Radionuclide Ventricular Function Imaging: Interpretation and Clinical Application

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Honoraria—Digirad, Inc.
First Pass Radionuclide Ventriculography (RNV)
LVEF = 59%
RIGHT VENTRICLE

ED Image

ES Image
Components of a Pulmonary Time-Activity Curve In a Normal Individual

Kuruc AR and Treves S, “Pediatric Cardiovascular Nuclear Medicine” in Diagnostic Nuclear Medicine vol 1, pp 414-426, 1979, Williams and Wilkins
Components of a Pulmonary Time-Activity Curve in a Patient with a Left-to-Right Shunt

Shunt Fraction, \( K = \frac{S_1}{P} \); \( \frac{Q_p}{Q_s} = \frac{1}{1-K} \)

Kuruc AR and Treves S, “Pediatric Cardiovascular Nuclear Medicine” in Diagnostic Nuclear Medicine vol 1, pp 414-426, 1979, Williams and Wilkins
Effect of Prolonged Delivery of Radiopharmaceutical on the Pulmonary Time-Activity Curve

Kuruc AR and Treves S, “Pediatric Cardiovascular Nuclear Medicine” in Diagnostic Nuclear Medicine vol 1, pp 414-426, 1979, Williams and Wilkins
Effect of Fragmentation of the Radiopharmaceutical Bolus on the Pulmonary Time-Activity Curve

Kuruc AR and Treves S, “Pediatric Cardiovascular Nuclear Medicine” in Diagnostic Nuclear Medicine vol 1, pp 414-426, 1979, Williams and Wilkins
Exercise First Pass Radionuclide Angiography
A Clinical Resurgence
Rationale: Evaluation of stress and/or rest LV and RV function provides diagnostic and prognostic information that is adjunctive to MPI SPECT.

78465 (myocardial perfusion imaging; tomographic ... )
PLUS
78481 (single) or 78483 (multiple) first pass technique

Centers for Medicare and Medicaid Services (CMS), June 28, 2006
•~7000,000 cps when
dead time approaches
20%
Equilibrium Radionuclide Ventriculography

ERNV

MUGA
RBC LABELING METHODS

IN VIVO

MODIFIED IN VIVO

IN VITRO
Drugs That Compromise RBC Labeling with $^{99m}$Tc $O_4$

- Heparin
- Digoxin
- Lidocaine
- Hydralazine
- Methyldopa
- Quinidine
- Prazosin
RBC labeling in a heparanized patient
LVEF = 63%
LVEF = \frac{(ED \text{ cts} - BKG) - (ES \text{ cts} - BKG)}{(ED \text{ cts} - BKG)}
LVEF = \frac{ED\ cts - ES\ cts}{ED\ cts - BKG}

Note: LV volume determination is not possible without blood sampling and counting of samples in a chest torso phantom.
LVEF = 28%
LVEF = 25%
LVEF = 67%
Evaluation of Diastolic LV Dysfunction
PFR = 1.17 EDV/sec (normal = >3.0 EDV/sec)
Diagnostic Accuracy of ERNV

Excellent correlation with contrast ventriculography
LVEF \( (r = 0.93) \) (1-3)
Point-by-point LV volume curve (1,4)

Excellent LVEF precision
Robust automated computer processing (90% correlation with manual analysis) (5)
Repeat acquisitions (3.7% variability) (6)
Repeat processing (2% variability) (6)
Excellent intra-observer agreement (1.4% variability) (6)
Excellent inter-observer agreement (1.6% variability) (6)

6. Wackers FJ, Am J Cardiol 979; 43:1159-1166
Quality Control Considerations for Equilibrium Radionuclide Ventriculography
correct
too anterior
too lateral
leads repositioned
LVEF = \((ED\ cts-BKG) - (ES\ cts-BKG)\) \\
\(\frac{(ED\ cts-BKG)}{(ED\ cts-BKG)}\)

COMMON ERRORS IN LVEF DETERMINATION

UNDERESTIMATION:
- INCLUSION OF LEFT ATRIUM IN END SYSTOLIC ROI
- INCLUSION OF ASCENDING AORTA IN ROI
- BACKGROUND TOO LOW
- ANTERIOR WALL MOTION ABNORMALITY
- TEMPORAL SMOOTHING OF LV VOLUME CURVE

OVERESTIMATION:
- EXCLUSION OF LV APEX IN END SYSTOLIC ROI
- BACKGROUND TOO HIGH
- INFEROPOSTERIOR WALL MOTION ABNORMALITY
CLINICAL APPLICATIONS OF RESTING ISOTOPE VENTRICULOGRAPHY-1990

Diagnosis of LV systolic and diastolic dysfunction*
Diagnosis of LV aneurysm
Screening cardiomyopathy – prone patients*
Diagnosis of LV decompensation in valvular disease
Assessment of LV and RV function following infarction*
Assessment of RV function in COPD*
Evaluation of surgical intervention (ACB, aneurysmectomy)
Assessment of response to therapeutic maneuvers digitalis, diuretics, nitroprusside, prazosin, adriamycin, antithyroid drugs
PEEP
Predicting reversibility of ischemic dysfunction

*2005
Taliercio, C P et al, Mayo Clinic Proc, 1988
Multicenter Post-Infarct Research Group, NEJM, 1983
Guidelines for Monitoring Doxorubicin (Adriamycin) Therapy with Serial Resting RNA

NORMAL LVEF > 50% AT BASELINE

- Baseline MUGA within first 100 mg/m² in all patients
- Next MUGA at 250 - 300 mg/m²
- Next MUGA at 450 mg/m²
  (400 mg/m² if high risk: cyclophosphamide, heart disease, mediastinal radiation, abnormal ECG)
- Next MUGA prior to each dose > 450 mg/m²
- Discontinue therapy if LVEF decreases > 10% from baseline AND reaches < 50%.

Guidelines for Monitoring Doxorubicin (Adriamycin) Therapy with Serial Resting RNA

**ABNORMAL LVEF < 50% AT BASELINE**

- Baseline MUGA within first 100 mg/m² in all patients
- Serial MUGA prior to each subsequent dose
- Discontinue therapy if LVEF decreases ≥ 10% from baseline OR reaches LVEF ≤ 30%.

SPECT RNV

• 180° arc, 45° RAO to 45° LPO
• 6° angular stops
• 1 min./stop, 30 minute total acquisition time
• 8-frame/cycle gating, 20% rhythm acceptance window
FINDINGS: R.B.

Left and right ventricular volumes and regional wall motion are normal.

Left ventricular ejection fraction is 79%.

- LVEDV = 105 cc
- LVESV = 22 cc

Right ventricular ejection fraction is 53%.

- RVEDV = 189 cc
- RVESV = 88 cc

Note: 8-frame/cycle LV volume curve inadequate to evaluate diastolic function.
FINDINGS

Marked left ventricular enlargement is present. Marked LV wall motion abnormalities are present with distal septal akinesis, severe hypokinesis of the apex, and generalized hypokinesis of the remainder of the LV.

Left ventricular ejection fraction is 18%.

\[
\begin{align*}
LVEDV & = 170 \text{ cc} \\
LVESV & = 139 \text{ cc}
\end{align*}
\]

Right ventricular ejection fraction is 46%.

\[
\begin{align*}
RVEDV & = 154 \text{ cc} \\
RVESV & = 84 \text{ cc}
\end{align*}
\]
FINDINGS: B.J.

There is moderate global hypokinesia of both the right and left ventricles. Contraction of the LV and RV is dyssynergic.

Left ventricular ejection fraction is 39%.

- LVEDV = 148 cc
- LVESV = 91 cc

Right ventricular ejection fraction is 33%.

- RVEDV = 183 cc
- RVESV = 122 cc
Comparison between SPECT ERNA and MRI to Assess RV Function in 15 PPH and 13 TOF Patients

<table>
<thead>
<tr>
<th></th>
<th>RVEF</th>
<th>RVEDV (ml)</th>
<th>RVESV (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SPECT ERNA</strong></td>
<td>42 ± 11%</td>
<td>135 ± 67</td>
<td>87 ± 54</td>
</tr>
<tr>
<td><strong>MRI</strong></td>
<td>41 ± 10%</td>
<td>139 ± 91</td>
<td>85 ± 61</td>
</tr>
<tr>
<td><strong>P Value</strong></td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td><strong>R Value</strong></td>
<td>0.85</td>
<td>0.94</td>
<td>0.93</td>
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</tbody>
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THANK YOU