



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

Safe Operation of an Echocardiography Practice During the COVID-19 Pandemic: Single-Center Experience



Vidhu Anand, MBBS; Jeremy J. Thaden, MD; Patricia A. Pellikka, MD;
and Garvan C. Kane, MD, PhD

Echocardiography plays a key role in the diagnosis of cardiac complications of coronavirus disease 2019 (COVID-19) and follow-up of other cardiac conditions.¹⁻³ We present our opinion and review of the practices currently involved in the echocardiography practice at Mayo Clinic during the COVID-19 pandemic.

TRIAGING

All patients coming for outpatient evaluation undergo a clinical survey encompassing questions about recent symptoms or exposures for COVID-19 infection before the appointment and again upon arrival. In addition, many patients referred for outpatient transthoracic echocardiography (TTE) undergo polymerase chain reaction (PCR) testing as a requirement for other clinical evaluations. All patients have a PCR nasopharyngeal swab testing 48 to 72 hours before exercise stress testing (EST) or transesophageal echocardiography (TEE) and on admission to the hospital; results are typically available within 24 hours. In patients with a positive clinical screen or positive PCR test result, the indication and acuity of the study are evaluated by the responsible echocardiography physician to determine whether the indication for the study is urgent/emergent or whether the test can be safely postponed. Patients in whom the study (TTE, EST, or TEE) indication is deemed to be urgent/emergent where the PCR test results are pending are managed similar to PCR test–positive patients with respect to requirements for personal protective equipment (PPE) (Figure 1).

PERSONAL PROTECTIVE EQUIPMENT AND SANITIZATION PROTOCOLS

Universal Precautions

Universal precautions include universal masking at all times for patients and staff, wearing protective eyewear or face shield by health care workers for all patient interactions, monitoring daily symptoms and twice daily temperature by all staff, and hand sanitation before and after every patient interaction.^{4,5} Equipment, scanning bed, and the examination room are wiped after each patient. Frequent wiping of surfaces, keyboards, and phones are encouraged with ready availability of appropriate cleaning materials.

Physical Distancing

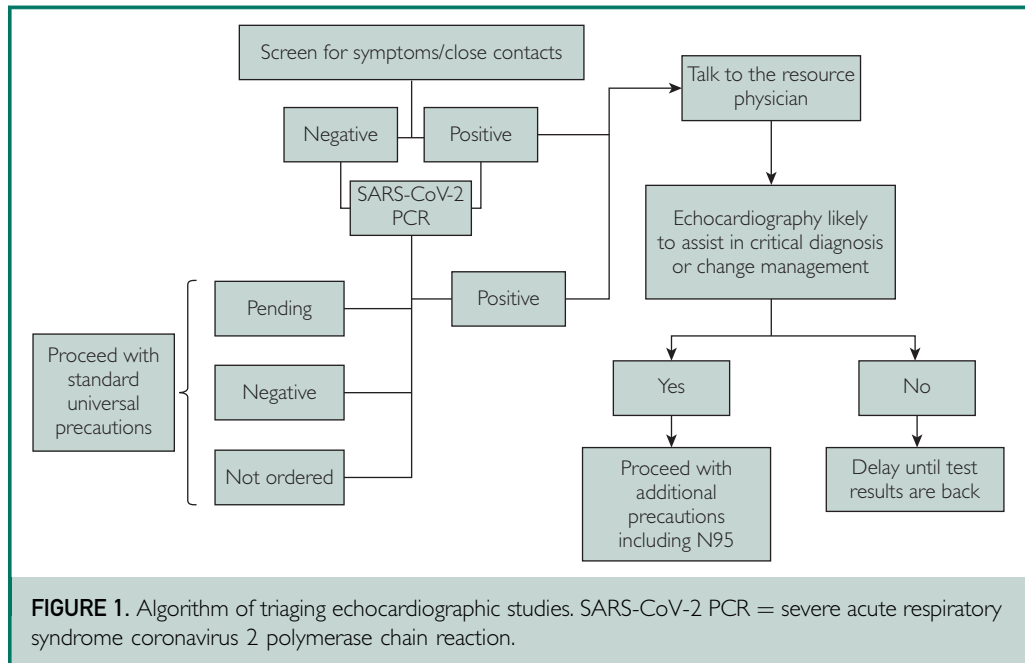
Coronavirus disease 2019 has necessitated a reorganization of the physical space of the laboratory, including conference rooms, classrooms, and offices to accommodate workstations 6 feet apart. Further measures to ensure distancing in break room locations include staggered schedules and alternate break room locations.

Personal Protective Equipment for Staff Performing TTE

For the typical patient without COVID-19 or in whom testing is pending but without clinical suspicion of infection, the sonographer wears a surgical mask and protective eyewear. For patients with known or suspected COVID-19, although a surgical mask may be sufficient in some cases, to provide a consistent approach, the sonographer performing a TTE wears an N95 respirator,



From the Department of
Cardiovascular Medicine,
Mayo Clinic, Rochester,
MN.



face shield, gown, and gloves. This policy was strongly influenced by the close proximity of the sonographer's front and side of the face to the patient's face, the duration of exposure (>30 minutes), and the common frequency that the inpatient is unable to wear a mask and that many patients have had a concomitant aerosol generating procedure (AGP) (recent intubation, positive pressure ventilation, nebulizer use, or high flow oxygen). Between wearings, N95 respirators are carefully stored in a clean, labeled, plastic container. A continually worn N95 respirator should be replaced at the end of each shift and after cumulative use for 10 to 12 hours, when it has been worn 5 times, or if the user seal check fails, the mask is visibly soiled, breathing through it becomes difficult, or it becomes wet. Dedicated space for storage of masks is available in the laboratory.

All staff members were fitted for N95 respirators. For those staff members who failed fit testing, a powered air-purifying respirator (PAPR) is used in place of an N95. Fluoroscope cover drapes as a barrier between the patient and the sonographer are available for use in COVID-19–positive patients. All

staff with direct patient contact are encouraged to wear scrubs.

Management of the Machine

Machines are cleaned carefully after every use using a viricidal disinfectant, with emphasis on manufacturer-recommended “wet time.” Reduction in contamination of the critical machine elements (keyboard, controls, and touch panel) is accomplished through the use of an elastic fluoroscope drape (Genesys, Echolab) (Figure 2) for all TEE and TTE procedures performed on patients with COVID-19. For studies performed in patients with COVID-19, the machine is cleaned in the room and again after leaving the room. We have dedicated machines for use on COVID-19–positive patients, which we store in a separate location. The standard procedure for TEE scope processing is adequate to kill the virus, but staff must follow standard processes carefully including the use of PPE while cleaning the probe.

TRANSESOPHAGEAL ECHOCARDIOGRAPHY

Transesophageal echocardiography is recognized as a high-risk AGP with an increased

risk of transmission; therefore, airborne precautions are necessary for all team members (gown, gloves, N95/PAPR, surgical cap, and face shield) (Figure 3) in all patients with an unprotected airway, regardless of COVID-19 PCR status. For the intubated and paralyzed patient (eg, in the operating room), TEE staff are not required to wear N95/PAPR unless the patient is known or suspected to have COVID-19 infection.

EXERCISE STRESS TESTING AND PERICARDIOCENTESIS PROCEDURES

Exercise stress testing is also considered aerosol generating. For the supervision of EST, all staff members wear N95 respirators (or PAPRs) and face shields during exercise and recovery periods. Exercise stress testing is not performed in patients with active COVID-19 infection. Pharmacological testing and pericardiocentesis procedures, as non-aerosol generating, are treated similarly to TTE with respect to PPE. As cardiopulmonary resuscitation is considered aerosol generating, PPE kits (N95 and gown) are available outside all stress rooms in case of emergency.

ROOM TURNOVER AFTER AGP

All AGP rooms used were tested for air exchange by our department of engineering, with alterations (additional air filtration units) to increase air flow made where possible. After TEE or EST, the room must be left idle for 7 complete air exchanges to allow for 99.9% clearance before the next patient can be roomed. Air exchange rates dictated that most rooms have a 10- to 30-minute idle time between procedures. For TEE, the time starts upon removal of the TEE probe, and for EST, 6 minutes after the termination of exercise.

TRANSTHORACIC ECHOCARDIOGRAPHY IN PATIENTS WITH KNOWN OR SUSPECTED COVID-19 INFECTION

Inpatient studies are performed at the patient's bedside. Studies are focused to address the specific indication accurately while minimizing the contact time of staff with the patient. The study scope is discussed with the physician before entering the patient's room. Usually this will be a focused study evaluating



FIGURE 2. Use of an elastic fluoroscopy drape (Genesys, Echolab) placed over the keyboard, controls, and touch panel allows a degree of protection of these critical difficult-to-clean machine elements from contamination. This is recommended for all transesophageal echocardiography and transthoracic echocardiography procedures performed in patients with COVID-19.

biventricular function, assessment for pericardial effusion, and initial 2-dimensional and color Doppler screening for significant valvular stenosis or regurgitation (Supplemental Figure, available online at <http://www.mayoclinicproceedings.org>). Additional image acquisition and quantification of valvular heart lesions are performed only when pertinent. Staff have a low threshold for echocardiography enhancement (contrast) imaging to reduce imaging time. Measurements are performed *outside* the room. To allow instantaneous study review and optimize diagnostic scanning, special internal phones are used for direct communication between the sonographer and the reviewer.

Because myocardial injury reported in up to half of patients, point-of-care ultrasound (POCUS) has a role in bedside assessment and triage of patients with clinical deterioration.^{6,7} Point-of-care ultrasound can help diagnose acute left ventricular dysfunction (myocarditis, acute coronary syndrome, or stress cardiomyopathy), right ventricular systolic dysfunction (worsening hypoxia or pulmonary embolism), and worsening pulmonary status (consolidation, effusion, and pulmonary edema). Transthoracic echocardiography is often needed for

Steps for PPE for transesophageal echocardiography

All cases are considered modified droplet for high risk AGP

Steps for donning PPE, before entering room

- Sanitize hands
- Don your N-95 mask
- Sanitize hands
- Don shoe covers
- Don gown
- Don surgical cap or bonnet
- Don gloves
- Don face shield
- Enter room**
- Physician may decide to place a 2nd set of gloves

Steps for doffing PPE, before exiting room

- Remove gown and gloves and dispose
- Remove face shield
- Sanitize hands
- Remove hat and dispose
- Remove shoe covers and dispose
- Remove inner gloves and dispose
- Sanitize hands
- Exit room**
- Sanitize hands
- Either place N95 mask into trash if soiled, recycle bin or secure N95 mask into personal tub for re-use or continue to wear for next case

Instructions for N95 mask storage:

- Sanitize hands
 - Take a plastic tub and label with your name and date
- Remove your N-95 mask, being careful not to touch, or let straps fall into, the inside of the mask
- Place mask in labeled tub
- Re sanitize hands

Instructions for face shield storage:

If washing with soap and water:

- Remove face shield and wash well in warm soapy water for minimum of 30 secs

If wiping down:

- Sanitize hands and don gloves
- Remove face shield & spray with viricidal solution
- Leave sit for appropriate wet time
- Rinse and dry
- Remove gloves
- Re sanitize hands

FIGURE 3. Steps for donning and doffing personal protective equipment (PPE) for transesophageal echocardiography. AGP = aerosol generating procedure.

confirmation of findings and when POCUS is nondiagnostic.⁷ The POCUS protocol includes basic cardiac views (parasternal long, parasternal short, apical, and subcostal view) for cardiac function assessment as well as lung views.

ECHOCARDIOGRAPHY IN PRONE-POSITION MECHANICALLY VENTILATED PATIENTS

Prone positioning is reported to improve outcomes in intubated and nonintubated patients with COVID-19 lung infection.^{8,9}

Because of unstable respiratory and hemodynamic status in these patients, TTE is often requested and can provide important information on biventricular function. Apical views can be obtained by deflating the mattress on the left thorax or slight repositioning of the patient. Modification of previously described “swimmer’s position” with the patient’s left arm up may be used.¹⁰ The sonographer is positioned on the left side of the patient and scans with his or her left hand.

TEACHING OF FELLOWS AND TRAINEES

To ensure adequate trainee teaching and experience while maintaining safety, we adopted the following measures. Echocardiography reading sessions were changed to live sessions on Zoom within 2 weeks of the declaration of the pandemic, and additional teaching sessions included those on congenital echocardiography, core curriculum sessions, and informal reading sessions for level 1 fellows led by advanced fellows. We scheduled simulator training for basic understanding of different TEE views for fellows as TEE practice was restricted to urgent cases and only advanced fellows with previous training and experience in TEE participated in performing these studies. As the elective clinical practice returned, fellows returned to in-person training, working 1-on-1 with sonographers (learning to scan) and with physicians (learning to interpret and perform TEE). With careful organization of the schedule, almost all learners (~40 at one time) have been accommodated with only modest limitations placed on numbers. All echocardiography educational conferences and meetings are now held virtually, including a weekly morning imaging grand rounds and a noon case conference in which the interesting cases of the week are informally presented and discussed by fellows and faculty.

RESEARCH

Whether as part of clinical practice or a clinical research trial, monitoring with echocardiography is important in the serial assessment of cardiovascular function and has continued throughout the pandemic.

Many investigators, both trainees and staff, were able to take advantage of the reduction in clinical volume to engage in research activities that normally occurred off hours.

CONCLUSION

Within the current era of COVID-19, it is important to provide echocardiography services safely for staff and patients as echocardiography remains the cornerstone of the diagnosis and follow-up of most cardiac conditions and cardiac manifestations of COVID-19 infection. Here we provide our experience of safe practices while maintaining excellent patient care and learner education.

ACKNOWLEDGMENTS

The authors appreciate the tireless work of the echocardiography laboratory administration and supervisor team including Melissa Bowman, CEP, Joshua Finstuen, MA, RDCS, Kristy Hockens, Mark Johnson, RN, Adriana Lange, CRAT, Daniel McCullough, MBA, RDCS, Lezlie Peterson, RN, and Stacy Pronga, MA, RDCS; the Safety, Management and Resource Taskforce (SMaRT); Francisco Lopez-Jimenez, MD, MBA; and all the laboratory and division staff for their input regarding these processes and their care to patients.

SUPPLEMENTAL ONLINE MATERIAL

Supplemental material can be found online at: <http://www.mayoclinicproceedings.org>. Supplemental material attached to journal articles has not been edited, and the authors take responsibility for the accuracy of all data.

Potential Competing Interests: The authors report no competing interests.

Correspondence: Address to Patricia A. Pellikka, MD, Department of Cardiovascular Medicine, Mayo Clinic, 200 First St SW, Rochester, MN 55905 (pellikka.patricia@mayo.edu); Twitter: [@pattyPELLIKKA](https://twitter.com/pattyPELLIKKA)).

ORCID

Vidhu Anand: <https://orcid.org/0000-0001-7770-1823>; Patricia A. Pellikka: <https://orcid.org/0000-0001-6800-3521>; Garvan C. Kane: <https://orcid.org/0000-0002-4308-6356>

REFERENCES

1. Hung J, Abraham TP, Cohen MS, et al. ASE statement on the reintroduction of echocardiographic services during the COVID-19 pandemic. *J Am Soc Echocardiogr*. 2020;33(8):1034-1039.
2. Szekely Y, Lichter Y, Taieb P, et al. Spectrum of cardiac manifestations in COVID-19—a systematic echocardiographic study. *Circulation*. 2020;142(4):342-353.
3. Bennett CE, Anavekar NS, Gulati R, et al. ST-segment elevation, myocardial injury, and suspected or confirmed COVID-19 patients: diagnostic and treatment uncertainties. *Mayo Clin Proc*. 2020;95(6):1107-1111.
4. Chu DK, Akl EA, Duda S, Solo K, Yaacoub S, Schünemann HJ. COVID-19 Systematic Urgent Review Group Effort (SURGE) study authors. Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis. *Lancet*. 2020;395(10242):1973-1987.
5. West CP, Montori VM, Sampathkumar P. COVID-19 testing: the threat of false-negative results. *Mayo Clin Proc*. 2020;95(6):1127-1129.
6. Dweck MR, Bularga A, Hahn RT, et al. Global evaluation of echocardiography in patients with COVID-19. *Eur Heart J Cardiovasc Imaging*. 2020;21(9):949-958.
7. Johri AM, Galen B, Kirkpatrick JN, Lanspa M, Mulvagh S, Thamman R. ASE statement on point-of-care ultrasound (POCUS) during the 2019 novel coronavirus pandemic. *J Am Soc Echocardiogr*. 2020;33(6):670-673.
8. Razonable RR, Pennington KM, Meehan AM, et al. A collaborative multidisciplinary approach to the management of coronavirus disease 2019 in the hospital setting. *Mayo Clin Proc*. 2020;95(7):1467-1481.
9. Elharrar X, Trigui Y, Dols AM, et al. Use of prone positioning in nonintubated patients with COVID-19 and hypoxemic acute respiratory failure. *JAMA*. 2020;323(22):2336-2338.
10. Ugalde D, Medel JN, Romero C, Comejo R. Transthoracic cardiac ultrasound in prone position: a technique variation description. *Intensive Care Med*. 2018;44(6):986-987.