MRI features of unstable carotid plaques

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No disclosures
Agenda:

✓ Introduction of plaque characterization in MRI
✓ Prognostic value of different plaque features
✓ Newer methods of plaque characterization
✓ Summary
Why do we need plaque characterization:

- Benefit of CEA and CAS in patients with symptomatic high grade carotid stenosis are clear
- Stoke can be caused by plaques not causing stenosis
- Treating all those patients with CEA/CAS is not regarded as economically reasonable; further, benefit over operative/interventional risks are unclear

Urgent need to detect the vulnerable plaque
Different plaque feature in MRI

Types (qualitative): Lipid Core, fibrous cap, fibrous tissue, haemorrhage and calcified.

<table>
<thead>
<tr>
<th>Type</th>
<th>T1 pre</th>
<th>T1 post</th>
<th>T2</th>
<th>PD</th>
<th>TOF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipid core</td>
<td>Iso/high</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Fibrous cap</td>
<td>Iso</td>
<td>Iso</td>
<td>Mixed</td>
<td>Mixed</td>
<td>Low</td>
</tr>
<tr>
<td>Fibrous tissue</td>
<td>Iso/high</td>
<td>v. high</td>
<td>Iso/high</td>
<td>Iso/high</td>
<td>Low</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>v. high</td>
<td>Variable</td>
<td>Variable</td>
<td>Variable</td>
<td></td>
</tr>
<tr>
<td>Calcification</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

From Vulnerable Plaque to Vulnerable Patient: A Call for New Definitions and Risk Assessment Strategies: Part I

Morteza Naghavi, MD; Peter Libby, MD; Erling Falk, MD, PhD; S. Ward Casscells, MD; Silvio Litovsky, MD; John Rumberger, MD; Juan Jose Badimon, MD; Christosdoulos Stefanadis, MD; Pedro Moreno, MD; Géreard Duval, MD, PhD; Zahi Fayad, MD; Peter H. Stone, MD; Sergio Waxman, MD; Paolo Raggi, MD; Mehrdad Majid, MD; Aireza Zarrabi, MD; Allen Burke, MD; Chun Yuan, PhD; Peter J. Fitzgerald, MD, PhD; David S. Siscovick, MD; Chris L. de Korte, PhD; Masanori Aikawa, MD, PhD; K.E. Juhani Airaksinen, MD; Gerd Assmann, MD; Christoph R. Becker, MD; James H. Chesebro, MD; Andrew Farb, MD; Zorina S. Gads, PhD; Chris Jackson, PhD; Ik-Kyung Jang, MD, PhD; Wolfgang Koenig, MD, PhD; Robert A. Lodder, PhD; Keith March, MD, PhD; Jasenka Demirovic, MD, PhD; Mohamad Navab, PhD; Silvia G. Priori, MD, PhD; Mark D. Rekhter, PhD; Raymond Bahr, MD; Scott M. Grundy, MD, PhD; Roxana Mehran, MD; Antonio Colombo, MD; Eric Boerwinkle, PhD; Christie Ballantyne, MD; William Insull, Jr, MD; Robert S. Schwartz, MD; Goran K. Hansson, MD, PhD; David P. Faxon, MD; Sanjay Kaul, MD; Helmut Drexler, MD; Philip Greenland, MD; James E. Muller, MD; Renu Virmani, MD; Paul M Ridker, MD; Douglas P. Zipes, MD; Prediman K. Shah, MD; James T. Willerson, MD

2015
### Different plaque features in MRI

**AIM-HIGH Primary Endpoint**

<table>
<thead>
<tr>
<th>Carotid plaque burden</th>
<th>All Subjects (N = 214)</th>
<th>Yes (N = 18)</th>
<th>No (N = 196)</th>
<th>HR‡</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum wall thickness, mm</td>
<td>2.7 ± 1.4</td>
<td>3.3 ± 2.1</td>
<td>2.7 ± 1.3</td>
<td>1.43</td>
<td>0.96-2.11</td>
<td>0.08</td>
</tr>
<tr>
<td>Maximum percent wall area</td>
<td>48 ± 15</td>
<td>54 ± 27</td>
<td>48 ± 14</td>
<td>1.34</td>
<td>0.92-1.94</td>
<td>0.12</td>
</tr>
<tr>
<td>Percent wall volume</td>
<td>41.8 ± 7.1</td>
<td>42.5 ± 7.5</td>
<td>41.7 ± 7.1</td>
<td>1.12</td>
<td>0.72-1.74</td>
<td>0.60</td>
</tr>
</tbody>
</table>

**Carotid plaque characteristics**

<table>
<thead>
<tr>
<th></th>
<th>All Subjects (N = 214)</th>
<th>Yes (N = 18)</th>
<th>No (N = 196)</th>
<th>HR‡</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRNC volume, mm³</td>
<td>40 ± 99</td>
<td>130 ± 206</td>
<td>31 ± 78</td>
<td>1.43</td>
<td>1.16-1.75</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LRNC volume, %</td>
<td>6.6 ± 9.6</td>
<td>14 ± 15</td>
<td>5.9 ± 8.7</td>
<td>1.57</td>
<td>1.22-2.01</td>
<td>0.002</td>
</tr>
<tr>
<td>Calcification volume, mm³</td>
<td>12 ± 24</td>
<td>6 ± 11</td>
<td>13 ± 25</td>
<td>0.60</td>
<td>0.26-1.41</td>
<td>0.2</td>
</tr>
<tr>
<td>Calcification volume, %</td>
<td>2.8 ± 4.2</td>
<td>1.7 ± 2.4</td>
<td>2.9 ± 4.3</td>
<td>0.66</td>
<td>0.35-1.27</td>
<td>0.2</td>
</tr>
<tr>
<td>Intraplaque hemorrhage</td>
<td>8</td>
<td>22</td>
<td>7</td>
<td>3.00</td>
<td>0.99-9.13</td>
<td>0.053</td>
</tr>
<tr>
<td>Thin/ruptured fibrous cap</td>
<td>14</td>
<td>39</td>
<td>11</td>
<td>4.31</td>
<td>1.67-11.1</td>
<td>0.003</td>
</tr>
</tbody>
</table>

**High-risk plaque classifications**

<table>
<thead>
<tr>
<th></th>
<th>All Subjects (N = 214)</th>
<th>Yes (N = 18)</th>
<th>No (N = 196)</th>
<th>HR‡</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHA type VI‡</td>
<td>11</td>
<td>22</td>
<td>10</td>
<td>2.36</td>
<td>0.77-7.17</td>
<td>0.13</td>
</tr>
<tr>
<td>CAS-4§</td>
<td>12</td>
<td>28</td>
<td>11</td>
<td>2.79</td>
<td>0.99-7.85</td>
<td>0.051</td>
</tr>
</tbody>
</table>
Different plaque feature in MRI

Carotid Plaque Lipid Content and Fibrous Cap Status Predict Systemic CV Outcomes

The MRI Substudy in AIM-HIGH

Jie Sun, MD, Xue-Qiao Zhao, MD, Niranjan Balu, Ph.D, Moni B. Neradilek, MS, Daniel A. Isquith, BA, Kiyofumi Yamada, MD, Ph.D, Gador Cantón, Ph.D, John R. Crouse III, MD, Todd J. Anderson, MD, John Huston III, MD, Kevin O'Brien, MD, Daniel S. Hippe, MS, Nayak L. Polissar, Ph.D, Chun Yuan, Ph.D, Thomas S. Hatsu, MD
Prognostic value of intraplaque haemorrhage

Detection of intraplaque hemorrhage by magnetic resonance imaging in symptomatic patients with mild to moderate carotid stenosis predicts recurrent neurological events

Nishath Altaf, MRCS, Lucy Daniels, MRCP, Paul S. Morgan, PhD, Dorothee Auer, PhD, Shane T. MacSweeney, FRCS, Alan R. Moody, FRCP, and John R. Gladman, FRCP, Nottingham, United Kingdom; and Toronto, Ontario, Canada

Determinants of magnetic resonance imaging detected carotid plaque components: the Rotterdam Study

Quirijn J.A. van den Bouwhuijsen, Meike W. Vernooij, Albert Hofman, Gabriel P. Krestin, Aad van der Lught, and Jacqueline C.M. Witteman

2011

MRI features of unstable carotid plaques
Jonathan Nadjiri, M.D. | Technical University Munich | Munich | 06.12.2018
Prognostic value of thin cap fibroid atheroma

Figure 2: Kaplan-Meier Estimates of Event-Free Survival

Title: Prognostic value of thin cap fibroid atheroma

Main Points:
- **Figure 2**: Kaplan-Meier Estimates of Event-Free Survival
- Thin cap fibroatheroma
- Plaque rupture – ulcerated
- Carotid Plaque Lipid Content and Fibrous Cap Status Predict Systemic CV Outcomes
- High-Risk Carotid Plaque: Lessons Learned from Histopathology

Authors:
- Jonathan Nadjiri, M.D.
- Technical University Munich
- Munich

Date: 06.12.2018

Conference: 8th Munich Vascular Conference | CAROTID ARTERY DISEASE (CAD) - LECTURE HALL B
Overview of Meta-Analysis

<table>
<thead>
<tr>
<th>Plaque Component</th>
<th>No. of studies</th>
<th>Total population</th>
<th>Follow-up period (mean)</th>
<th>HR/OR [95% CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intraplaque hemorrhage</td>
<td>8</td>
<td>689</td>
<td>1–38 (20) months</td>
<td>5.7 [3.0–10.9]</td>
</tr>
<tr>
<td>Gupta et al 2013 (HR)</td>
<td>7</td>
<td>678</td>
<td>9–38 (20) months</td>
<td>4.6 [2.9–7.2]</td>
</tr>
<tr>
<td>Hosseini et al 2013 (OR)</td>
<td>7</td>
<td>667</td>
<td>9–38 months</td>
<td>10.0 [5.5–16.4]</td>
</tr>
<tr>
<td>Lipid-rich necrotic core</td>
<td>4</td>
<td>403</td>
<td>12–38 (24) months</td>
<td>3.0 [1.5–5.9]</td>
</tr>
<tr>
<td>Thin or ruptured fibrous cap</td>
<td>4</td>
<td>363</td>
<td>12–38 (22) months</td>
<td>5.9 [2.7–13.2]</td>
</tr>
</tbody>
</table>

*Combined data on symptomatic and asymptomatic stenosis. NB: the studies included in the 3 meta-analyses largely overlap. CI, confidence interval; HR, hazard ratio; OR, odds ratio.

Investigations of Carotid Stenosis to Identify Vulnerable Atherosclerotic Plaque and Determine Individual Stroke Risk

Madieke I. Liem, MD; Fiona Kennedy, MD; Leo H. Bonati, MD; Aad van der Lugt, MD; Bram F. Cooien, PhD; Aart J. Nederveen, PhD; Hans R. Jager, MD; Martin M. Brown, MD; Paul J. Nederkoorn, MD

2017
Issues with current data:

✓ Populations are very small

✓ Several sequences needed:

✓ Time consuming → reduces availability

✓ Might require expert at the scanner

✓ Qualitative approaches
Newer methods of plaque characterisation

Four-point Dixon sequence

Quantitative Fat and R2* Mapping In Vivo to Measure Lipid-Rich Necrotic Core and Intraplaque Hemorrhage in Carotid Atherosclerosis

Sandeep Koppal, Marcel Warntjes, Jeremy Swann, Petter Dyverfeldt, Johan Kihlberg, Rodrigo Moreno, Derek Magee, Nicholas Roberts, Helene Zachrisson, Claes Forssell, Tosto Länne, Darren Treanor, and Ebo D de Muinck
Newer methods of plaque characterization

Four-point Dixon sequence:
10 min.

2016

Only 5 different patients. No prognostic data.
Summary:

- Plaque detection in patients and then characterization is necessary
- More data is needed
- Quantitative values might further improve diagnostic performance
Thank you very much for your attention!