Automated Classification of Brain Tumours from ^{1}H MRS Spectra in INTERPRET, a Multi-Centre Collaboration

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ABSTRACT: A subset of 144 histopathologically-validated brain tumour spectra in the INTERPRET database, obtained from three of the collaborating centres, was grouped into meningiomas, low-grade astrocytomas and "aggressive tumours" (glioblastomas and metastases). Spectra from two centres formed the training set while the third acted as the test set. Linear Discriminant Analysis successfully classified 48/50; the remaining two were atypical cases. These spectra had been obtained using different protocols (STEAM and PRESS), different echo times (20, 30 and 32 ms) and different manufacturers' instruments (GE and Philips). Databases for pattern recognition algorithms are less sensitive to acquisition parameters than had been thought.

INTRODUCTION: It is now possible to obtain excellent ^{1}H MR spectra of brain tumours from the 1.5T MRI instruments used for routine radiology. Different tumour classes and even different grades (higher-grade means more malignant) have characteristic chemical compositions, so MR spectra could become important in radiological diagnosis. Ideally, one would like to be able to use this non-invasive information instead of the highly invasive gold-standard method, stereotactic biopsy followed by histopathology.

Interpretation of MR spectra can be aided by pattern recognition algorithms that automatically and objectively discriminate between different classes of tumour. They require a large "training set" – a database of spectra whose diagnoses are accurately known – with which the unknown spectrum is compared, and there are considerable practical difficulties in building this up. Data from several centres must be combined in order to acquire sufficient spectra of the rarer tumours. These centres may have different generations of instrument or software, or even instruments from different manufacturers. Furthermore, equipment and acquisition protocols are likely to change over the period of years in which the database is accumulated, and still further over the period in which the method is in use. Only one study[1] has so far demonstrated that pattern recognition was possible on spectra from two different instruments, and in that case the differences were quite minor: instruments from the same manufacturer and acquisition differing only in TR and TE.

The present study reports early experience in the INTERPRET Project, a four-country collaboration that is developing a decision support tool to assist in diagnosing brain cancer from MRS spectra. More than 300 cases have so far been entered into the database, and formal validation of MRS, clinical data and histopathology has been performed on 250 of them. This presentation describes preliminary studies on 144 fully-validated spectra from three of the centres. It proved possible to classify spectra obtained on instruments from different manufacturers using STEAM and PRESS acquisition protocols that differed in TE values and other parameters. PRESS gives stronger signals from coupled spectra (e.g. glutamine/glutamate) than STEAM, and STEAM 20ms gives stronger signals from short T_2 signals, such as macromolecules and lipids, than STEAM 30ms.

METHODS: 1.5T spectra were acquired both before and after contrast administration. Voxels were placed entirely within the lesion as defined by T2 images; St George's Hospital Medical School, London (SGHMS), GE Signa, STEAM and PRESS, both TR=2s, TE=30-32 ms, 2048dp; IDI, Bellvitge, Barcelona (IDI), Philips ACS-NT, PRESS, TE=30ms, TR=2000 ms, 512dp; Centre Diagnòstic Pedralbes, Barcelona (CDP), GE Signa, STEAM, TE=20ms TR=1600 or 2000 ms, 2048dp.

Validated pathology classifications: SGHMS: 17 glioblastomas (gl, 12 STEAM, 5 PRESS), 10 low grade astrocytomas (ast-lg, 6 STEAM, 4 PRESS), 10 meningiomas (mn, 3 STEAM, 8 PRESS), 13 metastases (me, 5 PRESS, 7 STEAM); IDI: 24 gl, 6 ast-lg, 22 mn, 14me; CDP: 16 gl, 2 ast-lg, 5 mn, 5 me.

RESULTS Linear discriminant analysis (LDA) could distinguish spectra from different centres (results not shown) but it could also be trained to ignore these differences and classify the spectra according to tumour type and grade. Glioblastomas (gl), which are high-grade astrocytomas, could not be discriminated from metastases (me) but they could be clearly distinguished from the low-grade (Grades I and II) astrocytomas (ast-lg). Both gl and me are aggressive tumours so we have grouped them together.

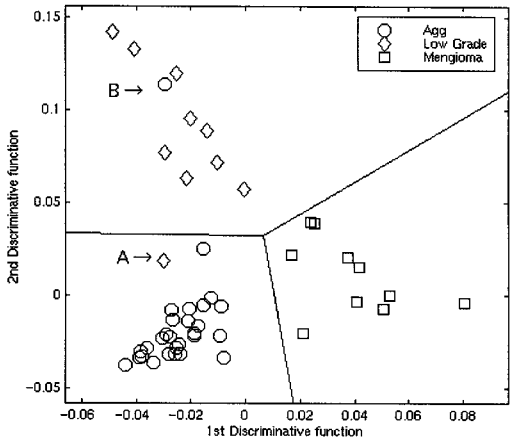

Fig 1. Plot of the first two linear discriminant scores for the SGHMS (independent) test set (50 patients). The Barcelona data (94 patients) was used to develop the discriminant functions. A and B show the two cases that were misclassified by the LDA.

DISCUSSION: All but two of the spectra in Fig 1 were classified accurately. The two spectra whose classification did not reflect the histopathological diagnoses were both atypical cases. A was an astrocytoma about which the histopathology panel disagreed. The majority voted for ast-lg, but the patient died within a year, suggesting that astIII (the minority diagnosis) might have been more appropriate. B was a tumour in a 9-year old child that was classified as gl. This was the only paediatric case, and the spectrum might not have been typical of the adult gl pattern. These results demonstrate that algorithms developed using data acquired on different scanners (GE/Philips), with different sequences (STEAM/PRESS) and echo times (20-32 ms) are robust enough for classifying with 96% accuracy an independent test set obtained in a different centre.

References

1. Tate, AR, Barton, SJ, Howe, F, Griffiths, JR, Moreno, A, Barba, I and Arus, C. Proc ISMRM 1388, 1999.

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