ASE Statement on Adapting Pediatric, Fetal, and Congenital Heart Disease Echocardiographic Services to the Evolving COVID-19 Pandemic

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Over the 12 months since the start of the coronavirus disease 2019 pandemic, an explosion of investigation and an increase in experience have led to vast improvement in our knowledge about this disease. However, coronavirus disease 2019 remains a huge public health threat. (J Am Soc Echocardiogr 2021;■:■-■.)

Keywords: COVID-19, Pediatric, Fetal, Congenital, Heart disease

Over the 12 months since the start of the coronavirus disease 2019 (COVID-19) pandemic, an explosion of investigation and an increase in experience have led to vast improvement in our knowledge about this disease.

However, COVID-19 remains a huge public health threat. With ongoing fluctuations of disease prevalence and spread, countries, states, and municipalities have moved from strict lockdowns to varying degrees of restricted movement and activity. Further change is expected in the months ahead as pandemic surges continue amid the initiation of successful vaccine distribution. This evolution in the pandemic and community response requires us constantly to adapt our strategies for practice management.

During the initial phase of the pandemic, the American Society of Echocardiography (ASE) provided guidance to our echocardiography community with "Specific Considerations for Pediatric, Fetal, and Congenital Heart Disease Patients and Echocardiography Service Providers during the 2019 Novel Coronavirus Outbreak"[1] as a supplement to the broader ASE statement.[2] Initial concerns that elective office visits and procedures could fuel propagation among patients, families, and providers (particularly to pregnant women and fetuses and from asymptomatic children) along with incomplete knowledge of the best methods of mitigating transmission risk led to a dramatic reduction in echocardiographic services provided to pregnant women and pediatric and congenital heart disease patients.

As the pandemic trajectory somewhat ameliorated, the ASE released the statement "Reintroduction of Echocardiography Services during the COVID-19 Pandemic"[3] in May 2020 to help echocardiography providers realign practice and care. In the months following these statements, we have learned much. We have observed that, typically, healthy children are less severely affected than adults

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Endorsed by the Society of Pediatric Echocardiography and the Fetal Heart Society.

Conflicts of interest: None.

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0894-7317/$36.00

https://doi.org/10.1016/j.echo.2021.01.012

Abbreviations

ASE = American Society of Echocardiography

CDC = Centers for Disease Control and Prevention

COVID-19 = Coronavirus disease 2019

KD = Kawasaki disease

MIS-C = Multisystem inflammatory syndrome in children

MRI = Magnetic resonance imaging

PPE = Personal protective equipment

SARS-CoV-2 = Severe acute respiratory syndrome coronavirus 2

during acute severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection.[4] Mortality of pediatric patients requiring hospitalization is low, at approximately 0.18%.[5] Socioeconomically disadvantaged and/or minority children are more likely infected, and there is increased risk for severe disease and complications in the very young or in those with chronic medical conditions.[6-9] Chronic medical conditions posing additional risks in children overlap some risk factors in adults (obesity and diabetes) but diverge in others (less risk for asthma but higher risk for neurologic, genetic, and metabolic maladies, among others).[8,9] There has been obvious concern for increased risk in children with congenital heart disease because of underlying physiologic and anatomic abnormalities, yet these cases have been only rarely reported.[10,11] Although children seem less predisposed to serious illness during the acute infection, a subset develop multisystem inflammatory syndrome in children (MIS-C), with potential accompanying hemodynamic compromise and myocardial dysfunction that may be severe enough to require support with extracorporeal membrane oxygenation in some cases.[12]

Beyond the acute infection risks and short-term complications, the propensity of SARS-CoV-2 to injure the heart has raised concerns about the safe return of children to recreational and competitive sports. This concern has led to further debate about how best to screen children with histories of COVID-19, including whether cardiac testing should universally be performed. For fetal cardiology patients, there have been minimal nosocomial, clinic-acquired infections among pregnant patients. At the same time, pregnancy has been demonstrated to raise the risk for maternal complications from COVID-19, and there are anecdotal reports of concerning cases of critical heart disease presenting postnatally that could have been detected prenatally if typical fetal echocardiographic practices had been in place. Fetal echocardiographic services were not specifically addressed in the ASE reintroduction statement, and many practices have continued stringently to restrict access. Therefore, staged reexpansion of fetal echocardiographic services is necessary to address now. In view of our improved understanding of the risks for transmission, and the differences in acute and postinfectious courses in our pediatric, congenital heart disease, and fetal cardiology patients, this statement on adapting pediatric, fetal and congenital heart disease echocardiographic services to the evolving COVID-19 pandemic is written to update information and guidance to clinicians who provide echocardiographic services. Additional updates are provided on the impact for our sonographers and laboratory work flow, strategies to address trainees' education, and sedation practices.

In considering echocardiographic service practice changes, readers should refer to the broader ASE reintroduction document for operational considerations and prioritization tiers.[3] The Centers for Disease Control and Prevention (CDC) has supplied gating criteria to be met initially and then defined four phases of pandemic reopening statewide or by community (governor prerogative), shown in Table 1.[13] Providers should refer to the CDC for more detailed information on gating criteria and take into account CDC phases and regional vaccination rates, aligning with applicable state, county, or municipal mandates and public health policies.

Table 1 CDC gating criteria and phases of pandemic reopening[13]

Gating criteria to enter phase 1	• Decrease in severity of identified COVID-19 cases • Decreases in emergency center and outpatient visits for COVID-19-like illnesses • Decrease in percentage of positive test results • Robust testing program for health care workers • Ability to treat all patients without crisis care
Phase 1	• Downward trajectory of positive test results as percentage of total tests • <20% positive test results for 14 days • Inpatient and ICU bed availability <80% capacity
Phase 2	• Continued downward trajectory of positive test results after entering phase 1 • <15% positive test results for 14 days • Inpatient and ICU availability <75% capacity
Phase 3	• Continued downward trajectory of positive test results after entering phase 2 • <10% positive test results for 14 days • Inpatient and ICU availability <70% capacity
Phase 4	• End of the pandemic • Resumption of normal activities

ICU, Intensive care unit.

ADAPTATIONS FOR SONOGRAPHERS AND ECHOCARDIOGRAPHY LABORATORY PROCESSES

The COVID-19 pandemic has required sonographers rapidly to change their work flow, personal safety measures, and examination protocols. The initial lockdowns decreased clinical volume so significantly that many sonographers had their hours flexed down and were at risk for being furloughed, raising personal financial stresses. Subsequently, as laboratories and clinics expand services, the drive to "catch up" on the accumulation of deferred examinations places different physical and emotional stresses on sonographers and laboratory personnel. The increase in number of patients coming to the echocardiography laboratory is occurring concurrently with resumption of complete, comprehensive echocardiographic examinations with longer scan times. Young children remain less compliant with facemasks and have difficulty cooperating, particularly during the long examinations necessary to evaluate complex congenital heart disease. Optimal social distancing is difficult or impossible to achieve in a small echocardiography examination room with a child, caretaker, and sonographer. Some sonographers considered at high risk for COVID-19 have chosen to stay home, leaving fewer on-site sonographers to tackle an increased workload. Sonographer availability is also limited by the quarantine required when suspicious symptoms arise or a COVID-19 exposure occurs. All of these factors can lead to sonographer exhaustion and burnout, similar to what is observed in other frontline providers. To minimize this fatigue, measures to ensure

HIGHLIGHTS

- This Statement offers updated information and guidance for providing echocardiography services in light of improved understanding of COVID-19 risks and course in our pediatric, congenital heart disease, and fetal cardiology patients.
- Referral for fetal echo may be gradually reintroduced to pre-pandemic norms, with the addition of telemedicine as an essential and valuable tool.
- MIS-C is frequently associated with cardiac abnormalities, with echo playing a vital role in assessment for abnormal ventricular function by ejection fraction and strain imaging, valvulitis, coronary artery dilation, intra-cardiac thrombus, or pericardial effusion.
- Essential trainee education in pediatric, congenital and fetal echo is feasible with stringent attention to PPE, incorporation of remote learning, thoughtful patient selection, and the use of scan protocols.
- Excellent communication, focused but thorough scan protocols, PPE, and flexible scheduling are essential for successful lab workflow and sonographer well-being.

appropriate patient workload and adequate rest between cases should include[3]:

- staggered scheduling with lengthened, dedicated time between echocardiography appointments and
- daily and weekly rotating shift adjustments.

To maintain personal safety for sonographers, patients, families, echocardiography and clinic personnel the following measures should be employed:

- mandatory use of masks for age-appropriate patients and their caretakers at all times;
- universal use of personal protective equipment (PPE; including eye protection) for the sonographer and ancillary staff (as per the reintroduction statement, the levels of PPE used will depend on the phase of the response, local institutional policies, and COVID-19 testing status)[3];
- limiting caretakers to one individual per patient when possible;
- maintaining meticulous sanitation protocols for machines, probes, rooms, and workstations; and
- social distancing in waiting areas or staggered entrance to the hospital for echocardiography appointments using text messaging.

Enhanced communication remains paramount and can markedly improve the physical and emotional effects of the pandemic for sonographers. The indications and goals for each scan should be clearly communicated among referring physicians, echocardiography faculty members, and sonographers. This communication and the development of focused lesion-specific protocols help the sonographer perform studies that obtain all the required information with minimal scan and exposure time. Echocardiography laboratory leadership must be constantly proactive in adjusting protocols and staffing, as risk levels change with the highly fluid nature of this pandemic.

Leadership decisions must be communicated to physicians and sonographers in real time to ensure that teams retain confidence that their welfare and the welfare of the patients and families is the highest priority. In return, sonographers encouraging their sonographer colleagues to communicate openly regarding their physical and mental health will assist in developing strategies for coping and adjusting to evolving echocardiography laboratory operations.

FETAL ECHOCARDIOGRAPHY

For fetal cardiology providers, the priority at the onset of the pandemic was to minimize the exposure of pregnant women and fetuses to SARS-CoV-2. The previous ASE statement described a triaging system for scheduling fetal echocardiographic examinations and consultations considering the risk for congenital heart disease, significant fetal arrhythmia, or anomaly by referral indication while keeping in mind the scheduling limitations imposed by a finite gestational period for pregnancy decision-making and perinatal and neonatal management planning.[1] This triaging system resulted in a rapid decrease in fetal cardiology visits at multiple centers (by approximately 20%–35%) and decreased referrals. As a consequence, less face-to-face counseling occurred. When in-person visits did occur, they often did so with a single or even no support person accompanying the pregnant mother, even in the setting of a new diagnosis of a significant fetal congenital heart defect. Depending on local conditions, some centers began to resume more normal fetal cardiology scheduling practices and allow more support persons to accompany the patient. Reexpansion of fetal cardiologic services has been highly variable, however, with some centers continuing to restrict services and see fewer referrals, with concomitant lower volumes and persistently decreased sonographer hours. Furthermore, with increases in infection rates, other centers may reinstate more restrictive strategies.

Without question, pregnant mothers have experienced increased psychosocial stress related to regulations limiting in-person support during fetal cardiology consultations. Pregnancy itself creates a higher risk state for COVID-19-related complications.[14-16] SARS-CoV-2 testing of pregnant women has become standard practice before delivery given the 10% rate of positive test results in asymptomatic women.[15,17] For neonates born to SARS-CoV-2-positive mothers, the greatest risks at present appear to be preterm labor and fetal distress.[18] Fortunately, there have been only a few reported cases of perinatal transmission of SARS-CoV-2, with most affected babies being asymptomatic. There are rare reports of placental infection and abnormalities, along with stillbirths in fetuses of pregnant women who are SARS-CoV-2 positive but asymptomatic.[18-22] Thus far, there have been no reports of associated neonatal cardiac disease or documented fetal anomalies from early second trimester maternal COVID-19.[14,18]

Moving forward, our better knowledge of risks and enhanced strategies for protection of sonographers and pregnant women has allowed the reexpansion of fetal cardiologic services, while minimizing any negative impact of these strategies on holistic patient care. For example, if local obstetric and maternal-fetal medicine clinicians accurately perform fetal cardiac screening for low-risk indications, this strategy could continue, especially if images are available for review by the fetal cardiology providers if needed. It is critical, however, for certain patients to be scanned by a fetal cardiology team with in-person consultation for appropriate assessment and management. These patients include those at high risk for fetal congenital heart disease, those already diagnosed or suspected to have complex fetal cardiac diagnoses, hydrops fetalis, significant extracardiac anomalies, fetal anomalies requiring intervention or affecting the fetal heart, or significant fetal arrhythmias.

Telemedicine has become a valuable tool in fetal cardiology, with myriad possible applications offering maximum flexibility.

Table 2 Fetal cardiology phased reopening during the COVID-19 pandemic

Fetal cardiac risk category	Phase of CDC reopening			
	Phase 1	Phase 2	Phase 3	Phase 4
High	Follow ASE COVID-19 guidelines	• Resume scheduling of fetal echocardiography if anatomic scan does not confirm normal cardiac structures regardless of gestational age • Resume scheduling of all monochorionic-diamniotic twin pregnancies • Resume every 1- to 2-week follow-up for SSA/SSB-positive mothers		Return to standard practice before COVID-19 pandemic
Moderate	Follow ASE COVID-19 guidelines	• Resume all scheduling regardless of gestational age • Resume in-person follow-up counseling for CHD		Return to standard practice before COVID-19 pandemic
Low	Follow ASE COVID-19 guidelines	Follow ASE COVID-19 guidelines	Resume scheduling	Return to standard practice before COVID-19 pandemic

CHD, Congenital heart disease; *SSA*, Anti–Sjögren's syndrome antibody type A; *SSB*, anti–Sjögren's syndrome antibody type B.

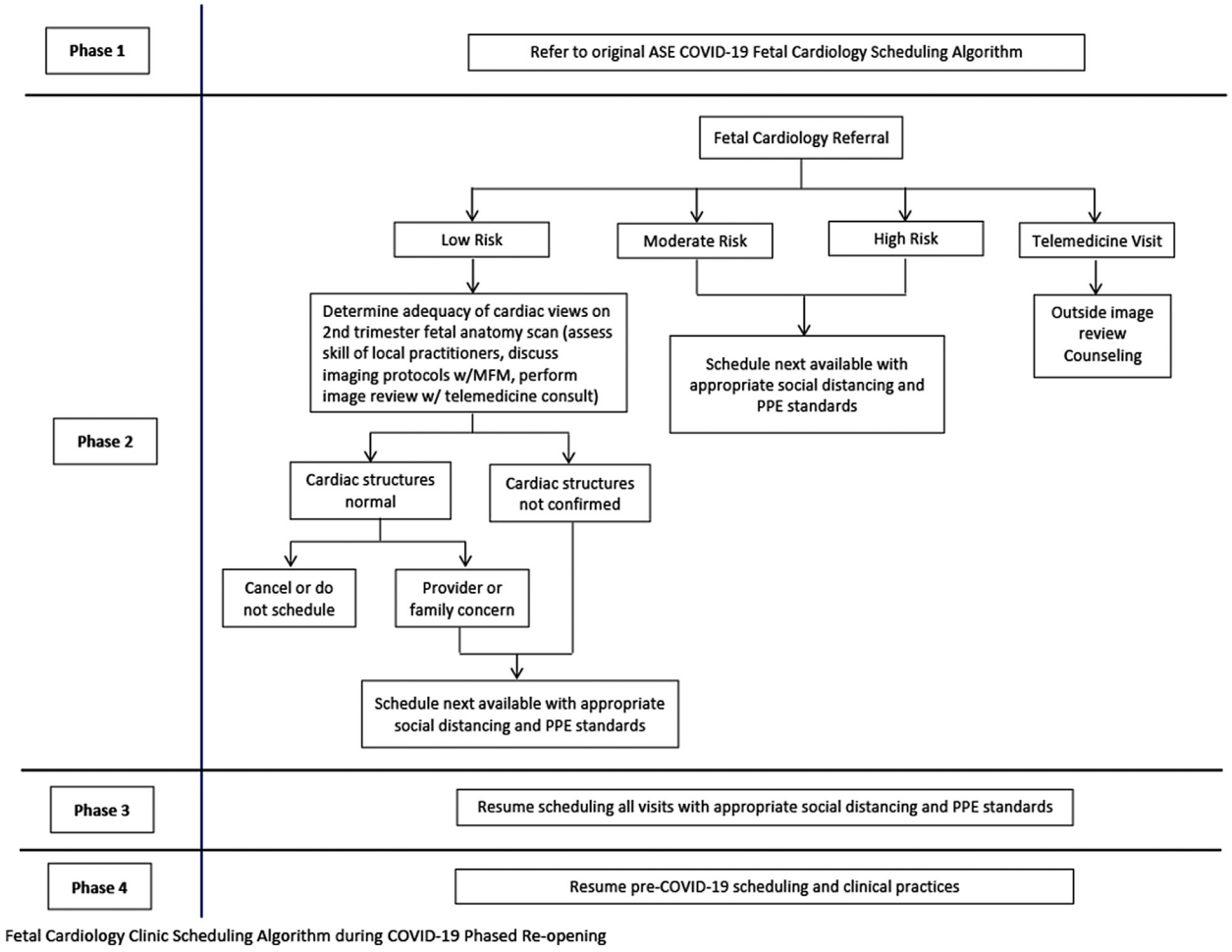

Figure 1 Fetal cardiology scheduling algorithm. *MFM*, Maternal-fetal medicine.

Telemedicine fetal cardiology consultation can occur after the fetal cardiologist has reviewed images performed by obstetric and maternal-fetal medicine clinicians for low-risk indications or after review of images done in a fetal cardiology clinic or echocardiography laboratory. Telemedicine can allow remote counseling for a new diagnosis or follow-up for congenital heart disease. With restrictions still in place on the number of family members or other support persons a pregnant woman can bring to the appointment, telemedicine can allow those crucial support persons to join the patient during her in-person consult. The availability of telemedicine has also enhanced options for multidisciplinary counseling. Additional providers such as genetic counselors, other fetal or pediatric subspecialties, and ancillary support such as social work and/or the palliative care team can join the consultation without compromising social distancing practices. These multiple benefits will continue to be realized as a lasting approach for comprehensive fetal cardiology care after the pandemic ends.

Table 3 Elements for successful and safe training in the COVID-19 environment

Face masks for everyone (patients, family members, practitioners) at all times, excluding young infants and children who cannot wear them
PPE, including masks and face shields, worn during all imaging encounters
Extensive PPE with N-95 masks and powered air-purifying respirator systems when echocardiograms must be obtained in patients with COVID-19
Focused echocardiographic examinations for trainees and sonography students as appropriate to minimize contact with patients and their families
Selection of cooperative patients for training examinations
Review and feedback of obtained echocardiograms in a socially distant manner, consider with remote video technology
Continuation of didactic echocardiography lectures by virtual platforms
Participation of fellows and sonography students in national and international echocardiography webinars

Table 4 Definition of MIS-C

Age < 21 y with fever (>38.0°C or subjective) for ≥24 h
Laboratory evidence of inflammation
Multisystem (more than two) organ involvement
No alternative plausible diagnoses
Positive for current or recent SARS-CoV-2 infection or exposure within the 4 weeks before the onset of symptoms (noting that because infection may occur from an asymptomatic contact, children and their caregivers may not even know that they had been infected)

A proposed strategy for reexpansion of fetal cardiologic services adapting the previously published triage system and the CDC pandemic phases is delineated in Table 2 and Figure 1. In this new strategy, pregnant women in the moderate-risk and low-risk categories are added slowly back sequentially as societal viral burden decreases and regulations loosen.

PROCEDURAL SEDATION AND ANESTHESIA

The indications for procedural sedation and anesthesia remain largely unchanged from previous recommendations.[1] On the basis of the high risk for aerosolization with transesophageal echocardiography, especially in patients with unsecured airways, preprocedural testing for SARS CoV-2 is strongly recommended for all cases. However, preprocedural testing should not lead to any degree of complacency with risk reduction strategies, given the varied available testing options, the interpretation of the results on the basis of type of test, and the possible development of symptoms or infection during the intervening time from test to procedure. The removal of airborne or contact isolation precautions after a positive test result, in consultation with infectious disease experts, will alter the choice of procedural precautions. Institutional protocols to define those patients requiring airborne isolation, contact isolation, or no isolation are expected to continue to evolve as more individuals acquire immunity via disease or vaccine administration.

Transesophageal Echocardiographic Algorithms

An algorithm for transesophageal echocardiographic procedures was outlined in the ASE guidance document for pediatric and fetal echocardiography.[1] Sedation and anesthesia personnel should continue to follow existing society guidelines and institutional protocols.[23] The risk for transmission of SARS-CoV-2 from known infected patients to health care workers who adopt adequate precautions is low. Separate procedural rooms are recommended for patients requiring airborne isolation precautions with minimal staffing for procedures with aerosolization risk such as intubation, extubation, and transesophageal echocardiography with an unsecured airway.[24] Contact precautions (gloves, gown, facemask) may be adequate for those patients who have previously tested positive but are not considered airborne risk.[25] Additionally, standard precautions for all sedation and anesthesia requiring procedures should include gloves and facemasks at a minimum, with strict attention to hand hygiene before and after the procedure.

TRAINEES IN THE PEDIATRIC CONGENITAL HEART DISEASE AND FETAL IMAGING ENVIRONMENT

The COVID-19 pandemic has severely affected all aspects of medical education. The strategies implemented to adapt to this new environment have changed rapidly on the basis of the regional prevalence of the disease and the ability to protect trainees from infection and transmission using adequate access to PPE. At the onset of the pandemic, much of the activity that was strictly educational was substantially curtailed. Fellows transitioned to frontline providers. Fellows performed echocardiographic examinations as part of the essential care team on call, but elective training in the echocardiography laboratory was limited to minimize patient and provider contact. Many programs nimbly transitioned to virtual platforms for didactic learning, and a number of national organizations, including the ASE, the Fetal Heart Society, and the Society of Pediatric Echocardiography, quickly developed webinars to provide ongoing education and pertinent and timely pandemic-related information.

Although virtual learning has aided us through this vulnerable time, training in pediatric and congenital heart disease or fetal echocardiography cannot be completed in a virtual environment. For both pediatric cardiology fellows and sonographers, hands-on clinical experience for the acquisition of technical skills and knowledge is required. Fortunately, over the course of the pandemic we have learned how to perform echocardiography and fetal echocardiography with maximal safety for provider and patient. Accordingly, institutions have had their trainees return to the clinical learning environment successfully. Ongoing vigilance is needed to protect trainees, faculty members, patients, and their families to whom we provide care. Steps should continue to be developed and implemented to prevent the transmission of SARS-CoV-2 using the most up-to-date information on transmission risks and PPE.[1,3] All trainees should be encouraged to voice any hands-on scanning safety concerns and be offered alternative learning solutions when appropriate. With eventual widespread effective vaccine distribution, we may be able to return to more traditional rotations and interactions, but the

Table 5 Indications for echocardiography in patients with suspected or confirmed MIS-C

• Hemodynamic instability
• Clinical characteristics of KD
• Arrhythmias
• ECG changes suggestive of pericarditis, myocarditis, or ischemia
• Elevated BNP or NT-proBNP levels
• Elevated troponin
• Gallops
• Rubs
• New murmurs
• Cardiomegaly
• Abnormal findings on POCUS examination
• Previous abnormal echocardiographic findings: serial follow-up needed

BNP, Brain natriuretic peptide; *ECG*, electrocardiographic; *NT-proBNP*, N-terminal pro–brain natriuretic peptide; *POCUS*, point-of-care ultrasound.

Table 6 Essential elements of COVID-19 echocardiographic examination

Valves	• Tricuspid insufficiency, including velocity to provide estimate of right ventricular and pulmonary pressures • Mitral insufficiency
Pericardium	• Pericardial effusion
Right ventricle	• Function
Left ventricle	• Global and regional function • Global longitudinal strain imaging • Doppler tissue imaging for diastolic function (optional) • Thrombus if severely depressed function
Coronary arteries	• Follow KD protocol to assess for dilation, aneurysm, thrombus
Pulmonary arteries	• If concern for pulmonary embolism

effectiveness of virtual education for some aspects of learning will mean that this modality is here to stay. Elements for successful and safe echocardiography training combining a hybrid model of virtual and hands-on clinical training are outlined in Table 3.

MULTISYSTEM INFLAMMATORY SYNDROME IN CHILDREN

The emergence of a severe multisystem inflammatory syndrome with features similar to those seen in Kawasaki disease (KD) and toxic shock syndrome, frequent hemodynamic instability, and association with previous COVID-19 infection in otherwise previously healthy children was first reported in the United Kingdom on April 26, 2020.[26] The CDC case definition for MIS-C is provided in Table 4.[27] In the United States as of the last update posted by the CDC on January 8, 2021, there have been 1,659 reported cases and 26 deaths.[28] Most children were 1 to 14 years of age (average, 8 years), but cases were reported in infants <1 year of age as well. More than 75% of children were Hispanic/Latino or non-Hispanic black. MIS-C in patients with known preexisting congenital or acquired heart disease has not been reported to date.[29]

Cardiac involvement may manifest in three predominant and overlapping presentations: atypical KD-like spectrum (with particularly prominent gastrointestinal symptoms), vasodilatory or hyperinflammatory shock, or cardiogenic shock from impaired ventricular function.[29] Given the potential for pancarditis, there should be a low threshold for performing or repeating echocardiography, with indications for echocardiography outlined in Table 5 and the essential elements of an MIS-C echocardiographic study presented in Table 6.

Ventricular dysfunction may range from mild to severe. As measured by ejection fraction, 33% to 75% of patients with MIS-C have ventricular dysfunction, with an even higher prevalence (90%) of dysfunction detected by global longitudinal strain.[29-32] The right ventricle may also be affected.[33] Regional abnormalities have been noted, including apical hypokinesia resembling Takatusbo cardiomyopathy.[33] Diastolic impairment has been reported with abnormal findings on Doppler tissue imaging.[32] Other cardiac findings have included pericardial effusion in about 8% to 25% of patients, mitral valve insufficiency in 50%, and greater than physiologic tricuspid valve insufficiency in 60%.[32] Coronary artery dilation has been described in 6% to 24% of patients, although true aneurysms are quite unusual.[12,29-31,34-36] Thrombus formation has been noted in the setting of severely depressed ventricular function, severe coronary artery dilation, or pulmonary embolism, although this complication appears to be less prevalent in MIS-C as opposed to the thromboembolic phenomena and coagulopathy reported in acute COVID-19 infections in adults.

Serial echocardiographic examinations are warranted during the acute illness, as ventricular function can worsen precipitously in the first 24 to 48 hours after admission, which is often around day 7 of illness.[32,33] Timing of studies should be guided by clinical status in individual patients, but if ventricular dysfunction is present, repeat assessment is warranted at least every 5 to 7 days.[29] Fortunately, in most patients ventricular function improves after therapy and supportive care, but residual dysfunction can persist at the time of discharge, with abnormal global longitudinal strain potentially persisting even after ejection fraction normalizes.[29,32,33,36,37] If coronary artery dilation is present, serial echocardiograms should be obtained following the KD guidelines.[35]

ROLE OF ECHOCARDIOGRAPHY AND MULTIMODALITY IMAGING IN MIS-C FOLLOW-UP

Recommendations for mid- and long-term cardiac imaging are still evolving for MIS-C, depending on the clinical course and the severity and type of residual cardiac involvement at time of discharge. Careful follow-up is essential as we continue to learn more about this disease.[37,38] One proposed strategy is for cardiology follow-up with echocardiography at 7 to 10 days after the onset of illness, 4 to 6 weeks, 4 to 6 months, and 9 to 12 months.[29] More frequent follow-up would be necessary if there is marked coronary dilation, again using the KD guidelines.[31,34,35] Long-term follow-up with stress echocardiography should be considered for those with chronic changes in ventricular function or coronary artery involvement.

Cardiac magnetic resonance imaging (MRI) may be useful in patients with MIS-C to further quantify ventricular function and assess for myocardial edema or scar or fibrosis. The best timing for cardiac MRI is not yet clear; however, MRI at 2 to 6 months in recovery could play a pivotal role in determining when patients with MIS-C may safely return to active play and sports. Following KD guidelines, cardiac computed tomographic angiography may be useful during either the acute or the follow-up phase to assess coronary artery involvement, progression of dilation, or suspected coronary thrombosis.[36]

Vascular Function in Patients with MIS-C

There is growing recognition that MIS-C includes a component of vascular injury, similar in concept if not necessarily pathophysiology to the vascular injury seen in adults with COVID-19. However, the newness of the disease makes the long-term implications of MIS-C in children unclear. In the acute setting, multiple inflammatory markers are elevated, including erythrocyte sedimentation rate, C-reactive protein, ferritin, alanine aminotransferase, fibrinogen and D-dimer levels, with accompanying lymphocytopenia, neutrophilia, anemia, thrombocytopenia, hypoalbuminemia, and a prolonged international normalized ratio.[12] It remains to be seen if this widespread inflammation will permanently affect endothelial function and put these children at risk for adult cardiovascular disease over time. If MIS-C behaves in a similar fashion to KD or other inflammatory diseases, there is certainly concern for the development of accelerated atherosclerotic disease in this population. In the long-term follow-up of patients affected by MIS-C, vascular function assessment such as brachial artery reactivity testing and measurement of carotid intima-media thickness should be considered.

ROLE OF ECHOCARDIOGRAPHY AND MULTIMODALITY IMAGING IN LONG-TERM CARE AND RETURN TO AGE-APPROPRIATE ACTIVITY AND ATHLETICS IN PATIENTS WITH COVID-19

Most pediatric patients with mild COVID-19 infection are asymptomatic at short-term follow-up. However, a subset may experience persistent cough, dyspnea, chest discomfort, or palpitations long after resolution of acute infection.[39] The American Academy of Pediatrics in conjunction with the CDC currently recommends that pediatricians screen children after acute COVID-19 infection for these symptoms before authorizing return to sports and athletics.[40] If symptoms are present, rest and referral to pediatric cardiology is recommended given the possibility that subclinical myocarditis or myocardial injury occurred during the acute illness.

Strategies for the evaluation of young athletes to determine their eligibility to return to organized sports have been proposed by the American College of Cardiology and other organizations and include echocardiography, electrocardiography, stress testing, and possibly cardiac MRI depending upon the severity of symptoms and the results of other testing.[39-42] The degree of evaluation needed for children to return to physical education classes and other age-appropriate activities has not yet been established but is likely to parallel the assessment for athletics. Echocardiographic examinations in patients recovered from COVID-19 infection should focus on assessing left and right ventricular function completely (including assessment of global longitudinal strain), the presence and degree of coronary artery dilation, and valve function. The range of adjunct diagnostic testing recommended from institution to institution is broad, and therefore until standardized guidelines are developed, each practice must develop its own as deemed appropriate. As long-term immunity to COVID-19 infection may not be universal, all studies should be performed using institution-specific recommendations for patients with unknown SARS-CoV-2 status unless preprocedural testing is obtained.

CONCLUSION

As with any new disease, the long-term course of COVID-19 and associated MIS-C is largely unknown. The above recommendations are based upon very limited short-term and midterm data and upon our understandings of disease processes thought to be similar. We will need continued observation, meticulous investigation, creativity, and a high degree of flexibility in order to be able to provide the best patient care and effectively train our fellows and sonographers while remaining safe during this pandemic. With vaccine distribution having begun recently, we look forward to eventually moving beyond the pandemic and returning to some more normal processes. This is unlikely, unfortunately, to be in the near future as the pandemic continues to evolve with recent strong surges. Some strategies that have been developed and successfully deployed during this time should continue now and beyond the pandemic, such as telemedicine for fetal cardiology consultation and video conferences allowing readily available access to webinars, national meetings, and remote local teaching and echocardiogram review. Reliance on the development of expert guidelines and standards, such as those developed by the ASE, will be essential to create a safe and effective environment for staff members, patients, and families.

Through it all, collaboration with peers and colleagues across the country has proved to be a bedrock and an essential resource for our pediatric, congenital, and fetal cardiology community.

ACKNOWLEDGMENTS

This statement was prepared by Carolyn Altman, MD, Mary Donofrio, MD (representing the Fetal Heart Society), Bhawna Arya, MD, Melissa Wasserman, RDCS, RCCS, Gregory Ensing, MD, Meryl Cohen, MD, MS Ed, Mark Lewin, MD (representing the Society of Pediatric Echocardiography), Madhav Swaminathan, MD, and Piers Barker, MD, and was approved by the ASE Executive Committee on January 11, 2021.

Protocols and procedures used in the preparation of this document courtesy of the authors, Luciana Young, University of Washington/Seattle Children's Hospital, Seattle (for the transesophageal echocardiographic algorithm) and many others through the COVID-19 Cardiology Listserv (Seattle Children's Hospital), Society of Pediatric Echocardiography discussion groups, and Fetal Heart Society Forum members discussion group.

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