiac imaging test should be carefully considered, and only those tests considered essential to patient care performed.

Cardiologists and cardiology departments are heavily affected by this rapidly changing situation.⁵ The Covid-19 pandemic also increases the burden on cardiac imaging services generally. However, given its wide availability and key role as a bedside test, echocardiography is the most affected cardiac imaging modality. Common challenges faced by all cardiac imaging modalities during the pandemic include limited expert staff availability (sickness or redeployment in prioritised areas, such as intensive care units) and the risk of peri-procedural transmission of SARS-CoV-2 between patients and staff. The scope of these EACVI recommendations is to summarise how these challenges may be addressed during the pandemic. In particular we focus upon bold prioritisation and provide specific indications and recommendations on how to perform an echocardiogram during the pandemic whilst safeguarding both patient and staff safety.

Some of our recommendations relating to the appropriate use of imaging modalities in the COVID-19 pandemic must be considered only as expert advices due to the lack of evidence-based scientific data and the rapidly changing global situation.

General considerations:

For all modalities the main question is: *Will undertaking this study substantially change patient management or be lifesaving?* If yes, use the imaging modality with the best capability to meet the request, but consider also the safety for medical staff regarding exposure. It is very important that every cardiac imaging study is performed appropriately to minimise the risk of further dissemination of the disease. **Key-point 1.**

This question needs to be considered in detail for each echocardiogram requested given the risk of cross-infection and the consumption of personal protective equipment. However, computed tomography (CT) and cardiac magnetic resonance (CMR) may also have a significant potential for contamination of personnel and patients, especially linked to

transportation, but also via direct contamination during the scan. In parallel with echocardiography and other imaging modalities, CMR and CT should only be performed if the expected information is critical for clinical management and can be justified in the face of the following considerations: a) risk of transportation from ICU of critically ill or high risk patients; b) time duration of CMR; c) Possible/significant risk of infection for professionals (technicians, physicians, nurses, other personnel); d) Possible/significant risk of contamination of equipment and facilities, leading to the need for full disinfection; e) whether the test is necessary to confirm the diagnosis, or whether this can be achieved based simply upon the clinical probability. In many countries, imaging exams for elective non-urgent patients have been cancelled or postponed. However, cardiac imaging is still being widely requested for inpatients or those presenting to the Emergency Department.

Key-point 2.

Indications:

Patients with suspected or confirmed COVID-19 and no previous history of cardiac disease

The chest radiograph is the most commonly used imaging test in COVID-19 patients, but CT is frequently used to confirm COVID-19 pneumonia. Whilst this might conceivably provide some possible synergies and opportunities to gain information about the cardiovascular system, this requires bespoke protocols that are not widely employed. Dedicated coronary CT angiography is therefore usually required. One emerging clinical issue is that numerous patients with pneumonia caused by COVID-19 experience elevated Troponins with and without signs of obstructive coronary artery disease. In this situation coronary CT angiography can be of great help in excluding or confirming an acute coronary syndrome if the clinical picture is uncertain, substituting an invasive coronary angiogram and the associated exposure of all the members of the cardiac catheterisation laboratory team.⁶ Coronary CT angiography is also increasingly used to assess patients with chronic coronary syndromes, and can be considered in the COVID-19 pandemic in patients with severe symptoms. Another important and emerging role of CT in the pandemic is as a replacement for transoesophageal echocardiography (TOE) to rule out the presence of thrombus in the left atrial appendage before direct current (DC) cardioversion, thereby limiting operator exposure. Key-points 3.

Echocardiography should not routinely be performed in patients with typical signs of COVID-19 disease. Indeed, it should be restricted to those patients in whom it is likely to result in a change in management. Nevertheless many COVID-19 patients will develop a range of different cardiovascular manifestations which will require a bedside echocardiographic study.⁷ Moreover, there are reasons to believe that the need for echocardiography might expand further as we understand more about COVID-19, with early reports indicating that patients with established cardiovascular disease and cardiovascular risk factors have worse prognosis than others, and are more likely to be admitted to hospital and need respiratory support.¹

Dyspnoea is a typical finding in patients with cardiac disease and echocardiography may be indicated in the diagnostic work-up, particularly in patients with subacute onset of dyspnoea, oedema or cardiac murmurs and elevated cardiac biomarkers. Conversely, a

normal proBNP-test can frequently be used to exclude the need of an echocardiogram in patients with dyspnoea or oedema.

In the intensive care unit, echocardiography has sometimes been used to routinely monitor the progress of certain patients.⁷ This should not be routinely performed in the COVID-19 pandemic. Instead, echocardiography should be restricted to patients with cardiovascular instability or signs of right ventricular dysfunction or pulmonary hypertension. Lung ultrasound to detect COVID-19 pneumonia is also useful.⁸ Thickening of the pleurae, appearance of B-lines and lung consolidation indicates pneumonia, with pleural effusions rarely reported. Due to its bedside availability, scanning of the lungs by ultrasound can be performed as a quick diagnostic tool.

Transthoracic echocardiography protocol:

If transthoracic echocardiography is required to change patient management, we recommend a focused cardiac ultrasound study (FoCUS) as described below. The aim is to reduce the time exposure with the patient and to decrease the risk of contamination.⁹ Handheld or smaller lap-top based scanners may have an advantage as they are easier to cover, clean and disinfect than larger machines with higher capability.¹⁰ At a minimum such a focused echocardiographic study in patients with verified or suspected COVID-19 should include:

Left ventricle: Systolic global function (ejection fraction), signs of regional dysfunction, end-diastolic cavity dimension.

Right ventricle: Global function (Right ventricular fractional area change (RVFAC) or Tricuspid annular plane systolic excursion (TAPSE)), end-diastolic cavity dimension, Tricuspid regurgitation pressure gradient (TRP) (if possible).

Valves: Gross signs of valvar disease, but only in cases of critical clinical importance should an in-depth evaluation should be considered.

Pericardium: Thickening or effusion.

Lung ultrasound (see below)

ECG monitoring during imaging can be omitted and measurements should be performed offline to reduce exposure of contamination. If a curtailed echocardiogram is performed because of the COVID-19 situation, this should be stated in the report.

Patients with confirmed COVID-19 and known or acute cardiac disease:

Due to increased metabolic and haemodynamic demands, infection and concomitant fever acts as a cardiac stress test potentially aggravating the effects of pre-existing valve disease, heart muscle disease, coronary artery disease and congenital heart disease. Similar and additional effects can be caused by reduced oxygenation of the blood due to respiratory failure. This may help explain why coexisting cardiovascular disease is a negative predictor in COVID-19 patients.¹ Clinical decision-making may be complicated in these critically ill patients and cardiac imaging may be decisive. However, unnecessary examinations of

critically ill patients should be avoided to reduce risk of contamination of personnel and misuse of resources. Indeed, careful consideration should be given to whether echocardiography and cardiac imaging will change management, including whether patients would be candidates for more advanced treatment strategies on the basis of the results of an echocardiogram. If not, the scan may be futile.

Patients without symptoms or signs of COVID-19 but with known or acute cardiac disease:

Clinical priorities and procedures will change during this pandemic. Echocardiography should therefore generally be reserved for patients with symptomatic heart disease (NYHA III-IV) in this phase. Routine follow-up echocardiographic studies of patients with non-severe symptoms or those not eligible for invasive or surgical treatment should be postponed or cancelled. This includes patients with stable congenital heart disease. Patients with acute heart failure and patients with valvar heart disease with severe symptoms such as chest pain, syncope and dyspnoea during daily activity should be prioritised and receive adequate treatment. Their prognosis without treatment is probably worse than most COVID-19 patients.

Acute endocarditis, with no relation to COVID-19, will also continue to appear and the number of patients may even increase as visits to the dentist get cancelled. Endocarditis has a high mortality and these patients should continue to have a high priority for echocardiography and treatment according to state of the art recommendations.¹¹ If the patient has concomitant COVID-19, an individualised approach is necessary.

In STEMI we recommend an LV angiogram for LV function in patients having an invasive revascularisation procedure. Echocardiography can then be avoided in these patients with the exception of those that become haemodynamically unstable or develop potential post-STEMI complications. In unstable Non-STEMI patients with positive troponins and clinical signs of heart failure, echocardiography may be of importance to justify a faster invasive revascularisation procedure. Patients with murmurs should undergo echocardiography to rule out valve disease as the cause of their chest pain presentation.

Transoesophageal echocardiography:

TOE might be stressful to our patients and should be avoided in most patients with ongoing COVID-19. The risk of contamination of equipment and personnel is also very high during the procedure due to droplets and aerosols containing virus. The incremental role of TOE over TTE should be carefully considered. This procedure should therefore be reserved for patients where the suspected findings are of crucial importance to confirm or exclude a diagnosis or to guide treatment.

Indication for other echocardiographic methods:

Indications for stress echocardiography, as well as for other stress imaging techniques, seem very limited in the COVID-19 pandemic, and should be avoided in patients with acute infection. Coronary CT angiography should be the preferred method if patients are being investigated for chronic coronary syndromes.⁶ Ultrasonic contrast agent may be useful in some patients, but should not be used in circulatory unstable or critically ill patients.¹²

Fetal echocardiography:

It is currently unclear whether maternal infection affects the fetus, by causing either structural heart disease or fetal myocarditis, and therefore routine fetal echocardiography in infected mothers is not recommended for the indication of COVID-19 infection alone. However, the indications for fetal echocardiography remain the same during the pandemic, in that pregnancies judged to be at high risk for fetal cardiac disease need to continue to be referred according to local guidelines, and assessed within the appropriate time frame.¹³ Counselling may be undertaken using video conferencing or other technology in order to reduce time in physical proximity to the patient, and the minimum number of healthcare professionals should attend scanning and counselling.

Indication for other imaging methods:

Given the acute nature of the disease, and restrictions of hospital facilities for chronic patients, there are probably few defined indications for coronary CT angiography, CMR or nuclear cardiology in patients with COVID-19 infection during the acute phase.

Similar as for echocardiography, patients scheduled for CMR, CT and nuclear cardiology, with non-severe symptoms or not eligible for invasive or surgical treatment, should be postponed. Routine follow-up scans should be re-scheduled. A possible indication for CMR is the suspicion of COVID-19 myocarditis, but the clinical implication of detecting myocarditis in these patients is not determined. We suggest that positive troponins and myocardial dysfunction or severe arrhythmia not explained by other methods, may be an indication for acute CMR if of crucial importance for the treatment and the patient is stable enough to be scanned.

Cleaning, disinfection and protection in patients with suspected or confirmed COVID-19:

Equipment:

All equipment used in close contact with patients has the potential to carry droplets containing the virus. This includes ECG-leads which should therefore be avoided when performing echocardiographic studies in COVID-19 patients.

Moderately warm water and a mild detergent constitute the basis of equipment cleaning in all cardiac imaging machines, including the echocardiographic probe. An ordinary water-soluble disinfectant should also be added, but not on the membrane. A non-alcoholic disinfectant should be used on the echocardiographic probe (please confirm with recommendations for each vendor). Dedicated wipes may also be used in this process.

Protecting the echocardiographic machines with custom-made covers may be possible if available, but if not other protective equipment can be fashioned using local entrepreneurs and ingenuity. It is, however, important not to cover the screen in a way that reduces the view for the echocardiographer. This may reduce the quality of the study and increase scan duration. Similarly, the keyboard should be fully operative during the investigation. To facilitate the cleaning of the scanner, all additional 3D and single-Doppler probes should be removed before the scanning starts, if they are not needed for proper diagnosis. ECG leads should also be removed, although this may make the recordings of loops more difficult and potentially more time consuming. In high volume centres one can consider dedicating

separate scanners to be used exclusively for COVID-19 positive patients, that remain within designated COVID-19 areas. No additional disinfection procedure is necessary for a TOE probe as every location should have proper routines for cleaning and disinfection of these probes. A protective coat on the TOE probe might also be considered.

The positioning of the patient versus the echocardiographer and the scanner may be of importance. Patients placed in the left lateral position with the scanner positioned on the right side of the bench will result in the longest possible distance between the faces of the patient and the echocardiographer. The contamination of airborne droplets from the patient to the scanner will also probably be minimized. However, the preferred patient position is different among echocardiographers, and these recommendations should not be a hindrance to perform high quality fast echocardiograms. A surgical mask on the patient will also reduce contamination by air droplets.

Facilities:

The echocardiographic study will usually be performed in the intensive care unit or in emergency rooms in critically ill patients. Less critical patients are usually examined in their ward rooms. Dedicated room(s) may be prepared in the echocardiographic lab, where unnecessary equipment can be removed to make the cleaning of the room as easy as possible. However, there is less risk of virus spread if the echocardiographer brings the echocardiographic machine to the patient, and the patient can remain in their isolation. Local factors must be considered with dedicated COVID-19 areas respected, ensuring COVID-19 “clean” and “dirty” areas are not mixed.

Reading and conference rooms where echocardiograms are presented on small PC-screens may prevent the recommended 2 metres of distance between the experts. Thus, larger rooms, with projectors that can present the images on large screens are recommended. Virtual communication technology that allows several colleagues to simultaneously visualise images on geographically remote screens, is the preferred solution for multidisciplinary team meetings.

Healthcare personnel:

All advice regarding personal protective equipment (PPE) should follow the internal rules in each institution. This will vary according to the local nature of the pandemic and the availability of PPE. We here offer some general advice. Repeated and thorough handwash is the basis of virus protection for everyone, including patients and health professionals. In addition to handwashing after every examination, disinfecting agents should be used on the hands.

When examining a patient with confirmed or suspected COVID-19, protective clothing, hand gloves, headcovers, specific facemasks and eye shields must be used (Table 1). Patients should wear a surgical mask during imaging (Table 2). During TOE, medical protective masks must be used due to risk of aerosols and airborne spread (Table 3). How to adequately dress and undress is described in several publications and is not further described in this paper.

When performing an echocardiogram in patients without confirmed COVID-19, surgical facemasks should be used in regions where the risk of virus spread is high or uncertain. Non-

sterile hand gloves should also be used and renewed between every patient since the persistence of the virus on plastic is long. If the patient has low risk of infection due to low risk in the respective regions or has no symptoms this may be omitted, especially if there is shortage of face masks or hand gloves in the hospital.

Precautions in other imaging modalities:

Precautions for all the other imaging modalities are similar. Imagers and technologists should wear protective clothing, gloves and face masks while undergoing scanning, and patients should wear a surgical mask during imaging. The scanner, coils and ECG cables are mandatory for cardiac CMR and CT scans but need to be thoroughly disinfected after imaging (table 1). Cleaning of the scanners after imaging patients with COVID-19 infection is also obligatory (see above). An important strategy to reduce contamination is to reserve one scanner for known infected patients and another for low-risk and non-infected patients.

Conclusion:

The COVID-19 pandemic has forced us to reconsider how best to perform cardiac imaging in the right patients at the right time and how to minimise the risk of cross infection for imagers and patients alike. These recommendations are suggested as tools to guide good clinical practice during what is a turbulent period in our practice, and one that is rapidly changing both the premises and demands for cardiac imaging. We expect our understanding of how best to image patients during the COVID-19 pandemic to change rapidly and will adapt our guidance accordingly.

Table 1: Recommendations during TTE and fetal echo:

Risk of contamination	Hand-wash	Surgical mask and gloves	Protective clothing, eye protection	Head cap	Study completeness	Equipment protection
Lower risk	Obligate	Preferable	Probably not	No	Full	None
Moderate risk	Obligate	Obligate	Preferable	No	Preferably full/ depending on severity of the cardiac pathology	Intermediate/ Protection of probe, leads and other patient near parts
Severe risk/ confirmed Covid-19	Obligate	Advanced mask – FFP2/FFP3/N95/N99	Obligate	Obligate	Problem focused, adjusted for clinical importance of the cardiac pathology	Full cover/ dedicated scanners

Lower risk: Patients with no symptoms, no increased risk behaviour or recent negative virus test or in areas with low risk of COVID-19. **Moderate risk:** Patients with nonspecific/unclear symptoms or patients without symptoms in area with moderate or high risk of COVID-19. **Severe risk:** Patients with typical symptoms or confirmed COVID-19. **FFP2:** Filtering Facepiece Particulate class 2 (FFP2 corresponds to US N95, FFP3 corresponds to US N99).

Table 2.

Recommendations for patients during all imaging modalities.

Risk of infection	Surgical mask
Lower risk	Preferable
Moderate risk	Obligate
Severe risk/ confirmed Covid-19	Obligate

Table 3: Recommendations during TOE:

Risk of contamination	Hand-wash	Surgical mask and gloves	Protective clothing, eye protection, head cap	Study completeness	Equipment protection
Lower risk	Obligate	Obligate	Optional/ Preferable	Full	None/ Protection of patient-near parts
Moderate risk	Obligate	Obligate	Obligate	Preferably full/ depending on severity of the cardiac pathology	Intermediate/ Protection of leads and other patient near parts
Severe risk/ confirmed Covid-19	Obligate	Obligate, (double gloves, Protective masks FFP2/FFP3 /N95/N99)	Obligate “Advanced kit”	Problem focused adjusted for clinical importance of the cardiac pathology	Full cover/ dedicated scanners

Definition of risks of contamination, see table 1. Washing and disinfection of the TOE probe and its leads are not further described as standard procedures should include sufficient virus protection.

Key-points 1

Important considerations in patients with suspected or confirmed COVID-19:

- Cardiac imaging should be performed if appropriate and only if it is likely to substantially change patient management or be lifesaving
- Use the imaging modality with the best capability to meet the request, but consider also the safety for medical staff regarding exposure
- Elective non-urgent and routine follow-up exams may be postponed or even cancelled

Key-points 2

Risks of contamination in patients with suspected or confirmed COVID-19 include:

- Possible/significant risk of infection for professionals (technicians, physicians, nurses, other personnel)
- Possible/significant risk of contamination of equipment and facilities
- Risk of widespread contamination due to transportation from ICU of critically ill or high-risk patients – the echo machine should be brought to the patient
- Prolonged duration of a cardiac imaging study will increase the likelihood of contamination

Key-points 3

Advice for cardiac imaging:

- Echocardiography should not routinely be performed in patients with typical signs of COVID-19 disease

- A range of different cardiovascular manifestations can be found in COVID-19 which may require cardiac imaging including a bedside echocardiographic study
- A focused cardiac ultrasound study (FoCUS) is recommended to reduce the time of exposure
- The risk of contamination of equipment and personnel is very high during TOE – consider repeat TTE, CT scan or CMR as alternatives
- Chest CT is frequently used to confirm COVID-19 pneumonia and might provide possible synergies and opportunities of cardiac imaging
- Coronary CT angiography can exclude or confirm an acute coronary syndrome in COVID-19 pneumonia where elevated Troponins are common
- LV function can be assessed by LV angiogram in patients with acute coronary syndromes during the invasive revascularisation procedure
- Positive troponins and myocardial dysfunction or severe arrhythmia suggestive of Tako-tsubo or myocarditis, may be an indication for acute CMR if of vital importance for treatment and patient can be safely transferred for imaging
- Indications for fetal echocardiography remain the same as outside the COVID-19 pandemic

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