Role of Cardiac CT in Patient with Heart Failure

Dr. Ghormallah Alzahrani
Cardiac Imaging division, PSCC
Introduction

- Improved temporal and spatial resolution has allowed noninvasive imaging of coronary arteries.
- It also provides reliable information on:
  - LV structure and function
  - Cardiac venous anatomy
  - Pulmonary venous system
  - RV function

All are important in the management of HF patients.
O Other potential unique applications
  O Cardiac dyssynchrony evaluation
  O Assessing cardiomyopathies
  O post-transplant annual follow-up

O MDCT as alternative to MRI when contraindicated. Mainly in HF pt with devices
Scanning Patients With HF

- β-blockers, Optimal HR
- Breath-hold
- Radiation exposure
- Contrast exposure
Coronary artery imaging

- Evaluation of Coronaries is valuable in
  - New-onset HF
  - Patients with known HF and previous revascularizations
  - Recurrence of angina

- CTA can assess coronaries, grafts and stents
LV Volumes:

- LV structure and function, specifically EF, determine prognosis and therapy for HF patients.
- MRI is the gold standard; but with limitations:
  - Duration
  - Multiple prolonged breath-holds
  - Patients with devices
  - Claustrophobia
LV volumes are measured from short-axis image; at the mid LV, a single image is reconstructed every 5% of the R-R interval, to obtain both a diastolic and systolic phase.

To select the Minim. (approximately 25%) and the max. diameter (approximately 85%).

LV volume can be measured using two approaches.
1. Simpson method
2. The threshold-based
LV Volumes

- **Simpson method** (also used in MRI), LV volume is calculated by adding all cross sectional areas. quite accurate as it has no reliance on geometric assumptions.

- **The threshold-based**, direct-volume measurement method
  - uses a segmentation technique that detects density or signal intensity differences between contrast-filled cardiac chambers and the myocardium.
  - Using a predefined attenuation threshold, the sum of contiguous voxels greater than this threshold is defined as the total chamber volume.
- LV volumes

Compared to other modalities

- Correlate well with both MRI and TTE for LV assessment
- Volumes and EF are slightly higher compared with TTE.
- MDCT had the tendency to underestimate the degree of impairment in pt with RWMA compared with MRI
MDCT is a TRUE volumetric; remodeling of the chambers should not influence accuracy.
Abdelrhaman M. Al-Absi

259694 M/44 Y

Wall Mass: 1.8 cm
Philips, Brilliance 64

Dose: 12 Feb, 2011 9:25:18.00

6841-1sec

Cardiac Output: 6361.6 ml/min

ES Volume: 214.7 ml

Stroke Volume: 101.0 ml

Ejection Fraction: 31%

Vol(ml)

LV Volume

ED

ES

284

315

31

0

10

20

30

40

50

60

70

80

90

Phase (%)

PHILIPS
Myocardial infarct and viability

- MRI depend on “delayed enhancement”
- By MDCT
  - Dual-phase evaluation; more predictable of recovery in the chronic infarcted states.
  - Increased radiation
  - Shorter acquisition time (10–30 seconds) and can accommodate metal devices
Myocardial infarct and viability

- **First-pass** CE-MDCT imaging performed immediately following an IV contrast bolus (a hypodense region).

- **Delayed** CE-MDCT (DE-MDCT). performed between 5 and 15 minutes after of contrast. a hyperenhanced region indicates infarcted myocardium
Higher radiation, contrast and lower signal than MRI

Koen N et al. Radiology 2008; 247 49-56
Cardiac dyssynchrony

- TDI is the most commonly used technique
- To improve success rates of CRT
  - Correlating venous anatomy to the most desynchronized area
  - Avoiding scared area.
- Pre-evaluation via MDCT can be used for
  - Anatomy; feasibility of a transvenous approach Vs a minimally invasive surgical approach for LV lead implantation.
  - Dyssynchrony
Cardiac dyssynchrony

Recently, Truong, et al, evaluated 64-slice MDCT using a novel CT-based measure of LV dyssynchrony, a “dyssynchrony index,” which is based on timing of changes in wall thickness.

Compared with 2D echo and 3D, good correlation was seen (r = 0.65, P = 0.012 , r = 0.68, P = 0.008).

Limited # in this study (n = 13),

Limitation

The major limitation with MDCT in dyssynchrony evaluation has been temporal resolution. Other newer modalities, such as dual-source CT (which provides improved temporal resolution below 100 ms) may improve sensitivity.
Cardiac venous system

- Anatomy

- Ablation (RFA)
  - AF is common in the HF population and is associated with worse outcomes.
  - Precise mapping of the anatomic origin of these arrhythmogenic foci, the atriopulmonary venous junction, must be delineated.
Cardiac venous system

- Cardiac MRI and cardiac MDCT use for 3D mapping has been well-delineated.
- CT is an alternative to MRI in some HF patient.
- Imaging reconstruction models involve 3D, VR (including endoscopic images).
- Post procedural complications can also be detected with MDCT.
Post–cardiac transplant

O Evaluation include

  O Anatomy, allograft vasculopathy
  O Function

O Coronary allograft vasculopathy, an aggressive form of coronary disease develops in 10% of recipients each year; often initiates in distal vessels with eventual involvement of the entire coronaries.

O Routine angiography, limited with its outline of the coronary lumen via contrast, underestimated early lesions with less than 25% luminal narrowing.
MDCT compared with IVUS showed 70% sensitivity, 92% specificity, and negative predictive value 77%, with an accuracy of 82%.

MDCT has been compared with 2D echo.

- Volume and diameter measurements tended to be higher using MDCT.
- These differences may be explained by the inherent geometric assumptions and limitations that are forced with 2D Echo with 3D modalities (e.g. CT and MRI).
Right ventricle

- Plumhans et al, evaluated RV assessment via MDCT compared with MRI and found excellent correlations for EF ($r = 0.97$), RV EDV ($r = 0.99$), ESV ($r = 0.98$), and SV ($r = 0.98$).
- Similar to LV volumetric assessment, MDCT was noted to have a slight overestimation.

Cardiomyopathies

- CP
- HOCM,
  - MDCT used for simultaneous delineation of the septal branches.
- ARVD;
  - MRI and MDCT were shown to be excellent modalities for Dx
- Non compaction
MDCT Limitations

- Beat-to-beat variability
- Breath-hold.
- Contraindications to CT;
- Repetitive use of MDCT may pose an issue in regard to radiation exposure.
Conclusions

- CT can be used in HF patient for
  - Etiology
  - Function
  - Guide management; Dyssynchrony, EP and post transplant

- Limitations