Understanding the basic concept of multimodality imaging?

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Outlines
- Background
- Goals of multimodality imaging
- Advantages of imaging modalities
- Multimodality approach
Several decades ago ancient cardiologist was looking for the best way to identify the heart problem, with clinical examination takes the upper hand to reach diagnosis.

Technological advancement in CV imaging was targeting comprehensive information, with less invasive, more accurate and least risk to the patient.
The importance of multimodality imaging is highlighted by the fact that most recent guidelines of a countless number of cardiac pathologies incorporate it into their recommendations. Multimodality imaging—the side-by-side interpretation of data obtained from various noninvasive imaging techniques, such as echocardiography, radionuclide techniques, multidetector CT (MDCT), and MRI—allows anatomical, morphological, and functional data to be combined, increases diagnostic accuracy, and improves the efficacy of CV interventions and clinical outcomes.

van der Hoeven, B. L. et al. Nat. Rev. Cardiol. 9, 333–346 (2012);
Anatomical & Functional imaging

Multi-Modality Imaging

- what to expect from each imaging modality?
- When & how to integrate them?
- The potential gain in decision making
- Cost / Benefit ratio
Multimodality Imaging

Limitation to exercise
Availability
Guidelines/Appropriateness Criteria
CLINICAL EXPERTISE
OBJECTIVE OF THE STUDY & PRETEST LIKELIHOOD
CHARACTERISTICS OF THE METHOD X PATIENT (asthma, acoustic window,
SINGLE METHOD X ASSOCIATION

Are there the trained specialist for doing that?
Echocardiography remains the most common tool used in the diagnosis of heart disease and is the first line for the assessment of function with traditional parameters.

J Cardiovasc Ultrasound 2016;24(1):7-17
Normal Values:
- LONG -20%
- Circ -20%
- Radial 40%

DEFORMATION IMAGING ESSENTIALLY FOR THE ROBUST ASSESSMENT OF LV LONGITUDINAL FUNCTION

Prognostic value of Basal Longitudinal Strain in patients with severe asymptomatic AoS

Direct relationship between myocardial fibrosis and longitudinal function especially in the basal segments

Lafitte, S. et al. Echocardiography
Dobutamine Stress Echo (True Aortic Stenosis)

REST

Peak V = 3.5 m/s
Mean P = 32 mmHg
AVA = 0.7 cm²

DOBUTAMINE

Peak V = 4.9 m/s
Mean P = 56 mmHg
AVA = 0.7 cm²

Dobutamine Stress Echo (Aortic Pseudostenosis)

REST

Peak V = 3.5 m/s
Mean P = 32 mmHg
AVA = 0.7 cm²

DOBUTAMINE

Peak V = 4.0 m/s
Mean P = 36 mmHg
AVA = 1.1 cm²
**Echocardiography**

**Strengths:**
- Portable, available
- Global experience
- Instant results
- No radiation

**Limitations:**
- Acoustic windows
- Coronary arteries difficult to visualize
- Limited Quantifications
- Learning curve
Magnetic Resonance Imaging

**Strengths:**
- No ionizing radiation
- Good images of coronary arteries
- Calcium does not induce artifacts
Magnetic Resonance Imaging

Limitations

- High cost, lack of portability
- In most cases, cannot perform in ill patients, arrhythmias, and those with pacemakers.
- Patient must be able to follow the instructions, breath holding,
- Long acquisition time (may take hours)
- Nephrogenic system fibrosis (gadolinium)

Potential risk with pacemaker

- Lead heating – unintended cardiac stimulation
- Device interaction

FDA approved for MRI use
The first pacing system to break the image barrier
Cardiac Computed Tomography

**Strength:**

- Short acquisition time
- High spatial and temporal resolution
- Safe imaging of patients with pacemakers, defibrillations and metallic implants.

Van der Hoeven, B. L. et al. Nat. Rev. Cardiol. 9, 333–346 (2012); published online 14 February 2012
**Cardiac Computed Tomography**

**Strength:**
- Assessment of coronary anatomy

Van der Hoeven, B. L. et al. Nat. Rev. Cardiol. 9, 333–346 (2012); published online 14 February 2012

**Cardiac Computed Tomography**

**Strength:**
- Assessment of coronary anatomy and intracardiac structures simultaneously.
- Low radiation (1-2 msv)
- Easily interpretable.
- Can identify non-coronary causes ACP
The pathological correlates of the maladaptive phenotype include eccentric RV hypertrophy and dilatation, and increased fibrosis.

Selected cross-sectional view of a CT Pul angio demonstrating large filling defects consistent with thrombus in right & left pulmonary arteries and a severely dilated pulmonary artery. **C and D, Segmentation** of the intra-parenchymal pulmonary vasculature reconstructed from pulmonary CT angiograms in a subject without cardiopulmonary disease (C) and in a patient with PAH (D). The lower panels illustrate quantification of the blood volume distribution profile, demonstrating loss of smaller vessel volume in contrast to the large vessels described as vascular pruning.

(Circulation. 2016;133:2640-2661)
Cardiac Computed Tomography

Limitations:
- Rapid (>80 bpm) and irregular HR
- Contrast requirements (Cr > 2.0 mg/dl)
- Small vessels (<1.5 mm) and collaterals
- Obese and uncooperative patients
- Limited quantitative information
- Limited access to equipment and trained personnel.
- Post-processing required
- Does not assess flow (yet…)


CCT ---- When is it useful?
- Chest pain syndrome
  - Exclude CAD (99% NPV)
  - CP in Emergency room
- Equivocal stress test
- Non-coronary artery cardiac surgery
  - Exclude CAD
- Prior bypass surgery
  - Determine patency of grafts (not great for severe native disease)
- Congenital anomalies of the coronary circulation
- Coronary or pulmonary venous anatomy

(Circulation. 2016;133:2640-2661)
The two main pillars of nuclear cardiology are SPECT and PET. Both use emission tomography, in which photons are emitted from the body after injecting a radioactive substance with a very low activity. Isotopes taken up by viable myocardial cells in quantities proportional to perfusion. Well perfused regions appear brighter.
Myocardial Perfusion Imaging (MPI)

- In the evaluation of CAD, (SPECT) or PET with CT coronary angiography provides both morphological and functional data in a single procedure. Accordingly, the functional consequences (myocardial hypoperfusion on SPECT or PET) of anatomical pathology (coronary anatomy on MDCT or MRI) can be assessed.


Myocardial Perfusion Imaging (MPI)

The degree of reversibility should be described. If an area of infarcted myocardium with a fixed defect has perfusion > 50% of the database norm, it is considered to be at least partially viable Stress-induced transient ischemic dilatation, a finding that is indicative of severe and extensive CAD and a high risk for a hard cardiac event, also should be reported.

Myocardial Perfusion Imaging
SPECT

Indications

• Detects presence/location/extent of myocardial ischemia in patients with R/O ACS.
• Risk stratification after ACS.
• Identify fixed defects, evaluate EF and viability.
• CP with abnormal EKG’s.
• Equivocal ETT.
• Inability to exercise (pharmacological stress).
Multimodality imaging in MI

- CA did not demonstrate significant new coronary stenosis compared with prior angiography. 2D strain identify the mechanical dysfunction of apical region. SPECT showed a fixed defect in the apical segments and mid anterior wall indicating scar /confirmed a transmural infarction in the anteroapical region with nontransmural scar in the interventricular septum.

Cardiac Sarcoidosis

- CMR showed the thinning of the basal septum. Late gadolinium enhancement (LGE) showed a significantly increased signal intensity in antero-septal area, and entire circumference of the area of basal and lateral wall.
Combine Use of Cardiac MRI and PET for Suspected Cardiac Sarcoidosis

Cardiac MRI

- LGE

When CMR is inconclusive or high suspicious of CS remains

FDG PET

No FDG uptake
- Possible scar from burnt out CS
- No role for immunosuppressive therapy

Abnormal FDG Uptake
- Myocardial inflammation
- Consider immunosuppressive therapy

Consider ICD

Accuracy for diagnosis of CAD

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise Treadmill</td>
<td>68%</td>
<td>77%</td>
</tr>
<tr>
<td>Stress ECHO</td>
<td><strong>83%</strong></td>
<td><strong>93%</strong></td>
</tr>
<tr>
<td>SPECT (Tc-99m)</td>
<td>90%</td>
<td>77%</td>
</tr>
<tr>
<td>PET (Rb-82, N-13)</td>
<td>93%</td>
<td>82%</td>
</tr>
<tr>
<td>CTA (64-MDCT)</td>
<td><strong>96%</strong></td>
<td><strong>93%</strong></td>
</tr>
</tbody>
</table>
### Parameters Assessed with Various imaging Modalities

<table>
<thead>
<tr>
<th></th>
<th>LV Function</th>
<th>Perfusion</th>
<th>Coronary pathology</th>
<th>Viability</th>
<th>Valve function</th>
<th>Radiation Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>PET</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>10-25 msv</td>
</tr>
<tr>
<td>SPECT</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>ECHO</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>MSCT</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>9.3-11.3 msv</td>
</tr>
<tr>
<td>MRI</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Cardiac Cath</td>
<td>+</td>
<td>+</td>
<td>TIMI Flow</td>
<td>TIMI Blush</td>
<td>+</td>
<td>3-5 MSV</td>
</tr>
</tbody>
</table>

**What is the rational behind the multimodality imaging?**
■ There are great opportunities for multimodality imaging in the changing paradigm of value-based medicine and clinical translation of imaging innovations.

■ Understand the future challenges and requirements for training future generations of imaging scientists and clinical specialists.
Conclusion

Cardiovascular imaging is at a crossroad with respect to technological advances, with a shift in focus from single modality-based diagnosis to an integrated multimodality approach to comprehensive assessment of morphology, patho-physiology, and biology of disease phenotype. This allow better and earlier risk stratification, and guidance of therapy.