SE 03 CV-01

2017 multimodality appropriate use criteria on noninvasive cardiac imaging: expert consensus of the Asian Society of Cardiac Imaging

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In 2010, the ASCI provided recommendations for cardiac CT and MRI. This document reflects an updating of the prior 2010 ASCI appropriate use criteria (AUC). In 2016, the ASCI formed a new working group for revision of AUC on noninvasive cardiac imaging. A major change that we made in this document is the rating of various noninvasive tests (exercise electrocardiogram, echocardiography, positron emission tomography, single-photon emission computed tomography, radionuclide imaging, cardiac magnetic resonance, cardiac computed tomography/angiography), compared side by side for their applications in various clinical scenarios. Ninety-five clinical scenarios were developed from the selected eight pre-existing guidelines and classified into four sections as follows: 1) detection of coronary artery disease-symptomatic or asymptomatic, 2) cardiac evaluation in various clinical scenarios, 3) use of imaging modality according to prior testing, and 4) evaluation of cardiac structure and function. Ninety-five clinical scenarios were scored by a separate rating committee on a scale of 1-9 to designate appropriate, uncertain, or inappropriate according to modified Delphi method.

Overall, the AUC ratings for CT were higher than those of previous guidelines. These new AUC are intended to provide guidance for clinicians when it comes to making a reasonable testing choice among the available testing modalities for various cardiac diseases. These new AUC are also unique as most AUC for noninvasive imaging include only one imaging technique. As cardiac imaging is multimodality in nature we believe that these AUC can be more useful in clinical practice decision making.

SE 03 CV-02

A rare cardiac involvement: hepatocellular carcinoma

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A 67-year-old man with chronic hepatitis B and right lobe hepatocellular carcinoma (HCC) had received 3 sessions of transcatheter arterial chemoembolization for unresectable tumor 3 years before this admission. He had mistreated from progressive dyspnea in the past 2 months, with continual episodes of near syncope and atypical chest pain. Physical examination revealed lower extremities edema, mild respiratory distress, with 28 breaths/min, and a grade 3/6 systolic murmur was audible over the left lower sternal border. His pulse rate was 124 beats/min, blood pressure was 90/50 mmHg, and oxygen saturation was 85% while he was breathing ambient air. Cardiac computed tomography (CT) was performed. CT revealed a mass in the wall of the right cardiac ventricle (Fig. 1, arrows). Partial resection of the tumor was performed. HCC was identified via pathological examination. He was treated with chemotherapy. Clinical symptoms reduced after treatment.
SE 03 CV-03
Cardiac hydatid cyst presenting as acute myocardial infarction
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A 33-year-old male presented to the cardiology clinic with complaints of intermittent atypical chest pain, mimicking acute myocardial infarction. An electrocardiography revealed non-specific T wave changes, whereas physical examination was unremarkable. Transthoracic echocardiography showed the cystic structure with compressing the left cardiac ventricle. Cardiac magnetic resonance imaging (MRI) was performed. MRI showed left ventricular myocardial cyst that was hyperintense T2-weighted (T2W) images, and it wasn’t enhanced after contrast administration (Fig. 1). The blood level of Echinococcus IgG by ELISA was 158 RU/mL, which was considered as a positive serologic test for Echinococcus infection. According to radiological and laboratory findings, the lesions were evaluated Echinococcosis involvement of the ventricular. The patient underwent surgical treatment. Lesion was identified as a hydatid cyst via pathological examination. Therefore, albendazole therapy was introduced. Hydatid cyst is a parasitic infection caused by larvae of Echinococcus granulosus. Hydatid infections can be located in various tissues, although they are most common in the lung and the liver. Cardiac involvement in hydatid cyst is rare.

SE 03 CV-04
The correlation of epicardial adipose tissue by echocardiography to acute coronary syndrome
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PURPOSE: To describe an echocardiography protocol optimized for correlation of epicardial adipose tissue and acute coronary syndrome.

MATERIALS AND METHODS: One hundred and sixty patients (M:F = 135:25; mean age, 54.94 ± 8.87, respectively) admitted for coronary angiogram underwent assessment of epicardial adipose tissue thickness by echocardiography. Epicardial adipose tissue thickness was measured on the free wall of right ventricle in parasternal long-and short-axis views at end-systole for 3 cardiac cycles. Subjects were segregated into the acute coronary syndrome group and control group.

RESULTS: Mean epicardial adipose tissue thickness was higher in patients with acute coronary syndrome than in the control group (5.46 ± 0.70 vs. 3.02 ± 0.68 mm, p < 0.001). Epicardial adipose tissue thickness was larger in patients with myocardial infarction than in patients with unstable angina (5.59 ± 0.72 vs. 5.14 ± 0.56, p < 0.005). EF was lower in patients myocardial infarction than in patients with unstable angina (53.4 ± 8.07 vs. 58.5 ± 6.57, p < 0.006).

CONCLUSION: Increased epicardial adipose tissue is strongly associated with acute coronary syndrome. Mean epicardial adipose tissue thickness was higher in patients with myocardial infarction than in patients with unstable angina.

SE 03 CV-05
Arterial tortuosity syndrome in a Korean adult patient
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INTRODUCTION: Arterial tortuosity syndrome (ATS) is an uncommon congenital connective tissue disorder with autosomal recessive inheritance. The most specific features are elongation, tortuosity, aneurysm, and stenosis formation of the major arteries including aorta. Skin hyperextensibility, cutis laxa, joint laxity, and inguinal hernias can also be observed.

MATERIALS AND METHODS: A 57-year-old man presented with chest pain. The cardiologist attempted to perform invasive coronary angiography but his iliac and radial arteries were too tortuous to perform. So we took CT scan of the patient from carotid artery to iliac artery. CTA shows generalized tortuosity and lengthening of all his major arteries-the carotid arteries, the aorta from the arch to the bifurcation, and the iliac, splenic,
hepatic, renal, brachial and radial arteries. Imaging of the aorta and the aortic side-branches was performed by ultrasonography and CTA. Cytochemical studies excluded Marfan syndrome, Ehlers-Danlos type IV and type VII syndrome. We review 13 previously described reports.

RESULTS:

Fig. 1. Aorta CT angiography showing tortuosity of splenic and both iliac arteries in the LPO projection. The thoracic aorta is slightly serpentine and shows an aneurysm.

Fig. 2. Neck CT angiography showing tortuosity (arrows) of both internal carotid arteries in the LPO projection.

Fig. 3. Upper extremity CT angiography showing markedly tortuosity (arrows) of both brachial and radial arteries in the LPO projection.
CONCLUSION: Severe vascular involvement with tortuosity, elongation, aneurysms, or stenosis of the mid-size and large vessel is suggestive of the rare arterial tortuosity syndrome. While no specific therapy is available for ATS, long-term follow-up is indicated to identify and treat complication.

SE 03 CV-06
CT imaging in acquired aortic diseases
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LEARNING OBJECTIVES:
1. Discuss the role of CT in the comprehensive evaluation of aortic pathologies.
2. List the causes of acute aortic syndrome and identify potential complications.

IMAGING PROTOCOL:
NECT- For Intra Mural Hematoma
CECT- 100 ml at 4 ml/sec, start 10-12 sec after contrast injection, delayed films-in case of dissection, slice thickness: 0.1 mm

Aortic Dissection (AD)
- Most common cause of acute aortic syndrome
- Men > 60 yr
- Hypertension > 70%

Stanford Type A & B
Beak sign
Cobwebs
Impaired perfusion of end-organs: STATIC / DYNAMIC Obstruction.

Aortic aneurysm
Focal dilatation of the abdominal aorta > 3 cm in maximum diameter.

Two types: True & False aneurysms
M:F ratio = 4:1
Atherosclerosis is most common cause

CT angiography
Gold standard
Pre-operative planning - size and shape aneurysm relationship to branch arteries and aortic bifurcation.

Complications: Rupture, pseudoaneurysm
Risk of rupture is more if > 5.0 cm in women & 6.0 cm in men, > 10 mm expansion per year
Signs of rupture: Draped aorta sign, crescent sign, retroperitoneal hematoma

Intra-mural Hematoma (IMH)
Hemorrhage into the wall from the vasa vasorum without an intimal tear.

NECT- high attenuation cuff around the aortic lumen
Intimal calcification may be displaced inwards.

D/D:
AD: No intimal flap, Does not spiral around the true lumen
Aortitis: Shows concentric uniform thickening of the aortic wall with peri-aortic inflammatory stranding, IMH often eccentric.

Penetrating Atherosclerotic Ulcer:
A deep atheromatous ulcer that penetrates through the elastic lamina and into the media

CT- contrast-filled, pouch-like protrusion of the aorta or into the thickened aortic wall, absence of an intimal flap or a false lumen, extensive atherosclerosis in other sites

Sign of progression In follow-up studies: increasing max. diameter (> 20 mm), Increasing depth of the ulcer (> 10 mm)

Takayasu Arteritis (idiopathic medial aortopathy or pulseless disease):
Granulomatous large vessel vasculitis
F > M
15-30 years of age.

CLASSIFICATION:
Type I - aortic arch and its branches
Type II - thoracoabdominal aorta and its branches
Type III - involvement of the thoracic and abdominal aorta distal to the arch and its major branches
Type IV - additional involvement of pulmonary artery

CT:
- Acute phase-wall thickening, wall enhancement
- Aortic valve disease - stenosis, regurgitation
- Occlusion
- Aneurysmal dilatation
- Pseudoaneurysm formation
- Diffuse narrowing
BEAK SIGN - A wedge of hematoma is thought to create a space for the development of the false lumen.

Static Obstruction

Dynamic Obstruction
Prediction of infarct size and long-term adverse cardiac outcome by tissue tracking cardiac MR in ST-segment elevation myocardial infarction: comparison to infarct size by late gadolinium enhancement

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PURPOSE: Tissue tracking (TT)-cardiac magnetic resonance (CMR) has technical advantages over traditional myocardial tagging-CMR to analyze left ventricular (LV) strain. We sought to investigate whether quantification of global LV strains by TT-CMR can be used to estimate infarct size and clinical outcomes in patients with acute ST-segment elevation myocardial infarction (STEMI).

METHODS AND RESULTS: We studied 247 consecutive patients (age, 58 ± 12 years; male, 81%) who underwent CMR after STEMI and 20 age- and gender-matched controls (age, 58 ± 11 years; male, 80%). Global radial, circumferential, and longitudinal peak strain (GRS, GCS, and GLS, respectively) were measured by TT-CMR. Adverse cardiac event was defined as cardiac death and heart failure hospitalization. During follow-up (median, 7.8 years), 20 patients (8.1%) experienced adverse cardiac events. Deformation by GRS, GCS, and GLS were significantly decreased in STEMI patients compared to control subjects and were closely related to infarct size by late gadolinium enhancement (LGE)-CMR. Decreased deformation by GRS, GCS, and GLS were all the significant predictors of adverse cardiac events independent to clinical risk factors. Especially, GLS > -14.1% was independently associated with a > 5-fold hazard increase for adverse cardiac events even after adjustment to diabetes, decreased LV ejection fraction (< 50%) and extensive LGE (≥ 20%).

CONCLUSION: TT-CMR is feasible and reliable in acute STEMI. Assessment of LV strain by TT-CMR was significantly related to infarct size and adverse cardiac events. Especially, assessment of GLS provides strong prognostic information in patients with STEMI even after adjusted to LV dysfunction and LGE.

Incidental cardiac findings on non-gated chest CT: is it clinically meaningful?
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TEACHING POINTS:
1. To know that incidental cardiac findings can be identified on routine non-gated chest CT
2. To demonstrate the incidental cardiac findings on non-gated chest CT with multimodality imaging
3. To realize that the incidental cardiac findings on non-gated chest CT should not be overlooked and systematic evaluation should be performed

TABLE OF CONTENTS/OUTLINE:
1. Introduction
2. Normal cardiac anatomy on routine non-gated chest CT
3. Cardiac findings on non-gated chest CT
   1) Coronary artery abnormality
   2) Valvular abnormality
   3) Myocardium and heart chamber abnormality
   4) Pericardial abnormality
   5) Congenital heart abnormality
   6) Cardiac tumor or tumor-like lesion
7) Postoperative cardiac finding

4. Diagnostic pitfalls of cardiac findings on non-gated chest CT

**SE 03 CV-09**
Single coronary artery: report of three cases with literature review
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Congenital coronary artery anomalies are rare with the reported incidence of 0.2-1.4% of the normal population. Single coronary artery is extremely rare anomaly with the incidence ranging from 0.024% to 0.066%. Awareness of this anomaly will have an influence on the diagnostic and therapeutic decisions. Herein, the authors report three types of single coronary artery detected by CT angiography. Each of these three cases corresponds to L-I, L-IIA and L-IIB subtypes based on the modified Lipton classification. The authors review the classification and clinical significance of the single coronary artery. The differentiation from other anomalies such as coronary ostial atresia will also be discussed.

**SE 03 CV-10**
Important MR findings of cardiac amyloidosis: a true alternative for diagnosis
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**PURPOSE:** To review MR imaging findings of cardiac amyloidosis.

**CONTENTS:** Amyloidosis is an infiltrative disorder caused by extracellular deposition of amyloid fibrils in various organ system. It is characterized by 4 subtypes with different etiologies, severity, prognosis and treatment, and cardiac involvement varies with the type the amyloidosis. Early detection of cardiac involvement is critical to improve outcomes which is often difficult due to nonspecific symptoms. The gold standard for the diagnosis of cardiac amyloidosis remains the endocardial biopsy, but this is an invasive procedure and is related to severe complications. Echocardiography is a simple non-invasive technique but it is highly operator dependent. MRI is a non-invasive and non-operator dependent technique. It offers a true alternative because it can evaluate both myocardial function and myocardial tissue changes using various techniques such as late gadolinium enhancement technique. MRI allows detection of cardiac involvement earlier than could otherwise be possible by morphologic assessment and therefore could change the clinical course and prognosis. In this educational exhibition, we will review important MRI findings of cardiac amyloidosis.

**CONCLUSION:** MRI can be an important tool for diagnosis of cardiac amyloidosis. Radiologists should be familiar with these findings in MRI to reach a prompt diagnosis and initiate efficient treatment.

**SE 03 CV-11**
Myocardial delayed enhancement CT: initial experience in children and young adults
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**OBJECTIVE:** To describe initial experience of myocardial delayed enhancement CT regarding image quality, radiation dose, and identification of myocardial lesions in children and young adults.

**MATERIALS AND METHODS:** Between August 2013 and November 2016, 29 consecutive children and young adults (median age 16 months, range 4 days - 28 years; M:F = 25:4) with suspected coronary artery or myocardial abnormality, performed arterial- and delayed-phase cardiac CT. CT densities were measured in normal myocardium, left ventricular cavity, and arterial and delayed hypoenhancing and delayed hyperenhancing myocardial lesions. Contrast-to-noise ratios of myocardial lesions were calculated. Artifacts and radiation dose percentage were evaluated for delayed-phase CT. The extent of delayed hyperenhancing lesions on CT was compared with delayed enhancement MRI or thallium single-photon emission computed tomography. Associated wall thinning was assessed on arterial-phase CT.

**RESULTS:** Normal myocardium and left ventricular cavity showed significantly higher CT numbers on arterial-phase CT than on delayed-phase CT (120.4 ± 39.2 HU vs. 97.3 ± 27.0 HU, P < 0.001; 430.6 ± 166.5 HU vs. 145.3 ± 52.6 HU, P < 0.0001; paired t-test). Contrast-to-noise ratios of the arterial and delayed hypoenhancing and delayed hyperenhancing myocardial lesions on CT were 26.7, 17.6, and 18.7, respectively. Artifacts on delayed phase were seen in the lateral and the basal inferior wall in 48.3% (14/29) and 13.8% (4/29), respectively. Delayed-phase CT accounted for approximately 31% of total radiation dose. Delayed-phase CT findings were equivalent to those of delayed enhancement MRI in all cases (7/7) and to those of thallium single-photon emission computed tomography...
in 70% (7/10). Wall thinning on arterial-phase CT was seen in 13.8% (4/29).

CONCLUSION: Myocardial delayed enhancement CT can be added to evaluate myocardial lesions in the selected children and young adults with suspected coronary artery or myocardial abnormality.

SE 03 CV-12
Pulmonary vascular volume ratio measured by cardiac CT in children and young adults with congenital heart disease: comparison with lung perfusion scintigraphy
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PURPOSE: To test whether cardiac CT can provide pulmonary vascular volume ratio in patients with congenital heart disease in comparison with lung perfusion scintigraphy as reference.

MATERIALS AND METHODS: Between June 2011 and December 2016, 52 children and young adults (median age, 4 years; age range, 2 months-28 years; M:F = 31:21) with congenital heart disease underwent ECG-synchronized cardiac CT and lung perfusion scintigraphy without an interim surgical or transcatheter intervention and within one year. The right and left pulmonary vascular volumes were calculated by using a threshold-based CT volumetry. Right pulmonary vascular volume percentages at cardiac CT were compared with right lung perfusion percentages at lung perfusion scintigraphy by using paired t-test and Bland-Altman analysis. According to impaired pulmonary circulation and systemic collaterals, the study population was divided into five groups and subgroup analysis was performed by using Bland-Altman analysis and Mann-Whitney U test.

RESULTS: The right pulmonary vascular volume percentages at cardiac CT (66.3 ± 14.0%) were significantly smaller than the right lung perfusion percentages at lung perfusion scintigraphy (69.1 ± 15.0%; p = 0.001). Bland-Altman analysis showed a small mean difference of -2.8 ± 5.8% and 95% limits of agreement (-14.1%, 8.5%) between these two variables. Subgroup analysis demonstrated that the agreement between the two imaging modalities was influenced by the confounding factors.

CONCLUSION: Cardiac CT, in a single examination, can offer pulmonary vascular volume ratio in addition to pulmonary artery anatomy essential for evaluating peripheral pulmonary artery stenosis in patients with congenital heart disease. However, we still need to be cautious in omitting an additional lung perfusion scintigraphy due to a wide range of agreement between the two imaging modalities.

SE 03 CV-13
Serial changes in anatomy and ventricular function on dual-source cardiac CT after Norwood procedure for hypoplastic left heart syndrome
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PURPOSE: To assess serial changes in anatomy and ventricular function on dual-source cardiac CT after Norwood procedure for hypoplastic left heart syndrome.

MATERIALS AND METHODS: In 14 consecutive patients with hypoplastic left heart syndrome, end-systolic and end-diastolic phase cardiac dual-source CT was performed before and early (average, 1 month) after Norwood procedure, and repeated late (median, 4.5 months) after Norwood procedure in six patients. Ventricular functional parameters and indexed morphologic measurements including pulmonary artery size, right ventricular free wall thickness, and ascending aorta size on cardiac CT were compared between different time points. Moreover, morphologic features including ventricular septal defect, endocardial fibroelastosis, and coronary ventricular communication were evaluated on cardiac CT.

RESULTS: Right ventricular function and volumes remained unchanged (indexed end-systolic and end-diastolic volumes, 38.9 ± 14.0 vs. 41.1 ± 21.5 ml/m², p = 0.7 and 99.5 ± 30.5 vs. 105.1 ± 33.0 ml/m², p = 0.6; ejection fraction, 60.1 ± 7.3 vs. 63.8 ± 7.0%, p = 0.1; and indexed stroke volume, 60.7 ± 18.0 vs. 64.0 ± 15.6 ml/m², p = 0.5) early after Norwood procedure, but function was decreased (ejection fractions, 64.2 ± 2.6 vs. 58.1 ± 7.1%, p = 0.01) and volume was increased (indexed end-systolic and end-diastolic volumes, 39.2 ± 14.9 vs. 68.9 ± 20.6 ml/m², p < 0.003 and 107.8 ± 36.5 vs. 162.9 ± 36.2 ml/m², p < 0.006; and indexed stroke volume, 68.6 ± 21.7 vs. 94.0 ± 21.3 ml/m², p = 0.02) later. Branch pulmonary artery size showed a gradual decrease without asymmetry after Norwood procedure. Right and left pulmonary artery stenoses were identified in 21.4% (3/14) of the patients. Indexed right ventricular free wall thickness showed a significant increase early after Norwood procedure (25.5 ± 3.5 vs. 34.8 ± 5.1 mm/m², p = 0.01) and then a significant decrease late after Norwood procedure (34.8 ± 5.1 vs. 27.2 ± 4.2 mm/m², p < 0.0001). The hypoplastic ascending aorta smaller than 2 mm in diameter was identified in 21.4% (3/14) of the patients. Ventricular septal defect (n = 3), endocardial fibroelastosis (n = 2), and coronary ventricular
Coronary computed tomography angiography (CCTA) is a non-invasive technique with visualization of both coronary artery luminal narrowing and coronary calcification. The ability to noninvasively image the coronary artery lumen and wall and obtain information on the presence and severity of luminal obstruction and atherosclerotic plaque, constitutes an attractive addition to currently available diagnostic tools. This was a single-center based short-term study of experience with 256-slice CT coronary angiography to diagnose and characterize coronary artery lesions in patients with ischemic heart disease. 75 patients clinically suspected to have ischemic heart disease were evaluated over 2 years. Potential calcified plaques were detected with the help of automated software and assigned to the proper arteries and Agatston calcium score was calculated for each patient. Each vessel segment was studied for stenosis using normal part of coronary artery just proximal and distal to stenosis as reference. Stenosis was graded significant if diameter reduction was greater than 50% or more. In the present study during CT coronary angiography as heart rate increased above 72 bpm, there was increase in non-assessable segments 12.94% noted as compared to heart rate below 72 bpm where there were 6.11% non-assessable segments. Out of 75 patients, 20 patients had calcium score 101 to 400. As calcium score increased there was increase in degree of stenosis. There were total 39 plaques in patients with calcium score > 400 out of which 20 plaques were causing severe stenosis (> 70%). Patients with calcium score 101 to 400, all had at least one significant stenosis whereas only 2 patients with calcium score zero had significant stenosis. 26 patients had single vessel disease involving either RCA or LAD or LCX, 15 patients had two vessel disease. Most commonly involved vessels were proximal and midsegments of LAD and RCA. Because of its non-invasive nature, MDCT coronary angiography can be introduced into the diagnostic work up of patients with anginal complaints having an optimal heart rate, at an earlier stage, when catheters based angiography is not yet indicated. Since, this study was carried out in a tertiary care center the sample size may not be representative of the population.