Transthoracic Echocardiography (TTE), Resting

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Link to Codes

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Clinical Indications

- Transthoracic echocardiography (TTE) may be indicated for **1 or more** of the following(1)(2)(3)(4)(5):
  - Acute thromboembolic event, as indicated by **ALL** of the following(14)(15)(16)(17):
    - Clinical diagnosis of acute thromboembolic event, as indicated by **1 or more** of the following:
      - Abrupt occlusion of major peripheral or visceral artery at any age(19)
      - Transient ischemic attack or acute ischemic stroke, suspected, and **1 or more** of the following(20)(21):
        - Age younger than 45 years
        - Age 45 years or older, in absence of known cause, including cerebrovascular disease
        - Atrial fibrillation, without previous echocardiogram(22)
        - Atrial septal defect, including patent foramen ovale(23)
        - Left ventricular mural thrombus

    - Mitral stenosis
    - Recent myocardial infarction(24)(25)
    - Severe left ventricular dysfunction (ie, left ventricular ejection fraction less than or equal to 35%)
  - Results would influence management (eg, anticoagulation, intervention to treat cardiac defect).
- Aortic dissection, suspected, as indicated by **1 or more** of the following(26)(27)(28)(29):
  - Acute aortic regurgitation
  - Asymmetric or absent pulses in setting of chest pain
  - Chest pain described as sharp, tearing, or stabbing
  - Chest x-ray with suggestive findings (eg, widening of aortic silhouette or mediastinum or left-sided pleural effusion)
  - Neurologic deficit accompanying chest pain
- Ascending aortic aneurysm, known, or history of aortic dissection, as indicated by **1 or more** of the following(27)(29)(31):
  - Follow-up evaluation after surgical repair(33)
  - Re-evaluation for change in clinical status, on examination, or when results would influence management(28)(34)
  - Re-evaluation to establish baseline rate of expansion, or when rate of expansion is excessive
- Atrial fibrillation, as indicated by **1 or more** of the following(35):
  - Before electrophysiologic or ablative procedure, if no recent echocardiogram or angiogram available
  - Change in cardiac status (eg, worsening heart failure, new myocardial infarction, new chest discomfort or dyspnea)(36)
  - Congenital heart disease, suspected(39)
  - Initial episode of atrial fibrillation(22)(37)(40)
- Cardiac device evaluation (eg, pacemaker, implantable cardioverter-defibrillator, cardiac resynchronization therapy)(41)(42)
- Cardiac tumor or mass, known or suspected(44)(45)(46)
- Cardiac shunt, suspected, as indicated by **1 or more** of the following(14)(51):
  - Cardiac murmur typical of intracardiac shunt (eg, congenital heart disease)(39)(54)
  - Central cyanosis(14)
  - End-stage liver disease and unexplained hypoxia (eg, suspected hepatopulmonary syndrome)
  - Paradoxical embolism (eg, stroke associated with lower extremity deep venous thrombosis)
  - Pulmonary hypertension with unexplained hypoxia (eg, suspected patent foramen ovale)(55)
- Cardiac trauma, known or suspected
- Cardiotoxic cancer treatment planned, and baseline evaluation of cardiac function needed(18)(58)(59)(60)(61)(62)(63)(64)
- Cardiotoxicity surveillance in survivor of cancer therapy (eg, anthracyclines, chest radiation)(28)(61)(62)(64)(65)(66)(67)(68)(69)(70)(71)(72)
- Cardiovascular evaluation in acute setting, as indicated by **1 or more** of the following(74):
  - Acute aortic regurgitation, suspected(81)(82)
  - Acute mitral regurgitation, suspected(81)
  - Acute myocardial infarction or ischemia, and subsequent mechanical complications, known or suspected (eg, papillary muscle rupture, left ventricular dysfunction, acute right heart failure, pericardial effusion, ventricular septal defect, ventricular rupture)(83)(84)(85)(86)
  - Cardiac tamponade, known or suspected(82)(83)
  - Heart failure, suspected, due to clinical signs (eg, rales, pedal edema, or elevated jugular venous pulse)(84)(87)(88)(89)
  - Hypotension or Hemodynamic instability, and need for further evaluation(81)
  - Mural thrombus, suspected(25)(83)(90)
  - Myocardial ischemia, suspected, when cardiac biomarkers and ECG are nondiagnostic(85)
  - Myocarditis, known or suspected(65)(78)(84)(91)(92)(93)(94)
  - Prior myocardial infarction(16)(24)(76)

- Takotsubo cardiomyopathy (stress-induced cardiomyopathy), suspected[A](16)(77)

- Chest pain, pediatric, as indicated by **1 or more** of the following(14):
  - Exertional chest pain
  - Family history of cardiomyopathy
  - Family history of sudden unexplained death
  - Nonexertional chest pain associated with abnormal ECG
- Congenital heart disease, known or suspected, as indicated by **1 or more** of the following(9)(14)(39)(95)(96)(97)(98):
  - After surgical repair or transplant and need to monitor **1 or more** of the following(106)(107)(108)(109):
    - Changes in signs or symptoms (eg, syncope, angina, heart failure, decreasing exercise tolerance, fatigue, cyanosis)
    - Left or right ventricular function
    - Pulmonary artery pressure
    - Residual defects (eg, shunts, valvular and conduit obstruction, valvular regurgitation)
  - Changes in symptoms (eg, syncope, angina, heart failure, decreasing exercise tolerance, fatigue, cyanosis, dyspnea, murmur), and results would change management
  - Coronary artery anomaly, suspected(110)(111)(112)
  - Down syndrome, at time of diagnosis and surveillance for acquired valvular disease
  - Findings on ECG, plain chest x-ray, newborn pulse oximetry screening, or echocardiogram suggestive of congenital heart disease(113)(114)
  - Guidance of percutaneous repair procedure(102)(115)(116)(117)
  - Need to monitor pulmonary artery pressure (eg, in patient with moderately large ventricular or atrial septal defect or single ventricle)
  - Patient is pregnant or considering pregnancy.(28)(104)(118)(119)(120)
  - Turner syndrome, at time of diagnosis and surveillance at interval based on age and dissection risk(27)(121)
  - Unexplained arterial desaturation
  - Unexplained cyanosis
  - Unexplained murmur
- Endocarditis, known or suspected, as indicated by **1 or more** of the following(14)(16)(81)(122)(123)(124)(125)(126):
  - Detection of complications (eg, abscess, shunt)(131)
  - Embolic infarcts in fingers or toes
  - Fever of unknown origin,[B] as indicated by **ALL** of the following(132)(133)(134)(135)(136):
    - Chest x-ray negative
    - Hematology and chemistry tests negative
    - Serology for antinuclear antibody and rheumatoid factor negative
    - Temperature of 101 degrees F (38.4 degrees C) for 3 weeks or longer (intermittent or persistent)[C]
    - Urinalysis and urine culture negative
  - Follow-up evaluation of valvular damage during and after treatment of endocarditis
  - Hemodynamic compromise or ventricular decompensation
  - Libman-Sacks endocarditis, suspected, in patient with systemic lupus erythematosus or antiphospholipid syndrome(137)(138)
  - Linear hemorrhages (splinter hemorrhage) in proximal nail bed in absence of trauma
  - New or changing heart murmur and **1 or more** of the following(139):
    - Current or history of use of injection drugs
    - Modest toxicity (eg, fever, malaise) developing over weeks to months
    - Positive blood cultures (ie, bacteremia or fungemia) with unknown source
    - Structural heart disease, known

    - Oval retinal hemorrhages (Roth spots)
    - Petechiae
    - Re-evaluation of complex endocarditis
    - Small erythematous or hemorrhagic macular lesions on palms or soles (Janeway lesions)
    - *Staphylococcus aureus* bacteremia(140)
    - Subcutaneous nodules (Osler nodes) in pulp of fingers
  - Gene mutation or chromosomal abnormality associated with cardiovascular disease (eg, Marfan syndrome, 22q11.2 deletion syndrome), initial and regular surveillance based on condition(14)(27)(141)(142)N
  - Guidance for noncoronary cardiac procedures (eg, pericardiocentesis, myocardial biopsy)(115)(143)N
  - Heart failure, cardiomyopathy, or left ventricular dysfunction, known or suspected, as indicated by **1 or more** of the following(14)(28)(144)(145)(146):N
    - Arrhythmogenic right ventricular dysplasia, known or suspected(162)(163)(164)
    - Carcinoid heart disease, known or suspected(148)(165)
    - Cardiac asynchrony, suspected, and need for evaluation for possible cardiac resynchronization therapy via biventricular pacemaker(166)(167)
    - Cardiomegaly on physical examination or chest x-ray
    - Chagas cardiomyopathy, known or suspected(168)(169)
    - Congenital heart disease, suspected(39)(170)
    - Current or history of use of chest radiation, doxorubicin and other anthracyclines, cyclophosphamide, paclitaxel, trastuzumab, or other cardiotoxic chemotherapeutic agents(58)(59)(60)(62)(63)(64)(66)(67)(70)(144)(171)(172)
    - Elevated serum BNP or N-terminal pro-BNP level[D](147)
    - Familial dilated cardiomyopathy in first-degree relative[E](156)(160)(174)
    - Heart failure, suspected, due to clinical signs (eg, rales, pedal edema, elevated jugular venous pulse, poor peripheral pulses, feeding difficulty in pediatric patient), and results would influence management(84)(89)(175)(176)(177)(178)
    - High clinical suspicion, with need for preoperative cardiac assessment and risk stratification to guide perioperative management(11)
    - History of neuromuscular disorder with known arrhythmic risk (eg, myotonic dystrophy, Becker or Duchenne muscular dystrophy, mitochondrial myopathies)(179)(180)(181)(182)(183)
    - Hypertrophic cardiomyopathy, known or suspected, as indicated by **1 or more** of the following(157)(184)(185)(186)(187)(188):
      - Initial evaluation and surveillance of degree of hypertrophy, left ventricular outflow tract, mitral regurgitation, and myocardial function(189)(190)
      - Evaluation of effects of surgical myectomy or alcohol septal ablation in patient with obstructive hypertrophic cardiomyopathy
      - Intraprocedural guidance of alcohol septal ablation
      - Repeat testing for known hypertrophic cardiomyopathy with change in clinical status or new cardiovascular event(120)
    - Hypertrophic cardiomyopathy in first-degree relative[F](157)(161)(184)(186)(187)
    - Left ventricular assist device present, and postoperative surveillance, troubleshooting, or optimization of device function needed(155)(191)(192)
    - Left ventricular hypertrophy on ECG
    - Left ventricular noncompaction cardiomyopathy, known or suspected(193)(194)
    - Myocarditis diagnosed at least 3 months prior, and need to ensure safe return to exercise(94)(195)
    - Peripartum cardiomyopathy, known or suspected, for diagnosis, surveillance, or clinical changes(28)(34)(196)(197)(198)(199)
    - Sustained and marked change in New York Heart Association functional class[G]
    - Systemic disease associated with heart failure (eg, thyroid disease, amyloidosis, hemochromatosis, Fabry disease)(149)(151)(152)(153)(200)(201)(202)(203)(204)
    - Widened QRS on ECG (eg, greater than 0.12 seconds)

- Heart murmur (new), as indicated by **1 or more** of the following(14)(81)(122):
    - Endocarditis, known or suspected(139)
    - History of rheumatic heart disease(205)
    - New diastolic murmur
    - New systolic murmur determined by experienced observer not to be functional or benign, as indicated by **1 or more** of the following:
        - Accompanied by abnormal ECG findings
        - Accompanied by cardiorespiratory symptoms
        - Accompanied by other abnormal physical examination findings (eg, abnormal rhythm, gallop, rub, lower extremity edema, or abnormalities on pulmonary examination)
        - Associated with either syncope or thromboembolism
        - Change with physical maneuvers such as Valsalva, squatting, or hand grip
        - Intensity
        - Timing during cardiac cycle (holosystolic or mid-to-late systolic, or accompanied by click or ejection sound)
- Hereditary hemorrhagic telangiectasia, known or suspected, and screening for pulmonary arteriovenous malformations needed(206)(207)(208)(209)
- Hypertension and **1 or more** of the following(14):
    - Child or adolescent, and **1 or more** of the following(218):
        - Initial assessment for cardiac target organ damage (eg, left ventricular mass and function) when considering initiation of pharmacologic treatment
        - Repeat evaluation in patient without initial target organ damage to assess for development of target organ injury
        - Repeat evaluation to monitor improvement or progression of target organ damage
    - ECG evidence of left ventricular hypertrophy, left bundle branch block, or repolarization abnormality
    - Heart disease, known or suspected
    - Unexplained cardiac symptoms
- Kawasaki disease, known or suspected(219)
- Left bundle branch block, new(221)
- Multisystem inflammatory syndrome in child, known or suspected(222)(223)
- Palpitations in adult, as indicated by **1 or more** of the following(225)(226)(227):
    - Abnormal ECG (eg, Q waves, left bundle branch block, atrioventricular block, prolonged QT interval)
    - Family history of hypertrophic cardiomyopathy or sudden cardiac death
    - Signs or symptoms of structural heart disease or heart failure (eg, murmur, syncope, elevated jugular venous distention, pedal edema, rales)
- Palpitations in child, as indicated by **1 or more** of the following(14):
    - Family history of placement of pacemaker or implantable defibrillator before age 50 years
    - Family history of sudden cardiac arrest or death before age 50 years
- Patient being considered for kidney or liver transplant(228)(229)(230)(231)
- Pericardial disease, as indicated by **1 or more** of the following(143)(233)(234)(235):
    - Follow-up of previously diagnosed pericardial disease(236)
    - Pericardial bleeding, suspected
    - Pericardial effusion or constrictive pericarditis, suspected(236)(237)(238)
    - Pericardial friction rub after myocardial infarction
    - Pericardial mass, suspected
    - Pericardial tamponade, suspected(238)
    - Post cardiac surgery

- Preoperative or preprocedural planning needed, as indicated by **1 or more** of the following(11):
  - Evaluation of candidacy for device therapy (including pacemaker, implantable cardioverter-defibrillator, or cardiac resynchronization devices) or to help guide selection of optimal device after revascularization or optimal medical therapy(239)
  - Evaluation of candidacy for ventricular assist device(155)(156)(191)(192)(239)
  - Preoperative assessment of left ventricular function needed, as indicated by **1 or more** of the following(11):
    - Patient has dyspnea of unknown origin.
    - Patient with history of heart failure with change in clinical or functional status
    - Patient with previously documented left ventricular dysfunction, and no assessment within past year
  - Preoperative assessment of right ventricular function needed, as indicated by **1 or more** of the following:
    - Patient has dyspnea or syncope, unexplained, and **1 or more** of the following(84):
      - Enlargement of main pulmonary artery on chest x-ray
      - Patient has peripheral edema of unknown origin.
      - Physical examination findings suggestive of pulmonary hypertension (eg, right ventricular lift or increased pulmonary component of second heart sound)
      - Pulmonary disease pattern on ECG
      - Right ventricular hypertrophy on ECG
    - Patient with history of known pulmonary hypertension and no assessment within past year
    - Patient with known pulmonary hypertension with change in clinical or functional status
  - Prior to valve repair or replacement procedure(81)(113)(240)(241)(242)(243)
- Prosthetic heart valve, as indicated by **1 or more** of the following(81)(122)(244)(245):
  - Abrupt occlusion of major peripheral or visceral artery
  - Baseline study after valve replacement(241)(247)(248)
  - Endocarditis, known or suspected(139)(249)
  - Patient is pregnant or considering pregnancy, and has had no echocardiogram within past year.(28)(34)(103)(118)
  - Prosthetic valve dysfunction, known, when results would influence management(16)(250)
  - Prosthetic valve dysfunction, suspected (eg, stenosis, regurgitation, thrombosis, dehiscence, change in murmur or clinical status)(16)(248)(249)(250)(251)(252)
  - Routine surveillance of normal bioprosthetic or mechanical valve(248)(250)
  - Thrombus, known or suspected(16)(253)
  - Transcatheter valve repair or replacement procedure, and imaging guidance needed
- Pulmonary embolism, as indicated by **1 or more** of the following(254):
  - Need to guide therapy (ie, thrombectomy or thrombolytics)
  - Re-evaluation of known pulmonary embolism after thrombectomy or thrombolysis to assess change in right ventricular function or pulmonary artery pressure(256)
- Pulmonary hypertension, cor pulmonale, or unexplained dyspnea, as indicated by **1 or more** of the following(84)(257)(258)(259)(260):
  - Bronchopulmonary dysplasia, known, and need for screening of infant for pulmonary hypertension(265)(268)(269)
  - Dyspnea or syncope, unexplained, and **1 or more** of the following:
    - Enlargement of main pulmonary artery on chest x-ray
    - Peripheral edema
    - Physical examination findings suggestive of pulmonary hypertension (eg, right ventricular lift or increased pulmonary component of second heart sound)
    - Pulmonary disease pattern on ECG

        - Right ventricular hypertrophy on ECG
        - Surveillance of known pulmonary hypertension
    - Family history of pulmonary hypertension(14)
    - Increasing dyspnea in setting of diagnosis associated with pulmonary hypertension, as indicated by **1 or more** of the following(270)(271):
        - Chronic hemolytic anemia (eg, sickle cell disease, thalassemia)
        - Congenital heart disease(39)(272)
        - Connective tissue disease (eg, systemic sclerosis, systemic lupus erythematosus)(273)(274)(275)
        - Constrictive pericarditis
        - Emphysema
        - Gaucher disease
        - Glycogen storage disease
        - HIV
        - Interstitial lung disease(276)
        - Liver disease associated with portal hypertension (eg, cirrhosis, schistosomiasis)(277)
        - Mitral valve disease
        - Myeloproliferative neoplasms (eg, polycythemia vera, essential thrombocythemia, myelofibrosis)(278)
        - Sarcoidosis
        - Sleep-disordered breathing
    - Patient being considered for lung transplant or other surgical intervention
    - Patient is pregnant or considering pregnancy.(28)(34)(118)(279)
    - Re-evaluation of known pulmonary hypertension for change in clinical status, or results would influence management(280)
    - Surveillance of known pulmonary hypertension
- Supraventricular or ventricular arrhythmia, and need for further evaluation(161)(281)(282)
- Syncope, as indicated by **1 or more** of the following(283)(284):
    - Adult and **1 or more** of the following:
        - Abnormal ECG findings
        - Abnormal physical findings suggestive of structural cardiac disease (eg, significant murmur, click, abnormal heart sounds, signs of heart failure)
        - Abnormal plain chest x-ray findings suggestive of ventricular dysfunction, valvular disease, or cardiomyopathy
        - History of cardiac disease
        - Syncope that occurs during or after exertion
    - Child and **1 or more** of the following(14)(287):
        - Abnormal ECG findings
        - Abnormal physical examination findings (eg, pathologic murmur, irregular or ectopic rhythm, sternotomy scar)
        - Family history of cardiomyopathy
        - Family history of placement of pacemaker or implantable defibrillator before age 50 years
        - Family history of sudden cardiac arrest or death before age 50 years
        - Syncope that occurs during or after exertion
- Thoracic aortic dilatation or aneurysm, suspected, as indicated by **1 or more** of the following(26)(27)(28)(82)(288):
    - Chest x-ray with suggestive findings
    - First-degree relative of patient with thoracic aortic aneurysm and dissection(29)

- Marfan syndrome or other connective tissue syndrome involving aortic root (eg, Loeys-Dietz syndrome), as indicated by **1 or more** of the following(29)(142):
    - Aortic root dilated greater than 1.5 times mean diameter predicted for body size on previous echocardiogram: Assess more frequently than annually.
    - Aortic root dilated less than 1.5 times mean diameter predicted for body size on previous echocardiogram: Assess annually.
    - At time of diagnosis and 6 months thereafter, with further assessment as indicated by **1 or more** of the following(121):
        - If significant growth from baseline: Assess more frequently than annually.
        - If stability documented: Assess annually.
    - Patient is pregnant or considering pregnancy.(28)(34)(120)(142)
- Screening of first-degree relative of patient with Marfan syndrome(29)

- Thoracic aortic aneurysm in patient with bicuspid aortic valve, as indicated by **1 or more** of the following(122):
    - Aortic diameter greater than 4.0 cm: Assess annually.
    - Aortic diameter greater than 4.5 cm: Assess at least annually.
    - New or worsening signs or symptoms(28)
- Tuberous sclerosis complex, known(50)
- Valvular heart disease, as indicated by **1 or more** of the following(81)(122)(205)(245)(289)(290):
    - Assessment at time of diagnosis(293)(294)(295)(296)
    - Assessment of effects of medical treatment on severity of regurgitation or ventricular function, or results would influence management(295)(296)
    - Before cardiovascular surgery or intermediate-risk to high-risk noncardiac surgery, as indicated by **ALL** of the following:
        - Moderate to severe aortic or mitral valve disease
        - Most recent echocardiogram was more than 6 months ago.
    - Before or at beginning of pregnancy for patient with moderate to severe valve disease(28)(103)(118)(119)(279)
    - Bicuspid aortic valve, known or suspected(27)(82)(121)(297)
    - Changing physical examination (eg, heart murmur, pulmonary or peripheral edema)
    - Changing symptoms (eg, syncope, angina, heart failure, dyspnea, decreasing exercise tolerance, fatigue, palpitations)(36)(74)(282)
    - First-degree relative of patient with bicuspid aortic valve(27)
    - Mitral valve prolapse, as indicated by **1 or more** of the following:
        - High clinical suspicion due to first-degree relative with myxomatous valve disease
        - Physical findings suggestive of mitral valve prolapse (eg, mid-systolic click, late-systolic murmur)
        - Previous diagnosis of mitral valve prolapse
    - Need for periodic re-evaluation of asymptomatic aortic regurgitation with normal left ventricular function, as indicated by **1 or more** of the following(298):
        - Mild aortic regurgitation with normal left ventricular size and function, and no clinical evidence that regurgitation has worsened: Assess every 3 to 5 years.
        - Moderate aortic regurgitation with normal left ventricular size and function: Assess every 1 to 2 years.
        - Previous echocardiogram showed progressive ventricular dilatation: Assess more frequently than every 6 months.
        - Severe aortic regurgitation with no left ventricular dilatation: Assess every 6 to 12 months.
    - Need for periodic re-evaluation of asymptomatic aortic stenosis with normal left ventricular function, as indicated by **1 or more** of the following(299)(300):
        - Mild aortic stenosis (valve area greater than 1.5 cm^2): Assess every 3 to 5 years.
        - Moderate aortic stenosis (valve area greater than 1 cm^2 up to 1.5 cm^2): Assess every 1 to 2 years.
        - Severe aortic stenosis (valve area 1 cm^2 or less): Assess every 6 to 12 months.(301)

- Need for periodic re-evaluation of asymptomatic mitral regurgitation with normal left ventricular function, as indicated by **1 or more** of the following:
  - Mild mitral regurgitation: Assess every 3 to 5 years.
  - Moderate mitral regurgitation: Assess every 1 to 2 years.
  - Previous echocardiogram showed progressive ventricular dilatation: Assess more frequently than every 6 months.
  - Severe mitral regurgitation: Assess every 6 to 12 months.
- Need for periodic re-evaluation of asymptomatic mitral stenosis with normal left ventricular function, as indicated by **1 or more** of the following(302):
  - Mild mitral stenosis (valve area greater than 1.5 cm^2 or mean gradient less than 5 mm Hg): Assess every 3 to 5 years.
  - Moderate mitral stenosis (valve area 1.0 cm^2 to 1.5 cm^2): Assess every 1 to 2 years.
  - Severe mitral stenosis (valve area less than 1.0 cm^2): Assess annually.
- Postoperative assessment of valve intervention, as indicated by **1 or more** of the following(82)(240)(243)(247)(303):
  - Initial postoperative assessment: 6 weeks to 3 months postoperatively(293)
  - Re-evaluation of patient with suspected dysfunction of repaired valve: less than 1 year postoperatively
  - Re-evaluation in patient without suspected valve dysfunction: greater than or equal to 1 year postoperatively
- Valvular mass, known or suspected

- Vascular ring in child, suspected(14)

Alternatives

- Alternatives include(122)(244):
  - For assessment of left ventricular function (eg, cardiotoxic chemotherapy monitoring): cardiac radionuclide angiography or radionuclide ventriculography. See Cardiac Radionuclide Angiography (Radionuclide Ventriculography) AC for further information.
  - For thoracic dissection or aneurysm: chest CT scan, cardiac CT, or cardiac MRI. See Chest CT Scan AC, Cardiac CT Scan AC, and Cardiac MRI AC for further information.(27)(304)
  - Intracardiac echocardiography(305)(306)(307)
  - Stress echocardiography. See Stress Echocardiography AC and Pharmacologic Stress Echocardiography AC for further information.
  - Transesophageal echocardiography. See Transesophageal Echocardiography (TEE) AC for further information.

Evidence Summary

Background

TTE is used to visualize the heart and great vessels via an ultrasound probe that is placed on the chest wall. Using pulsed or continuous wave Doppler ultrasonography, TTE can also assess the velocity of blood passing through various chambers of the heart or the great vessels, allowing estimation of valvular function and ejection fraction. It is noninvasive, safe, and rapid, making it particularly useful in emergency clinical settings or with acutely ill patients.(1)(5)(6)(7) **(EG 2)** Three-dimensional TTE is now widely available and has been found to provide information complementary and additional to that of traditional 2-dimensional TTE in many cases, including valvular imaging and evaluation of congenital heart disease.(2)(5)(8)(9) **(EG 2)**

Criteria

The evidence for the clinical indications found in this guideline includes 215 published peer reviewed articles, 70 specialty society or other evidence-based guidelines, and 7 book sections.

For acute thromboembolic events, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** TTE is useful for detecting a cardiovascular etiology (eg, atrial thrombus, patent foramen ovale, atrial septal defect, atrial myxoma) for possible stroke, transient ischemic attack, or sudden onset of lower extremity ischemia.(1)(18) **(EG 2)** A specialty society guideline supports the use of TTE for the evaluation of pediatric patients with acute stroke.(14) **(EG 2)**

For aortic dissection, evidence demonstrates at least moderate certainty of at least moderate net benefit. **(RG A1)** A specialty society guideline states that TTE is commonly used for initial assessment of the thoracic aorta, noting its ease of use at the bedside and its particular utility in imaging the aortic root, ascending aorta, and aortic valve anatomy and function.(27) **(EG 2)** A systematic review and meta-analysis of 11 studies (3406 patients) evaluating echocardiography as a diagnostic test for acute aortic dissection found that TTE had a pooled sensitivity and specificity of 85.4% and 84.5%, respectively, for the diagnosis of type A dissection and 45.9% and 87.1%, respectively, for the diagnosis of type B dissection.(30) **(EG 1)**

For ascending aortic aneurysm or history of aortic dissection, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** Guidelines endorsed by multiple specialty societies note that TTE is appropriate for the follow-up of known ascending aortic aneurysm, particularly when limited to the aortic root or in combination with other noninvasive imaging modalities such as CT scan or MRI.(18)(27) **(EG 2)** An expert consensus statement notes that TTE is an appropriate diagnostic test for serial evaluation of the aortic valve, root, and ascending aorta in patients with chronic aortic dissection with associated dilation of the unrepaired aortic root.(32) **(EG 2)**

For atrial fibrillation, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** Specialty society appropriate-use criteria note that TTE is an appropriate imaging modality for cardiac evaluation in the setting of atrial fibrillation.(1)(18)(36) **(EG 2)** Specialty society guidelines recommend that all patients with atrial fibrillation undergo TTE as part of their initial evaluation in order to detect underlying structural heart disease, evaluate atrial dimensions, and assess cardiac function.(22)(37)(38) **(EG 2)**

For cardiac device evaluation, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** Appropriate-use criteria statements endorsed by multiple specialty societies note that TTE is appropriate for evaluation of implanted cardiac devices (eg, pacemaker, implantable cardioverter-defibrillator, cardiac resynchronization therapy), both for candidacy prior to device placement and for evaluation following device placement.(1)(18) **(EG 2)** Expert consensus statements note that transthoracic echocardiography is an appropriate test to evaluate suspected cardiovascular implantable device pocket or lead infection.(42)(43) **(EG 2)**

For cardiac mass, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** Appropriate-use criteria statements endorsed by multiple specialty societies state that TTE is appropriate for the evaluation of suspected cardiac mass lesions, such as atrial myxoma, papillary fibroelastoma, cardiac hemangioma, cardiac lipoma, rhabdomyoma, sarcoma, or cardiac metastases.(1)(16)(18)(47) **(EG 2)** Review articles note that TTE allows for rapid acquisition of real-time images with high spatial and temporal resolution that is useful for identification and characterization of cardiac tumors.(44)(48)(49) **(EG 2)** An international tuberous sclerosis consensus guideline recommends that TTE be performed in follow-up of rhabdomyoma diagnosed on fetal echocardiogram at least once postnatally, in newly diagnosed or suspected tuberous sclerosis patients (especially if younger than 3 years), and in asymptomatic pediatric patients with cardiac rhabdomyoma every 1 to 3 years until regression is documented.(50) **(EG 2)**

For cardiac shunt, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** TTE with agitated saline or contrast agent enhancement is useful in the evaluation of unexplained hypoxia, cardiac murmur suspicious for shunt, or paradoxical emboli (eg, patent foramen ovale or hepatopulmonary syndrome).(1)(51)(52) **(EG 2)** A systematic review and meta-analysis of 35 studies (4209 patients) evaluating the diagnostic accuracy of TTE for detection of right-to-left shunt found a sensitivity and specificity of 73% and 94%, respectively; in 27 studies published in the year 2000 or later, the sensitivity and specificity were 80% and 94%, respectively.(53) **(EG 1)** An appropriate-use criteria statement notes that TTE is appropriate for the evaluation of pediatric patients with suspected cardiac shunt due to congenital heart disease; these patients may manifest with symptoms such as central cyanosis, hepatomegaly, and pathologic cardiac murmurs.(14) **(EG 2)**

For cardiac trauma, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** A systematic review and meta-analysis evaluating the accuracy of tests for the diagnosis of cardiac trauma included 20 studies evaluating TTE that found a sensitivity of 47.0% and specificity of 91.4% for the diagnosis of blunt cardiac injury.(56) **(EG 1)** A specialty society statement notes that TTE is appropriate as part of the evaluation of severe deceleration injury or chest trauma when cardiac injury, valve injury, or pericardial effusion are possible or suspected.(1) **(EG 2)** An appropriate-use criteria document states that TTE is the first-line imaging modality for patients with suspected blunt chest trauma, as it can detect the presence of ventricular systolic dysfunction, pericardial effusion, and septal or valvular injuries.(57) **(EG 2)**

For cardiotoxic cancer treatment planned, and baseline evaluation of cardiac function needed, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** Specialty society guidelines note that TTE is appropriate for measuring heart function before initiation of cardiotoxic chemotherapy as well as evaluating heart function after receipt of chemotherapy.(18)(58)(59)(61)(65)(66) **(EG 2)**

For cardiotoxicity surveillance in survivors of cancer therapy, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** Exposure to cardiotoxic chemotherapy or chest radiotherapy in childhood or adolescence leads to stage A (ie, asymptomatic) heart failure that may be progressive as a result of the development of cardiomyopathy, coronary artery disease, or valvular disease. The initiation and frequency of screening are based on patient factors (eg, age, obesity) and treatment factors (eg, cumulative anthracycline dose, combination chest radiotherapy and anthracycline use).(72)(73) **(EG 2)** An international expert consensus guideline on cardiomyopathy surveillance after childhood cancer notes that childhood cancer survivors exposed to anthracyclines or chest radiotherapy are at increased risk of developing progressive heart failure preceded by an asymptomatic period. Lifelong echocardiography surveillance is recommended to occur at a minimum of every 5 years; closer monitoring is appropriate during pregnancy.(67) **(EG 2)**

For cardiovascular evaluation in the acute setting, evidence demonstrates at least moderate certainty of at least moderate net benefit. **(RG A1)** TTE is useful in the evaluation of chest pain to evaluate for wall motion abnormalities suggestive of myocardial ischemia when cardiac biomarkers and ECG are nondiagnostic.(1)(75) **(EG 2)** It is also used to identify complications of myocardial ischemia or infarction, including acute mitral regurgitation, thrombus, global left ventricular systolic dysfunction, free-wall rupture, tamponade, and heart failure.(1)(16)(18)(76) **(EG 2)** A review article and a specialty society guideline note that TTE is the preferred initial imaging modality for early evaluation of patients with suspected Takotsubo syndrome (stress-induced cardiomyopathy).(16)(77) **(EG 2)** Review articles and a multidisciplinary clinical practice guideline note that TTE can be used to evaluate suspected myocarditis due to immune checkpoint inhibitor therapy.(78)(79)(80) **(EG 2)** Appropriate-use criteria endorsed by multiple specialty societies state that TTE is appropriate for the initial evaluation of patients with hypotension or hemodynamic instability and a suspected cardiac etiology, as well as for assessment of suspected acute mitral or aortic regurgitation.(81) **(EG 2)**

For chest pain (pediatric), evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** A specialty society guideline supports the use of TTE for the evaluation of pediatric patients with exertional chest pain, nonexertional chest pain associated with an abnormal ECG, and chest pain associated with a family history of sudden unexplained death or cardiomyopathy.(14) **(EG 2)**

For congenital heart disease, evidence demonstrates at least moderate certainty of at least moderate net benefit. **(RG A1)** Multiple specialty society guidelines state that TTE is indicated for diagnosis and follow-up of congenital heart disease in both pediatric and adult patients.(1)(14)(39)(99)(100) **(EG 2)** A review article notes that TTE can provide a comprehensive evaluation for the diagnosis of patent ductus arteriosus and for related therapeutic decisions.(101) **(EG 2)** A prospective randomized trial comparing TTE to transesophageal echocardiography for the guidance of percutaneous atrial septal defect closure in pediatric patients found that TTE was as efficacious and safe as transesophageal echocardiography for this purpose, and may reduce fluoroscopy exposure.(102) **(EG 1)** A review article notes that TTE is safe and useful for evaluating congenital heart disease in women who are pregnant or considering pregnancy, as it can delineate cardiac anatomy in complex congenital heart disease, stratify maternal risk during pregnancy, and monitor ventricular and valvular anatomy and function.(103) **(EG 2)** Another review article states that cardiology follow-up, including TTE during the second trimester, is appropriate for pregnant patients with known atrial septal defect.(104) **(EG 2)** Expert consensus statements and appropriate-use criteria endorsed by multiple specialty societies note that 3-dimensional TTE has become a useful modality in the management of patients with congenital heart disease, particularly for purposes of functional assessment, preoperative planning, and guidance of catheter interventions, and is increasingly being used in pediatric patients due to its good acoustic windows and noninvasive nature.(9)(95)(105) **(EG 2)**

For endocarditis, evidence demonstrates at least moderate certainty of at least moderate net benefit. **(RG A1)** TTE is indicated to detect vegetations on heart valves and to evaluate *Staphylococcus aureus* endocarditis, severe hemodynamic compromise, persistent bacteremia, or a change in clinical status suggestive of valve compromise; TTE can be repeated 5 to 7 days after a negative test if clinical suspicion for endocarditis remains high.(1)(4)(16)(81)(127) **(EG 2)** A meta-analysis of 16 studies including 2807 patients with suspected infective endocarditis found that standard TTE had a sensitivity of only 61% for detection of vegetations as compared with transesophageal echocardiography.(128) **(EG 1)** However, review articles note that TTE can detect the majority of right-sided infective endocarditis.(129)(130) **(EG 2)** An appropriate-use criteria statement endorsed by multiple specialty societies notes that TTE is appropriate for the evaluation of suspected endocarditis in pediatric patients even in the absence of blood culture data or with a negative blood culture.(14) **(EG 2)**

For gene mutation or chromosomal abnormality associated with cardiovascular disease, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** A specialty society guideline on TTE in pediatrics notes that echocardiography is appropriate for patients with gene mutations or chromosomal abnormalities that are known to be associated with cardiovascular disease, such as aortopathy syndromes or cardiomyopathy syndromes.(14) **(EG 2)** An appropriate-use criteria statement endorsed by multiple specialty societies notes that TTE is an appropriate test for evaluation of patients with a genetic mutation that predisposes to aortic pathology (eg, Marfan syndrome).(18) **(EG 2)**

For guidance of noncoronary cardiac procedures, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** An appropriate-use criteria statement endorsed by multiple specialty societies notes that TTE is appropriate for guidance of percutaneous noncoronary cardiac procedures, such as pericardiocentesis, right ventricular biopsy, and septal ablation, among others.(1) **(EG 2)** A review article notes that TTE provides additional information over fluoroscopy alone for guidance of noncoronary interventional procedures such as myocardial biopsy, percutaneous valvular interventions, and pericardiocentesis.(115) **(EG 2)**

For heart failure or left ventricular dysfunction, evidence demonstrates at least moderate certainty of at least moderate net benefit. **(RG A1)** TTE is used to evaluate left ventricular function in the recovery phase after acute myocardial infarction and in patients with known or suspected heart failure.(1)(18)(144) **(EG 2)** Multiple specialty society guidelines support the use of TTE as the initial diagnostic imaging test for suspected heart failure.(14)(18)(144)(145)(147) **(EG 2)** TTE is useful for evaluating suspected left ventricular dysfunction due to hypertension; valvular disease; infiltrative diseases such as amyloidosis, sarcoidosis, or Fabry disease; and cardiotoxic drugs used for cancer chemotherapy, among other causes.(14)(66)(144)(148)(149)(150)(151)(152)(153)(154) **(EG 2)** For heart failure patients with left ventricular assist devices, a specialty society statement recommends the use of TTE for preoperative patient selection, perioperative imaging, postoperative surveillance, troubleshooting of device alarms, optimization of device function, and evaluation of native myocardial recovery.(155)(156) **(EG 2)** Specialty society guidelines recommend the use of TTE in the initial evaluation of all patients who are suspected to have hypertrophic cardiomyopathy. Repeat TTE is recommended in hypertrophic cardiomyopathy patients when there is a change in clinical status or a new cardiovascular event. TTE may be used to assist in the intraprocedural guidance of alcohol septal ablation in patients with hypertrophic cardiomyopathy. TTE is also recommended to evaluate the effects of surgical myectomy or alcohol septal ablation in patients with obstructive hypertrophic cardiomyopathy.(157)(158)(159) **(EG 2)** For hypertrophic cardiomyopathy screening, a specialty society guideline recommends the use of TTE as part of the screening algorithm for relatives of patients with hypertrophic cardiomyopathy, unless the relative is known to be genotype-negative in a family with known mutations definitive for hypertrophic cardiomyopathy. Periodic TTE screening (every 2 to 3 years) is recommended for children of patients with hypertrophic cardiomyopathy, beginning no later than age 12 years (earlier if signs of puberty are evident, participation in competitive sports is planned, or there is a family history of sudden cardiac death).(157) **(EG 2)** Specialty society guidelines recommend screening with TTE for all first-degree relatives of individuals with familial dilated cardiomyopathy.(160)(161) **(EG 2)** A specialty society guideline supports the use of TTE for the evaluation of pediatric patients who are genotype-positive or have a family history of hypertrophic cardiomyopathy; who have a family history of nonischemic dilated (idiopathic) cardiomyopathy; or who have signs or symptoms of heart failure, such as respiratory distress, poor peripheral pulses, decreased urine output, feeding difficulty, edema, and hepatomegaly.(14) **(EG 2)** A specialty society guideline recommends TTE as part of a comprehensive assessment of patients with cancer prior to initiation of potentially cardiotoxic therapies. There is low-quality evidence to support the recommendation to perform routine TTE surveillance in patients with metastatic breast cancer treated with trastuzumab.(58) **(EG 2)**

For heart murmurs, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** TTE is used to evaluate asymptomatic and symptomatic adults and children with new cardiac murmurs.(14)(122) **(EG 2)** A specialty society guideline states that a comprehensive TTE with 2-dimensional imaging and Doppler interrogation should be performed in the evaluation of a new heart murmur that is suspected to indicate valvular heart disease.(122) **(EG 2)**

For hereditary hemorrhagic telangiectasia, evidence demonstrates at least moderate certainty of at least moderate net benefit. **(RG A1)** Hereditary hemorrhagic telangiectasia is associated with cardiopulmonary comorbidities, including heart failure, pulmonary hypertension, and pulmonary arteriovenous malformations; TTE is useful for assessing these cardiopulmonary findings and is recommended for pulmonary arteriovenous malformation screening in adults and children with the disorder.(206)(207)(208)(210)(211) **(EG 2)** Although high-resolution chest CT scan is considered the gold standard for diagnosing pulmonary arteriovenous malformations, prospective studies have validated the high sensitivity of TTE, particularly contrast TTE, in predicting pulmonary arteriovenous malformations in adult and pediatric patients.(208)(212)(213) **(EG 2)** A prospective study of 772 patients with known or suspected hereditary hemorrhagic telangiectasia found that pulmonary shunt grade on contrast TTE predicted the size of pulmonary arteriovenous malformations on chest CT scan as well as feasibility for subsequent transcatheter embolotherapy; the authors concluded that chest CT scan can be safely deemed unnecessary in patients with a low pulmonary shunt size on TTE.(214) **(EG 2)** A retrospective analysis of 293 pediatric patients included in a single-center hereditary hemorrhagic telangiectasia registry concluded that the use of an echocardiographic grading system for pulmonary arteriovenous malformation screening may reduce the need for downstream chest CT scanning in children.(206) **(EG 2)**

For hypertension, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** TTE is used to assess left ventricular hypertrophy, concentric remodeling, diastolic dysfunction, and left ventricular mass, which are independent risk factors for cardiac and cerebrovascular events in hypertensive patients.(215)(216)(217) **(EG 2)** A specialty society guideline supports the use of TTE for the evaluation of pediatric patients with hypertension.(14) **(EG 2)**

For Kawasaki disease, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** A specialty society guideline states that echocardiographic findings, in combination with clinical and laboratory findings, can support the diagnosis of incomplete Kawasaki disease in patients whose clinical presentation suggests the disease but whose clinical features do not meet the epidemiologic case definition. This guideline notes that the diagnosis of Kawasaki disease can be considered confirmed when coronary aneurysms are identified by echocardiography.(220) **(EG 2)**

For left bundle branch block, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** A specialty society guideline and an appropriate-use criteria statement endorsed by multiple specialty societies recommend performance of TTE to exclude structural heart disease in all patients with newly detected left bundle branch block.(18)(221) **(EG 2)**

For multisystem inflammatory syndrome in children, known or suspected, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** An expert consensus statement recommends TTE imaging in all patients presenting with suspected pediatric inflammatory multisystem syndrome temporally associated with COVID-19, as well as follow-up TTE imaging to monitor clinical status during and after treatment.(224) **(EG 2)** A specialty society guideline states that TTE should be performed at diagnosis of multisystem inflammatory syndrome in children and repeated at a minimum of 7 to 14 days and 4 to 6 weeks after presentation to assess ventricular function, valvular function, presence of any pericardial effusion, and coronary artery dimensions.(222) **(EG 2)**

For palpitations in adults, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** Echocardiography may be indicated as part of the diagnostic workup of adult patients presenting with palpitations if there is evidence of ischemia or conduction abnormalities on ECG (eg, Q waves, left bundle branch block, atrioventricular block, prolonged QT interval) or if there are signs or symptoms of structural heart disease (murmur, elevated jugular venous distention, pedal edema, rales) on the history and physical examination.(225)(226)(227) **(EG 2)**

For palpitations in children, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** A specialty society guideline on TTE in pediatrics notes that echocardiography is appropriate in children with palpitations and family history of cardiomyopathy or sudden cardiac death and/or pacemaker or implantable defibrillator placement.(14) **(EG 2)**

For patients being considered for kidney or liver transplant, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** A systematic review and meta-analysis of 12 retrospective studies (93,984 patients) evaluating the utility of screening for pulmonary hypertension prior to kidney transplant found that evidence of pulmonary hypertension on pretransplant TTE was associated with higher all-cause mortality and higher rates of graft dysfunction or failure following transplant, compared with patients who did not have evidence of pulmonary hypertension on pretransplant TTE.(232) **(EG 1)** An expert consensus statement endorsed by multiple specialty societies notes that TTE is recommended for patients without symptomatic cardiac disease who are candidates for kidney or liver transplant in order to screen for heart disease that may benefit from further cardiac testing or treatment prior to transplant.(228) **(EG 2)**

For pericardial disease, evidence demonstrates at least moderate certainty of at least moderate net benefit. **(RG A1)** TTE is the first-line diagnostic study to determine the hemodynamic significance of pericardial effusion; it may also detect other pericardial disease, including pericardial mass, constrictive pericarditis, or a mixed effusive-constrictive presentation.(1)(18)(36)(233) **(EG 2)**

For preoperative or preprocedural planning, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** A specialty society guideline notes that preoperative evaluation of left ventricular function by TTE is reasonable in patients with dyspnea of unknown origin or in patients with heart failure who have had a recent change in clinical or functional status.(11) **(EG 2)** Appropriate-use criteria endorsed by multiple specialty societies note that TTE is indicated to evaluate candidacy for cardiac device therapy, such as left ventricular assist devices, implantable cardioverter-defibrillators, or cardiac resynchronization therapy, and to guide optimization of the device after implantation.(1)(155)(156) **(EG 2)** A review article states that TTE and cardiac MRI are the key imaging modalities for the assessment of Ebstein anomaly to guide the timing and type of surgery.(113) **(EG 2)** An appropriate-use criteria statement endorsed by multiple specialty societies notes that TTE is indicated before surgery to evaluate right ventricular function in patients with suspected pulmonary hypertension, as well as in patients with known pulmonary hypertension who have not been evaluated within the past year or who have had a change in clinical or functional status.(1) **(EG 2)**

For prosthetic heart valves, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** An appropriate-use criteria statement endorsed by multiple specialty societies notes that TTE is appropriate for evaluation of prosthetic heart valves, including the initial postoperative evaluation for establishment of a baseline, routine follow-up surveillance of prosthetic valve function, and when valvular dysfunction is known or suspected.(1)(244) **(EG 2)** A specialty society guideline states that repeat TTE is recommended in patients with prosthetic heart valves if there is a change in clinical signs or symptoms that suggests valve dysfunction. This guideline also notes that annual TTE is reasonable in patients with a bioprosthetic valve after the first 10 years following implant, even in the absence of a change in clinical status.(122) **(EG 2)** A review article notes that intraprocedural TTE can provide real-time imaging guidance during transcatheter aortic valve replacement and may contribute to improving procedural results.(246) **(EG 2)**

For pulmonary embolism, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** A systematic review and meta-analysis of 55 observational studies (17,090 patients) evaluating hemodynamically stable or low-risk to intermediate-risk patients with acute pulmonary embolism found that right ventricular dysfunction measured by TTE was associated with higher pulmonary embolism-related and overall mortality.(255) **(EG 1)** An appropriate-use criteria statement endorsed by multiple specialty societies notes that TTE is appropriate to guide therapy in the setting of a known pulmonary embolism and for re-evaluation following intervention.(1) **(EG 2)**

For pulmonary hypertension, evidence demonstrates at least moderate certainty of at least moderate net benefit. **(RG A1)** TTE is used to assess right ventricular function and estimate pressures in the pulmonary artery.(1)(18)(260)(261)(262) **(EG 2)** A systematic review and meta-analysis of 27 studies (4386 patients) evaluating the diagnostic accuracy of TTE for pulmonary hypertension found a pooled sensitivity and specificity of 85% and 74%, respectively.(263) **(EG 1)** A specialty society guideline supports the use of TTE for the evaluation of pediatric patients with suspected pulmonary hypertension or a family history of pulmonary hypertension.(14) **(EG 2)** A prospective observational study of 63 children (mean age 9 years) with pulmonary arterial hypertension (66.7% idiopathic and 33.3% associated with congenital heart disease or connective tissue disease) found, at a median follow-up of 4 years (during which 17 patients died and 4 underwent lung transplant), that multiple TTE parameters (including left and right ventricular dimensions and severity of pulmonary arterial hypertension measured by tricuspid regurgitation velocity) were independently associated with transplant-free survival.(264) **(EG 2)** A guideline endorsed by multiple specialty societies recommends serial evaluations of pediatric patients with known pulmonary hypertension with TTE; this same guideline recommends screening for pulmonary hypertension by echocardiogram in infants with known bronchopulmonary dysplasia.(265) **(EG 2)** A meta-analysis found that the sensitivity of TTE for detecting pulmonary hypertension was 82%, but its specificity was 68%, suggesting that TTE may be useful as a first-line surveillance imaging modality in patients with suspected pulmonary hypertension.(266) **(EG 2)** In an emergent setting of acute and unexplained hemodynamic compromise, respiratory distress, or chest pain (as may occur in the setting of pulmonary embolism), echocardiography can reveal impairment of right ventricular function and/or pulmonary hypertension.(267) **(EG 2)**

For supraventricular or ventricular arrhythmias, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** Appropriate-use criteria endorsed by multiple specialty societies note that, in addition to its use for atrial fibrillation, TTE is appropriate for the assessment of sustained or nonsustained supraventricular or ventricular tachycardia.(1)(18) **(EG 2)** A specialty society guideline supports the use of TTE for the evaluation of pediatric patients with supraventricular or ventricular tachycardia.(14) **(EG 2)** Another specialty society guideline recommends the use of TTE for evaluation of cardiac structure and function in patients with known or suspected ventricular arrhythmia that may be associated with underlying structural heart disease or a risk of sudden cardiac death.(161) **(EG 2)**

For syncope, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** TTE is useful in the evaluation of possible underlying cardiac causes of syncope.(283)(284) **(EG 2)** A retrospective review of 139 patients admitted with syncope found abnormal TTE findings in 43.75% of patients with an abnormal ECG or physical examination compared with 10% of patients with a normal ECG and physical examination.(285) **(EG 2)** Specialty society guidelines note that TTE can be useful in the evaluation of syncope when a cardiac etiology is suspected.(283)(284)(286) **(EG 2)** A specialty society guideline supports the use of TTE for evaluation of syncope in pediatric patients when associated with abnormal ECG; syncope that occurs during or after exertion; or family history of cardiomyopathy, sudden cardiac arrest or death before age 50 years, or placement of pacemaker or implantable defibrillator before age 50 years.(14) **(EG 2)**

For thoracic aortic aneurysms, evidence demonstrates at least moderate certainty of at least moderate net benefit. **(RG A1)** TTE is used to evaluate aortic root disorders, such as those found in Marfan syndrome and bicuspid aortic valve disease.(1)(18)(82) **(EG 2)** A specialty society guideline recommends that evaluation for bicuspid aortic valve and thoracic aortic disease be performed for first-degree relatives of a patient with thoracic aortic aneurysm and dissection using noninvasive imaging such as TTE. TTE should also be performed at the time of diagnosis of Marfan syndrome to assess the aortic root and ascending aortic diameters and 6 months thereafter to determine the rate of enlargement of the aorta; future TTE frequency based on the growth rate over that 6-month period is recommended.(27) **(EG 2)** An expert consensus statement and a review article note that serial TTEs should be performed in pregnant patients with Marfan syndrome to evaluate for progressive dilation of the aorta.(34)(120) **(EG 2)**

For thoracic aortic aneurysm in a patient with a bicuspid aortic valve, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** A specialty society guideline recommends that in patients with a bicuspid aortic valve who have a known thoracic aortic diameter greater than 4.5 cm, evaluation by TTE, cardiac MRI, or cardiac CT angiography should be performed at least annually; more frequent surveillance intervals may be required in patients who manifest a rapid rate of progression of aortic dilatation or who have a family history of aortic dissection or rupture.(122) **(EG 2)**

For tuberous sclerosis complex, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** A specialty society consensus statement states that echocardiography is the imaging modality of choice for evaluating cardiac involvement in cases of known tuberous sclerosis complex and notes that cardiac rhabdomyomas can be detected prenatally or postnatally.(50) **(EG 2)**

For valvular heart disease, evidence demonstrates at least moderate certainty of at least moderate net benefit. **(RG A1)** TTE is used to evaluate possible stenosis, regurgitation, mitral valve prolapse, valvular vegetations, thrombus on an artificial valve, or other valvular structural and functional abnormalities. It is used for patients with valve disease who are experiencing a change in clinical status, for serial monitoring in those with severe stenosis or regurgitation, and following valve repair or replacement.(1)(122)(253)(291)(292) **(EG 2)** Specialty society guidelines recommend that all patients with bicuspid aortic valve have both the ascending aorta and the aortic root evaluated for evidence of dilatation.(27)(122) **(EG 2)** A specialty society guideline recommends that evaluation for bicuspid aortic valve and thoracic aortic disease be performed in first-degree relatives of a patient with bicuspid aortic valve.(27) **(EG 2)** A specialty society guideline states that TTE is indicated for the evaluation of patients with signs or symptoms of aortic valve disease in order to obtain accurate diagnosis of the etiology and severity of regurgitation or stenosis as well as to assess left ventricular size and function. This specialty society guideline also notes that TTE is indicated for the evaluation of patients with mitral stenosis or regurgitation to establish diagnosis, quantify hemodynamic severity, assess other valvular lesions, and define valve morphology.(122) **(EG 2)** Appropriate-use criteria endorsed by multiple specialty societies state that TTE is appropriate for further evaluation of valvular masses, including incidental findings noted on noncardiac imaging studies.(81) **(EG 2)**

For a vascular ring in a child, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** An appropriate-use criteria statement endorsed by multiple specialty societies notes that TTE is appropriate for assessment of pediatric patients when an abnormal barium swallow or bronchoscopy suggests the presence of a vascular ring.(14) **(EG 2)**

Inconclusive or Non-Supportive Evidence

For athletic screening, evidence demonstrates a lack of net benefit; additional research is recommended. **(RG C1)** According to a specialty society scientific statement, echocardiography is not recommended for routine screening of asymptomatic competitive athletes.(10) **(EG 2)**

For perioperative evaluation in low-risk patients, evidence demonstrates a lack of net benefit; additional research is recommended. **(RG C1)** Specialty society guidelines state that the use of TTE is inappropriate for routine ventricular function screening in low-risk patients with no known or suspected cardiovascular disease.(1)(11) **(EG 2)**

For pulmonary embolism diagnosis, evidence is insufficient, conflicting, or poor and demonstrates an incomplete assessment of net benefit vs harm; additional research is recommended. **(RG B)** While TTE is useful for assessing the downstream hemodynamic effects on the heart and great vessels, specialty society statements note that the use of TTE is inappropriate to establish the diagnosis of a suspected pulmonary embolism.(1)(12) **(EG 2)** A systematic review and meta-analysis of 22 studies found a low sensitivity of various signs on TTE (eg, right heart strain, ventricle size ratio, right heart thrombus) for the diagnosis of pulmonary embolism.(13) **(EG 1)**

Rationale

Use of this MCG care guideline helps the clinician determine if a particular treatment, medication, or service might be appropriate for a specific patient, taking into account their unique health complexities.

Use of these evidence-based clinical criteria to support decision making benefits the patient by identifying patient-specific complex clinical factors and conditions, promoting personalized treatment. Utilizing evidence-based clinical criteria promotes patient safety by helping ensure that potential patient benefits outweigh the risks. In addition, the use of evidence-based guidelines can increase consistency in treatment thresholds, leading to less variation in care and promoting equitable treatment among patients.

Related CMS Coverage Guidance

This guideline supplements but does not replace, modify, or supersede existing Medicare regulations or applicable National Coverage Determinations (NCDs) or Local Coverage Determinations (LCDs).

Code of Federal Regulations (CFR): 42 CFR 419.22(308); 42 CFR 422.101(309)

Internet-Only Manual (IOM) Citations: CMS IOM Publication 100-02, Medicare Benefit Policy Manual, Chapter 14 - Medical Devices(310); CMS IOM Publication 100-02, Medicare Benefit Policy Manual, Chapter 15 - Covered Medical and Other Health Services(311); CMS IOM Publication 100-02, Medicare Benefit Policy Manual, Chapter 16 - General Exclusions from Coverage(312)

Medicare Coverage Determinations: Medicare Coverage Database(313)

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Footnotes

[A] Takotsubo cardiomyopathy is an acute reversible form of heart failure precipitated by a physically or emotionally stressful event. It is typically characterized by reversible apical ventricular ballooning, chest pain, ECG abnormalities, and minimal rise of cardiac biomarkers mimicking myocardial infarction without ischemia.(2)(77) [A in Context Link 1]

[B] Fever of unknown origin should first be evaluated with a focused history, physical examination, and targeted laboratory testing, and followed by imaging studies that are guided by suspected organ involvement or diagnostic category. Fevers of unknown origin may have infectious, neoplastic, inflammatory, or other causes. The relative frequencies of the diagnostic categories vary by age; infection is most common in the pediatric population, while inflammatory causes, including temporal arteritis, are most common in the elderly population.(132)(133)(134) [B in Context Link 1]

[C] Patients who are neutropenic, hospitalized, or have HIV may be diagnosed with fever of unknown origin after a 3-day inpatient evaluation for fever.(134) Some pediatric literature defines a fever of unknown origin as a temperature greater than 100.4 degrees F (38.0 degrees C) for greater than 8 days.(135) [C in Context Link 1]

[D] BNP and N-terminal pro-BNP are biomarkers of cardiac function that are released in response to increased wall stress associated with elevated ventricular filling pressures and ventricular volume expansion, as may be seen with reduced left ventricular ejection fraction, left ventricular hypertrophy, acute myocardial infarction, and ischemia.(144)(173) [D in Context Link 1]

[E] Familial dilated cardiomyopathy is most commonly inherited as an autosomal dominant disorder. Clinically affected individuals may present with heart failure or arrhythmias. TTE screening is recommended for all first-degree relatives of individuals with the condition.(156)(160) [E in Context Link 1]

[F] Hypertrophic cardiomyopathy is inherited as an autosomal dominant disorder with variable penetrance.(157) [F in Context Link 1]

[G] The New York Heart Association classifies heart failure severity based on the degree of effort needed to elicit symptoms: rest (class IV), less-than-ordinary exertion (class III), ordinary exertion (class II), or exertion that would limit normal individuals (class I).(144)(173) [G in Context Link 1]

Definitions

Altered mental status

- Altered mental status (ie, different from baseline), as indicated by **1 or more** of the following(1)(2)(3)(4):
  - Confusional state (eg, disorientation, difficulty following commands, deficit in attention)
  - Lethargy (eg, awake or arousable, but with drowsiness; reduced awareness of self and environment)
  - Obtundation (ie, arousable only with strong stimuli, lessened interest in environment, slowed responses to stimulation)
  - Stupor (ie, may be arousable but patient does not return to normal baseline level of awareness)
  - Coma (ie, not arousable)

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Hemodynamic instability

- Hemodynamic instability, as indicated by **1 or more** of the following:
  - Vital sign abnormality not corrected by appropriate treatment, as indicated by **1 or more** of the following[A]:
    - Tachycardia that persists despite appropriate treatment (eg, treatment of underlying cause, despite observation care)[A]
    - Hypotension that persists despite appropriate treatment (eg, treatment of underlying cause, despite observation care)[A]
    - Orthostatic hypotension that persists despite appropriate treatment (eg, treatment of underlying cause, despite observation care)[A]
  - Severe hypotension in adult patient, as indicated by **1 or more** of the following:
    - Systolic blood pressure less than 80 mm Hg(1)[A]
    - Shock index greater than 1.0 (shock index is the heart rate divided by systolic blood pressure)[A](2)(3)(4)
    - Mean arterial pressure[B] less than 65 mm Hg MAP Calculator[A](1)(6)
    - IV inotropic or vasopressor medication required to maintain adequate blood pressure or perfusion(3)(6)
    - Hypoperfusion due to hypotension, as indicated by **ALL** of the following:
      - Hypotension
      - Evidence of hypoperfusion, as indicated by **1 or more** of the following:
        - Lactate of 2.0 mmol/L (18 mg/dL) or more secondary to hypotension (ie, hypoperfusion)[C](3)(6)(8)
        - Metabolic acidosis (arterial or venous[D] pH less than 7.35) not otherwise explained(3)(6)(8)
        - Significant end organ dysfunction due to hypotension (eg, Altered mental status, myocardial ischemia, 2-fold or higher acute increase in serum creatinine)(3)(6)
  - Severe hypotension in pediatric patient, as indicated by **1 or more** of the following:
    - Systolic blood pressure less than 80 mm Hg in child 6 to 17 years of age[A](14)
    - Systolic blood pressure less than 75 mm Hg in child 6 months to 5 years of age[A](14)
    - Shock index greater than 0.9 in child 13 to 17 years of age (shock index is the heart rate divided by systolic blood pressure)[A](2)(15)
    - Shock index greater than 1.0 in child 7 to 12 years of age (shock index is the heart rate divided by systolic blood pressure)[A](2)(15)
    - Shock index greater than 1.2 in child 4 to 6 years of age (shock index is the heart rate divided by systolic blood pressure)[A](2)(15)
    - IV inotropic or vasopressor medication required to maintain adequate blood pressure or perfusion(5)(6)
    - Hypoperfusion due to hypotension, as indicated by **ALL** of the following:
      - Hypotension
      - Evidence of hypoperfusion, as indicated by **1 or more** of the following:
        - Lactate of 2.0 mmol/L (18 mg/dL) or more secondary to hypotension (ie, hypoperfusion)[C](6)(8)
        - Metabolic acidosis (arterial or venous pH less than 7.35) not otherwise explained[D](5)(6)(14)
        - Significant end organ dysfunction due to hypotension (eg, Altered mental status, myocardial ischemia, 2-fold or higher acute increase in serum creatinine)(5)(6)(14)

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Footnotes

A. Criteria based upon clinician-acquired numeric values (eg, vital signs, oxygen saturation) should be used if they are accurate reflections of the patient's condition. Transitory findings (eg, abnormal only upon initial emergency department intake or only one time out of multiple readings) that rapidly improve with no or minimal treatment usually do not reflect disease severity or risk for deterioration. This does not imply that an initial or one-time reading cannot ever be applicable. The goal is to separate erroneous or incidental findings from those that truly represent the patient's clinical picture.

B. The mean arterial pressure (MAP) takes into account both SBP and DBP readings.(3)(5)

C. There are numerous causes of an elevated lactate level. The most common are cardiogenic or hypovolemic shock, severe heart failure, severe trauma, or sepsis. However, there are also other etiologies to consider such as vigorous exercise, seizures, liver disease, or medication use (eg, metformin, beta2-agonists); therefore, interpretation of elevated lactate levels requires consideration of the clinical context (eg, well-appearing post exercise vs hypotensive). The severity and persistence of the elevation can sometimes be helpful in this differentiation. In most instances of lactic acidosis, blood pH is less than 7.35, with a serum bicarbonate level of 20 mEq/L (mmol/L) or lower. However, a coexisting respiratory or metabolic alkalosis can mask these findings.(7)(8)

D. Analyses have concluded that venous and arterial pH measurements are highly correlated, with small differences between them that are usually not clinically significant.(9)(10)(11)(12)(13) If a mixed acid-base disorder is suspected, an arterial blood gas is indicated.(10)

Hypotension

- Hypotension, as indicated by **1 or more** of the following:
  - Hypotension in adult patient, as indicated by **1 or more** of the following:
    - Systolic blood pressure less than 90 mm Hg[A][B](1)
    - Mean arterial pressure[C] less than 70 mm Hg[A][B] MAP Calculator(1)(2)
    - Decrease in baseline systolic blood pressure of 30 mm Hg or more, with significant signs or symptoms due to lower blood pressure (eg, near syncope, syncope, chest pain)[A][B](1)
  - Hypotension in pediatric patient, as indicated by **1 or more** of the following:
    - Systolic blood pressure less than 110 mm Hg in child 13 to 17 years of age[A][D](3)
    - Systolic blood pressure less than 100 mm Hg in child 6 to 12 years of age[A][D](3)
    - Systolic blood pressure less than 95 mm Hg in child 3 to 5 years of age[A][D](3)
    - Systolic blood pressure less than 90 mm Hg in child 1 or 2 years of age[A][D](3)
    - Systolic blood pressure less than 80 mm Hg in infant 6 to 11 months of age[A][D](3)
    - Systolic blood pressure less than 70 mm Hg in infant 3 to 5 months of age[A][D](3)
    - Systolic blood pressure less than 65 mm Hg in infant 1 or 2 months of age[A][D](3)

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Footnotes

A. Criteria based upon clinician-acquired numeric values (eg, vital signs, oxygen saturation) should be used if they are accurate reflections of the patient's condition. Transitory findings (eg, abnormal only upon initial emergency department intake or only one time out of multiple readings) that rapidly improve with no or minimal treatment usually do not reflect disease severity or risk for deterioration. This does not imply that an initial or one-time reading cannot ever be applicable. The goal is to separate erroneous or incidental findings from those that truly represent the patient's clinical picture.

B. Interpretation of blood pressure requires clinical judgment and consideration of several patient-specific factors, such as the patient's baseline blood pressure, medications, and clinical impact. For example, an elderly patient with heart failure may be prescribed medication with the intentional goal of a reduced pressure. If the patient's baseline SBP is 92 mm Hg to 96 mm Hg, absent signs or symptoms of hypotension, an emergency department SBP of 86 mm Hg should not automatically be categorized as hypotensive. This would hold for mean arterial pressure (MAP) as well. The numeric values included in this definition are provided to allow for consistency in terms of a technical definition of the term hypotension. Whether a blood pressure below the technical threshold is clinically meaningful is a matter of persistence, context, and clinical judgment.

C. The mean arterial pressure (MAP) takes into account both SBP and DBP readings.

D. Interpretation of blood pressure requires clinical judgment and consideration of several patient-specific factors, such as the patient's baseline blood pressure, medications, and clinical impact. The numeric values included in this definition are provided to allow for consistency in terms of a technical definition of the term hypotension. Whether a blood pressure below the technical threshold is clinically meaningful is a matter of persistence, context, and clinical judgment.

Orthostatic hypotension

- Orthostatic hypotension,[A][B] as indicated by **1 or more** of the following(1)(2)(3):
  - Fall in SBP of 20 mm Hg or more 1 to 3 minutes after patient sits or stands from recumbent position
  - Fall in DBP of 10 mm Hg or more 1 to 3 minutes after patient sits or stands from recumbent position

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Footnotes

A. Concomitant measurements of the heart rate are important to measure to help diagnose subtypes of orthostatic hypotension (eg, the lack of a compensatory increase in heart rate is typical of autonomic failure and an exaggerated tachycardia may be reflective of volume depletion). However, the heart rate is not a component of the definition of orthostatic hypotension, which relies upon blood pressure alone.(1)(2)(3)

B. Criteria based upon clinician acquired numeric values (eg, vital signs, oxygen saturation) should be used if they are accurate reflections of the patient's condition. Transitory findings (eg, abnormal only upon initial emergency department intake or only one time out of multiple readings) that rapidly improve with no or minimal treatment usually do not reflect disease severity or risk for deterioration. This does not imply that an initial or one-time reading cannot ever be applicable. The goal is to separate erroneous or incidental findings from those that truly represent the patient's clinical picture.

Tachycardia

- Tachycardia,[A][B] as indicated by **1 or more** of the following:
  - Heart rate greater than 100 beats per minute in adult[A][B](1)
  - Heart rate greater than 85 beats per minute in child 13 to 17 years of age[A][C](2)
  - Heart rate greater than 95 beats per minute in child 6 to 12 years of age[A][C](2)
  - Heart rate greater than 110 beats per minute in child 1 to 5 years of age[A][C](2)
  - Heart rate greater than 120 beats per minute in infant 3 to 11 months of age[A][C](2)
  - Heart rate greater than 150 beats per minute in infant 1 or 2 months of age[A][C](2)

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Footnotes

A. Criteria based upon clinician acquired numeric values (eg, vital signs, oxygen saturation) should be used if they are accurate reflections of the patient's condition. Transitory findings (eg, abnormal only upon initial emergency department intake or only one time out of multiple readings) that rapidly improve with no or minimal treatment usually do not reflect disease severity or risk for deterioration. This does not imply that an initial or one-time reading cannot ever be applicable. The goal is to separate erroneous or incidental findings from those that truly represent the patient's clinical picture.

B. Interpretation of heart rate requires clinical judgment and consideration of several patient-specific factors, such as the patient's baseline heart rate, medications, and clinical impact. For example, an elderly patient on a beta-blocker medication with a baseline resting heart rate of 60 beats per minute may be clinically tachycardic at a heart rate of 94 beats per minute. Likewise, a patient who is upset, in pain, or nervous in the emergency department with a heart rate of 106 beats per minute may meet the technical definition of tachycardia, but this tachycardia (absent associated findings such as chest pain or hypotension) may not be clinically important. The numeric values included in this definition are provided to allow for consistency in terms of a technical definition of the term tachycardia. Whether a heart rate above or below the technical threshold is clinically meaningful is a matter of persistence, context, and clinical judgment.
C. Interpretation of heart rate requires clinical judgment and consideration of several patient-specific factors, such as the patient's baseline heart rate, medications, and clinical impact. A patient who is upset, in pain, or nervous in the emergency department with an elevated heart rate may meet the technical definition of tachycardia, but this tachycardia (absent associated findings such as hypotension) may not be clinically important. The numeric values included in this definition are provided to allow for consistency in terms of a technical definition of the term tachycardia. Whether a heart rate above or below the technical threshold is clinically meaningful is a matter of persistence, context, and clinical judgment.

Codes

CPT®: 0439T, 93303, 93304, 93306, 93307, 93308, 93319, 93320, 93321, 93325, 93356

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