Management of patients with internal carotid artery near-total occlusion

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NO DISCLOSURES RELATED TO THE TOPIC
ICA near total occlusion

synonyms

critical stenosis,
near total occlusion,
sub-occlusion,
pre-occlusion,
pseudo-occlusion,
string sign,
slim sign
lotus root sign

Lee et.al., Neurological Science, 2012
Radiological criteria for the diagnosis of ICA string sign

- reduction in ICA diameter compared with the ipsilateral ECA
- obviously reduced diameter of the ICA compared with the contralateral ICA
Radiological criteria for the diagnosis of ICA string sign

- intracranial collaterals seen as cross-filling of contralateral vessels or ipsilateral contrast dilution
- delayed cranial arrival of ICA contrast compared with that of the ECA

Fox. et.al., American Journal of Neuroradiology, 2005
Carotid Pseudo-Occlusion in Hyperacute Stroke

Acute stroke patients with an apparent tandem occlusion on conventional single-phase CTA can have delayed antegrade ICA flow on 4D-CTA.

4D-CTA is a novel noninvasive technique that can identify carotid pseudo-occlusion in the acute stroke setting.

Ng FC et.al J Neuroimaging. 2016
Outcomes associated with carotid string sign

- n=500
- Method of examination DSA
- Group CS: Stenosis ≥ 70%
- Group PO: Carotid string sign
- Primary endpoint: Stroke, myocardial infarction, or death
- Patients without any events were censored at 60 months

CONCLUSION:
Patients in the carotid string sign group more frequently had neurological and cardiac events or died compared with those in the CS group (p = 0.013).
Natural history of ICA string sign

Incidence: 4.3% (NASCET, ECST) Risk of stroke: 6.2% per year

Progression to occlusion

40% at 12 months: Radak et al, Ann Vasc Surg 2010

100% at 34 months: O'Leary et al, Stroke 1989
Risk of Stroke at the Time of Occlusion in asymptomatic patients with severe carotid stenosis

Only 1 patient (0.3%) had a stroke at the time of the occlusion, and only 3 patients (0.9%) had an ipsilateral stroke during follow-up.

Among this patient population, 48 (14.4%) became symptomatic during follow-up and had carotid intervention. RESULTS?

«The risk of progression to carotid occlusion is well below the risk of carotid stenting or endarterectomy and has decreased markedly with more intensive medical therapy». 

Yang C., Bogiatzi C., Spence JD JAMA Neurol. Sept.2015
Asymptomatic carotid stenosis is associated with cognitive impairment independent of known vascular risk factors for vascular cognitive impairment. Approximately 49.4% of these patients demonstrate impairment in at least two neuropsychological domains. The deficit is driven primarily by reduced motor/processing speed and learning/memory and is mild to moderate in severity. The mechanism for impairment is likely to be hemodynamic as evidenced by reduced cerebrovascular reserve and the likely result of hypoperfusion from a pressure drop across the stenosis in the presence of inadequate collateralization.
ICA string sign
Pooled data from NASCET, ECST, VA:
5-year risk of any stroke among symptomatic patients

CETC: 5-Year Risk of Any Stroke (Including 30-Day Stroke or Death) from the Combined VA, ECST, and NASCET Trials

<table>
<thead>
<tr>
<th>Trial</th>
<th>Stenosis</th>
<th>n</th>
<th>30-Day CEA Risk (%)</th>
<th>Surgery (%)</th>
<th>Medical (%)</th>
<th>ARR (%)</th>
<th>RRR (%)</th>
<th>NNT</th>
<th>Strokes Prevented per 1000 CEAs at 5 Years‡</th>
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</thead>
<tbody>
<tr>
<td>CETC</td>
<td>&lt;30%</td>
<td>1746</td>
<td>Unknown</td>
<td>18.36</td>
<td>15.71</td>
<td>-2.6</td>
<td>N/B</td>
<td>N/B</td>
<td>None</td>
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<tr>
<td>CETC</td>
<td>30-49%</td>
<td>1429</td>
<td>6.7</td>
<td>22.80</td>
<td>25.45</td>
<td>+2.6</td>
<td>10</td>
<td>38</td>
<td>26</td>
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<tr>
<td>CETC</td>
<td>50-69%</td>
<td>1549</td>
<td>8.4</td>
<td>20.00</td>
<td>27.77</td>
<td>+7.8</td>
<td>28</td>
<td>13</td>
<td>78</td>
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<tr>
<td>CETC</td>
<td>70-99%</td>
<td>1095</td>
<td>6.2</td>
<td>17.13</td>
<td>32.71</td>
<td>+15.6</td>
<td>48</td>
<td>6</td>
<td>156</td>
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<tr>
<td>CETC</td>
<td>String sign</td>
<td>262</td>
<td>5.4</td>
<td>22.40</td>
<td>22.30</td>
<td>-0.1</td>
<td>N/B</td>
<td>N/B</td>
<td>None</td>
</tr>
</tbody>
</table>

No benefit of surgery over BMT for **symptomatic** patients with **string sign**

ECST Inclusion criteria: No mention of string sign cases

*Rothwell et.al, Lancet, 2003*
2017 ESC Guidelines on the Diagnosis and Treatment of Atherosclerotic Cardiovascular Diseases, in collaboration with the European Association for Cardiovascular Imaging (EACVI), the European Society of Cardiology (ESC) and the European Society of Vascular Surgery (ESVS)

Document covering atherosclerotic disease of the coronary, cerebral, peripheral, renal, upper and lower extremity arteries

Endorsed by: the European Society of Cardiology (ESC), the European Society of Cardiology (ESC), the European Society of Cardiology (ESC) and the European Society of Cardiology (ESC)

Authors: European Task Force: Jean-Baptiste Rico, Marie-Louise E.L. Bartelink, Martin Björck, Marie-Christine Capet, Per Collet, Martin Czerny, Marco De Carlo, Sebastian Debus, Christer Elam, Jan-Dirk Finsterbusch, Jiri Hrubá, Maria T. Kauschke, John V. Kowalewski, Sergio Kownator, Lucia Mazzolai, A. Ross Naylor, Marco Roffi, Joachim Röther, Murray S. Stein, Sascha Stoffel, Gunnar Tepe, Maarit Venermo, Charalampos Vlachopoulos, Ileana Desormais

String sign carotids are excluded from recent RCTs !!!

Anatomic Exclusions

ICSS, 2010

common carotid artery stenosis, or internal carotid artery pseudo-occlusion were excluded, as were patients unsuitable for endarterectomy because of the distal site

CREST, 2010

“string sign” >1 cm of the ipsilateral common or internal carotid artery.

CREST-2

32. "String sign" of the ipsilateral common or internal carotid artery.

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Management of Patients with Internal Carotid Artery Near-total Occlusion: An Updated Meta-analysis

S.N. Mylonas, C.N. Antonopoulos, K.G. Moulakakis, J.D. Kakisis, C.D. Liapis
Ann Vasc Surg 2015
# Management of Patients with Internal Carotid Artery Near-total Occlusion: An Updated Meta-analysis

<table>
<thead>
<tr>
<th>Method</th>
<th>Studies</th>
<th>Patients</th>
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<tbody>
<tr>
<td>CEA</td>
<td>15</td>
<td>774</td>
</tr>
<tr>
<td>CAS</td>
<td>10</td>
<td>342</td>
</tr>
<tr>
<td>BMT</td>
<td>5</td>
<td>186</td>
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## CEA (n)

<table>
<thead>
<tr>
<th>Author, year</th>
<th>CEA (n)</th>
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<tbody>
<tr>
<td>Ogata, 2011</td>
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<td>Radak, 2010</td>
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<td>Bowman, 2009</td>
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<td>Fox, 2005</td>
<td>148</td>
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<td>Greiner, 2004</td>
<td>40</td>
</tr>
<tr>
<td>Ascher, 2002</td>
<td>12</td>
</tr>
<tr>
<td>Samson, 1999</td>
<td>5</td>
</tr>
<tr>
<td>Pulli, 1997</td>
<td>24</td>
</tr>
<tr>
<td>Regina, 1997</td>
<td>15</td>
</tr>
<tr>
<td>Kniemeyer 1996</td>
<td>76</td>
</tr>
<tr>
<td>Archie, 1994</td>
<td>17</td>
</tr>
<tr>
<td>Berman, 1994</td>
<td>91</td>
</tr>
<tr>
<td>Fredericks, 1990</td>
<td>26</td>
</tr>
<tr>
<td>O’Leary, 1989</td>
<td>25</td>
</tr>
<tr>
<td>Ringelstein, 1983</td>
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## CAS (n)

<table>
<thead>
<tr>
<th>Author, year</th>
<th>CAS (n)</th>
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<tbody>
<tr>
<td>Ruiz-Salmerón, 2013</td>
<td>54</td>
</tr>
<tr>
<td>Sakamoto, 2013</td>
<td>14</td>
</tr>
<tr>
<td>Son, 2013</td>
<td>24</td>
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<tr>
<td>Spacek, 2012</td>
<td>19</td>
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<tr>
<td>Gonzalez, 2011</td>
<td>116</td>
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<tr>
<td>Barker, 2010</td>
<td>9</td>
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<tr>
<td>Choi, 2010</td>
<td>48</td>
</tr>
<tr>
<td>Razuk, 2010</td>
<td>13</td>
</tr>
<tr>
<td>Nikas, 2010</td>
<td>25</td>
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<tr>
<td>Terada, 2006</td>
<td>20</td>
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## BMT (n)

<table>
<thead>
<tr>
<th>Author, year</th>
<th>BMT (n)</th>
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<tbody>
<tr>
<td>Radak et al 2010</td>
<td>50</td>
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<tr>
<td>Bowman et al, 2009</td>
<td>8</td>
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<tr>
<td>Fox et al, 2005</td>
<td>114</td>
</tr>
<tr>
<td>Ascher et al, 2002</td>
<td>5</td>
</tr>
<tr>
<td>O’Leary et al, 1989</td>
<td>9</td>
</tr>
</tbody>
</table>

ICA near total occlusion
Should we treat? CEA or BMT

Risk of stroke

Crude Incidence Rates

CEA 5.5%
BMT 14%
P<0.01

Incidence Rates per year

CEA 2.2%
BMT 6.2%
P<0.01

ICA near total occlusion
Should we treat? CAS or BMT

Crude Incidence Rates

Risk of stroke

Incidence Rates per year

CAS
4.4%
P<0.01

BMT
14%

CAS
1.8%
P<0.01

BMT
6.2%

# ICA near total occlusion

## Results of meta-analysis on CAS and CEA

### Crude Incidence Rates (%)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>CAS</th>
<th>CEA</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% (95%CI)</td>
<td>% (95%CI)</td>
<td></td>
</tr>
<tr>
<td>TIA</td>
<td>2.1 (0.9-3.8)</td>
<td>3.5 (1.4-6.6)</td>
<td>0.35</td>
</tr>
<tr>
<td>Stroke</td>
<td>4.4 (2.5-6.8)</td>
<td>5.5 (2.8-9.0)</td>
<td>0.58</td>
</tr>
<tr>
<td>Stroke-related Death</td>
<td>1.5 (0.5-3.0)</td>
<td>1.9 (0.7-3.6)</td>
<td>0.72</td>
</tr>
<tr>
<td>MI</td>
<td>3.1 (1.5-5.1)</td>
<td>2.5 (1.0-4.7)</td>
<td>0.65</td>
</tr>
<tr>
<td>Overall Mortality</td>
<td>9.3 (6.5-12.6)</td>
<td>6.4 (2.6-11.84)</td>
<td>0.31</td>
</tr>
<tr>
<td>MAE</td>
<td>8.4 (5.7-11.5)</td>
<td>7.3 (4.0-11.53)</td>
<td>0.64</td>
</tr>
<tr>
<td>Restenosis</td>
<td>4.4 (2.5-6.8)</td>
<td>13.0 (5.4-23.4)</td>
<td>0.03</td>
</tr>
</tbody>
</table>

No differences in TIA, Stroke, Stroke-Related Death, MI, Mortality, MAE

Significantly lower restenosis after CAS, compared to CEA

Possible moderators of Restenosis Rate

The effect of patch

No significant effect of the use of patch on Restenosis after CEA

Possible moderators of Restenosis Rate: Duration of follow-up

Patients treated with CEA had significantly longer follow-up


P=0.04

P=n.s
ICA near total occlusion
Limitations of meta-analysis

Proportion meta-analysis plot [random effects]

Outliers ?

Restenosis after CEA

Heterogeneity

Endovascular Treatment for Near Occlusion of the Internal Carotid Artery: 30-Day Outcome and Long-Term Follow-Up

MATERIAL AND METHODS:
Between 2004-2014 a total of 182 patients with ICA NO were evaluated for CAS. The study included 132 male (72.5%) and 50 female (27.5%) patients with a mean age of 70.2 years. Of the patients 80 (44%) were asymptomatic. The median clinical and carotid Doppler ultrasound (DUS) follow-up period was 64 months (range 18-124 months).

RESULTS: Technical success 100% !!
4 patients (2.2%) developed minor stroke, 2 patients (1.1%) developed myocardial infarction but no major stroke or death occurred in the following 30-day period. Asymptomatic restenosis was detected in seven patients (3.8%).

CONCLUSION:
With sufficient neurological evaluation during pretreatment and post treatment and when the procedure is performed with technologically developed products by an experienced interventional team, CAS is beneficial in patients with ICA NO.
4 recent ICA string sign cases

M, 70-y, symptomatic, multiple (L) TIA
ICA string sign

M, 70-y, recently symptomatic

C. Liapis
M, 80y, (R) CVA

C. Liapis
M, 59y (R) CVA
M, 62y (L) CVA
ICA string sign is a frequent finding with a reported potential to progress to total occlusion up to 40% per year and with an incidence of stroke up to 6% per year.
Our meta-analysis evidenced that BMT presents increased Stroke Incidence Rates, compared to CEA or CAS !!!
Conclusions

Literature review indicates similar stroke rates and significantly lower restenosis during short-term follow-up after CAS, compared to CEA.
Conclusions

We must include patients with ICA string sign in the RCTs

In the meantime

Surgical treatment of patients with carotid string sign is justified on a selected basis using neurological status and anatomical criteria

C. Liapis
Thank you for your attention