AmeriHealth Caritas Louisiana

National Imaging Associates, Inc.*	
Clinical guideline **CT HEART** **CT HEART Congenital** **(Not including coronary arteries)**	**Original Date: September 1997**
CPT Codes: 75572, 75573	**Last Revised Date: March 2020**
Guideline Number: NIA_CG_025	**Implementation Date: ~~January 2021~~TBD**

GENERAL INFORMATION

It is an expectation that all patients receive care/services from a licensed clinician. All appropriate supporting documentation, including recent pertinent office visit notes, laboratory data, and results of any special testing must be provided. All prior relevant imaging results, and the reason that alternative imaging cannot be performed must be included in the documentation submitted.

INDICATIONS FOR HEART COMPUTED TOMOGRAPHY (CT)

(Douglas, 2011~~;~~; Taylor, 2010)

Congenital Heart Disease (Sachdeva, 2020)

~~When transthoracic echocardiography (TTE) and/or transesophageal echocardiography (TEE) have been done or are expected to be insufficient for clinical management in complex congenital heart disease, cardiac magnetic resonance imaging (CMR) or computed tomography (CT) may be required~~

For all indications below, either CT or CMR can be done:

- All **congenital lesions**~~defects~~: ~~E~~evaluation prior to planned repair and ~~evaluation~~ for change in clinical status and/or new concerning signs or symptoms
- Patent Ductus Arteriosus: routine surveillance (1-2 years) in a patient with postprocedural aortic obstruction
- Aortic Stenosis or Regurgitation: routine surveillance (6-12 months) in a child with aortic sinus and/or ascending aortic dilation with increasing **size**~~z-scores~~

* National Imaging Associates, Inc. (NIA) is a subsidiary of Magellan Healthcare, Inc.

- Aortic Coarctation and Interrupted Aortic Arch:
    - Routine surveillance (3–5 years) in a child or adult with mild aortic coarctation
    - Post procedure (surgical or catheter-based) routine surveillance (3–5 years) in an asymptomatic patient to evaluate for aortic arch aneurysms, in-stent stenosis, stent fracture, or endoleak
- ~~Tetralogy of Fallot:~~
-
    - **Routine surveillance (2–3 years) in a patient with valvular or ventricular dysfunction, right ventricular outflow tract obstruction, branch pulmonary artery stenosis, arrhythmias, or presence of an RV-to-PA conduit**
        - ~~Routine surveillance (2–3 years) in a patient with valvular or ventricular dysfunction, right ventricular outflow tract~~RVOT ~~obstruction, branch pulmonary artery stenosis, arrhythmias, or presence of an RV-to-PA conduit~~
- D-Loop Transposition of the Great Arteries (postoperative):
    - Routine surveillance (3–5 years) in an asymptomatic patient
    - Routine surveillance (1–2 years) in a patient with dilated ~~neo~~aortic root **w**~~w~~ith
        - increasing **size**~~Z scores~~, or ~~neo~~aortic regurgitation
    - Routine surveillance (3–12 months) in a patient with ≥moderate systemic AV
        - valve regurgitation, systemic RV dysfunction, LVOT obstruction, or arrhythmias
- Congenitally Corrected Transposition of the Great Arteries:
    - Unrepaired: routine surveillance (3–5 years) in an asymptomatic patient
    - Postoperative: routine surveillance (3–5 years) in an asymptomatic patient
    - Postoperative anatomic repair: routine surveillance (6–12 months) in a patient with valvular or ventricular dysfunction, right or left ventricular outflow tract obstruction, or presence of an RV-to-PA conduit
    - Postoperative physiological repair with VSD closure and/or LV-to-PA conduit: routine surveillance (3–12 months) in a patient with ≥moderate systemic AV valve regurgitation, systemic RV dysfunction, and/or LV-to-PA conduit dysfunction
- Truncus Arteriosus: routine surveillance (1–2 years) in an asymptomatic child or adult with ≥ moderate truncal stenosis and/or regurgitation
- Single-Ventricle Heart Disease: postoperative routine surveillance (3–5 years) in an asymptomatic patient

Cardiomyopathy

- Quantification of myocardial (muscle) mass (CMR or CT)
- Assessment of right ventricular morphology in suspected arrhythmogenic right ventricular cardiomyopathy, based upon other findings such as:
    - Nonsustained VT
    - Unexplained syncope

- ECG abnormalities
- First degree relative with positive genotype of ARVC (either, but CMR is superior to CT) (Marcus, 2010; te Riele, 2015)

~~Left Ventricular Function Assessment~~
~~Left ventricular systolic dysfunction in the absence of severe valvular disease, when TTE and MUGA are inadequate (Fihn 2012, Patel 2013)~~
Infective Endocarditis

Valvular Heart Disease

- Characterization of native or prosthetic valves with clinical signs or symptoms suggesting valve dysfunction, when TTE, TEE, and/or fluoroscopy have been inadequate (Doherty, 2017)
- Evaluation of RV function in severe TR, including systolic and diastolic volumes, when TTE images are inadequate and CMR is not readily available
- Pulmonary hypertension in the absence of severe valvular disease
- Evaluation of suspected infective endocarditis with moderate to high pretest probability (i.e. staph bacteremia, fungemia, prosthetic heart valve, or intracardiac device), when TTE and TEE have been inadequate.
- Evaluation of suspected paravalvular infections when the anatomy cannot be clearly delineated by TTE and TEE (Nishimura, 2014)
- ~~Patients with bicuspid aortic valve and aortic dilation > 4.0 cm require annual imaging with CT, MRI, or echocardiography. Echocardiography is required when it can evaluate the full extent of pathology under surveillance. This would increase to biannual (twice-yearly) imaging in the event of any one of the additional conditions: diameter > 4.5 cm, rapid rate of change 0.5 cm/yr, or a family history of a first degree relative with aortic dissection. Initial imaging with first 6-month re-evaluation for rate of expansion is appropriate.~~

Evaluation of Intra- and Extra-cardiac Structures

- Evaluation of cardiac mass, suspected tumor or thrombus, or cardiac source of emboli, when imaging with TTE and TEE have been inadequate
- Re-evaluation of prior findings for interval change (i.e. reduction or resolution of atrial thrombus after anticoagulation), when a change in therapy is anticipated (Baumgartner, -2017; Doherty, 2017; Nishimura, 2014)
- Evaluation of pericardial anatomy, when TTE and/or TEE are inadequate or for better tissue characterization of a mass and detection of metastasis [CMR superior for physiologic assessment (constrictive versus restrictive) and tissue characterization, CT superior for calcium assessment] (Klein, 2013; Pennell, 2010)

Electrophysiologic Procedure Planning (Taylor, 2010)

- Evaluation of pulmonary venous anatomy prior to radiofrequency ablation of atrial fibrillation and for follow up when needed for evaluation of pulmonary vein stenosis ~~(Niinuma 2008, Ohana 2015, Raijah 2013, Schoenhagen 2010, Wai-ee 2012)~~
- Non-invasive coronary vein mapping prior to placement of biventricular pacing leads ~~(Heydari 2012, Raijah 2013, Van de Veire 2006)~~
- ~~Evaluation of suspected post-ablation pulmonary vein stenosis~~

Transcatheter Structural Intervention Planning

- Evaluation for transcatheter aortic valve replacement (TAVR) (Doherty, 2017~~;~~ Otto, 2017~~;~~ ~~Raijah 2013;~~ Schoenhagen, 2010)
- When TTE and TEE cannot provide adequate imaging, CT imaging can be used for planning: robotic mitral valve repair, atrial septal defect closure, left atrial appendage closure, ventricular septal defect closure, endovascular grafts, and percutaneous pulmonic valve implantation (~~Flachskampf 2014,~~ Pison, 2015~~;~~ ~~Raijah 2013,~~ Schoenhagen, 2010)
- Evaluation for suitability of transcatheter mitral valve procedures, alone or in addition to TEE (Wunderlich, 2018)

Aortic Pathology (Baumgartner, 2014~~;~~ Bhave, 2018~~;~~ Doherty, 2017, ~~Doherty~~ 2018~~;~~ Erbel 2014~~;~~ Hendel 2006~~;~~ Hiratzka 2010~~;~~ Nishimura 2014~~;~~ Svensson 2013)~~.~~

~~TTE is recommended when it can evaluate the full extent of pathology under surveillance.~~

- CT, MR, or echo can be used for screening and follow up, with CT and MR preferred for imaging beyond the proximal ascending thoracic aorta (see table below for top normal sizes) in the following scenarios:
    - Evaluation of dilated aortic sinuses or ascending aorta identified by TTE
    - Suspected acute aortic pathology, such as dissection
      Re-evaluation of known aortic dilation or aortic dissection with a change in clinical status or cardiac examination or when findings would alter management
    - Screening first degree relatives of individuals with a history of thoracic aortic aneurysm (defined as ≥ 50% above top normal) or dissection, or an associated high-risk mutation for thoracic aneurysm in common
    - Screening second degree relative of a patient with thoracic aortic aneurysm (defined as ≥ 50% above top normal), when the first degree relative has aortic dilation, aneurysm, or dissection
    - Six-month follow up after initial finding of a dilated thoracic aorta, for assessment of rate of change
    - Annual follow up of enlarged thoracic aorta that is above top normal for age, gender, and size up to 4.4 cm.
    - Biannual (twice/yr) follow up of enlarged aortic root ≥ 4.5 cm (> 4.5 cm for bicuspid aortic valve) or showing growth rate ≥ 0.5 cm/year
    - ~~Adapted from Wolak 2008, Cikach 2018.~~

- Patients with Marfan's syndrome **may undergo**~~require~~ annual imaging with CT, MRI or TTE, with increase to biannual (twice-yearly) when diameter ≥ 4.5 cm or when expansions is > 0.5 cm /yr
- Patient with Turner's syndrome patients should undergo initial imaging with CT, MRI, or TTE for evidence of dilatation of the ascending thoracic aorta. If imaging is normal and there are no risk factors for aortic dissection, repeat imaging should be performed every 5 - 10 years, or if otherwise indicated. If the aorta is enlarged, appropriate follow up imaging should be done according to size, as above.
- Evaluation of the aorta in the setting of a known or suspected connective tissue disease or genetic condition that predisposes to aortic aneurysm or dissection (i.e. Loeys-Dietz, Ehlers-Danlos), with re-evaluation at 6 months for rate of expansion. Complete evaluation with CMR from the cerebrovascular circulation to the pelvis is recommended with Loeys-Dietz syndrome.
-

BACKGROUND:

Table 17. Suggested Follow-Up of Aortic Pathologies After Repair or Treatment

Pathology	Interval	Study
Acute dissection	Before discharge, 1 mo, 6 mo, yearly	CT or MR, chest plus abdomen TTE
Chronic dissection	Before discharge, 1 y, 2 to 3 y	CT or MR, chest plus abdomen TTE
Aortic root repair	Before discharge, yearly	TTE
AVR plus ascending	Before discharge, yearly	TTE
Aortic arch	Before discharge, 1 y, 2 to 3 y	CT or MR, chest plus abdomen
Thoracic aortic stent	Before discharge, 1 mo, 2 mo, 6 mo, yearly Or 30 days*	CXR, CT, chest plus abdomen
Acute IMH/PAU	Before discharge, 1 mo, 3 mo, 6 mo, yearly	CT or MR, chest plus abdomen

*US Food and Drug Administration stent graft studies usually required before discharge or at 30-day CT scan to detect endovascular leaks. If there is concern about a leak, a predischarge study is recommended; however, the risk of renal injury should be borne in mind. All patients should be receiving beta blockers after surgery or medically managed aortic dissection, if tolerated. Adapted from Erbel et al (539).

AVR indicates aortic valve replacement; CT, computed tomographic imaging; CXR, chest x-ray; IMH, intramural hematoma; MR, magnetic resonance imaging; PAU, penetrating atherosclerotic ulcer; and TTE, transthoracic echocardiography.

~~Adapted from Hiratzka, 2010~~

~~BACKGROUND:~~

- Cardiac computed tomography (Heart CT) images the cardiac chambers, great vessels, valves, myocardium and pericardium to assess cardiac structure and function, particularly when echocardiography (transthoracic echocardiography and transesophageal echocardiography) cannot provide adequate information
- CT imaging can be used for assessment of:
  - Structures of the heart (chambers, valves, great vessels, masses, etc.), as in this guideline
  - ~~The coronary circulation, as in the separate coronary computed tomography angiography (CCTA) guideline~~
  - Quantitative level of calcium in the walls of the coronary arteries, in the separate coronary artery calcium (CAC) scoring guideline

~~Some scenarios might provide more detail with low dose CT than with CMR, thereby overriding the radiation risk (Ohana 2015, Schoenhagen 2005)~~

OVERVIEW

(~~Raijah 2013, Schoenhagen 2005,~~ Taylor, 2010)

Imaging in Congenital Heart Disease

Echocardiography **is often utilized** ~~remains the best test~~ for initial assessment of congenital heart disease. However, if findings are unclear or need confirmation, CMR or CT can be useful. ~~CT and CMR provide 3D anatomic relationship of the blood vessels and cardiac anatomic~~ structures (Sachdeva, 2020)

CT and Cardiac Masses

CT and CMR are used to evaluate cardiac masses, describing their size, density, tissue characteristics, and spatial relationship to adjacent structures. ~~Cardiac myxoma is the most common type of primary heart tumor in adults and usually develops in the left atrium. Echocardiography is typically the first method for evaluation of cardiac myxoma. CT and CMR can provide adjunctive information on myxomas when necessary (Kassop 2014).~~

CT and Pericardial Disease

While echocardiography is most often used in the initial examination of pericardial disease, CT and CMR can evaluate pericardial thickening and masses which are often detected initially with echocardiography. CT and CMR can accurately define the site and extent of masses, e.g., cysts, hematomas and neoplasms (Klein, 2013).

Abbreviations

ARVD/C	Arrhythmogenic right ventricular dysplasia/ cardiomyopathy
CABG	Coronary artery bypass grafting surgery
CAD	Coronary artery disease
CCS	Coronary calcium score
CCT	Cardiac (heart) CT
CHD	Coronary heart disease
CMR	Cardiac magnetic resonance (imaging)
CT	Computed tomography
CTA	Computed tomography angiography
ECG	Electrocardiogram
EF	Ejection fraction
HF	Heart failure
MI	Myocardial infarction
MPI	Myocardial perfusion Imaging or cardiac nuclear imaging
MR(I)	Magnetic resonance (imaging)
PCI	Percutaneous coronary intervention
PVML	Paravalvular mitral leak
RV	Right ventricle
SE	Stress Echocardiogram
TAVR	Transcatheter Aortic Valve Replacement
TMVR	Transcatheter mitral valve replacement
TR	Tricuspid regurgitation
TTE	Transthoracic echocardiography

POLICY HISTORY:
Review Date: July 22, 2019
Review Summary:

- Added the following indication: Evaluation of anomalous thoracic arteriovenous vessels, such as transposition of the great arteries, when magnetic resonance imaging (MRI) cannot be performed
- For valvular heart disease added indication for pulmonary hypertension in the absence of severe valvular disease
- Removed indication: to assess degree of calcification in calcific aortic stenosis
- For evaluation of intra- and extra-cardiac structures, the following indication was added: Re-evaluation of prior findings for interval change (i.e. reduction or resolution of atrial thrombus after anticoagulation), when a change in therapy is anticipated
- Removed section: scenarios in which heart CT is not indicated
- Removed statement: CT imaging is competitive with MRI, but left in table in comparing two modalities (removed cost comparison)

Review Date: March 2020
Review Summary:

- Added general information section as Introduction **which outlines requirements for documentation of pertinent office notes by a licensed clinician, and inclusion of laboratory testing and relevant imaging results for case review**
- **Extensive update to the indications for Congenital Heart Disease to include the following:**
  - **For all indications noted, either CT or CMR can be done**
  - **All lesions: evaluation prior to planned repair and evaluation for change in clinical status and/or new concerning signs or symptoms**
  - **Specific indications based on lesion were added with interval and criteria for repeat imaging included**
- **Added separate section for infective endocarditis**
- **Removed tables of aortic diameter norms and suggested follow-up imaging**
- ~~Added comprehensive updated indications for congenital heart disease~~
- ~~Removed references related to aortic pathology~~
- **Edits to background with removal of table outlining radiation exposure and comment**
- **Edits to overview included, with removal of the following:**
  - **CT and CMR provide 3D anatomic relationship of the blood vessels and cardiac anatomic structures**
  - **Discussion of cardiac myxoma**
- Updated and added new references
- ~~**Updated and added new references**~~

REFERENCES

Baumgartner H, Falk V, Bax JJ et al. 2017 ESC/EACTS guidelines for the management of valvular heart disease, The Task Force for the Management of Valvular Heart Disease of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS). *Eur~~opean~~ Heart J~~ournal~~.* 2017; 38:2739–2791.

Bhave NM, Nienaber CA, Clough RE, et al. Multimodality imaging of thoracic aortic diseases in adults. *J Am Coll Cardiol Cardiovascular Imaging*. 2018; 11(6): 903-919.

~~Cikach F, Desai MY, Roselli EE, et al. Thoracic aortic aneurysm: How to counsel, when to refer. *Cleveland Clinic Journal of Medicine*. 2018; 85(6):4810492. Available at: https://www.mdedge.com/sites/default/files/Document/May-2018/cikach_thoracicaorticaneurysm_0.pdf~~

Cohen MS, Eidem BW, Cetta F, et al. Multimodality imaging guidelines of patients with transposition of the great arteries: A report from the American Society of Echocardiography Developed in Collaboration with the Society for Cardiovascular Magnetic Resonance and the Society of Cardiovascular Computed Tomography. *J Am Soc Echocardiogr.* 2016; 29(7):571-621.

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****~~JACC~~.* 2017; 70(13): 1647-1672.

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. ***J Am Coll Cardiol****~~JACC~~.* 2011; 57(9):1126-66.

Erbel R. 2014 ESC Guidelines on the diagnosis and treatment of aortic diseases. *Eur~~opean~~ Heart J~~ournal~~*. 2014; 35(41):2873–2926. Available at: https://academic.oup.com/eurheartj/article/35/41/2873/407693

Fihn SD, Gardin JM, Abrams J, et al. 2012 ACCF/AHA/ACP/AATS/PCNA/SCAI/STS Guideline for the diagnosis and management of patients with stable ischemic heart disease: A report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines, and the American College of Physicians, American Association for Thoracic Surgery, Preventive Cardiovascular Nurses Association, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. *Circulation.* 2012; 126(25):e354-471.

~~Flachskampf FA, Wouter PF, Edvardsen T, et al. Recommendations for transoesophageal echocardiography: EACVI update 2014. *European Heart Journal – Cardiovascular Imaging.* 2014; 15:353-365.~~

~~Heydari B, Jerosch-Herold M, Kwong. Imaging for planning of cardiac resynchronization therapy. *JACC Cardiovascular Imaging.* 2012; 5(1): 93-110. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4382349/pdf/nihms-561020.pdf~~

Hiratzka LF, Creager MA, Isselbacher EM, et al. Surgery for aortic dilatation in patients with bicuspid aortic valves: A statement of clarification from the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. ***J Am Coll Cardiol****~~JACC~~.* 2016; 67(6):724-731.

Hirshfeld JW, Ferrari VA, Bengel FM, et al. 2018 ACC/HRS/NASCI/SCAI/SCCT Expert consensus document on optimal use of ionizing radiation in cardiovascular imaging: Best practices for safety and effectiveness: A report of the American College of Cardiology Task Force on Expert Consensus Decision Pathways Developed in Collaboration with Mended Hearts. ***J Am Coll Cardiol****~~JACC,~~.* 2018; 92(2):203-221.

Klein AL, Abbara S, Agler DA, et al. American Society of Echocardiography clinical recommendations for multimodality cardiovascular imaging of patients with pericardial disease: endorsed by the Society for Cardiovascular Magnetic Resonance and Society of Cardiovascular Computed Tomography. *J Am Soc Echocardiogr.* 2013; 26:965–1012.

Marcus FI, Sherrill D, et al. Diagnosis of arrhythmogenic right ventricular cardiomyopathy/dysplasia: proposed modification of the task force criteria. *Circulation.* 2010; 121(13):1533-1541.

~~Niinuma H, George R, Armin A, et al. Imaging of pulmonary veins during catheter ablation for atrial fibrillation: The role of multi-slice computed tomography. *Europace*. 2008; 10:iii14-iii21.~~

Nishimura RA, Otto CM, Bonow RO, et al. 2014 AHA/ACC Guideline for the management of patients with valvular heart disease: A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. ~~*JACC.*~~ ***J Am Coll Cardiol.*** 2014; 63(22):e57-e185.

~~Ohana M, Bakouboula B, Labani A, et al. Imaging before and after catheter ablation of atrial fibrillation. *Diagnostic and Interventional Imaging*.2015; 96:1113-1123. Available at: https://ac.els-cdn.com/S2211568415001734/1-s2.0-S2211568415001734-main.pdf?_tid=f89a367c-7c47-4066-9b2b-a55ec3dae7dd&acdnat=1525713586_4846a92586b60ba24ee857f33f7e5258~~

Otto CM., Kumbhani DJ., Alexander KP., et al. ACC Expert consensus decision pathway for transcatheter aortic valve replacement in the management of adults with aortic stenosis: A report of the American College of Cardiology Task Force on Clinical Expert Consensus Document. ***J Am Coll Cardiol***~~*JACC*~~. 2017;69(10):1313 - 1346.

Patel MR, White RD, Abbara S, et al. 2013 ACCF/ACR/ASE/ASNC/SCCT/SCMR Appropriate utilization of cardiovascular imaging in heart failure: A joint report of the American College of Radiology Appropriateness Criteria Committee and the American College of Cardiology Foundation Appropriate Use Criteria Task Force. ***J Am Coll Cardiol***~~*JACC*~~. 2013; 61(21): 2207-2231.

Pennell DJ. Contemporary reviews in cardiovascular medicine, cardiovascular magnetic resonance. *Circulation.* 2010; 121:692-705.

Pison L, Potpara TS, Chen J, et al. Left atrial appendage closure – indications, techniques, and outcomes: Results of the European Heart Rhythm Association Survey. *Europace*. 2015; 17:642-646.

~~Raijah, P, Schoenhagen, P. The role of computed tomography in pre-procedural planning of cardiovascular surgery and intervention. *Insight Imaging.* 2013; 4(5):671-689. Available at: https://link.springer.com/article/10.1007%2Fs13244-013-0270-8~~

Schoenhagen ~~-~~P, Numburi U, Halliburton SS, et al. Three-dimensional imaging in the context of minimally invasive and transcatheter cardiovascular interventions using multi-detector computed tomography: From pre-operative planning to intra-operative guidance. *Eur~~*opean*~~ Heart J~~*ournal*~~*. 2010; 31:2727–2741.

~~Schoenhagen P, Halliburton S, Stillman, A, et al. CT of the heart: principles, advances, clinical uses. *Cleveland Clinic Journal of Medicine*. 2005; 72(2):127-38. Available at: https://www.researchgate.net/publication/7977576_CT_of_the_heart_Principles_advances_cli~~

nical_uses

Steiner J, Rodes-Cabau J, Holmes D, et al. Mechanical intervention for aortic valve stenosis in patients with heart failure and Reduced Ejection Fraction. JACC. 2017; 70(24): 3026-3041. Available at: http://www.onlinejacc.org/content/70/24/3026

Svensson LG. Aortic valve and ascending aorta guidelines for management and quality measures. *Ann Thorac Surg*. 2013; 95:1-66. Available at: http://www.sts.org/sites/default/files/documents/AorticValveandAscendingAortaGuidelinesforManagementandQualityMeasures.pdf

Taylor AJ, Cerqueira MC, Hodgson JM, et al. ACCF/SCCT/ACR/AHA/ASE/ASNC/NASCI/SCAI/SCMR 2010 Appropriate use criteria for cardiac computed tomography*:* A report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, the Society of Cardiovascular Computed Tomography, the American College of Radiology, the American Heart Association, the American Society of Echocardiography, the American Society of Nuclear Cardiology, the North American Society for Cardiovascular Imaging, the Society for Cardiovascular Angiography and Interventions, and the Society for Cardiovascular Magnetic Resonance. ***J Am Coll Cardiol****JACC*. 2010; 56(22): 1864-1894.

te Riele ASJM, Tandri H, Saborn DM, et al. Non-invasive multimodality imaging in ARVD/C**.** ***J Am Coll Cardiol****JACC*. 2015; 8(5):597-611.

Van de Veire NR, Schuijf JD, De Sutter J, et al. Non-invasive visualization of the cardiac venous system in coronary artery disease patients using 64-slice computed tomography. *JACC.* 2006; 48(9):1832-38. Available at: https://ac.els-cdn.com/S0735109706019954/1-s2.0-S0735109706019954-main.pdf?_tid=ce7cf6f0-f954-49df-8fdc-7724ed94e45b&acdnat=1525724110_9d363a4a1db787c750e7805744ee5226

Wai-ee T, Wai B, Kaity L, et al. Pulmonary venous anatomy imaging with low-dose, prospectively ECG-triggered, high-pitch 128 slice dual-source computed tomography. *Circ Arrhythm Electrophysiol*. 2012; 5(3):521-30. Available at: http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=8&cad=rja&uact=8&ved=0ahUKEwjLorfmiPTaAhVCheAKHaCsBpcQFghbMAc&url=http%3A%2F%2Fcircep.ahajournals.org%2Fcontent%2F5%2F3%2F521.full.pdf%3Fdownload%3Dtrue&usg=AOvVaw392T_DTAtAUtMmYOAqn8Vu

Wolak A, Gransar H, Thomson LE, et al. Aortic size assessment by noncontrast cardiac computed tomography: normal limits by age, gender, and body surface area. *J Am Coll Cardiol Cardiovasc Imaging* 2008; 1(2):200–209.

Wunderlich NC, Beigel R, Ho SY, et al. Imaging for mitral interventions, methods and efficacy**.** ***J Am Coll Cardiol*** ~~*JACC*~~ *Cardiovascular Imaging*. 2018; 11(6):872-901.

Reviewed / Approved by Rosalind C. Watman D.O. **Rosalind C. Watman, D.O., Medical Director, Cardiology**

~~Reviewed / Approved by~~ ~~Patrick Browning, VP, Medical Director~~