Coronary Microvascular Resistance Estimated by A Nobel Dual-sensor (Pressure & Doppler Velocity) Guidewire Reflects Myocardial Viability After AMI

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Backgrounds (1)

- LV function recovery is the final goal of PCI in cases with AMI.
- Many predictors of LV function recovery in AMI have been proposed previously.
ASV & DcT vs LVWMSI

\[ r = -0.54 \quad p < 0.01 \]

\[ r = -0.62 \quad p < 0.01 \]


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Relationship between Qc / Qn & LVWM recovery

Concept of hyperemic microvascular resistance

\[ h-R_{mv} : \text{hyperemic microvascular resistance} = \frac{(P_d - P_v)_{HE}}{Q_s}_{HE} \]

\[ h-MR_v : \text{hyperemic microvascular resistance index} = \frac{(P_d - P_v)_{HE}}{APV}_{HE} \]

\[ IMR : \text{index of microcirculatory resistance} = Pa \cdot T_{mn} \cdot \left[ \frac{(P_d - P_w)}{(Pa - P_w)} \right] \]

Qs: coronary flow through the stenosis

APV: time-averaged peak velocity

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A dual-sensor (pressure and Doppler velocity) guidewire has an ability to estimate coronary microvascular resistance (MVR).
Transmural Extent of Infarction by delayed enhancement by MRI

Grade 1
Grade 2
Grade 3
Grade 4

Every 25%

Extent of infarction
0% 10% 30% 50% 70% 90% 100%
Transmural Extent of Acute Myocardial Infarction Predicts Long-Term Improvement in Contractile Function

The aim of this study was to assess the relationship between MVR and the transmural extent of infarction (TEI) after primary percutaneous coronary intervention (PCI) in AMI.
Methods(1)

Study population

- 24 patients who underwent primary PCI for the first anterior AMI within 12 hours from the onset of symptoms

Exclusion criteria

- Left main trunk lesion
- History of prior MI
- Cardiogenic shock
- Renal insufficiency (serum creatinine $>1.5$ mg/dl)
- Insulin-dependent diabetes mellitus
- Contraindications to MRI (pacemaker, atrial fibrillation, claustrophobia and so on)
Methods(2)

Primary percutaneous coronary intervention
- Thrombectomy • Bare metal stent

Hemodynamic measurements and data analysis
- Immediately after PCI, a 0.014-inch dual-sensor guidewire was placed distal to the culprit lesion to take per-beat averages of pressure and flow velocity simultaneously.
- Microvascular resistance index (MVRI) during maximal hyperemia;
  \[
  \frac{\text{Mean distal pressure}}{\text{Average peak flow velocity}} \quad (\text{mmHg} \cdot \text{cm}^{-1} \cdot \text{s})
  \]
- Hyperemic agent; intravenous infusion of adenosine (150 µg / kg / min)

Creatine kinase (CK) and CK-MB fraction measurements
- Before and immediately after primary PCI, and every 3 hours for the first 24 hours after primary PCI.
Methods (3)

Delayed contrast-enhanced MRI and data analysis

- Two weeks after the onset of AMI
- Gadolinium-diethlenetriamine pentaacetic acid (0.1 mmol/kg)
- 1.5-T MR scanner (Gyroscan Intera CV, Philips, the Netherlands)
- Transmural extent of infarction (TEI) by delayed contrast-enhanced MRI;
  grade 1 = 0 to 25% of hyperenhanced extent of left ventricular wall,
  grade 2 = 26 to 50%, grade 3 = 51 to 75% and grade 4 = 76 to 100%

grade 1

grade 2

grade 3

grade 4
Methods (4)

- Infarct size by delayed ce-MRI (%LV);

\[
\frac{\text{Sum of the volume of DE regions for all slices}}{\text{Sum of the LV myocardial cross-sectional volumes}} \times 100
\]
## Patient characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>65 ± 11</td>
</tr>
<tr>
<td>Male sex n, (%)</td>
<td>17 (81)</td>
</tr>
<tr>
<td>Non-insulin dependent-diabetes mellitus n, (%)</td>
<td>7 (29)</td>
</tr>
<tr>
<td>Hypertension n, (%)</td>
<td>14 (58)</td>
</tr>
<tr>
<td>Dyslipidemia n, (%)</td>
<td>9 (38)</td>
</tr>
<tr>
<td>Current smoking n, (%)</td>
<td>9 (38)</td>
</tr>
<tr>
<td>Family history of coronary artery disease n, (%)</td>
<td>12 (57)</td>
</tr>
<tr>
<td>Culprit vessel</td>
<td>LAD</td>
</tr>
<tr>
<td>Time to the evaluation of coronary microcirculation (hour)</td>
<td>4.96 ± 2.1</td>
</tr>
<tr>
<td></td>
<td>n=24</td>
</tr>
</tbody>
</table>
ECG at the time of admission

( 70 y.o., male )
Combowire

Baseline

Hyperemia

\[ h-MVr = \frac{h-Pd}{h-APV} \]

\[ = \frac{40}{59} \]

\[ = 0.68 \text{ (mmHg/cm} \cdot \text{sec}^{-1}) \]
Contrast-enhanced MRI
(two weeks after primary PCI)

Transmural extent of hyperenhancement Grade 0,
peak CK 185 → avoted MI
ECG at the time of admission
(64 y.o., male)
**Combowire**

\[ h-MVr = \frac{h-Pd}{h-APV} \]

= \frac{73}{24}

= 3.04 (mmHg/cm \cdot \text{sec}^{-1})
Coronary microvascular resistance estimated by a novel dual-sensor (pressure and Doppler velocity) guidewire reflects myocardial viability after myocardial infarction.
Contrast-enhanced MRI (two weeks after primary PCI)

Transmural extent of hyperenhancement Grade 4, peak CK 7182 → transmural MI
Relationship between hyperemic microvascular resistance and peak CK

\[ y = 0.0005x + 0.831 \]

\[ r=0.892, \ p<0.0001 \]
Relationship between hyperemic microvascular resistance and transmural extent of MI by de-MRI

![Graph showing the relationship between MVRI and transmural extent of MI with P < 0.0001](image)

MVRI (mmHg cm⁻¹ s⁻¹) vs. Transmural Extent of Infarction

Grade 1 Grade 2 Grade 3 Grade 4

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ROC curve in each index

Sensitivity vs. 1-Specificity

- MVRI
- Pzf
- DDT
- CFR
Summary

1. The condition of coronary microcirculation is an important determinant of myocardial viability and clinical outcomes in AMI.

2. There would be some indexes to speculate microcirculation condition such as CFR, DDT, Pzf and microvascular resistance index.

3. A 0.014-inch dual-sensor (pressure and Doppler velocity) guidewire (Combowire™) may allow us to estimate these indexes at the same time.
Conclusion

Within the indexes to speculate micro-circulation condition such as CFR, DDT, Pzf and microvascular resistance index (MVRI), MVRI is the best predictor of the LV functional recovery.
Relationship between hyperemic microvascular resistance and transmural extent of MI by de-MRI
Combowire configuration

Combowire 1.5 cm offset

- Modular Plug for Pressure
- Pin Plug for Flow
- Body
- Nose
- Connects to Pimmette of ComboMap model 6800

Combowire 0.0 cm offset

- Flow Sensor
- Radiopaque Coil
- Pressure Sensor

Proximal End
- Contacts
- 0.014" Diameter
- Combowire Shaft

Flexible Coil
- 185cm Working Length

Soft Tip
- 29cm JET Coating

Radiopaque Coil
- Tip
Relation between the Transmural Extent of Hyperenhancement before Revascularization and the Likelihood of Increased Contractility after Revascularization

Case 1: 70 y.o., male

Main complaint) chest pain
Coronary risk factor) current smoking
family history of coronary artery disease

P. I.) Feb. 8, 2007  Admission to our hospital with 
continuous chest pain lasted > 30 minutes at rest.

ECG: ST segment elevation in aVL, V1-5 leads
Echocardiography: akinesis in the LAD territory

Emergency CAG:
   #6: 99% (collateral flow from RCA), #13: 100% (CTO)

Labo. data (emergency room):
   **WBC 11500**, CRP 0.10mg/dl, CK 43IU/l, CK-MB 13IU/l,
   GOT 15IU/l, GPT 16IU/l, LDH 215IU/l, TroponinT(-)
Case 2 : 64 y.o., male

Main Complaint) chest pain
Coronary risk factor) current smoking
P.I.) March 11, 2007  Admission to our hospital with aggravating chest pain at rest

ECG: QS pattern in V1-4 leads, abnormal Q in aVL
ST segment elavation in I, aVL, V1-5 leads

Echocardiogaraphy: akinesis in the LAD territory

Emergency CAG:
#6: 100% (collateral flow ; none)

Labo. data (emergency room):
WBC 9400, CRP 0.60mg/dl, CK 1535IU/l, CK-MB 113IU/l,
GOT 155IU/l, GPT 38IU/l, LDH 493IU/l, TroponinT(+)