Plaque protrusion during carotid artery stenting: risk factors determined by MR plaque imaging

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Disclosure

Speaker name:
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I have the following potential conflicts of interest to report:

- Consulting
- Employment in industry
- Stockholder of a healthcare company
- Owner of a healthcare company
- Other(s)

I do not have any potential conflict of interest
Plaque protrusion (PP) during carotid artery stenting (CAS) is closely associated with ischemic complications and a significant increase in PP susceptibility with open cell stent use and unstable plaque (1). However it seems that in this report the plaque diagnosis by MR plaque imaging is subjective, as it is only diagnosed visually.

PP was observed in 9 cases (2.6%).
Ischemic stroke occurred in 6 of 9 PP cases (66.7%; 1 major, 5 minor).
Ischemic lesions were observed on diffusion-weighted imaging in 8 of 9 cases (88.9%).
PP was strongly associated with perioperative ischemic stroke.
A significant increase in PP susceptibility was observed with open-cell stent use and unstable plaque.

Purpose

We aimed to determine objective risk factors for PP using MR plaque imaging.
Material & Methods

We retrospectively analyzed 308 consecutive carotid atherosclerotic stenoses in 289 patients (men, 285; women, 43; symptomatic, 126; mean age, 73.8 [range, 51-91] years; mean stenosis rate, 81.0%; range, 50-99%) who underwent CAS and preoperative MR plaque imaging between October 2007 and March 2017.
CAS using standard procedures in all cases, meaning stenting using embolic protection devices, with conservative postdilatation.

EPD insert  pre-dilatation  stent placement  post dilatation  EPD retrieve
MR protocol

1. MR machine: 1.5T or 3 T scanner
2. Sequence: A 2D T1-weighted fast spin-echo sequence using a black blood double inversion recovery preparation pulse and a fat-saturation pulse.
Methods

The signal intensities were measured with the region of interest drawn over the carotid plaque at the most severely stenotic level.

Signal intensity ratios (SIR) of carotid plaque relative to adjacent muscle were calculated.
MR plaque imaging

Signal Intensity Ratio (SIR) = 1495.4 / 950.8 = 1.57
Analysis

1. The PP incidence
2. The differences about SIRs between groups with PP and without PP
3. Cutoffs value in the group with PP
<table>
<thead>
<tr>
<th></th>
<th>OS (n:206)</th>
<th>CS (n:102)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline Characteristic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>74.5±7.7</td>
<td>72.5±7.7</td>
<td>n.s.</td>
</tr>
<tr>
<td>Male</td>
<td>170</td>
<td>93</td>
<td>n.s.</td>
</tr>
<tr>
<td>Female</td>
<td>36</td>
<td>9</td>
<td>0.043</td>
</tr>
<tr>
<td>Stenosis % (Ave.)</td>
<td>80.6±12.0</td>
<td>79.6±11.3</td>
<td>n.s.</td>
</tr>
<tr>
<td>Hypertension</td>
<td>173 (84%)</td>
<td>83 (81.3%)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>87 (42.2%)</td>
<td>108 (42.2%)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>105 (51.0%)</td>
<td>60 (58.8%)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Smoker</td>
<td>89 (43.2%)</td>
<td>47 (46.1%)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Symptomatic lesion</td>
<td>82 (39.8%)</td>
<td>44 (43.1%)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Signal intensity ratio</td>
<td>1.435±0.332</td>
<td>1.219±0.296</td>
<td>P&lt;0.0001</td>
</tr>
</tbody>
</table>

OS, open cell stent; CS, closed cell stent; n.s., not significant; SD, standard deviation
Results 1

PP was observed in 12 (3.9%) patients. These patients were all in the open cell stent group.

PP, plaque protrusion;
## Baseline Characteristic of comparison between with PP group and without PP

<table>
<thead>
<tr>
<th></th>
<th>PP (+) (n:12)</th>
<th>PP(-) (n:194)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>71.8 ± 6.9</td>
<td>74.6 ± 7.8</td>
<td>n.s.</td>
</tr>
<tr>
<td>Male</td>
<td>11</td>
<td>159</td>
<td>n.s.</td>
</tr>
<tr>
<td>Female</td>
<td>1</td>
<td>35</td>
<td>n.s.</td>
</tr>
<tr>
<td>Stenosis % (Ave.)</td>
<td>82.5 ± 10.1</td>
<td>80.5 ± 12.1</td>
<td>n.s.</td>
</tr>
<tr>
<td>Hypertension</td>
<td>11 (91.7%)</td>
<td>162 (83.5%)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>7 (58.3%)</td>
<td>80 (41.2%)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>6 (50%)</td>
<td>99 (51.0%)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Smoker</td>
<td>4 (33.3%)</td>
<td>85 (43.8%)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Symptomatic lesion</td>
<td>3 (25%)</td>
<td>79 (40.7%)</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

PP, plaque protrusion; n.s., not significant
Result 2: Comparison of SIR between Plaque Protrusion (+) and (-)

PP group  SIR1.935 ± 0.234

P<0.0001
Result 3: ROC curve of Plaque Protrusion in the open cell stent group

PP (++) Cut off Value

1.620 !!
Carotid artery stenting 69 F

NASCET 84%

Asymptomatic right ICA stenosis
Unstable plaque : high

2D T1WI
MR plaque imaging

Signal Intensity Ratio (SIR) = 2297.6/1208.8 = 1.90

Area: 2.1 mm²
Min: 1921.092 normalized
Max: 2549.141 normalized
Avg: 2297.595 normalized
SD: 161.159 normalized

Area: 2.1 mm²
Min: 1071.378 normalized
Max: 1311.514 normalized
Avg: 1208.831 normalized
SD: 60.967 normalized
Carotid artery stenting 69 F

- Pre PTA
- Post Stenting
- Precise 7mm x 4cm
- AP
- LAT
Carotid artery stenting 69 F

Aviator 4mm x 3cm

Precise 7mm x 3cm

Post PTA      Post Stenting

Plaque Protrusion !!
DWI next day
Symptomatic bright lesions

Minor stroke

Modified Rankin Scale 0 at 30 days
Carotid artery stenting 67 M

NASCET 94%

Symptomatic right ICA stenosis

Unstable plaque : high

TOF MRA

2D T1WI
MR plaque imaging

Signal Intensity Ratio (SIR)
2305.8/1260.5 = 1.83

Area: 3.6 mm²
Min: 1125.243 normalized
Max: 1416.973 normalized
Avg: 1260.507 normalized
SD: 81.98 normalized

Area: 5.2 mm²
Min: 2104.622 normalized
Max: 2563.055 normalized
Avg: 2305.886 normalized
SD: 105.612 normalized
Carotid artery stenting 67 M

- Pre PTA
- Post
- Stenting
- Post PTA
- Post

Carotid Wallstent 10x24mm
Aviator 4mm x 3cm
Post IVUS

1: 3.9mm
2: 3.1mm
DWI next day

Asymptomatic bright lesion
Prediction of Carotid Plaque Characteristics Using Non-Gated MR Imaging: Correlation with Endarterectomy Specimens


n:40

SIR (signal intensity ratio)

Fibrous tissue  0.54 –1.17
Lipid/necrosis  1.16 –1.53
Hemorrhage  1.40 –2.29

AJNR 34:191-197, 2013
Conclusion

SIRs >1.62 in MR plaque images indicated a high risk of PP. In such cases, closed cell stent instead of open cell stent should be used to avoid PP during CAS.
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