Scottish Government Health Directorates Chief Scientist Office

CHIEF SCIENTIST OFFICE

FOCUS ON RESEARCH

NON-INVASIVE MEASUREMENT OF REGIONAL BRAIN TEMPERATURE USING MAGNETIC RESONANCE SPECTROSCOPY

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Aim
Brain temperature is an important physiological parameter and potentially useful in clinical medicine. However, there are currently no validated non-invasive methods to measure it. We set out (1) to develop and validate a Magnetic Resonance Spectroscopic (MRS) technique for regional brain temperature measurement; and (2) to determine the repeatability of the technique with healthy volunteers in both standard and more modern (higher magnetic field, or "stronger") MRI scanners.

Project Outline/ Methodology
Following validation using a temperature-controlled test object, 31 healthy male volunteers were recruited. 11 of these had repeated scanning sessions in both standard and higher field scanners, with four temperature scans on each visit. The other 20 volunteers each had a single scan in the higher field scanner. Each 10-minute scan yielded brain temperature maps with approximately 1 cm^3 resolution in a slice near the middle of the brain. Statistical analysis was carried out to determine the effects of subject, session, scan number and location within the brain.

Key Results
The uncertainty associated with temperature measurements within a scanning session was 0.4°C and 0.1°C in the standard and high field scanners respectively, with an additional uncertainty of 0.2°C when scans were performed on different days. Temperature variation between people was 0.2°C. We also detected a small (0.05-0.10°C per scan) average reduction in brain temperature during scanning. When the type of brain tissue was incorporated into the analysis, parts of the brain containing more grey matter appeared to be slightly cooler than white matter regions.

Conclusions
We have validated the MRS temperature measurement technique in test objects and in humans and have shown that it can detect small regional differences and changes over time in small groups of subjects. There is a small but meaningful advantage of using a modern high field scanner compared with standard scanners. There is an apparent temperature difference between white matter and grey matter that should be taken into account when interpreting temperature maps.

What does this study add to the field?
Most of the literature relating to "brain" temperature is based on surrogate measurements of oral or ear temperature. We are one of very few groups to attempt absolute, non-invasive measurement of regional brain temperature. The current study has determined the precision of the technique and will assist in planning trials of therapeutic head cooling.

Implications for Practice or Policy
Cooling the brain to preserve tissue following brain damage after cardiac arrest, stroke or head injury is an exciting possibility. Cooling by as little as 0.5°C, which we have shown to be measurable, is believed to be clinically useful. Measurement of regional brain temperature will enable the investigation of devices intended to produce cooling. Measurements of the amount of cooling achieved will complement clinical outcomes currently used in such trials.

Where to next?
Further investigation of the apparent white matter-grey matter temperature difference. Testing of new cooling devices. Application in randomised trials of cooling. Extension to rapid multi-slice scanning to enable whole-brain temperature mapping.

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