

Echocardiography during the coronavirus disease 2019 (COVID-19) pandemic: expert opinion of the Working Group on Echocardiography of the Polish Cardiac Society

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ABSTRACT

Transthoracic and transesophageal echocardiography may be required in patients with coronavirus disease 2019 (COVID-19), resulting in direct contact with the patient and risk of transmitting the infection from patients to medical personnel. Therefore, we recommend to perform problem-oriented time-limited transthoracic examinations. Whenever possible, examinations should be analyzed offline, outside the isolation zones. Transesophageal echocardiography is considered an aerosol-generating procedure and should be performed only as a lifesaving procedure. Personnel should use appropriate personal protection equipment in the immediate vicinity of the patients in accordance with the relevant guidelines.

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Introduction In view of the rapidly evolving coronavirus disease 2019 (COVID-19) pandemic, there is an urgent need to reorganize the work of echocardiography laboratories in order to ensure the safety of patients and protection of physicians, technicians, and other staff members. We summarize briefly the nature of COVID-19 disease, its epidemiology, basic symptoms, cardiovascular complications, diagnostic ultrasound procedures (including lung ultrasound) as well as necessary protective measures, in order

to provide essential information for busy echocardiography teams facing epidemic threat.

Etiology, epidemiology, clinical presentation, diagnostic workup, and course of coronavirus disease 2019 Coronavirus disease 2019 is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).¹ The first cases of this disease occurred in the city of Wuhan, China in December 2019, where—as it is suspected—zoonotic transmission of the coronavirus

and its mutation, allowing the spread of infection between people, took place.² Due to the rapid increase in the number of cases, first in China and then in other parts of the world, the World Health Organization announced the COVID-19 pandemic on March 11, 2020. Current epidemiological data are available on the Worldometer website.³

In Poland, ordinances of the Minister of Health introduced the state of epidemiological threat first, and on March 20, 2020, the state of the COVID-19 epidemic.

The transmission of SARS-CoV-2 occurs mainly through the droplet route, but the possibility of airborne transmission and transmission through the fecal-oral route is also postulated, though the latter seems less relevant so far.⁴ The estimated median incubation time for COVID-19 is 5.1 days, and only 2.5% of patients develop symptoms within 2.2 days after infection, whereas 97.5% of patients develop symptoms within 11.5 days after infection.⁵ The most common symptoms are: fever, cough, fatigue, and shortness of breath, occurring on average in 91%, 67%, 51% and 30% of patients, respectively. The median time from onset of symptoms to dyspnea is 7 days. The most common comorbidities present in patients with SARS-CoV-2 infection include hypertension and other cardiovascular diseases, diabetes, and chronic obstructive pulmonary disease. Their prevalence is higher in patients with severe disease.⁶ More male than female patients are affected.

Definitive diagnosis of SARS-CoV-2 infection is based primarily on nucleic acid amplification tests, such as real-time reverse transcriptase-polymerase chain reaction (rRT-PCR).

In about 81% of patients, the disease is mild and does not require hospitalization, in 14% it is severe, and in 5% it is critical.⁷ The most common complications include sepsis, acute respiratory distress syndrome (ARDS), heart failure, and septic shock. The risk factors for

in-hospital death on admission are: older age, higher SOFA (Sequential Organ Failure Assessment) score, and D-dimer concentration over 1 µg/ml, indicators which are observed in severe pneumonia.⁸ The case fatality rate of COVID-19 in the overall population is estimated at 2.3%, it is minimal in young healthy individuals, but it reaches 14.8% or more in patients over 80 years of age.⁷

Coronavirus disease 2019 and cardiovascular diseases

SARS-CoV-2 is particularly dangerous to cardiac patients. It invades the lungs and causes interstitial pneumonia with the dynamic destruction of the alveoli and development of ARDS. Severely depressed gas exchange, accompanied by insufficiently active or hyper-regulated immune system, add a risk of mortality, mostly in patients with coexisting illnesses, particularly cardiovascular disease.

There are also reports about direct acute and chronic damage caused by SARS-CoV-2 to the cardiovascular system.⁹ The infection has been associated with the development of myocarditis, arrhythmias, heart failure, myocardial infarction, and thromboembolism.¹⁰ In Wuhan, it has been observed that patients treated in intensive care units had significantly higher cardiac troponin levels comparing with other patients.¹¹ Among those who died from COVID-19, 11.8% of patients without a history of previous heart disease had elevated troponin concentrations. It was estimated that 7% of deaths were caused by myocarditis with heart failure, and overall myocarditis might have been implicated in 33% of deaths.¹² Fulminant myocarditis has also been reported in some patients effectively treated with steroids and immunoglobulins.¹³ As a result, Chinese authors recommend transthoracic echocardiography in all patients with complicated COVID-19 disease.¹⁴ Apart from respiratory failure, the typical mode of death is distributive or cardiogenic shock.¹⁵ Neither pericardial nor pleural effusion is a typical finding in COVID-19.

Patients with cardiovascular disease represent a large proportion of deaths from COVID-19. In the meta-analysis of 1527 patients with COVID-19, the prevalence of hypertension was 17.1%, cardiac and cerebrovascular disease, 16.4%, and diabetes, 9.7%.¹⁶ In a series of 44 672 patients, a subset of patients with cardiovascular disease had 10.5% mortality. There is a higher probability of heart failure following infection which leads to a vicious circle of cardiorespiratory failure and shock.

It is also likely that patients with previous cardiovascular disease and early complaints caused by the infection may seek help in cardiology clinics and departments before the infection is confirmed. Thus, due to the prevalent coincidence of previous or

TABLE 1 Key messages for performing echocardiography

Ensure adequate medical personnel protection equipment
Ensure effective laboratory disinfection procedures
Ensure adequate training in personnel protection equipment use and laboratory disinfection
If possible, dedicate scanners to isolation areas
Consider using handheld or portable machines when available
Identify, defer, or eliminate previously planned elective echocardiography
Routine echocardiography in unselected patients with COVID-19 is not recommended
Limit direct interaction with patients by promoting problem-oriented examinations in medium-high-risk patients in whom the examination may significantly contribute to the change in management
Perform transesophageal examinations only if absolutely needed and with full personal protection equipment

acute cardiovascular disease, cardiologists will frequently be involved in the treatment of COVID-19 patients, also those with no specific signs of infectious disease. Reports from China and Italy emphasize the importance of evaluating cardiac function of hospitalized patients with COVID-19.¹⁷

Echocardiography and ultrasound protocols in the era of pandemic

The key messages from our expert opinion are presented in TABLE 1. According to the American Society of Echocardiography, ultrasound techniques play an important role in the management of patients with COVID-19. Due to the high prevalence of myocarditis and heart failure, transthoracic echocardiography is routinely recommended in patients with complicated COVID-19 in order to differentiate causes of dyspnea and monitor the sequelae of ARDS. Echocardiography may be used to monitor fluid management in shock or extracorporeal membrane oxygenation. We recommend to perform echocardiography selectively, only in hospitalized patients with either signs of heart failure/hemodynamic compromise or unexplained deterioration of their clinical status, if cardiac dysfunction is suspected. Routine echocardiography in all patients with COVID-19 is not recommended.

Performing the examinations requires direct contact with the patient and poses a risk of infection transmission both from patient to personnel, not only by symptomatic SARS-CoV-2-positive patients but also by undetermined cases and asymptomatic carriers.¹⁸ This is particularly important in case of transesophageal echocardiography since this is an aerosol generating procedure that may cause prolonged risk of airborne transmission by direct inhalation or contamination.

Personal protection is of key importance. It is estimated that medical personnel represent approximately 10% of Italian patients with COVID-19. Depending on local recommendations, staff with particular risk factors, such as advanced age, chronic conditions, pregnancy, or immunosuppression, may be advised not to have contact with patients with COVID-19. The duration of the examination should be limited to obtaining all clinically useful and important information as quickly as possible. Problem-oriented examinations are recommended, focused mainly on the identification of the most important abnormalities, such as: global or regional myocardial dysfunction, severe valvular disease, pericardial fluid, and vegetations. It is of utmost importance to perform echocardiography appropriately and avoid unnecessary examinations not affecting treatment decisions. An examination should be repeated only in the case of clear clinical deterioration, when cardiac involvement is strongly suspected, and the result

of the examination might significantly affect patient management. Elective examinations in stable patients and those with good clinical condition, without new electrocardiographic changes, dyspnea and/or tachycardia, and normal oxygen saturation (>93%) should be deferred.

Whenever possible, analyses and measurements should be performed offline, outside the contaminated area. Shortened echocardiography reports are recommended, provided they are sufficient to cover all clinically important elements. To avoid nondiagnostic examinations, the ultrasonic contrast, if available, may be useful to improve image quality. Other imaging options, such as computed tomography, should be considered as complementary or alternative depending on the clinical question-oriented diagnostic plan.

Point-of-care cardiac/lung ultrasound

Point-of-care cardiac ultrasound may play an important role in the care of patients with COVID-19, as it can be performed by properly trained clinicians directly involved in patient care, obviating the need to enter and leave the isolation zones. It may also be an alternative to lung auscultation.¹⁹

Point-of-care cardiac ultrasound focuses on confirming or excluding a specific diagnosis to facilitate therapeutic decisions. It is not equivalent to standard echocardiography as it has limited diagnostic capabilities. Simplified construction of handheld echocardiography machines (sometimes limited to the transducer connected to a tablet or a smartphone), which may be used for this purpose, is an advantage, especially in isolation units or intensive care units, where the movement of large equipment is difficult. Importantly, it facilitates rapid and effective disinfection of the device, reducing the risk of transmission of COVID-19. As patients are not allowed to leave isolation wards, eliminating the need to transport them to the echocardiography laboratory is crucial.

In the age of SARS-CoV-2 infections, ultrasound evaluation of the lung may be useful. It should not be used to confirm or exclude COVID-19 and is also currently not recommended as a screening tool, though lung abnormalities detected in COVID-19 may be present in the early stages of the disease, sometimes preceding other clinical manifestations.

The most common changes present in point-of-care lung ultrasound in COVID-19 are: pleural line abnormalities, B-line artifacts, and consolidation. Pleural line is normally about 1 mm thick but in COVID-19 it may thicken, appear irregular, and lose its continuity. B-line artifacts are the earliest signs in the disease course. They are a sensitive marker of fluid accumulation in the interstitial space. It should be remembered that they are

nonspecific and present in other diseases, especially in heart failure. Their location and density vary significantly, including focal, multifocal, and confluent patterns. Increased density leading to the image of a “white lung” (equivalent of the ground glass opacities on chest tomography) indicates more advanced disease, and its disappearance heralds the healing process. Consolidations are pathological airless areas of different shape and size. In patients with COVID-19, subpleural consolidations are most frequently seen. The appearance of fluid in the pleural cavity is a rare phenomenon in the course of COVID-19. A-lines can be observed during the recovery phase. However, these lesions are not specific for COVID-19 and may be present in other types of pneumonia. A clear and simple guide to pulmonary lung ultrasound in patients with COVID-19 can be found online both in English and in Polish.^{20,21}

Echocardiography laboratory setup When organizing work in the echocardiography laboratory, the World Health Organization recommendations on the types of personal protective equipment used in the context of COVID-19 may be accommodated, taking into account the circumstances, staff, and scope of activities.²² Two types of transmission routes, droplet and airborne, should be taken into account. The first is mainly related to performing examinations in the presence of SARS-CoV-2-positive patients in rooms when proper distancing is not observed (at least about 1.5 to 2 m) from the infected, the second is related to aerosol-generating procedures, such as transesophageal echocardiography.

Transthoracic echocardiography The use of dedicated ultrasound machines (also gel and probe covers) that do not leave contaminated areas is preferred. This is especially important in the isolation zones with the risk of airborne transmission, such as intensive care units.

Patients in the echocardiography laboratory should be categorized into 3 groups: 1) confirmed COVID-19, 2) suspected COVID-19 (eg, awaiting for the results of PCR test or patients with respiratory tract infection), and 3) patients with negative COVID-19 PCR test or low probability of COVID-19, based on the history and symptomatic status.²³

Medical personnel in the echocardiography laboratory performing transthoracic examinations in patients with COVID-19 (group 1) and suspected COVID-19 (group 2) should be dressed in long sleeved surgical gown, gloves, be provided with eye protection with goggles or full face visor, and use FFP2, FFP3, or equivalent particulate respirators. In patients with low probability of COVID-19 (group 3), based on the history and symptomatic status, we

recommend at least surgical mask (type IIR), plastic apron.

The time of direct contact with the patient should be kept to a minimum. With the right-handed scanning, tests should be carried out with the patient positioned on the left side, that is, with the back to the examiner. Gloves should be discarded after each test (wash and disinfect hands thereafter), the mask can be used without removing for up to 6 hours when caring for a cohort of COVID-19 patients. Other elements of the outfit, depending on their availability, should be used for no more than 6 to 8 hours. No one should leave the examination room into the clean area in the contaminated personal protective equipment. Patient undergoing the examination must wear a surgical mask, protecting against droplet transmission. A person not directly participating in the examination (eg, a technician) should keep a distance of at least 1.5 meters from the patient.

Since echocardiography devices are equipped with airflow cooling fans, air streams should be directed away from the staff. Optimally, there should be a continuously operating plasma air purifier in the room, preferably situated near the echocardiography machine. If not available, the laboratory should be cleaned 3 times a day with an ultraviolet lamp. The echocardiography ultrasound machine and examining beds should be fully wiped out after each examination. Detailed guidelines on how to clean ultrasound machines should be developed in cooperation with the manufacturers.^{24,25} The American Institute for Ultrasound in Medicine recommendations can help in this regard.²⁶ Dedicated cleaning wipes should be used to clean the probe, cables, keyboard, screen, and all other elements. If wipes are not available, alcohol may be used on most of the elements but it can damage the probe lens or the screen and it should not be applied directly but by using soaked cloths. The electronic probe connector should be kept dry and untouched. Rooms should be cleaned at least 3 times a day and every time after they get contaminated. Cleaning staff should be appropriately trained and protected. Detailed recommendations remain the responsibility of individual centers.

In case of transthoracic echocardiography performed outside the echocardiography laboratory, that is, at bedside, the machines should be cleaned when leaving the patient rooms, not after returning to the echocardiography laboratory. The use of portable machines that are easy to disinfect should be strongly considered. In case of transthoracic echocardiography performed in the areas at risk of airborne transmission, such as operating theaters, intensive care units, precautions should be identical as for transesophageal echocardiography (see below).

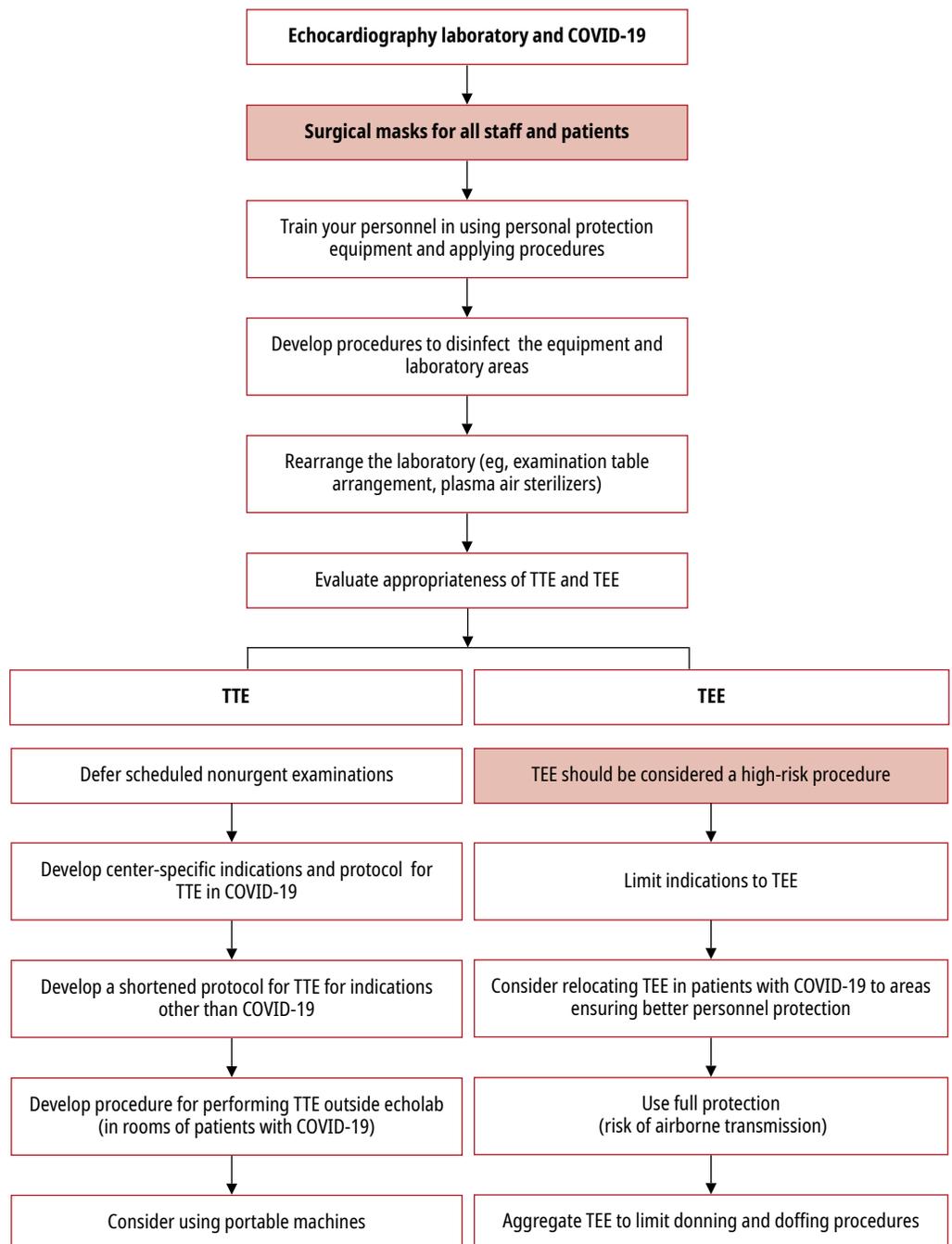


FIGURE 1 Organization scheme for echocardiography laboratories at risk of COVID-19 infection
Abbreviations: COVID-19, coronavirus disease 2019; TEE, transesophageal echocardiography; TTE, transthoracic echocardiography

Transesophageal echocardiography Transesophageal echocardiography is an aerosol-generating procedure. Therefore, indications for that procedure should be significantly limited primarily to suspected infectious endocarditis or acute mechanical valve dysfunctions, in cases in which it cannot be replaced with other imaging modalities. These limitations refer to all groups of patients: 1) confirmed COVID-19, 2) suspected COVID-19 (eg, awaiting for the results of PCR test or patients with respiratory tract infection), and 3) patients with negative COVID-19 PCR test or low probability of COVID-19, based on the history and symptomatic status.

Personnel should be appropriately trained and use maximum protection measures in the immediate vicinity of the patient, including at least FFP2, FFP3, or equivalent particulate respirator, long-sleeved surgical gowns, long surgical gloves, goggles, or full face visor, and sleeveless front waterproof apron.

Transesophageal echocardiography should not be performed in rooms where transthoracic examinations are carried out. If this is impossible, transesophageal examinations should be scheduled as the last examinations of the day.

It may be reasonable to relocate transesophageal examinations to zones where protective measures against airborne infections are

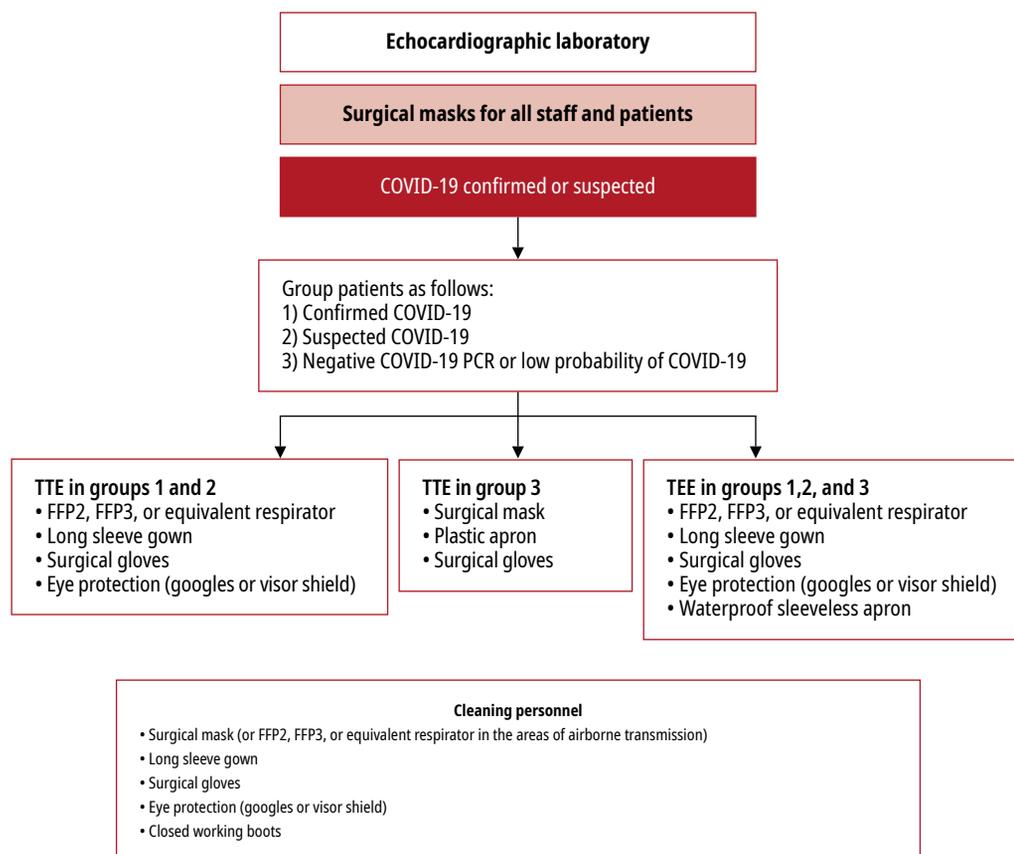


FIGURE 2 Protective equipment for transthoracic and transesophageal echocardiography
Abbreviations: see **FIGURE 1**

routinely used (eg, rooms dedicated for endoscopic procedures). For the same reasons, we propose grouping transesophageal examinations to limit multiple donning and doffing procedures. Echocardiography machines (including probes) and beds should be disinfected immediately after each examination. Detailed instructions on how to clean transesophageal probes should be developed in cooperation with the manufacturers.^{23,24}

All personnel (including technicians and cleaning teams) should be trained in dressing and removing personal protective equipment (donning and doffing) according to the institutional standard, which may be based on, for example, the recommendations of the European Centre for Disease Prevention and Control.²⁷ Training should be performed repeatedly in the presence of trained coaches. This applies in particular to the staff directly exposed to aerosol-generating procedures. Useful training videos are available online.²⁸

The organization scheme for echocardiography laboratories at risk of COVID-19 and protective equipment for transthoracic and transesophageal echocardiography are presented in **FIGURES 1** and **2**.

SUPPLEMENTARY MATERIAL

The Polish version of the paper is available at www.mp.pl/kardiologiapolska.

ARTICLE INFORMATION

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CONFLICT OF INTEREST None declared.

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