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BrainPET poster session: brain imaging—MRI/fMRI

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53. Assessing the existence of ischemic penumbra through automatically analyzing baseline diffusion-weighted imaging

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Objectives: Even though the PWI-DWI (perfusion- and diffusion-weighted imaging) mismatch model has been challenged, it remains the major clinical tool and has been proven useful.[1] Serious problems with PWI-DWI mismatch include the delineation of lesions manually (error prone and time consuming), invasiveness and interpretation uncertainty of PWI. A method to determine the existence of salvageable tissues fast and reliably is thus highly desirable and of vital clinical significance, which is our objective.

Methods: An image analysis system is developed to automatically determine the existence of salvageable ischemic tissues. It takes the baseline DWI as input and consists of the following steps:

(1) reference ADC_{ref} of normal brain tissues is taken as the most frequent value of apparent diffusion coefficient (ADC);
(2) regions with ADC smaller than $0.65*ADC_{ref}$ are approximated as the infarct regions (IRs) while those with ADC in between [$0.65*ADC_{ref}$, $0.85*ADC_{ref}$] as the transition regions (TRs);
(3) only those TRs neighboring IRs (area $> 10\,mm^2$) are kept;
(4) the region with the largest area of IR, and the region with the maximum area of the sum of IR and TR, are found;

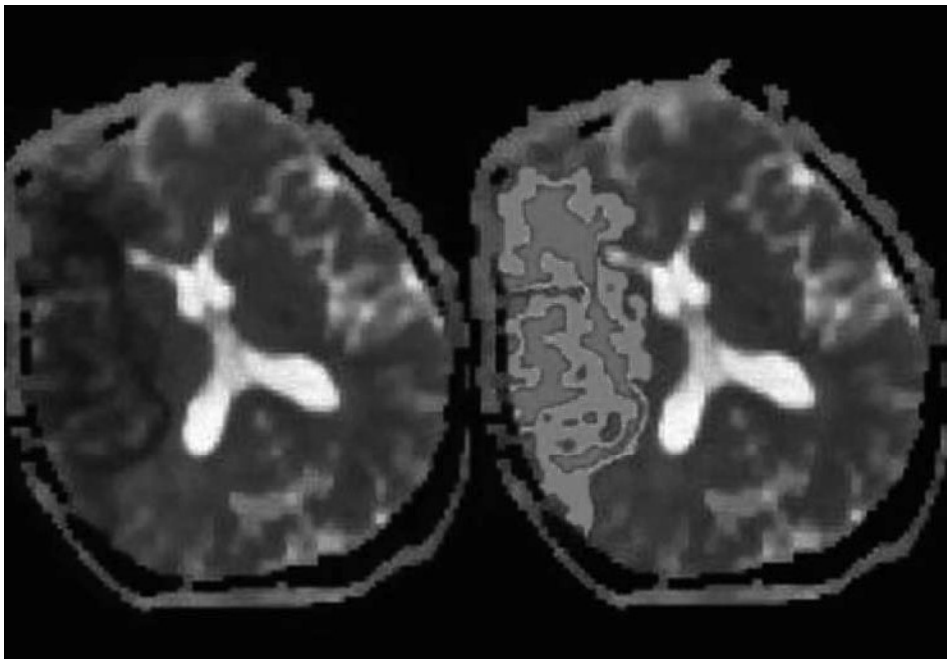

Figure 1

The application of residue analysis for quantification of the haemodynamic parameters flow, volume and mean transit time for perfusion CT/MR is well established. This technique requires the use of deconvolution of the acquired dynamic data to estimate the residue function (R) which by definition takes a positive and monotone decreasing shape. Reconstruction of R provides estimates of each parameter. In the case of MRI, the raw signal intensity is well approximated by Rician statistics. The standard approach to estimation involves logarithmic transformation and deconvolution by truncated singular value decomposition. At low signal to noise this approach may not be efficient. A maximum likelihood deconvolution method involving an iterative reweighted non-linear least squares algorithm incorporating residue function constraints has been developed. Simulation studies are presented to evaluate improvements in parameter estimates achieved by this approach relative to the standard deconvolution method. The results show that over a range of realistic signal to noise values, significant improvements in estimation accuracy are achieved (10% to 20% in flow and mean transit time). The method is applied to perfusion MRI data and smoothed parametric maps based on arterial input selected by shape driven segmentation are presented.

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696. Combined fMRI and metabolic voltammetry *in vivo*: understanding the neurochemical basis of functional imaging signals

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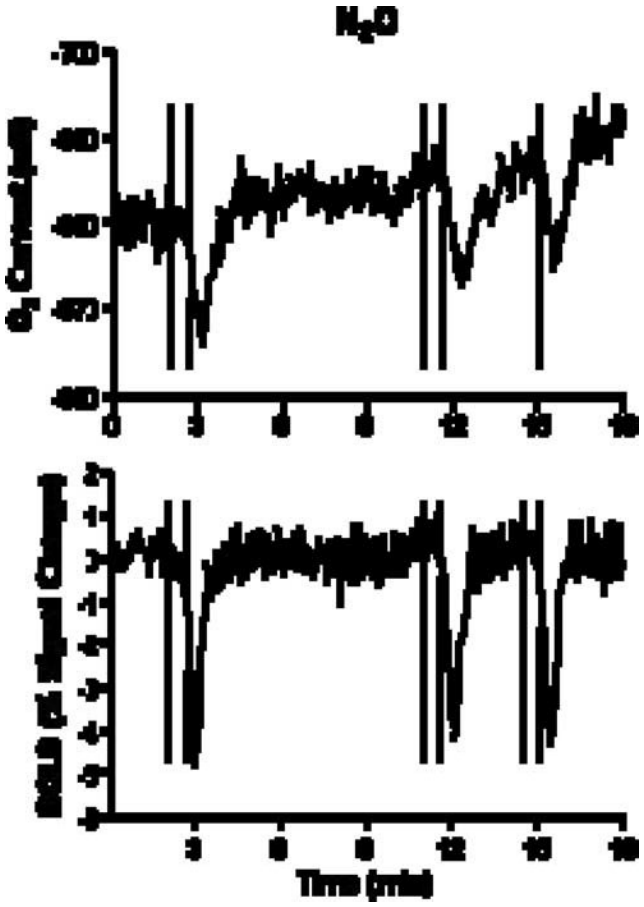
Objectives: The use of functional magnetic resonance imaging (fMRI) in both basic and clinical neuroscience is rapidly expanding. However, although advances have been made in correlating fMRI responses with the underlying neuronal activity, the fact remains that this technique does not directly measure neuronal activity but associated haemodynamic (and metabolic) events. Moreover, a constant relationship between neuronal, haemodynamic and metabolic processes across different brain regions is frequently assumed, despite substantial differences in neuronal architecture. Only by fully understanding the relationship between these parameters will we be able to fully utilise functional neuroimaging. Therefore, we must find a way of correlating fMRI data, which largely reflects the haemodynamic component, with neural and/or metabolic information. Long-term *in-vivo* electrochemistry (LIVE) enables real-time measurement of brain metabolites.[1] In this study we have developed methods for simultaneous fMRI and tissue oxygen measurements via LIVE for direct correlation of metabolic and haemodynamic factors.

Methods: Animals ($n = 3$) were anaesthetised with 1.8% isoflurane in 70%N_2O:30%O_2, and a carbon fibre electrode (CFE) implanted into the right motor cortex (Bregma −1.5 mm). Two further electrodes (auxiliary and reference) were implanted in the same cortical hemisphere (Bregma +3.5 and +4.5 mm). Changes in O_2 concentration at the recording CFE were monitored using constant potential amperometry, with the CFE held at −900 mV (versus reference CFE). A multi-echo gradient echo imaging sequence was used to obtain blood oxygenation level dependent (BOLD) fMRI data: flip angle = 20°; TR = 27.3 ms; TE = 7, 14, 21 ms. Mean echo images were calculated from the individual echo images. Both BOLD and voltametric data were acquired continuously. Following a baseline period of 2 mins, oxygen content of the inspired gases was either reduced (0% O_2) for 30 secs or increased (50%, 70%



Figure

or 100% O_2) for 1 mins. This paradigm was repeated 3 times for each condition.
Results: As shown in the Figure, tissue O_2 measurements and BOLD responses obtained simultaneously demonstrated close correlation during complete oxygen removal (100% N_2O; between dotted lines); BOLD data taken from ROI in region of recording CFE. Both measurements showed a slightly delayed, but marked negative response on elimination of inspired O_2, owing to increased deoxyhaemoglobin levels (BOLD) and decreased tissue oxygen. Conversely, when the inspired oxygen was increased positive changes in both the BOLD and tissue oxygen signals were observed.
Conclusions: Our findings demonstrate the feasibility of obtaining real-time metabolite information during fMRI acquisition. Although demonstrated here for oxygen measurements, the same LIVE technology can be applied to the measurement of many different neurochemicals, thus enabling comprehensive investigation of the relationship between fMRI signal changes and the underlying neurochemistry.

Reference

1. O'Neill RD, Lowry JP. Voltammetry *in vivo* for chemical analysis of the living brain. In *Encyclopedia of Analytical Chemistry* 2000, pp 676–709.

718. Fast bolus-tracking function magnetic resonance imaging (fMRI) in medetomidine-sedated rats using intravascular tracer

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Objectives: Using a recently described animal model for fMRI[1] that has potential for longitudinal studies, we investigated the feasibility of using a commercial MRI contrast agent to detect neuronal activation. We show that neuronal activation can not only be easily detected using our method, but that information about the hemodynamic response can be gleaned over and above that provided by blood-oxygen level-dependent (BOLD) fMRI.
Methods: MRI Images of rat primary somatosensory cortex were obtained using a 7Tesla Bruker BioSpin scanner with purpose-built transmit and receive coils. T1-weighted images of the coronal slice of interest were acquired using a fast gradient echo sequence (echo time 3.5 ms, repetition time 11.0 ms, matrix 64×64, 1 average, 120 repetitions, acquisition time 60 secs). Male Wistar rats ($n = 4$) were placed in the scanner under sedation with a continuous subcutaneous infusion of medetomidine[1] and electrically stimulated using 5 ms duration, 5 Hz, 3 V pulses via electrodes connected to the forepaw, enabling unilateral stimulation of the associated cortical area. Shortly after initiation of stimulation and during acquisition of images, a bolus of meglumine gadopentate was injected via a tail-vein. The resulting images were evaluated using a software script in IDL language, and bolus transit curves calculated for the active and contralateral regions.
Results: The temporal activation pattern of select primary somatosensory cortical neurons was clearly visible on subtraction maps (see Figure), and regions of activation selected from these maps showed a significant difference in both signal amplitude and time-to-peak of bolus arrival between activated and contralateral regions ($P < 0.01$, Student's *t*-test). Second moment is also significantly ($P < 0.05$) greater in the

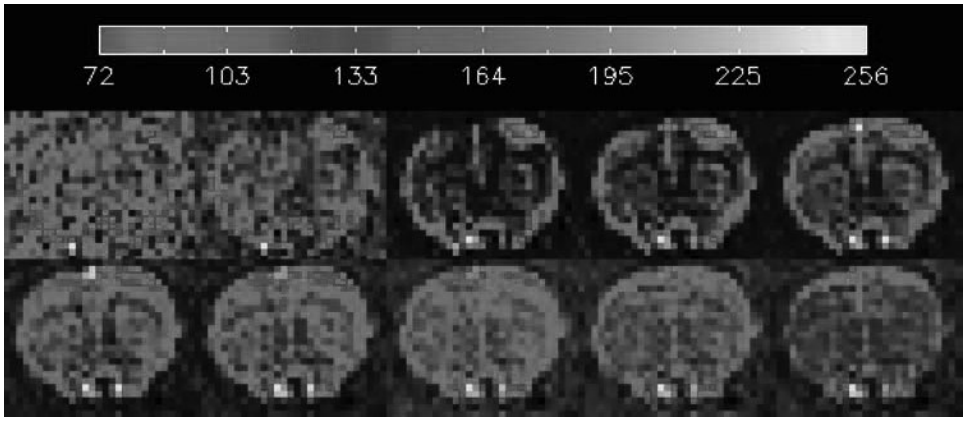

Figure Time evolution of neuronal activation.