Computational Assessment of Enlarged Perivascular Spaces (EPVS) on Brain MRI: a review
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Introduction
As automated and semi-automated segmentation of brain structures and lesions becomes a more common and manipulated practice in neuroimaging, it is noticeable that the computational assessment of enlarged perivascular spaces (EPVS), or also commonly named Virchow-Robin (VR) spaces, remains to require improvement. An automated, computational method to assess EPVS would eliminate the inconsistencies and disagreements that occur within and between visual rating schemes.

Aim:
The aim of this review is to discuss the latest literature; to outline other authors’ method of computational assessment and also to suggest recommendations for future research.

Methods
Using PubMed® and Google Scholar®, literature was found using search terms; computer, segmentation, enlarged perivascular space(s), EPVS, Virchow-Robin, VR, lacune, automated, semi-automated, MRI. This review considers all papers presenting computational methods published between 1999 and August 2011.

Challenges in the Literature
- Terminology of EPVS – competition with associated names such as Virchow-Robin and ‘giant’ EPVS
- Size of EPVS and lacunar lesions - the diagram (right) demonstrates that a simple scope of the literature identifies a 2mm overlap in the diameter that researchers consider correct for the maximum EPVS diameter and minimum lacune diameter
- Despite the association with brain disease (dementia and cognitive decline), research concerning EPVS is minimal

Results: Current Methods in the Literature
Two studies were identified that directly searched for EPVS and another four papers that indirectly searched for EPVS using a computational method of MRI analysis. Much disagreement regarding EPVS and lacunar infarction terminology was found in the literature. The diameter of both EPVS and lacunes is disputed and offers a 2mm overlap margin between the quoted maximum diameter of EPVS and minimum diameter of lacunes.

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Analysis approach</th>
<th>Data type</th>
<th>No. of cases</th>
<th>Type of cases</th>
<th>Compared with reference</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sachdev, P. et al [2]</td>
<td>1999</td>
<td>Manual delineation of the EPVS borders on a workstation using Analyze software.</td>
<td>T2W, T1W</td>
<td>95</td>
<td>All healthy 40+ with a diagnosis of Alzheimer’s and 50 healthy controls</td>
<td>Visual rating scale</td>
<td>The association between the visual and computational methods was good except for ratings for subcortical hyperintensities in subcortical nuclei.</td>
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<tr>
<td>Wuerfel, J. et al [3]</td>
<td>2002</td>
<td>Semi-automatic quantification of number and volume of EMVS.</td>
<td>T2W, T1W</td>
<td>75</td>
<td>45 MS patients and 50 healthy controls</td>
<td>Visual rating scale</td>
<td>The intra-class correlation coefficient was 0.994 (95% CI 0.985-0.991) for VRS ratings and 0.993 (95% CI 0.992-0.994) for VRS infarcts.</td>
</tr>
<tr>
<td>Ramirez, J. et al [4]</td>
<td>2010</td>
<td>Segmentation of EPVS using novel Lesion Explorer® software.</td>
<td>T1W, T1V, PD</td>
<td>20</td>
<td>Patients had probable or possible Alzheimer’s disease</td>
<td>Visual rating scale</td>
<td>Computational methods showed significant correlation with comparison to the visual rating scheme. Analysis showed high inter-rater reliability.</td>
</tr>
<tr>
<td>Decombe, X et al [5]</td>
<td>2004</td>
<td>Using a model based on the modified point process.</td>
<td>T1W, T2V</td>
<td>37</td>
<td>All cases feature EPVS, but otherwise undefined</td>
<td>Visual rating scale</td>
<td>An average of 597 lesions were found by the experts, compared with 468 automatically detected EPVS.</td>
</tr>
<tr>
<td>Uchiyama, Y. et al [6]</td>
<td>2001</td>
<td>White matter transformation Segmentation of lesions with manual identification.</td>
<td>T1W, T2V</td>
<td>99</td>
<td>Lacune infarction patients</td>
<td>Visual rating scale</td>
<td>Gradient by using a white-matter cut. It was indicated that the area under the ROC curve was 0.945.</td>
</tr>
</tbody>
</table>

Conclusions
Method of EPVS analysis using computational assessment is not currently valued and study is required to allow development of a reliable method. Agreement needs to be made regarding terminology of both EPVS and lacunar infarction to allow consistency across the literature.

References:

KEY INFO: EPVS surround the walls of vessels as they course from the subarachnoid space through the brain parenchyma [1].