Association of hyperdense middle cerebral artery sign with recanalization rates in patients with acute ischemic stroke

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Aims and objectives

Introduction

The hyperdense middle cerebral artery sign (HMCAS) was first described in 1983 as a high-density structure within the territory of the middle cerebral artery (MCA) at non-enhanced computed tomography (NECT) scans of patients with acute ischemic stroke [1-8]. The HMCAS is a result of acute clot formation within the artery and is recognized as one of the earliest signs of ischemic stroke. It has a high specificity of almost 100% but a very low sensitivity of 30% in the diagnosis of acute stroke [2]. This sign is said to be seen usually within approximately 90 minutes of the event and its presence is associated with a poor clinical outcome [2,9,10]. The HMCAS is found in approximately 40-60% of patients with acute MCA occlusion angiographically confirmed [4-6].

Conflicting and limited data exist regarding the value of assessing thrombus properties in cases of acute stroke treated with endovascular intra-arterial approaches. Moftakhar et al. [11] demonstrated that thrombi with a lower density were more resistant to local intra-arterial thrombolysis with recombinant tissue plasminogen activator or thrombectomy with the Merci (Concentric Medical, Mountain View, California, USA) or Penumbra device (Penumbra Inc, Alameda, California, USA). Likewise, Froehler et al. [12] demonstrated that the presence of hyperdense thrombi predicted successful recanalization using the Merci device. Similarly Mokin et al. [13] found that higher thrombus Hounsfield unit (HU) values are predictive of successful recanalization using the Solitaire device (ev3-Covidien, Irvine, California, USA). On the other hand, Martin et al. [14] found that the presence of the hyperdense vessel is a poor prognostic factor for the rates of recanalization with second-generation retrieval devices type stent-retriever. Finally, another study that included stroke cases treated primarily with the Penumbra aspiration system failed to show an association between thrombus density and recanalization [15].

Since there are few studies on the subject, with contradictory results, new studies are needed to define accurately whether HMCAS is associated with successful or poor rates of recanalization after mechanical thrombectomy.

Purpose:

This study aims to determine the frequency of HMCAS and its relationship with recanalization rates in patients with acute ischemic stroke treated with mechanical thrombectomy.
Methods and materials

We retrospectively analysed 62 patients admitted to our institution between January 2015 and October 2015 with acute anterior ischemic stroke presenting within 8 hours after the onset of symptoms and treated with mechanical thrombectomy of MCA occlusion, in the Interventional Neuroradiology Department.

All patients were examined with a baseline NECT of the brain (from foramen magnum to vertex) using a multidetector CT (MDCT). Images were reconstructed with a routine slice thickness of 4.0 mm and thin slice thickness of 1.0 mm.

Admission CT scans were assessed for the presence or absence of the HMCAS, which was defined as a vessel with an increased or asymmetric density in relation to the contralateral vessel or any other intracranial vessel (Fig. 1). The scans had to have clearly discernible MCAs and could not be affected by radiological artefact. The MCA attenuation was measured by placing oval or elliptical region of interest (ROI) over MCA on both sides. For an objective evaluation, the HMCAS was defined as combination of MCA attenuation $\geq 46$ HU and MCA ratio $> 1.2$ (using ROIs). Care was taken in particular to ensure that the boundaries of the ROI did not extend beyond the margins of the arteries.

The degree of recanalization was assessed using the Thrombolysis in Cerebral Infarction (TICI) scale (Table 1). Successful recanalization was defined as TICI 2b-3 on first angiography [16]. Recanalization rates in patients with and without HMCAS were compared.

Additionally, we analyse the relationship between recanalization rates and the location of the sign (proximal M1, distal M1, complete M1 or M2) and also assessed the control CT scan performed 24 hours after mechanical thrombectomy, determining the presence or not of haemorrhagic transformation.

Descriptive and frequency statistical analysis were obtained and comparisons were made using SPSS 20.0 software (SPSS, Inc., Armonk, NY).
Fig. 1: Non-enhanced axial CT scans in four different patients after an acute ischemic stroke showed HMCAS. A) Right HMCAS in the proximal M1-segment. B) Left HMCAS involving distal M1 segment. C) Left HMCAS in the complete M1-segment. D) Left MCA dot sign (M2 segment).

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**Table 1:** TICI scale [16].


<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
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<tbody>
<tr>
<td>Grade 0</td>
<td>No perfusion.</td>
</tr>
<tr>
<td>Grade 1</td>
<td>Perfusion past the initial obstruction, but limited distal branch filling with little or slow distal perfusion.</td>
</tr>
<tr>
<td>Grade 2a</td>
<td>Perfusion of less than 1/2 of the vascular distribution of the occluded artery (e.g., filling and perfusion through 1 M2 division).</td>
</tr>
<tr>
<td>Grade 2b</td>
<td>Perfusion of 1/2 or greater of the vascular distribution of the occluded artery (e.g., filling and perfusion through 2 or more M2 divisions)</td>
</tr>
<tr>
<td>Grade 3</td>
<td>Full perfusion with filling of all distal branches.</td>
</tr>
</tbody>
</table>
Results

The mean age of the patients was 70±11.7 years (range: 46-86 years), 38 were women (61.3%) and 24 were men (38.7%).

After analyzing each CT scan for the presence of a hyperdense vessel, the HMCAS was observed in 36 patients (58%) and wasn't present in 26 (42%). The mean attenuation of the HMCAS was 70 ±11.7 UH, range: 57 - 89 UH.

The intra-arterial procedure was performed in all patients with second-generation retrieval devices type stent-retriever. Regarding recanalization rates, it was found that the patients with the HMCAS were less likely to obtain a successful recanalization, occurring in 66% of cases with a positive sign and in 96% of cases with a negative sign (p=0.019). The results are summarized in Table 2.

As additional analysis, we compared the rates of recanalization with respect to the location of the HMCAS. The majority of patients presented the sign in proximal M1 (44%), followed by distal M1 (39%), M2 (11%) and complete M1 (5%). Successful recanalization rates were more frequently achieved when the HMCAS was located in proximal-M1 segment (87.5%) than in distal-M1 (64.2 %), complete-M1 (50%) or M2 (0%). The results are summarized in Table 3.

Regarding haemorrhagic transformation rates after mechanical thrombectomy, we found that 36% of the patients with HMCAS presented some degree of haemorrhagic transformation in the control CT scan, compared with 11.5% of the patients without the sign (p=0.053).
### Table 2

<table>
<thead>
<tr>
<th></th>
<th>SUCCESSFUL RECANALIZATION (TICI 2b - 3)</th>
<th>POOR RECANALIZATION (TICI 0, 1, 2a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMCAS</td>
<td>24 (66%)</td>
<td>12 (44%)</td>
</tr>
<tr>
<td>No HMCAS</td>
<td>25 (96%)</td>
<td>1 (4%)</td>
</tr>
</tbody>
</table>

### Table 3

<table>
<thead>
<tr>
<th></th>
<th>SUCCESSFUL RECANALIZATION (TICI 2b - 3)</th>
<th>POOR RECANALIZATION (TICI 0, 1, 2a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal M1</td>
<td>14 (87.5%)</td>
<td>2 (12.5%)</td>
</tr>
<tr>
<td>Distal M1</td>
<td>9 (64.2%)</td>
<td>5 (35.8%)</td>
</tr>
<tr>
<td>Complete M1</td>
<td>1 (50%)</td>
<td>1 (50%)</td>
</tr>
<tr>
<td>M2</td>
<td>0 (0%)</td>
<td>4 (100%)</td>
</tr>
</tbody>
</table>
Conclusion

The HMCAS was found in more than a half of patients with acute ischemic stroke treated with mechanical thrombectomy. It was associated with worse recanalization rates compared to patients without this sign. These findings are similar to those found in a previous study, but differ from others. So, we can conclude that there may be other factors that could influence the results, especially the type of procedure performed (only with proximal balloon catheter or distal aspiration catheter and type of stent retriever used) which should be evaluated in larger patient series.

Additionally, we found that the location of the HCMAS may influence in recanalization rates, observing best recanalization rates in patients with the HMCAS located proximally.
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References
