MR and CT compatible electrical heating system for mouse imaging.

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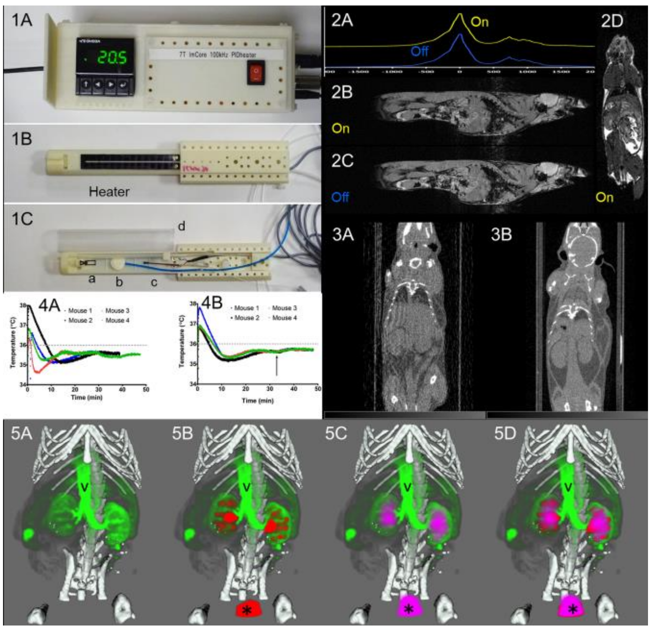
Introduction. Robust methods for maintaining temperature in the anaesthetised mouse are limited. Circulating warm fluids/air remain the most widely used but these require space that may come at a premium in preclinical MRI. We have developed a PID-controlled, resistive electrical system which uses a carbon fibre heating element. MR and CT compatibility, and temperature control of the mouse are demonstrated.

Methods. The assembly is shown in Fig. 1. 0.75 mm thick carbon fibre sheets (RS, 764-8700) were cut into U-shaped strips having a pair of 120 mm long, 7 mm wide legs separated by 1 mm giving a volume of <1.3 ml (Fig. 1B). These were mounted on the animal handling cradle and coupled to wires at the ends of each leg, such that the wired connections were beyond the extremes of the animals and of any useful FOV (Fig 1BC). A PID-controlled gain setting amplified a 100 kHz sine wave generated using a Pierce oscillator to maximum power of ca. 2 W (Fig1A). The input to the PID was derived from a fibre optic rectal temperature system (Opsens, Accusens). Anaesthesia was induced and maintained using isoflurane in O_2-enriched air. Rectal temperature monitoring and maintenance were performed twice in 4 mice, separately for MRI and PET/SPECT/CT imaging. Global pulse-acquire spectra, whole body respiratory-gated bSSFP and FLASH images were acquired with the heater turned on/off. CT–compatibility was tested and Hounsfield Units measured in the absence of any heater, and in the presence of the copper wire or carbon-fibre sheet heater elements. Multimodal MR-CT-PET-SPECT imaging of kidneys was performed using ^{99m}Tc-mercaptoacetyltriglycine (SPECT), ^{18}F-FDG (SPECT), CT, bSSFP and DCE-MRI.



Results and Discussion. Images showing MR and CT compatibility are shown in Fig. 2 and 3, respectively. Fig. 2 shows the absence of any lineshape distortion derived from the delivery of power using 100 kHz AC through the heater (Fig 2A). Similarly, no distortions attributable to the current were observed in respiratory-gated FLASH or bSSFP imaging (Fig. 2BD). Fig. 3A shows the distortions in CT that arise from use of high atomic mass material (Cu); organs were poorly-defined and poor estimations of CT intensities were made. Conversely, no heater-related artefacts were observed with the use of the low atomic mass carbon fibre (Fig 3B) and absolute image quantification was equivalent to that measured in the absence of any heater. Fig. 4 shows the approach to and maintenance of thermal equilibrium for mice positioned in the CT (Fig. 4A) and MRI (Fig. 4B) scanners. Fig. 5 shows a set of 4-modal images comprising of CT + DCE-MRI (5A), CT + DCE-MRI + ^{99m}Tc-SPECT (5B), CT + DCE-MRI + ^{18}F-SPECT (5C) and CT + DCE-MRI + ^{99m}Tc-SPECT + ^{18}F-SPECT (5D).

Discussion. A simple means for managing an animal's rectal temperature has been developed, which is compatible with MRI, CT, PET and SPECT imaging . The heater element is small, enabling small MRI coils with high filling factors to be used, and thermal equilibrium is reached quickly.