

Management of valvular and structural heart diseases during the coronavirus disease 2019 pandemic

An expert opinion of the Working Group on Valvular Heart Diseases, the Working Group on Cardiac Surgery, and the Association of Cardiovascular Interventions of the Polish Cardiac Society

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ABSTRACT

The ongoing pandemic of coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), represents a major challenge for healthcare. The involvement of cardiovascular system in COVID-19 has been proven and increased healthcare system resources are redirected towards handling infected patients, which induces major changes in access to services and prioritization in the management of patients with chronic cardiovascular disease unrelated to COVID-19. In this expert opinion, conceived by the task force involving the Working Groups on Valvular Heart Diseases and Cardiac Surgery as well as the Association of Cardiovascular Intervention of the Polish Cardiac Society, modification of diagnostic pathways, principles of healthcare personnel protection, and treatment guidelines regarding triage and prioritization are suggested. Heart Teams responsible for the treatment of valvular heart disease should continue their work using telemedicine and digital technology. Diagnostic

KEY WORDS

coronavirus disease 2019, pandemic, structural heart disease, valvular heart disease

tests must be simplified or deferred to minimize the number of potentially dangerous aerosol-generating procedures, such as transesophageal echocardiography or exercise imaging. The treatment of aortic stenosis and mitral regurgitation has to be offered particularly due to urgent indications and in patients with advanced disease and poor prognosis. Expert risk stratification is essential for triage and setting the priority lists. In each case, an appropriate level of personal protection must be ensured for the healthcare personnel to prevent spreading infection and preserve specialized manpower, who will supply the continuing need for handling serious chronic cardiovascular disease. Importantly, as soon as the local epidemic situation improves, efforts must be made to restore standard opportunities for elective treatment of valvular heart disease and occluder-based therapies according to existing guidelines, thus rebuilding the state-of-the-art cardiovascular services.

Introduction Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection has presently become a rapidly spreading pandemic. The virus penetrates into the lungs, the heart, the kidneys, or gastrointestinal cells using the angiotensin-converting enzyme 2 (ACE2) and receptor-mediated endocytosis. This may explain the wide spectrum of clinical symptoms. In addition, recent reports have emphasized the high risk of thromboembolic complications, which was particularly notable in nonsurvivors.¹

The treatment of coronavirus disease 2019 (COVID-19) is based on the use of various drugs (antivirals, antimalarials, antibiotics, and drugs affecting specific inflammatory pathways). In the case of respiratory or multiorgan failure, mechanical support may be necessary. However, several therapeutic strategies have proved to be partially ineffective or unsuccessful. Actually, there are no recommendations for using any antiviral drug or drug combination in Poland, which is why adaptation of adjuvant therapies is justified to achieve better outcomes.

About 81% of patients with COVID-19 have moderate symptoms and recover quickly, but 14% of patients develop severe respiratory failure requiring mechanical ventilation. The severe course of the disease is particularly frequently observed in patients over 65 years of age. Pulmonary or cardiac disease, diabetes, hypertension, and obesity are the risk factors for unfavorable outcomes.² Obviously, patients with valvular heart disease (VHD) are also included in this risk group.

Patient care before, during, and after hospitalization during the coronavirus disease 2019 pandemic

The primary purpose in the management of patients with VHD during the COVID-19 epidemic is to select those who require urgent intervention and those who may be monitored and treated pharmacologically. In patients who may be qualified for surveillance and in whom intervention may be safely postponed, such procedures should be preferred. Furthermore, pharmacotherapy and watchful waiting need to be implemented, with an individually adjusted frequency of follow-up visits, particularly in those at high risk of unfavorable outcome due

to COVID-19.¹ Patients with severe VHD must remain under telephone surveillance and should be encouraged to report progressive symptoms.

If possible, the initial visit of the patient and assessment of subjective symptoms should be carried out online. This is to protect patients from unnecessary contact with healthcare professionals, other patients on the ward, or outpatients, which may be associated with the risk of infection.^{1,3} When admitting a patient, every center is advised to perform a test for SARS-CoV-2 (preferably using the polymerase chain reaction [PCR]-based assay) and carry out triage selection to assess the patient's risk status. During admission to a cardiology clinic or hospitalization, it is crucial to reduce the risk of transmitting infection to healthy patients by the medical personnel and to protect medical teams (whose infection status should be verified with diagnostic tests) against infection or unnecessary contact with people with COVID-19 or those who are at risk of developing the disease. In patients with suspected COVID-19 (people in quarantine awaiting the test result and those with a history indicative of possible infection), invasive procedures should be deferred as far as possible, until infection is either confirmed or excluded (usually the day after testing). In directly life-threatening situations (eg, acute valve regurgitation or prosthetic valve dysfunction), persons with an unclear epidemiological status should undergo procedures without delay. During the procedures, protocols regarding the management of people with confirmed infection should be followed.⁴ Urgent procedures should be performed according to the protocols used so far.

It is essential to perform diagnostic tests for SARS-CoV-2 in patients with VHD just before any nonurgent admission to the hospital. As the epidemic may last in Poland for the following month, it is advisable to gradually expand the scope of diagnostic procedures and treatment using the appropriate personal protective equipment (PPE).

Organization of Heart Teams during the coronavirus disease 2019 pandemic

A Heart Team is a group of experienced specialists, including cardiologists (clinical

cardiologists, echocardiographers, and invasive cardiologists), cardiac surgeons, anesthesiologists, and, optionally, vascular surgeons and other specialists.⁵ Heart Teams are dedicated to consult patients referred for interventional procedures including cardiac surgery.⁶

Recently, various organization models for Heart Teams were established; however, during a pandemic, the most crucial task is to maintain the continuity of work. Currently, the essential clinical and imaging data are transferred electronically (using telemedicine or other means of virtual communication) to avoid direct contact between physicians. Phone calls are used when a face-to-face meeting is impossible. The Heart Team's recommendation is also sent back electronically.

In the era of a pandemic, the key issue is to ensure the safety of the medical team performing consultations. Therefore, Heart Team members should use standard personal protection equipment and keep the distance. Online consultations based on videoconference application and transmission of imaging data are recommended if available. Unfortunately, such a solution is actually limited. At the current stage, the consultation model described above is advised.

Noninvasive imaging during the coronavirus disease 2019 pandemic When noninvasive imaging is required in patients with VHD, the time and mode of examination are determined by patients' epidemiological and clinical status. In patients with suspected or confirmed infection, imaging should not be routinely performed. Elective, nonurgent examination should be performed after completed treatment for COVID-19. Imaging should be limited only to those situations when it is clinically relevant and may significantly influence patients' treatment.^{7,8}

Of note, the highest risk of virus transmission occurs during transesophageal echocardiography (TEE) and is higher than during transthoracic echocardiography (TTE) or other imaging examinations, such as those performed with the use of computed tomography, nuclear magnetic resonance (NMR) imaging, scintigraphy, or positron emission tomography. Exercise imaging in VHD is a potentially risky, aerosol-generating procedure and should be deferred during the pandemic.

Echocardiography and ultrasonography

Transthoracic echocardiography and TEE pose a risk of infection transmission. Transesophageal echocardiography should be performed only due to lifesaving indications, provided that other imaging modalities are inappropriate or inconclusive in a particular clinical problem. Transthoracic echocardiography requires direct contact with the patient and poses a risk of infection spread.

The shortened and modified protocol of examination, ensuring personal protection, is of key importance. Staff members with particular risk factors, such as advanced age of 65 years or more, chronic conditions, pregnancy, or immunosuppression, may be advised not to come in contact with patients with COVID-19.⁸

Echocardiographic examinations should be performed at the patient's bedside using portable devices. The increasing role of point-of-care ultrasound (POCUS) focused on lung ultrasound or cardiac problem-oriented examination (focused cardiac ultrasound [FoCUS]) is reported. When severe VHD is suspected, and clinical data support the potential necessity for surgical or interventional treatment, it is justified to perform full TTE examination to confirm the significance of VHD.

Computed tomography, nuclear examination, and nuclear magnetic resonance imaging

Computed tomography is currently not recommended as a screening tool for COVID-19. In patients with VHD, indications for CT include: diagnostic workup before urgent transcatheter aortic valve implantation (TAVI), transcatheter mitral valve implantation, and due to prosthetic valve dysfunction or thoracic aortic aneurysm. Other clinically relevant indications during the COVID-19 pandemic include: diagnosis of coronary artery disease, particularly before valvular surgery, suspected pulmonary embolism, and exclusion of thrombi in the heart cavities, particularly before cardioversion.⁹

Computed tomography, and, rarely during the pandemic, single-photon emission computed tomography with labeled leukocytes or positron emission tomography are recommended in patients in whom infective endocarditis is suspected, particularly in those with valvular prostheses or implantable devices.^{9,10}

The role of NMR imaging in cardiac diagnostic workup during the pandemic is not well established; however, it may be crucial when myocarditis is suspected.¹¹

Imaging should be limited only to those situations when it is clinically relevant and may significantly influence patients' treatment, to evaluate the severity of VHD or left ventricular dysfunction, and to prepare for urgent surgical or interventional treatment (eg, coronary artery multislice computed tomography or computed tomography angiography before TAVI).^{8,9}

Intraoperative echocardiography during the coronavirus disease 2019 pandemic

Transesophageal echocardiography in nonintubated patients is considered an examination of high risk of COVID-19 spread due to possible direct droplet transmission and/or transmission during positioning of the probe. After intubation, the risk of virus transmission decreases, but it

is still possible through patients' secretions carried on the TEE operator's gloves.

Patients with suspected or confirmed COVID-19 should be operated on in separate operating rooms. Those with confirmed COVID-19 may require TEE in many clinical situations, including cardiac surgery. This examination is essential in the following valvular diseases: left-sided endocarditis with a severe valvular defect or perivalvular involvement; symptomatic severe mitral valve insufficiency; prosthetic valve dysfunction; Stanford type A aortic dissection associated with aortic valve insufficiency, aortic root dissection, or pericardial effusion; or in another specific condition.

Transesophageal echocardiography should be performed by an experienced echocardiographer. Obtained imaging data should be recorded and not only focused on the main pathology but also they must be extensive enough to detect other significant, unexpected abnormal findings.^{12,13} Personnel protection and prevention against virus transmission should be a priority during the COVID-19 pandemic.

The levels and categories of PPE and the way of disinfecting echocardiography machines and TEE probes are covered in detail in the main expert opinion of the Working Group on Echocardiography of the Polish Cardiac Society.⁸

Surgical treatment of valvular heart disease during the coronavirus disease 2019 pandemic

If the patient has tested positive for SARS-CoV-2 and an operation is needed, the exposure time and the number of medical staff members involved should be reduced in the operating room. In addition, particularly during endoscopic procedures, it is crucial to reduce the time of exposure to patients' aerosol, as they may be unrecognized, asymptomatic carriers of COVID-19.⁸ Social distancing is another step to minimize the risk of transmission. Redirection of hospital equipment and PPE to emergency rooms prepared for patients with COVID-19 is recommended. Reduced utilization will conserve it for future critical incidents. This recommendation is also valid for blood unit conservation in the case of lower availability of donors. The number of blood units reserved for elective procedures should be reduced. The number of medical staff members must be reduced due to redeployment or COVID-19 developed among them. Each case should be individually discussed with regard to operation risk, alternative therapies such as medical treatment, percutaneous intervention, or readmission to another hospital offering higher availability of therapies for COVID-19. The experience of cardiac surgeons, involved in advanced cardiac disease treatment, can be utilized in implementing extracorporeal membrane oxygenation (ECMO), which is successfully used in acute respiratory distress

syndrome. Besides, cooperation with the Extracorporeal Life Support Organization can be useful when treating patients with COVID-19. Except for urgent and/or lifesaving indications, patients with confirmed COVID-19 and VHD should be operated after the treatment of COVID-19 is completed. During the pandemic, cardiac surgeons should sometimes choose more conservative rather than invasive treatment if the situation requires such approach.

Specific recommendations regarding operating rooms

The first step of the surgical procedure should comprise decision making and answering the question as to whether the procedure is absolutely necessary at present and what will happen if it is not performed. An "airway team" should include an anesthesiologist and a member of the operating room staff. If the patient is anesthesiologically challenging, consider involving an additional anesthesiologist. The scrub team should remove all unnecessary equipment from the operating room. It is recommended to plan the organization of the operating room staff to ensure that there is a "clean" runner outside the operating area (who will be in the anesthetic room, wearing an FFP3 mask, goggles, a plastic apron, and gloves) and the number of staff members present in the operating room is reduced to a minimum. The operating room staff, unlike the airway team, should wait outside during patient intubation (even though they use full PPE, since unnecessary exposure needs to be avoided). No staff member can be asked to reduce their level of personal protection against their wishes. Transfer to the operating room should be organized as follows: the transporting team should wear simple PPE. The patient should be transported in a dedicated tent and wear an FFP3 mask if COVID-19 is suspected or confirmed. If the patient receives oxygen support, a mask or another simple cover should be loosely placed over the oxygen mask. The most direct route to the operating room should be taken, bypassing the anesthetic preparation room. If possible, the patient's bed should be left in the operating room during the procedure. Notes and other medical documentation should be left with the patient. Rapid transit pathways, if available, should be used when transporting patients with confirmed or possible COVID-19. In the operating room, the anesthesiologists' protocol should be strictly followed during the intubation process: full PPE, with the second pair of nonsterile gloves and a plastic apron on the top of the gown, need to be worn during all intubations and extubations regardless of the patient's COVID-19 status (even if the disease is not suspected). The airway team dons in the scrub area before the patient arrives. The patient should be anesthetized and intubated in the operating room. Intubation needs to be performed by

the most experienced anesthesiologist. Only key staff members should be present for intubation (the chief anesthetist, an operating department practitioner). Consider turning the temperature down in the operating room, as there have been numerous reports on overheating while wearing full PPE.

The operation It is recommended for all staff members to wear full PPE. Discretion can be used to opt for simpler PPE, as discussed above, particularly in COVID-19-negative cases; however FFP2 or FF3 masks are necessary. Those scrubbing for the procedure should enter through the scrub area with FFP3 masks and eye protection in place, and then scrub as usual. Other staff members need to don outside and enter the room in full PPE. The scrub and surgical teams may enter the room once the airway is secured. All should wait for the anesthesiologist's instructions.

All staff, apart from the airway team, should leave the operating room before extubation. No other staff members can enter the operating room for 20 min, unless they wear full PPE. The anesthetic team should stay with the patient in their full PPE until the patient is awake, normally breathing, and any risk of reintubation has passed. The patient should be calm, receiving reasonable analgesic treatment, and not nauseated. If COVID-19 is not suspected, the patient can be moved to the recovery room. Otherwise, if COVID-19 is confirmed or possible, 20 min following the extubation, the anesthetic team can transition the patient's care to a recovery nurse in the operating room, wearing full PPE, and transfer the patient back to an appropriate ward. Return to the ward or general intensive care unit (ICU) should follow a similar pattern as in the case of transporting the patient to the operating room: the patient should be kept intubated. Maintain full PPE, as the patient will be switched to transfer ventilator tubing and, then, a general ICU ventilator, which poses the risk of inhaling aerosols by the medical team. Clamp the endotracheal tube prior to planned circuit disconnection and ensure that the heat and moisture exchanger is always present in the circuit.

Doffing PPE should take place where the patient is left, outside the patient's room or area. For transporting patients with confirmed or possible COVID-19, the rapid transit pathway should be used where the security staff is responsible for clearing corridors, calling lifts, etc.

Aortic stenosis: indications for intervention and monitoring during the coronavirus disease 2019 pandemic Aortic stenosis (AS) is the most common primary valvular heart disease. Aortic valve replacement (AVR) or transcatheter procedures are recommended for

symptomatic patients with severe AS.¹⁴ Lack of intervention is associated with poor prognosis and high 1-year mortality.¹⁵

According to the ESC guidelines, due to the limited possibility of intervention during the pandemic, patients with severe AS require risk re-stratification.⁷ It seems necessary to select vulnerable patients who need intervention first. Patients who are less symptomatic and have invasive treatment delayed will be included in the "waiting group." This group requires particularly close outpatient monitoring. It seems that regular telephone contact will be relevant for the triage of this patient group.

The group at higher risk should include patients with severe symptomatic AS and: decreased left ventricular ejection fraction (LVEF), symptomatic heart failure (HF) classified as the New York Heart Association (NYHA) class III to IV, syncope secondary to AS, and a high or very high transvalvular gradient.¹⁶ This group requires an urgent intervention or balloon aortic valvuloplasty may be considered in this population.

Patients with mild symptoms of severe AS (HF with the NYHA class I to II) and asymptomatic patients should be qualified for surgery at a later date,¹⁷ which will depend on the capacity of the center.

It seems that in the current, unusual epidemiological situation, the Heart Team plays a key role in the proper stratification of patients with AS. It is the Heart Team who should decide which patients with AS require intervention or surgery first, and which types of interventions are recommended (indications for TAVI may be extended to intermediate and selected low-risk patients). The regular assessment of patients on the "AVR waiting list" is crucial.¹⁸

Patients with AS should be treated individually, so that they do not lose the chance of surgery or intervention during the optimal period. Hospitals should consider both patients' medical needs and the logistic capacity to meet these needs in a timely manner.¹³

Transcatheter aortic valve implantation **Current situation and the proposed strategy for transcatheter aortic valve implantation in the era of the coronavirus disease 2019 pandemic** Transcatheter aortic valve implantation is the procedure of choice for the treatment of symptomatic AS in patients excluded from conventional surgical treatment (surgical aortic valve replacement [SAVR]) and the equivalent therapy for SAVR patients at high and moderate operational risk.^{5,19} The COVID-19 pandemic, especially in its early phase, was associated with logistic changes in the operation of hospital facilities and the reduction or centralization of human resources and equipment directed at selection (non-COVID-19 hospitals) and care

(COVID-19-specialized hospitals) of patients with COVID-19; it also significantly reduced the number of procedures performed in patients with symptomatic AS, both SAVR and TAVI.^{7,13} Of note, considering the natural course of AS, a very high 1-year mortality rate is reported in symptomatic patients treated only conservatively, reaching even 50%. In the light of these data, a quick yet gradual (depending on the development of the epidemiological situation in Poland) return to interventional treatment of symptomatic patients with AS should be attempted. It is advisable to first qualify patients with the highest risk of AS. High-risk clinical and echocardiographic features that should prompt accelerated or semi-urgent (up to 1 to 2 months in the time horizon) and, in selected cases, even in emergent and urgent referral (cardiogenic shock, severe NYHA class IV HF) are listed in TABLE 1. The decision on the date of procedure for hemodynamically stable patients without deterioration of echocardiographic features can be postponed, but, given the poor prognosis of patients treated only conservatively, this group should be closely monitored with regular follow-ups, preferably using telemedicine.

Logistic aspects of preparing patients to aortic interventions and the optimal transcatheter aortic valve implantation technique during the coronavirus disease 2019 pandemic The risk of spreading infection to the medical staff and the patient should be maximally reduced by the obligatory determination of the initial COVID-19 status using the PCR swab test, preferably a test enabling clinicians to obtain results after several hours. While waiting for test results, the patient should remain in the separated buffer zone of the ward or hospital and be treated as potentially infected. After confirming the negative result, it is recommended to perform TAVI in a hybrid room or hemodynamic laboratory separated from the sites

where diagnostic and therapeutic procedures are performed in patients with an undetermined status of SARS-CoV-2 infection. Due to the desirable minimization of the ICU load, patient safety, the lowest possible involvement of human resources and equipment, and the expected shortening of hospital stay, conducting TAVI through femoral access under conscious sedation and/or local anesthesia is feasible and seems to be the optimal solution. Patients with confirmed high-risk AS (TABLE 1) and the negative COVID-19 status require standard, precise diagnostic workup prior to TAVI (coronary angiography, computed tomography angiography). Both diagnostic and procedure-related hospital stay must be shortened. The above considerations also apply to patients who, due to age, general condition, or comorbidities with poor prognosis (eg, cancer), are scheduled to have balloon aortic valvuloplasty performed as a bridging or destination therapy.

Cardiac surgery for aortic stenosis Postponing or rescheduling the procedures is the principal recommendation in patients on the waiting list for cardiac surgery, if the likelihood of significantly impacting the further course of the disease is low.⁷ The reasons for that are multifactorial and involve protecting the cardiac patient by avoiding exposure to those with either suspected or confirmed COVID-19 in increasingly populated hospitals, which reduces the risk of infection. Additionally, protecting the institution and resources will result in preserving valuable means including ICU beds, ventilators, ECMOs, pharmaceuticals, and PPE. Lastly, it protects the cardiac surgery team consisting of highly specialized and dedicated individuals (scrub nurses, cardiac anesthesiologists, perfusionists, and surgeons), thus reducing their exposure to COVID-19, which may affect healthcare professionals in the next instances. It is recommended to organize telemedicine-based healthcare system,

TABLE 1 High-risk factors for transcatheter aortic valve implantation recommended within up to 1 to 2 months

Clinical	<ul style="list-style-type: none"> • Cardiogenic shock^a • Decompensated HF with NYHA class III or IV^a • Recurrent syncopal or presyncopal episodes • Recurrent chest pain • Aortic bioprosthetic valve dysfunction with severe regurgitation
Echocardiographic	<ul style="list-style-type: none"> • $V_{max} > 5$ m/s • $PG_{max} > 100$ mm Hg • Significant reduction of LVEF in a short time

a Emergent (balloon aortic valvuloplasty to be considered as a bridging procedure before transcatheter aortic valve implantation or surgical aortic valve replacement), particularly in patients with an uncertain coronavirus disease 2019 status and without computed tomography angiography performed—procedures with the use of full personal protective equipment by the medical staff as well as the proper disinfection of the room after they have been performed, as in patients diagnosed with coronavirus disease 2019

Abbreviations: COVID-19, coronavirus disease 2019; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association; PG, pressure gradient; V, velocity

particularly focused on monitoring the patients awaiting postponed procedures. Hospital bed capacity, particularly intensive care backup for current epidemic needs, is another reason for cancelling or postponing the surgeries.

In patients who need urgent intervention, surgery should be conducted to avoid patient's harm. This group of patients who may require urgent surgical procedures includes those with severe symptomatic AS and HF with NYHA class III to IV and syncope secondary to AS. Preoperative preparation of the patient is similar as for TAVI, with obligatory testing for SARS-CoV-2 within 24 to 48 hours before surgery. Patients appropriately qualified for AVR can be successfully treated with hospitalization below 7 days, as indicated. Current guidelines should be followed regarding the choice of treatment in patients with severe AS who are scheduled for urgent intervention.

Management of patients with mitral regurgitation during the coronavirus disease 2019 pandemic

So far, neither any direct effect of COVID-19 on the clinical course of primary (organic) and secondary (functional) mitral regurgitation (MR) nor any impact on the valvular function have been demonstrated. However, as in the management of other cardiovascular diseases, the COVID-19 pandemic imposed a series of procedural and logistic changes in terms of treatment strategies and hospital as well as ambulatory care.

The vast majority of patients with asymptomatic severe MR do not require urgent interventions and treatment may be postponed. Such patients may stay at home and can be monitored using a telemedicine system.

During the COVID-19 pandemic, general clinical indications for surgical treatment of organic or functional and acute or chronic MR remain unchanged, while the priority for both surgical and percutaneous interventions has changed. It

is necessary to reorganize the admission system and set new priorities. The slow deceleration of the COVID-19 pandemic, currently observed in some countries, forces clinicians to take further actions aimed at re-initialization of standard consultations and treatment in patients with VHD who stay at home and benefit exclusively from medical consultations using a telemedicine system.^{13,17} Patients with MR can now be classified into 3 different categories (tiers). The group requiring the most urgent procedures (tier 1) includes patients with acute MR and decompensated HF with NYHA class IV requiring intra-aortic balloon pump support and inotropic drugs. Low-priority procedures (tier 2) should be assigned to those with chronic MR, episodes of cardiac decompensation, lack of response to pharmacotherapy and cardiac resynchronization therapy, and a decrease in LVEF. The third category (tier 3) includes patients in whom surgical treatment may be postponed. The strategies of performing interventions in patients with MR, based on the ESC recommendations⁷ and the American experience of Chung et al,¹⁷ are presented in TABLE 2.

Percutaneous procedures limiting mitral regurgitation with the use of the edge-to-edge technique

The edge-to-edge procedures proved to be safe thanks to the support offered by an anesthesiologist, continuous periprocedural TEE monitoring, and 24-hour postoperative surveillance in the ICU. However, during the pandemic, this procedure could be associated with increased exposure of the medical staff to coronavirus transmission (during intubation and TEE monitoring) and exhaustion of the already depleted resources, that is, the medical personnel and ICU beds. It is of importance to set an appropriate priority when deciding whether to perform an intervention in an already hospitalized patient or to admit a patient for elective treatment.

TABLE 2 Strategy for mitral interventions during the coronavirus disease 2019 pandemic according to the European Society of Cardiology⁷ and Chung et al¹⁷

Tier 1		Tier 2		Tier 3			
Emergency (do not postpone)		Urgent (perform within days)		Lower priority (perform in <3 months)		Elective (postpone for >3 months)	
Surgical replacement or repair: Acute postinfarction MR, acute infectious (IE) regurgitation of a native valve or mitral prosthesis, complicated by cardiogenic shock		MitraClip procedure: Acute postinfarction MR without shock in inoperable patients		MitraClip procedure or surgical treatment: Functional MR in the course of decompensated heart failure, despite optimal pharmacotherapy / CRT, with NYHA class III, with EF decrease		MitraClip procedure or surgical treatment: Functional MR with a stable course of heart failure, without escalating diuretic treatment, with NYHA class I to II	
Decompensated MR requiring IABP support, inotropes		Decompensated MR with NYHA class IV					
		Surgical replacement: Acute postinfarction and postinfective (IE) MR, without shock					

Abbreviations: CRT, cardiac resynchronization therapy; EF, ejection fraction; IABP, intra-aortic balloon pump; IE, infective endocarditis; MR, mitral regurgitation; others, see TABLE 1

The highest priority for performing edge-to-edge procedures during the COVID-19 pandemic has been currently granted to the following groups of patients: 1) patients with severe MR and HF (NYHA class III to IV) despite optimal medical therapy and CRT when indicated, especially in the case of recurring appearance of HF decompensations requiring hospitalization within the preceding 30 days and/or NYHA class III to IV symptoms refractory to pharmacotherapy or requiring inotropes or mechanical cardiac support; refractory HF precluding discharge from the hospital; 2) patients with acute MR as a mechanical complication of myocardial infarction or related to the rupture of mitral chordae tendineae who fulfill the anatomical feasibility criteria and are deemed inoperable, except for those with infectious endocarditis.^{13,17}

Of note, in patients with secondary MR who fulfill the COAPT (Cardiovascular Outcomes Assessment of the Mitraclip Percutaneous Therapy) inclusion criteria, the MitraClip procedure not only reduces the number of hospitalizations due to HF but also decreases mortality, so it should not be postponed longer than absolutely necessary.^{17,20}

Similarly to other transcatheter interventions, patients' qualification should be based on the analysis of the risk-benefit profile. The factors to be considered are the potential mortality and morbidity benefit of the procedure, the risk

of SARS-CoV-2 infection in patients and the medical staff, as well as the disrupted workflow in heart valve centers. The key issues are limited blood donation and supply, which can jeopardize the access to blood products if complications occur, need for urgent cardiac surgery, and exposure of the medical staff to aerosols during intubation and TEE examination. Also, the shortage of the experienced anesthesiology staff may be the limiting factor.^{7,17} Given the fact that patients with MR are usually at high risk of death if infected with SARS-CoV-2 (due to age >65 years, HF, coronary heart disease, hypertension, and chronic obstructive pulmonary disease), preprocedural testing with the PCR test, separation from other patients, and fast discharge are reasonable steps to be taken.

The decision to perform an intervention in an already hospitalized patient or to admit a patient for treatment during the COVID-19 pandemic should be preceded by evaluating the severity of clinical symptoms of MR, valve morphology, patient prognosis, and should be also based on a reliable and reasonable assessment of hospital resources (FIGURE 1). Patients with "simple" valvular anatomy, symptoms, and good long-term prognosis should be prioritized for percutaneous treatment if hospital resources are not limited.

Other transcatheter mitral valve interventions

In addition to the procedures reducing MR, transcatheter mitral valve interventions include percutaneous mitral commissurotomy in patients with severe mitral stenosis (MS), as well as the closure of paravalvular leaks with occluders. Percutaneous mitral commissurotomy should be performed in specialized centers by experienced operators, only in patients with significant rheumatic MS if the risk-to-benefit ratio is acceptable. The following groups of patients should be considered: 1) pregnant women (>20 weeks of pregnancy) with HF related to MS (NYHA class III to IV) or pulmonary hypertension (systolic pulmonary artery pressure >50 mm Hg) despite optimized medical therapy; 2) patients with HF (NYHA class III to IV) with comorbidities exacerbating the disease, which cannot be adequately controlled (eg, atrial fibrillation and poor rate control).⁵ Transcatheter closure of paravalvular leaks should be considered in those without active infectious endocarditis who present with HF (NYHA class III to IV) or severe hemolytic anemia requiring transfusions.⁵

Surgical management of mitral regurgitation in the era of the coronavirus disease 2019 pandemic

The majority of patients with MR are stable and can have surgical interventions deferred. Decisions on whether to perform cardiac surgery or not will be easier in the low- and medium-escalation phase of the COVID-19

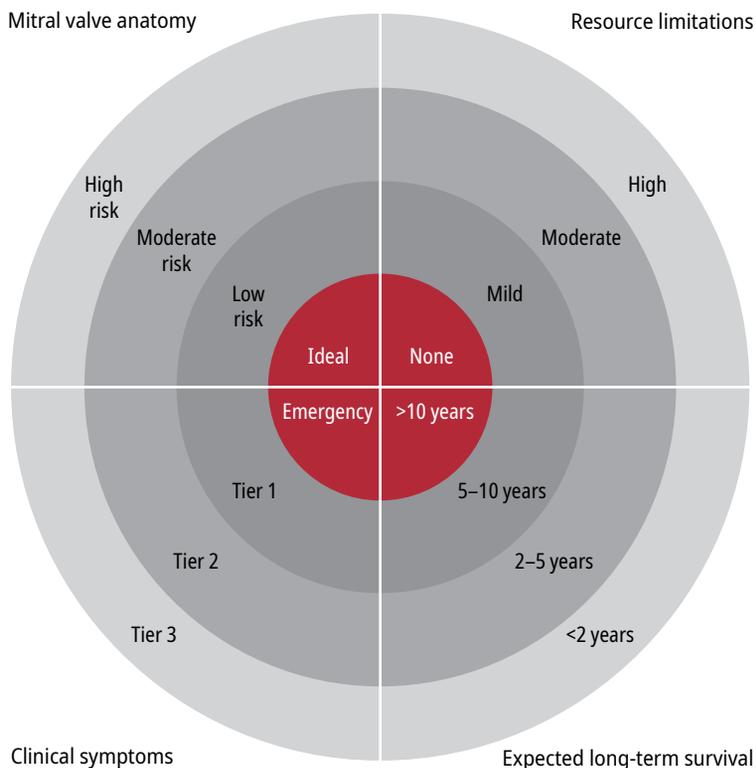


FIGURE 1 Decision criteria for prioritizing transcatheter treatment of mitral regurgitation, including clinical symptoms, mitral valve anatomy, prognosis and availability of medical staff, intensive care unit beds, and personal protective equipment. Based on Shah et al¹³

pandemic when the ICU beds will be still available. Continued escalation will make decisions to operate more difficult. In a progressively escalating situation, routine elective cardiac surgery should not be performed.⁷ Priority should be given to treating patients with: acute MR complicating acute myocardial infarction; infective endocarditis; MR due to acute degenerative chordal rupture; severe, symptomatic primary or secondary MR that is not responsive to guideline-directed medical and CRT treatment and requires hospital admission; and MR with low ejection fraction.^{13,17}

Patients with chronic primary MR (a flail leaflet and Barlow disease) are usually stable and procedures may be postponed in this population. Surgical repair in such patients should be deferred until the end of the COVID-19 pandemic. Close outpatient monitoring using telemedicine should be continued in all patients with severe MR. After decompensation requiring hospitalization, proper surgical intervention should be undertaken (TABLE 2).

Patients with suspected or confirmed COVID-19 should undergo procedures in dedicated operating rooms only if an urgent or emergent indication exists, as potential myocardial and pulmonary complications due to COVID-19 may occur. The choice of intervention (surgical or transcatheter) should be guided by the local Heart Team.²¹

Transvascular implantation of occluders in patients with cardiac disease Percutaneous implantation of occluders is a standard procedure used to treat hemodynamically significant congenital heart disease (shunt lesions in atrial and ventricular septal defects, patent ductus arteriosus) and to reduce the risk of cardiogenic embolism (closure of the patent foramen ovale or the left atrial appendage). These procedures are almost invariably elective. Scenarios which require urgent (within a few days) implantation of an occluder are very rare and include, for example, implantation of an occluder into the ventricular septal rupture (usually being a complication of myocardial infarction), severe perivalvular leak, or atrial septal defect associated with the high risk of paradoxical embolism, eg, in acute deep vein thrombosis.

Since occluder implantation is performed in the cardiac catheterization laboratory, usually under TEE guidance, it is considered a high-risk procedure due to possible droplet transmission and generation of aerosols, which requires prolonged contact between the patient and the medical staff. Therefore, it belongs to the category of treatments which can be postponed during the coronavirus pandemic. In clinically justified situations, exclusion of coronavirus infection must precede the procedure which is to be carried out wearing the adequate PPE (an isolation gown, eye protection, and a respirator, at least of class FFP2/N95).

In the time of significant and high incidence of COVID-19 in the community, elective procedures may (and, in infected patients, should) be deferred. In extremely rare urgent indications for the procedure in a patient infected with SARS-CoV-2 (eg, due to a mechanical complication of myocardial infarction), decisions must be made on a case-by-case basis. The use of a ventilator during surgery may reduce the risk of virus transmission.

However, in an epidemiological scenario with a moderate incidence of COVID-19, it is advisable to very gradually restore access to elective and prophylactic procedures in accordance with current guidelines, while maintaining the above mentioned safety measures and pretreatment testing for SARS-CoV-2.⁷ The duration of hospital stay and extent of in-hospital procedures performed in addition to the essential treatment should be minimized.

Anticoagulant management in patients with valvular heart disease Limited access to healthcare and patients' anxiety, which leads to avoiding office visits and laboratory testing, may adversely influence the international normalized ratio (INR) control in patients with mechanical valves who take vitamin K antagonists (VKAs). This can result in taking subtherapeutic VKA doses and an increased risk of thromboembolic events or bleeding related to overdose. Specifically, the thrombotic risk may be increased in patients with COVID-19.

We recommend to continue regular INR evaluation in patients with mechanical valves. Patients with mechanical prosthetic valves should continue anticoagulation with VKAs, yet non-vitamin K antagonist oral anticoagulants are contraindicated. Of note, in patients with stable VKA anticoagulation, the frequency of INR monitoring can be reduced to 10 to 12 weeks between INR checks. Organization of outpatient clinics and INR evaluation should be modified in order to limit close personal contacts. Importantly, if it is possible for the patient to self-test the INR using a CoaguChek device, this should be recommended. In such cases, the physician should adjust the VKA dose by phone. Moreover, when INR monitoring is not possible, low-molecular-weight heparin at a full therapeutic dose could be considered for a short time if the patient can be taught to self-inject the drug or a caregiver can administer the injection.^{7,22}

SUPPLEMENTARY MATERIAL

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

ARTICLE INFORMATION

CONFLICT OF INTEREST None declared.

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