The Utility of Cardiac Computed Tomography in Evaluating Left Ventricular Diastolic Dysfunction

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Disclosures

• The authors have nothing to disclose
Background: Diastolic Dysfunction

- Definition: Slow/incomplete LV relaxation, reduced compliance or increased stiffness
  - Accounts for ~40-50% of all cases of heart failure

- Non-specific presentation
  - Asymptomatic or overt heart failure
  - Normal or abnormal systolic function
  - Cardiac CTA often ordered to exclude CAD

- Increasing prevalence of diastolic dysfunction and diastolic heart failure
  - Unlike patients with systolic dysfunction, there has been no significant survival improvement over time

Assessment of Diastolic Dysfunction

• Involves quantification of abnormal LV volumes and pressures

• Left heart catheterization
  – Gold standard
  – Invasive, radiation exposure

• Transthoracic echocardiography
  – Most common first-line modality
  – Excellent temporal resolution
  – Limited by body habitus, inter-observer variability

• Cardiac MRI
  – Evaluation of LA size and transmitral flow

Caudron et al. Radiographics. 2011;31(1):239-59
Purpose

• To evaluate the utility of retrospective cardiac CTA in assessment of diastolic dysfunction
  – Utilization of routinely reported functional data
  – Cost of increased radiation dose

• Compare patients with diastolic dysfunction to normal controls
  – LV volume versus time curve in diastole and its first order derivative, \( LV \frac{d(V)}{d(t)} \)
  – Contribution of LA contraction to LV end diastolic volume
Study Design: Methods

• Retrospective cardiac CTA studies performed on Siemens Somatom Definition Flash scanner (Siemens, Erlangen, Germany)
  – Cardiac CTA performed over 10 month period, July 2013-April 2014
  – Echocardiography performed within 6 months of cardiac CTA

• Indications for retrospective cardiac CT:
  – High heart rate and contraindication or lack of response to rate control
  – Atrial fibrillation or arrhythmia despite rate control

• Study population: 20 patients with diastolic dysfunction
  • Indications: atypical chest pain(9), rule out CAD (5), SOBOE (4), non-diagnostic stress test (2)

• Control population: 13 normal controls
Study Design: Methods

• Exclusion criteria:
  – Systolic dysfunction
  – Mitral regurgitation
  – Atrial fibrillation

• Studies interpreted by fellowship-trained chest radiologist
  – Reader blinded to echocardiography findings

• LV volumes determined by syngo.via (Siemens Healthcare, Erlangen, Germany)
  – Automated post-processing software
Volume-Time Curve

- LV lumen traced on short axis, horizontal and vertical long axis planes

- LV volume plotted over cardiac cycle
  - 10% intervals
  - 41-60 ms
  - First order derivative (d)v/(d)t calculated
Volume-Time Curve

• **Early diastolic filling**
  – **Volume vs time curve**
    • Steepest slope volume vs time curve following systole (yellow arrows)
  – \( \frac{d(V)}{d(t)} \)
    • Greatest first order derivative

• **Atrial filling contribution**
  – **Volume vs time curve**
    • Late diastolic volume increase (blue arrows)
Diastolic Dysfunction: VT Curve

Slope of VT curve used to determine peak diastolic flow in diastolic dysfunction patients
Diastolic Dysfunction: Mean $d(V)/d(t)$

Filling rate is fastest at the peak of the $d(v)/d(t)$ curve.
Normal Controls: VT Curve

Slope of VT curve used to determine peak diastolic flow in normal controls
Normal Controls: Mean $d(V)/d(t)$

Higher peak filling rate achieved in normal controls

$D(V)/d(t)$
ml/s

Time (ms)
Results: Peak Early Diastolic Filling Rate

• Peak early diastolic filling rate
  – Diastolic dysfunction: 218.4 ml/sec (95% CI: 199.7 – 237.5)
  – Normal controls: 308.6 ml/sec (95% CI: 278 – 338.6)

  – Suggests impairment of early diastolic filling in patients with diastolic dysfunction, as reflected by slower peak filling rates
• Diastolic dysfunction
  – Flatter slope of early diastolic filling
  – More variable VT curves

• Normal controls:
  – Steeper slope of early diastolic filling
  – More uniform VT curves

• Left atrial contribution to late diastolic filling
  – Initially hypothesized that diastolic dysfunction patients may have greater left atrial contribution
  – Not significantly different between the groups
  – May be related to small sample, variability between patients
  – Late diastole and atrial filling time varied with cardiac cycle length
Limitations

- Small sample size
- Cardiac CTA limited to assessment of LV filling rate
- Correlation with echocardiography, not left heart catheterization (gold standard)
- Limited ability to evaluate moderate to severe diastolic dysfunction due to pseudo-normalization
Conclusions

• Retrospective cardiac CTA generates volume-time curves, which allow for evaluation of abnormal LV filling in early diastole and identification of diastolic dysfunction

• Further evaluation is required
  – Establish normal reference ranges
  – Grade severity of diastolic dysfunction

• Validation of automated volume measurement, potential future applications
References

• Caudron et al. Radiographics. 2011;31(1):239-59
Thank you

Questions?

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