Differentiation between glioblastomas and metastatic brain tumours using quantitative metrics of arterial spin labeling perfusion and diffusion tensor magnetic resonance imaging

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Authors: M. Talaat¹, A. A. A. Abdel Razek², G. Gaballa², L. Elserougy²; ¹Kafr El Sheikh/EG, ²Mansoura/EG
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Aims and objectives

Glioblastoma and brain metastasis are the most common brain tumors in adulthood accounting for about half of all cases. It is important to differentiate glioblastomas from brain metastasis, because these two entities differ from each other in clinical course and management. Glioblastomas and solitary brain metastases often have similar imaging appearances at conventional MR imaging. Arterial spin labeling (ASL), a perfusion imaging technique that utilizes electromagnetically labeled arterial blood water as an intrinsic tracer, could be used to assess cerebral blood flow in tumor. Diffusion tensor imaging (DTI) has used to differentiating glioblastomas from metastases.

The aim of our study was to differentiating glioblastomas from metastatic brain tumors using arterial spin labeling perfusion (ASL) and diffusion tensor imaging (DTI) metrics in tumor & peritumor regions.
Methods and materials

Patients

This prospective study was approved by the local ethics committee and full written consents were obtained from all patients prior to the examination. The study included 36 patients provisionally diagnosed to have intra-axial glioblastoma or brain metastasis based on conventional MR imaging.

MRI imaging

The MR imaging was performed using a 1.5 Tesla scanner. First non contrast study was done, including (T1, T2 & FLAIR sequences), then post IV contrast T1-weighted MR images study is done using gadoterate meglumine.

The ASL perfusion imaging was performed with pseudo-continuous labeling. Multiple time points acquired after the label pulse. The DICOM images were transferred to workstation. The post processing of arterial spin-tagging data typically involves subtraction of label and control images. The regions of interest (ROIs) were placed within tumor and peritumor regions (within 1cm from margin of enhanced tumor).

DTI data were obtained using a single-shot echo planar imaging sequence. Firstly automated registration of the DTI data was done to eliminate eddy current artifacts. the fraction anisotropy (FA) and mean diffusivity (MD) of the enhancing tumor parts and the immediate peri-tumor region (within 1 cm of the enhancing outer tumor margin) were measured.

Statistical analysis

Statistical analyses were carried out. Quantitative data were presented as mean ± standard deviation (SD). Normally distributed data were compared between the two major groups using independent samples t test. Data which violated the normality assumptions were compared using Mann-Whitney test. Probability (P) values < 0.05 were considered statistically significant. The receiver operating characteristic (ROC) curves of different matrices of the tumor and peri-tumor regions were done with calculation of the area under the curve.
Results

Based on histopathological results patients were divided into glioblastomas (n=21) [Fig.1] and metastatic brain tumors (n=15) [Fig.2].

Significant difference in TBF measured in the tumor and peritumor regions of glioblastomas and metastasis (P<0.001) for both. Selection of (29.75, 17.8 mL/100 g/min) as TBF cutoff of tumor and peritumor regions to differentiate between the two groups revealed accuracy (91.7%, 88.9%), specificity(95.2%, 90.5%)[Fig.3].

FA measured in the peritumor region revealed significant difference (p< 0.001) while tumor region revealed no significant difference (p<0.06). Selection of (0.145, 0.245) as FA cutoff of tumor and peritumor regions to differentiate between the two groups revealed accuracy (80.6%, 83.3%), specificity (81%, 76.2%)[Fig.4].

MD measured in tumor and peritumor region revealed significant difference (p<0.001) between the two groups. Selection of 1.275 and 1.33 as MD cutoff of tumor and peritumor regions to differentiate between the two groups revealed accuracy (83.3%, 88.9%), specificity (81.0%, 95.2%) [Fig.5].

Combined TBF, FA and MD of tumor region for differentiation of glioblastoma from metastasis revealed AUC of 0.987, accuracy of 91.7%, sensitivity of 95.2% and specificity of 86.7%. Combination TBF, FA and MD of peritumor region metrics for differentiation of glioblastoma from metastasis revealed AUC of 0.984, accuracy of 91.7%, sensitivity of 93.3% and specificity of 90.5% [Fig.6].
Fig. 1: Glioblastoma: (A) Contrast enhanced T1WI showing heterogeneously enhancing left occipital intra axial lesion. (B) TBF map show high signal intensity with TBF of tumor and peritumor regions are (45.7, 21.3 mL/100 g/min) respectively. (C) MD map shows the MD of tumor and peritumor regions are (1.04, 1.2) respectively. (D) FA map showing relative heterogeneous signal of the enhancing tumor parts, FA of tumor and of peritumor region are (0.13, 0.24) respectively.

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**Fig. 2:** Metastasis: (A) Contrast enhanced T1WI showing heterogeneously enhancing left temporal intra axial lesion. (B) TBF map show low signal intensity with TBF of tumor and peritumor regions are (22.6, 14.7 mL/100 g/min) respectively. (C) MD map shows the MD of tumor and peritumor regions are (1.3, 1.4) respectively (D) FA map showing relative heterogeneous signal of the enhancing tumor parts, FA of tumor and of peritumor region are (0.20, 0.39)respectively.

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Fig. 3: ROC curve of TBF parameters used to differentiate glioblastoma from metastasis (A)tumor region (B) peritumor region.

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Fig. 4: ROC curve of FA parameters used to differentiate glioblastoma from metastasis (A)tumor region (B) peritumor region.

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**Fig. 5:** ROC curve of MD parameters used to differentiate glioblastoma from metastasis (A)tumor region (B) peritumor region.

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**Fig. 6:** ROC curve of combined TBF, FA, MD parameters used to differentiate glioblastoma from metastasis (A)tumor region (B) peritumor region.

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<table>
<thead>
<tr>
<th>Peri-tumor region</th>
<th>Glioma n=21</th>
<th>Metastasis n=15</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD</td>
<td>1.22±0.11 (1.01-1.5)</td>
<td>1.42±0.16 (1.12-1.7)</td>
<td>0.001</td>
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<tr>
<td>FA</td>
<td>0.22±0.08 (0.09-0.45)</td>
<td>0.32±0.07 (0.13-0.43)</td>
<td>0.001</td>
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<td>TBF</td>
<td>20.37±2.6 (12.7-25.4)</td>
<td>14.13±3.1 (9.8-19.8)</td>
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<tr>
<td>Tumor region</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MD</td>
<td>1.18±0.14 (0.93-1.49)</td>
<td>1.39±0.14 (1.12-1.59)</td>
<td>0.001</td>
</tr>
<tr>
<td>FA</td>
<td>0.14±0.04 (0.1-0.29)</td>
<td>0.17±0.03 (0.1-0.22)</td>
<td>0.06</td>
</tr>
<tr>
<td>TBF</td>
<td>42.04±7.15 (22.9-52.1)</td>
<td>27.21±4.56 (21.7-37.9)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

**Table 1:** Table Mean, SD, minimum, maximum, TBF, FA, MD and of tumor and peritumor region of glioblastoma and metastasis.

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Conclusion

Both ASL and DTI metrics are valuable non invasive tools in differentiation between glioblastomas and metastasis. Moreover combined metrics of ASL and DTI increases the diagnostic accuracy of the differentiation between both groups specially in the peri-tumor rather than the tumor region.
Personal information

Mona Talaat

Mona_Talaat@med.kfs.edu.eg

Radiology Department/ Faculty of Medicine/ Kafr Elsheikh University / Egypt
References