University of Michigan
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Appropriate Use of Transthoracic Echocardiography in Adult Inpatients During the COVID Pandemic: A Suggested Approach

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Introduction and background

The goal of this document is to provide guidance regarding indications for inpatient TTE in the setting of the COVID pandemic. In order to limit exposure of sonographers to COVID-positive patients and asymptomatic carriers, and to minimize contact between sonographers and patients in the context of current social distancing practices, it is necessary to be particularly thoughtful about the clinical utility of all TTEs performed (1,2). As such, studies that are highly likely to change short-term management in a meaningful way are reasonable to perform, while those that are likely to be low-yield should be deferred or avoided. In our laboratory, an attending echocardiographer must approve all TTEs for COVID-positive patients and persons under investigation. Only studies that are expected to change management acutely and significantly are approved, and these are protocoled as limited studies, focused on answering specific clinical questions.

Under normal circumstances, TTEs are often ordered to reevaluate known cardiac conditions in the setting of changes in clinical status. In the current environment, we generally discourage repeat TTEs in patients who have had a TTE within the past 12 months. If an ordering provider feels that a repeat study is highly likely to change management, it may be appropriate to perform the study, but a limited study to answer the provider's focused clinical question should be considered. Provider-to-provider discussions may be helpful to clarify the utility of repeat studies.

In COVID-positive patients for whom focused cardiac point-of-care ultrasound (POCUS) is feasible, particularly ICU patients, POCUS may be considered for initial evaluation (1-3). In situations for which POCUS does not provide definitive answers to clinical questions, follow-up TTE may be needed. Serial TTEs are not advisable in COVID patients, given the risk of sonographer exposure and need to conserve PPE. For these patients, if findings are likely to change clinical management, serial assessment with POCUS may be the preferred option (1-2). Good communication between inpatient providers and echo lab faculty is needed to arrive at an optimal imaging strategy, especially in clinically complex cases.

Generally speaking, inpatients for whom TTEs are requested should have signs or symptoms suggestive of a cardiopulmonary process. Testing of asymptomatic patients, whether to screen for cardiovascular disease or to follow a known cardiovascular condition, should be deferred to the outpatient setting, at a time when restrictions on outpatient testing have been relaxed or

eliminated. One notable exception to this heuristic is pre-chemotherapy TTE to evaluate LV systolic function, as reduced LV systolic function may lead an oncology team to alter the chemotherapy regimen.

The following is a list of common indications for inpatient TTE, adapted from the ASE and multisociety appropriate use criteria for cardiac imaging in valvular and non-valvular heart disease (4-6), including some indications that will be particularly relevant in patients with confirmed or suspected COVID. TTEs performed for intraprocedural assessment, such as during TAVR, have been omitted from this list. For each indication, a recommendation of "appropriate to perform now" (A, green), "may be appropriate" (M, yellow) or "defer or avoid" (D, red) is given. Studies in the M category may merit discussion between the attending echocardiographer or echo lab staff and ordering provider. TTEs performed for intraprocedural assessment, such as during transcatheter aortic valve replacement (TAVR), have been omitted from this list and should be performed as per standard of care.

This document may be useful for reference by ordering providers as well as echo lab faculty and staff. As stated in the AUC, not all possible clinical scenarios are discussed, and careful clinical judgement should supersede any general recommendations made here.

References

1. Kirkpatrick J, Mitchell C, Taub C, et al. ASE statement on protection of patients and echocardiography service providers during the 2019 novel coronavirus outbreak. J Am Soc Echocardiogr. 2020. Accessed April 7, 2020 at https://www.asecho.org/wp-content/uploads/2020/03/COVIDStatementFINAL4-1-2020_v2_website.pdf [Epub ahead of print]

2. Skulstad H, Cosyns B, Popescu BA, et al. COVID-19 pandemic and cardiac imaging: EACVI recommendations on precautions, indications, prioritization, and protection for patients and healthcare personnel. Eur Heart J Cardiovasc Imaging. 2020; doi: 10.1093/ehjci/jeaa072. [Epub ahead of print]

3. Kirkpatrick JN, Grimm R, Johri AM, et al. Recommendations for Echocardiography Laboratories Participating in Cardiac Point of Care Cardiac Ultrasound (**POCUS**) and Critical Care Echocardiography Training: Report from the American Society of Echocardiography. J Am Soc Echocardiogr. 2020;33:409-422.

4. Douglas PS, Garcia MJ, Haines DE, et al. ACCF/ASE/AHA/ASNC/HFSA/HRS/SCAI/SCCM/ SCCT/SCMR 2011 Appropriate Use Criteria for Echocardiography. A Report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, American Society of Echocardiography, American Heart Association, American Society of

Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Critical Care Medicine, Society of Cardiovascular Computed Tomography, and Society for Cardiovascular Magnetic Resonance Endorsed by the American College of Chest Physicians. J Am Coll Cardiol. 2011;57:1126-66.

5. Doherty JU, Kort S, Mehran R, et al. ACC/AATS/AHA/ASE/ASNC/HRS/SCAI/SCCT/SCMR/ STS 2017 Appropriate Use Criteria for Multimodality Imaging in Valvular Heart Disease: A Report of the American College of Cardiology Appropriate Use Criteria Task Force, American Association for Thoracic Surgery, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Thoracic Surgeons. *J Am Coll Cardiol.* 2017;70:1647-1672.

6. Doherty JU, Kort S, Mehran R, et al. ACC/AATS/AHA/ASE/ASNC/HRS/SCAI/SCCT/SCMR/ STS 2019 Appropriate Use Criteria for Multimodality Imaging in the Assessment of Cardiac Structure and Function in Nonvalvular Heart Disease: A Report of the American College of Cardiology Appropriate Use Criteria Task Force, American Association for Thoracic Surgery, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Thoracic Surgeons. J Am Coll Cardiol. 2019;73:488-516.

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	Indication	Appropriateness Category	Comments/Caveats
	Arrhythmias, conduction disorders, palpitations, presyncope, and syncope		
1	Palpitations with no other signs/symptoms of cardiovascular disease	D	
2	Presyncope with no other signs or symptoms of cardiovascular disease	M	Carefully consider pre-test probability of a cardiovascular cause of presyncope before ordering TTE.
3	Syncope with no other signs or symptoms of cardiovascular disease	M	Carefully consider pre-test probability of a cardiovascular cause of syncope before ordering TTE.
4	Newly diagnosed LBBB (no prior assessment of LV systolic function)	A	
5	VT or VF	A	
6	SVT without other evidence of heart disease	M	
7	Atrial fibrillation or flutter (not for purposes of precardioversion evaluation)	A	TTE most likely to be useful if patient has signs/symptoms of heart failure, as LVEF may affect choice of rate-/rhythm-control therapy.
8	Evaluation of LV systolic function in setting of bradycardia to determine choice of device (pacemaker vs. ICD +/- CRT)	A	
	Hypotension or hemodynamic instability		
9	Assessment of volume status in a critically ill patient	M	In ventilated patients, IVC evaluation is less likely to be helpful as a proxy for volume status.
10	Hypotension or hemodynamic instability with uncertain or suspected cardiac etiology	A	
11	Suspected acute mitral or aortic regurgitation	A	TTE will likely be needed to confirm POCUS findings.
	Respiratory failure		
12	Respiratory failure or hypoxemia of uncertain etiology	A	In current environment, this scenario is most applicable to COVID-negative patients with respiratory failure potentially related to cardiac causes.
13	Respiratory failure or hypoexmia with an established non-cardiac etiology	D	Defer or avoid TTE unless other signs/symptoms of heart disease are present (e.g., arrhythmia, hypotension/shock).
	Acute coronary syndrome (ACS)		
14	Evaluation of LV function during initial presentation with ACS	A	
15	Suspected complication of myocardial ischemia/infarction, including but not limited to acute MR, VSD, RV infarct	A	
	Left heart failure, cardiomyopathy, myocarditis, and myocarditis		
16	Initial evaluation of known or suspected heart failure to assess left ventricular function and to assess etiology (including CAD, valvular heart disease)	A	This indication is applicable to patients with suspected COVID myocarditis.
17	Re-evaluation of known cardiomyopathy with a change in clinical status or cardiac examination or to guide therapy	M	Consider deferring TTE unless findings are likely to change short-term management.
18	Re-evaluation of known heart failure with a change in clinical status or examination with a clear precipitating change in medication or diet	D	
	Right heart failure, pulmonary hypertension, and pulmonary embolism (PE)		
19	Evaluation of suspected pulmonary hypertension, including evaluation of RV function and estimated pulmonary artery systolic pressure	A	
20	Suspected PE in order to establish diagnosis	D	Note that sensitivtity of TTE for pulmonary embolism is poor.
21	Known acute PE to guide therapy (thrombolytics, thrombectomy)	A	Serial studies in COVID-positive patients should be performed with POCUS if needed.

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	Indication	Appropriateness Category	Comments/Caveats
	Cardiac transplantation and LVAD		
22	Monitoring for rejection in a cardiac transplant recipient	A	
23	Cardiac structure and function evaluation in a potential heart donor	A	
24	Evaluation for LVAD candidacy	A	
25	Assessment of LVAD complications	A	
	Evaluation prior to cardiotoxic therapy		
26	Initial evaluation prior to exposure to medications (such as cancer chemotherapy) or radiation that could result in cardiotoxicity/heart failure or valvular heart disease	A	
27	Re-evaluation in a patient undergoing therapy with potentially cardiotoxic agents	M	If patient is asymptomatic and study will not affect short-term management (for instance, timing/dosing of chemotherapy), defer.
	Pericardial disease		
28	Suspected pericardial diseases, including pericardial effusion, tamponade, and constriction	A	Note that pericardial effusion size is often overestimated on CT.
29	Re-evaluation for progression of pericardial effusion size or development of tamponade	A	Serial studies in COVID-positive patients should be performed with POCUS if needed.
30	Re-evaluation for progression of pericardial constriction	A	
	Acute aortic pathology		
31	Suspected acute aortic pathology, such as dissection	M	TTE may be able to detect very proximal type A aortic dissection, but sensitivity of TTE for acute aortic syndrome is limited, and CTA is the test of choice.
	Intracardiac thrombus, mass, tumor, stroke/TIA, and cardiac source of emboli		
32	Initial evaluation of cardiac thrombus, mass, or tumor, or potential cardiac source of emboli (including stroke/TIA)	A	Sensitivity of TTE for small intracardiac thrombi is limited. If evaluation for left atrial appendage thrombus is needed, consider cardiac CT with contrast (consider low-contrast protocol if renal function is of concern).
	Valvular heart disease (VHD)		
33	Initial evaluation of unexplained murmur or abnormal heart sounds, with reasonable suspicion of valvular heart disease	A	
34	Re-evaluation of known VHD with a change in clinical status or cardiac examination, when results will guide therapy	A	
	Bacteremia/infective endocarditis (IE)		
35	Suspected IE *and* positive blood cultures or new murmur	A	
36	Transient fever; no bacteremia or new murmur	D	
37	Transient bacteremia; pathogen not typically associated with IE and/or documented nonendovascular source of infection	D	
38	Re-evaluation of prior TTE/TEE finding for interval change (for instance, resolution of vegetation) when no change in therapy is anticipated	D	
39	Re-evaluation of prior TTE/TEE finding for interval change when a change in therapy is anticipated	A	
40	Re-evaluation of patient with IE at high risk of progression or complications (e.g., large vegetation or staphylococcal, enterococcal, fungal endocarditis) in the absence of clinical change	M	TTE is indicated only if findings are likely to change management.
41	Re-evaluation of IE in a patient with a change in clinical status or cardiac examination (e.g., new murmur, new heart block, new or worsening heart failure)	M	TTE is indicated only if findings are likely to change management.

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	Indication	Appropriateness Category	Comments/Caveats
	Postoperative imaging after surgical or transcatheter valve replacement or repair		
42	Initial postoperative evaluation of bioprosthetic or mechanical valve replacement or repair for establishment of baseline (6 weeks to 3 months postoperatively)	M	
43	Characterization of mechanical or bioprosthetic valve or repaired valve if signs or symptoms suggest dysfunction	A	
44	Re-evaluation of known prosthetic valve dysfunction to guide management/therapy	A	
45	Post-TAVR assessment with suspicion of new or worsening valve dysfunction (including aortic regurgitation)	A	

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	Indication	AUC Mapping (V=valvular, NV=non-valvular)	Rating in Original AUC	Appropriateness Category	Comments/Caveats
	Arrhythmias, conduction disorders, palpitations, presyncope, and syncope				
1	Palpitations with no other signs/symptoms of cardiovascular disease	V:Table 2 #7, NV:Table 2 #18	M(4,6)	D	
2	Presyncope with no other signs or symptoms of cardiovascular disease	V:Table 2 #8, NV: Table 2 #19	M(NV:6), A(V:7)	M	Carefully consider pre-test probability of a cardiovascular cause of presyncope before ordering TTE.
3	Syncope with no other signs or symptoms of cardiovascular disease	V:Table 2 #9, NV: Table 2 #20	A(8) for both	M	Carefully consider pre-test probability of a cardiovascular cause of syncope before ordering TTE.
4	Newly diagnosed LBBB (no prior assessment of LV systolic function)	NV:Table 2 #11	A(7)	A	
5	VT or VF	NV:Table 2 #13 and 14	A(8 for NSVT, 9 for sustained VT/VF)	A	
6	SVT without other evidence of heart disease	NV: Table 2 #15	M(6)	M	
7	Atrial fibrillation or flutter (not for purposes of precardioversion evaluation)	NV: Table 2 #16	A(8)	A	TTE most likely to be useful if patient has signs/symptoms of heart failure, as LVEF may affect choice of rate-/rhythm-control therapy.
8	Evaluation of LV systolic function in setting of bradycardia to determine choice of device (pacemaker vs. ICD +/- CRT)	not specifically addressed - extrapolated from NV: Table 2 #33, Table 5 #74	A	A	
	Hypotension or hemodynamic instability				
9	Assessment of volume status in a critically ill patient	NV: Table 2 #22	M (V:6), A(NV:7)	M	In ventilated patients, IVC evaluation is less likely to be helpful as a proxy for volume status.
10	Hypotension or hemodynamic instability with uncertain or suspected cardiac etiology	V: Table 2 #10, NV: Table 2 #21	A (7, 9)	A	
11	Suspected acute mitral or aortic regurgitation	V: Table 2 #12	A (9)	A	TTE will likely be needed to confirm POCUS findings.
	Respiratory failure				
12	Respiratory failure or hypoxemia of uncertain etiology	V: Table 2 #13, NV: Table 2 #27	A(8)	A	In current environment, this scenario is most applicable to COVID-negative patients with respiratory failure potentially related to cardiac causes.
13	Respiratory failure or hypoexmia with an established non-cardiac etiology	V: Table 2 #14, NV: Table 2 #28	M(4)	D	Defer or avoid TTE unless other signs/symptoms of heart disease are present (e.g., arrhythmia, hypotension/shock).
	Acute coronary syndrome (ACS)				
14	Evaluation of LV function during initial presentation with ACS	NV: Table 2 #25	A(8)	A	
15	Suspected complication of myocardial ischemia/infarction, including but not limited to acute MR, VSD, RV infarct	NV: Table 2 #26	A(9)	A	

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	Indication	AUC Mapping (V=valvular, NV=non-valvular)	Rating in Original AUC	Appropriateness Category	Comments/Caveats
	Left heart failure, cardiomyopathy, myocarditis, and myocarditis				
16	Initial evaluation of known or suspected heart failure to assess left ventricular function and to assess etiology (including CAD, valvular heart disease)	NV: Table 2 #29, V: Table 2 #15	A(9)	A	This indication is applicable to patients with suspected COVID myocarditis.
17	Re-evaluation of known cardiomyopathy with a change in clinical status or cardiac examination or to guide therapy	NV: Table 5 #70	A(8)	M	Consider deferring TTE unless findings are likely to change short-term management.
18	Re-evaluation of known heart failure with a change in clinical status or examination with a clear precipitating change in medication or diet	NV: Table 5 #72	M(4)	D	
	Right heart failure, pulmonary hypertension, and pulmonary embolism (PE)				
19	Evaluation of suspected pulmonary hypertension, including evaluation of RV function and estimated pulmonary artery systolic pressure	NV: Table 2 #32	A(9)	A	
20	Suspected PE in order to establish diagnosis	2011 echo AUC: Table 2 #28	I (2)	D	Note that sensitivtity of TTE for pulmonary embolism is poor.
21	Known acute PE to guide therapy (thrombolytics, thrombectomy)	2011 echo AUC: Table 2 #29	A (8)	A	Serial studies in COVID-positive patients should be performed with POCUS if needed.
	Cardiac transplantation and LVAD				
22	Monitoring for rejection in a cardiac transplant recipient	NV: Table 2 #38	A(8)	A	
23	Cardiac structure and function evaluation in a potential heart donor	NV: Table 2 #39	A(9)	A	
24	Evaluation for LVAD candidacy	NV: Table 2 #36	A(9)	A	
25	Assessment of LVAD complications	NV: Table 5 #76	A(8)	A	
	Evaluation prior to cardiotoxic therapy				
26	Initial evaluation prior to exposure to medications (such as cancer chemotherapy) or radiation that could result in cardiotoxicity/heart failure or valvular heart disease	V: Table 1#6, NV: Table 1 #3, Table 2 #31	A	A	
27	Re-evaluation in a patient undergoing therapy with potentially cardiotoxic agents	NV: Table 4 #58; Table 5 #73	A(7, 9)	M	If patient is asymptomatic and study will not affect short-term management (for instance, timing/dosing of chemotherapy), defer.
	Pericardial disease				
28	Suspected pericardial diseases, including pericardial effusion, tamponade, and constriction	NV: Table 2 #40	A(9)	A	Note that pericardial effusion size is often overestimated on CT.
29	Re-evaluation for progression of pericardial effusion size or development of tamponade	NV: Table 5 #77	A(9)	A	Serial studies in COVID-positive patients should be performed with POCUS if needed.
30	Re-evaluation for progression of pericardial constriction	NV: Table 5 #78	A(8)	A	

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	Indication	AUC Mapping (V=valvular, NV=non-valvular)	Rating in Original AUC	Appropriateness Category	Comments/Caveats
	Acute aortic pathology				
31	Suspected acute aortic pathology, such as dissection	NV: Table 2 #42	A(7)	M	TTE may be able to detect very proximal type A aortic dissection, but sensitivity of TTE for acute aortic syndrome is limited, and CTA is the test of choice.
	Intracardiac thrombus, mass, tumor, stroke/TIA, and cardiac source of emboli				
32	Initial evaluation of cardiac thrombus, mass, or tumor, or potential cardiac source of emboli (including stroke/TIA)	NV: Table 2 #41, Table 6 #82; V Table 2 #19	A(8-9)	A	Sensitivity of TTE for small intracardiac thrombi is limited. If evaluation for left atrial appendage thrombus is needed, consider cardiac CT with contrast (consider low-contrast protocol if renal function is of concern).
	Valvular heart disease (VHD)				
33	Initial evaluation of unexplained murmur or abnormal heart sounds, with reasonable suspicion of valvular heart disease	V: Table 1 #1-2	A(9)	A	
34	Re-evaluation of known VHD with a change in clinical status or cardiac examination, when results will guide therapy	V: Table 5 #1-2	A(9)	A	
	Bacteremia/infective endocarditis (IE)				
35	Suspected IE *and* positive blood cultures or new murmur	V: Table 2 #16	A(9)	A	
36	Transient fever; no bacteremia or new murmur	V: Table 2 #17	R(2)	D	
37	Transient bacteremia; pathogen not typically associated with IE and/or documented nonendovascular source of infection	V: Table 2 #18	R(3)	D	
38	Re-evaluation of prior TTE/TEE finding for interval change (for instance, resolution of vegetation) when no change in therapy is anticipated	V: Table 4 #52	M(4)	D	
39	Re-evaluation of prior TTE/TEE finding for interval change when a change in therapy is anticipated	V: Table 4 #53	A(8)	A	
40	Re-evaluation of patient with IE at high risk of progression or complications (e.g., large vegetation or staphylococcal, enterococcal, fungal endocarditis) in the absence of clinical change	V: Table 4 #54	A(7)	M	TTE is indicated only if findings are likely to change management.
41	Re-evaluation of IE in a patient with a change in clinical status or cardiac examination (e.g., new murmur, new heart block, new or worsening heart failure)	V: Table 5 #56	A(9)	M	TTE is indicated only if findings are likely to change management.

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	Indication	AUC Mapping (V=valvular, NV=non-valvular)	Rating in Original AUC	Appropriateness Category	Comments/Caveats
	Postoperative imaging after surgical or transcatheter valve replacement or repair				
42	Initial postoperative evaluation of bioprosthetic or mechanical valve replacement or repair for establishment of baseline (6 weeks to 3 months postoperatively)	V: Table 6 #57, Table 6 #68	A(9)	M	
43	Characterization of mechanical or bioprosthetic valve or repaired valve if signs or symptoms suggest dysfunction	V: Table 6 #62-63	A(9)	A	
44	Re-evaluation of known prosthetic valve dysfunction to guide management/therapy	V: Table 6 #66, Table 6 #71	A(9)	A	
45	Post-TAVR assessment with suspicion of new or worsening valve dysfunction (including aortic regurgitation)	V: Table 7C #84-85	A(7-8)	A	