The Future of Coronary Physiology

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Disclosure:

Morton J. Kern, MD

Within the past 12 months, the presenter or their spouse/partner have had a financial interest/arrangement or affiliation with the organization listed below.

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Relationship</th>
</tr>
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<tbody>
<tr>
<td>St. Jude Medical Inc.</td>
<td>Speakers’ Bureau</td>
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<tr>
<td>Volcano Therapeutics</td>
<td>Speakers’ Bureau</td>
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<tr>
<td>Merit Medical Inc.</td>
<td>Consultant</td>
</tr>
<tr>
<td>Acist Medical Inc.</td>
<td>Consultant</td>
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<tr>
<td>Opsens</td>
<td>Consultant</td>
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</tbody>
</table>
The Birth of Interventional Physiology
Serial lesions

The Landscape

Left main

CTO

jailed side branch

bifurcation

ostial LAD
The Tools

FFR = \frac{P_d - P_w}{P_a - P_w}

IMR = Pa \times Tmn \left[ \frac{(P_d - P_w)}{(P_a - P_w)} \right]

CVR = \frac{H}{P_a - P_v}

HSR_v = P_a - P_v / APV_{hyper}

IC Doppler
<table>
<thead>
<tr>
<th>Index</th>
<th>Variables</th>
<th>comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary Flow Reserve, CFR, CVR, CFVR</td>
<td>$\text{APV}<em>{\text{Hyper}}/\text{APV}</em>{\text{base}}$</td>
<td>Resistance Sum, epicardial,microvasc</td>
</tr>
<tr>
<td>Relative CFR, rCFR</td>
<td>$\text{CFR}<em>{\text{target}}/\text{CFR}</em>{\text{ref}}$</td>
<td>Qs/Qn (?)</td>
</tr>
<tr>
<td>Resting translesional Pressure Ratio</td>
<td>$\text{Pd}/\text{Pa}$</td>
<td>Epicardial only</td>
</tr>
<tr>
<td>Instantaneous wave free pressure ratio, iFR</td>
<td>$\text{Pd}/\text{Pa}$, $\text{wf}$ period</td>
<td>Epicardial only</td>
</tr>
<tr>
<td>Hyperemic translesion Pressure Ratio, FFR</td>
<td>$\text{Pd}/\text{Pa}$, hyperemia</td>
<td>Epicardial only</td>
</tr>
<tr>
<td>Hyperemic Stenosis Resistance, HSR</td>
<td>$(\text{Pd}-\text{Pa})/\text{APV}$ hyperemic</td>
<td>Epi+Micro</td>
</tr>
<tr>
<td>Hyperemic Myocardial Resistance, HMR</td>
<td>$\text{Pd}/\text{APV}_{\text{hyperemic}}$</td>
<td>Myocardial Resistance</td>
</tr>
<tr>
<td>Index of Microcirculatory Resistance, IMR</td>
<td>$\text{P}_a \cdot Tmn \cdot \left[ (\text{P}_d-\text{P}_w)/(\text{P}_a-\text{P}_w) \right]$</td>
<td>Microcirculatory resistance</td>
</tr>
</tbody>
</table>
# The Future

## Technical Advances
- P-Q combowires
- Optical Fiber Pressure
- Microcatheters
- Co-registration
- Absolute Blood Flow
- CT FFR

## Outcome Studies
- STEMI/NSTEMI
- Side Branch
- Microvascular Dz
- Cardiomyopathy
- TAVR
- PVD

## Conceptual Advances
CFC/iFR/IMR/etc.
Microcatheter Monorail Pressure system

Ultrathin Profile
1.9F × 1.5F
0.025” × 0.020”

Sensor
Marker Band

26 cm distal shaft

Courtesy of ACIST Medical, Inc. Rxi System
FFR of LAD w microcatheter

Pa 113
Pd 52
Pv 0
FFR 0.46
FFR of Diagonal branch

Pa: 95
Pd: 61
Pv: 0
FFR: 0.65
FFR (Optical Fiber) with Co-Registration

Toggle off Co-Reg if desired

Courtesy of Boston Scientific
Pre-Angioplasty iFR Pullback Provides Virtual Intervention and Predicts Hemodynamic Outcome for Serial Lesions and Diffuse CAD

A iFR Pullback with gradient and lesion identification

B iFR fall per millimeter integrated onto coronary angiography

Using iFR to perform Virtual PCI

PRE-PCI (MEASURED)  VIRTUAL PCI (PREDICTED)  POST-PCI (MEASURED)
Intermediate lesion requiring physiological assessment
In ACS: intermediate *non-culprit* lesion

N=2500, 1:1 Randomisation

**FFR** guided PCI

- FFR>0.8: Defer PCI
- FFR≤0.8: Perform PCI

**iFR** guided PCI

- iFR≥0.9: Defer PCI
- iFR<0.9: Perform PCI

30 day, 1, 2 and 5yr follow-up
FAME 2: Two Year Follow-Up

Two year rate of primary endpoint: Death, MI, Urgent Revascularization

Where do we go from here?

1 year MACE Rates

<table>
<thead>
<tr>
<th>Procedure</th>
<th>PCI</th>
<th>CABG</th>
<th>PCI - angio</th>
<th>FFR</th>
<th>CABG - angio</th>
<th>PCI - FFR?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year MACE Rate</td>
<td>19.1</td>
<td>11.2</td>
<td>18.4</td>
<td>13.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SYNTAX

FAME

FAME 3
True Ischemia? Pressure (FFR) vs Flow (CFR)?

Rationale

Prognostic value of discordance

Postulated Physiologic Changes after TAVR for Lesion Assessment

<table>
<thead>
<tr>
<th></th>
<th>Aortic Stenosis</th>
<th>TAVR</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFR</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>IMR</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Dia Suction Wave</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>LV Relax</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>FFR</td>
<td>↑</td>
<td>↓</td>
</tr>
</tbody>
</table>
Patients with and without microvascular injury after primary PCI in anteroseptal myocardial infarction

without microvascular injury. Low HMR

with microvascular injury. High HMR

Paul F.A. Teunissen et al. Circ Cardiovasc Interv. 2015;8:e001786
The Future of STEMI
IRA-only? PRAMI and Culprit, Treat culprit and FFR rest?

Major Issue for STEMI Approach
Achieve **complete revascularization** for ischemia.

Culprit only approach: Potentially leaves non-culprit stenosis untreated

MV all approach: Potentially over treats non-culprit lesions which are not ischemic

FFR can identify ischemic lesions. Question about threshold for negative FFR in some patients.
# Contemporary Randomized STEMI MVD Trials

<table>
<thead>
<tr>
<th>Do All now</th>
<th>Do All, stage</th>
<th>Do All now, use FFR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRAMI (n=465)</strong></td>
<td><strong>CvLPRIT (n=296)</strong></td>
<td><strong>PRIMULTI (n=627)</strong></td>
</tr>
<tr>
<td>No patients per center per year</td>
<td>19</td>
<td>23</td>
</tr>
<tr>
<td>Lesion criteria</td>
<td>&gt;50% DS</td>
<td>&gt;70% DS or &gt;50% DS in 2 views</td>
</tr>
<tr>
<td>Strategy for non-IRA lesions</td>
<td>Immediate</td>
<td>Immediate or staged within index admission</td>
</tr>
<tr>
<td>Primary endpoint</td>
<td>D/MI/refractory ischemia</td>
<td>D/MI/HF/isch D R</td>
</tr>
<tr>
<td>Power (80%)</td>
<td>20% reduced to 14% (30% Rx effect)</td>
<td>37% PEP reduced to 22% (40% Rx effect)</td>
</tr>
<tr>
<td>Result</td>
<td>23% reduced to 9% (65% Rx effect)</td>
<td>21% reduced to 10% (55% Rx effect)</td>
</tr>
</tbody>
</table>

**University of California – Irvine**

**United States Department of Veterans Affairs**
$\text{FFR}_\text{CT}$ Superior to All Methods to Date

Source: Koo et al. JACC 2011, Min JK et al. JAMA 2012, Norgaard BL et al. JACC 2014
CFC 
"Coronary Flow Capacity"

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