An Animal Handling System for Small Animal in vivo MR

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Introduction: Advances in genomics and molecular imaging have resulted in the increasing use of small animal in vivo MR techniques to gain important insights into the functional and metabolic basis of disease. The animal of choice for many research groups has been the mouse, but for certain studies larger animals, such as the rat, are preferred. The concept of multi-mouse MRI for mouse phenotyping has recently been introduced to increase throughput for screening applications [1,2]. However, for applications where sensitivity cannot be compromised, single small animal MRI remains an important research tool. Animal handling with physiological maintenance and positioning/repositioning is an obvious requirement for small animal in vivo MR. For our mouse and rat cardiac MR research interests we developed an animal handling system which catered for body sizes ranging from juvenile mice to adult rats and interfaced to a range of commercially available RF probes. The design of this animal handling system is described in this work.

Design: The animal handling system comprised of detachable polycarbonate cradles of 20, 28, 35, 40 and 60 mm nominal diameter (**Fig. 1**), which catered for body weights of 10-450 g. These cradles were connected to a cradle holder assembly, which had physiological maintenance capability and enabled positioning/repositioning of animals within the magnet relative to the RF probe. An umbilical connected the cradle holder assembly to the ancillary physiological monitoring and maintenance equipment housed on an animal preparation table outside the 5 Gauss line. The animal handling system and animal preparation table are shown in **Figure 2**.

Physiological stability was maintained using anaesthetic gas delivered via 5 mm Portex™ tubing to a nose cone. Several sizes of nose cone were used with/without a surgical thread tooth-loop, depending on the animal's size. Spent anaesthetic gas was recovered using 5 mm Portex™ tubing connected to a Fluovac™ scavenging system (Stoelting Co., USA). An in-line peristaltic pump was used to generate additional suction for the scavenging system because of the small diameter and long tube lengths used. ECG and respiration were monitored using subcutaneous needle electrodes and a motion sensing loop respectively, and connected to a custom-built ECG and respiratory gating device [3]. Temperature control was maintained using a homoeothermic blanket control unit (Harvard Apparatus, USA) connected to a custom-built air heater. The air heater was housed immediately outside the sensitive volume of the RF probe and comprised an electric heating pad housed inside an aluminium foil-lined plastic cylinder with compressed air flowing axially through, but impeded by baffles for increased heat transfer. The exit temperature was monitored using a PT100 sensor with feedback to the heating control unit for temperature control. An interface flange between the detachable cradle and the cradle holder assembly housed 2 mm gold plated connectors for ECG and respiration sensors, and in-line connectors for delivery of anaesthetic gas, scavenging of spent anaesthetic gas and delivery of heated air to the cradle. Intraperitoneal lines were used for delivery of contrast agent, drug delivery, re-hydration or nourishment of animals whilst within the magnet.

Three sources of electromagnetic interference were considered in the design. (1) Extraneous RF noise introduced by the electrical cables of the ECG, respiration, electric heating and temperature sensing systems. (2) Electrical imbalance of the RF probe, due to the presence of the electrical cables. (3) Gradient induced eddy currents. These were minimised by low-pass filtering all electrical cables, introducing the RF probe and animal handling system from opposite ends of the magnet, and reducing the quantity of conductive material used in the construction of the animal handling system.

The end of the animal handling system comprised of an aluminium filter housing for the low-pass filters and an umbilical for the electrical cables and Portex™ tubing. The filter housing was clamped to the magnet using a simple screw clamp. This provided an earth point for the low-pass filters and continuity of shielding for the screened electrical cables within the umbilical, and allowed for quick and easy positioning/repositioning of the animal handling system relative to the RF probe from outside the magnet. A schematic of the animal handling system within the magnet is shown in **Figure 3**.

Fig. 1. Polycarbonate detachable cradles for 20, 28, 35, 40 and 60 mm nominal diameter RF probes.

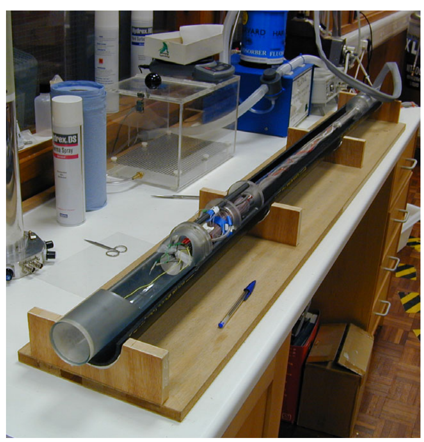

Fig. 2. Animal handling system and animal preparation table.

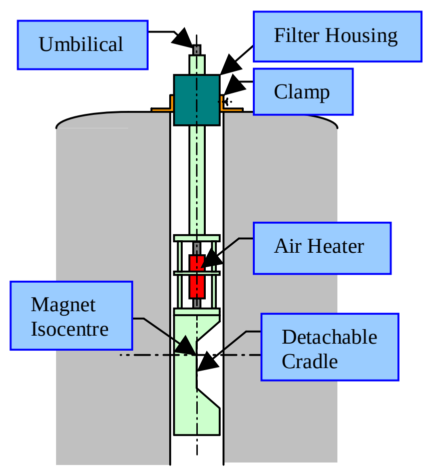

Fig. 3. Schematic of animal handling system within the bore of the magnet.

Discussion: Our animal handling system prooved to be a flexible and reliable platform upon which high-field in vivo MR research could be performed [4-6]. It was quick and easy to set-up, catered for a wide range of animal body and RF probe sizes and permitted routine use with no adverse electromagnetic interactions. We developed our own custom-built air heating system because we did not want to use circulating heating water which introduced additional protons into the sensitive volume of the RF probe and wasted valuable space, and we wanted to minimise electromagnetic interference by avoiding the use of electric heating pads within the sensitive volume of the RF probe. Also, for maximum heating efficiency we placed the air heater as close as possible to the animal, but outside the sensitive volume of the RF probe so that electromagnetic interference was minimised. The animal handling system presented in this work was designed for a vertical bore MR system, but could equally be applied to a horizontal system. Similarly, the animal handling system was designed for small animal cardiac applications, but owing to its flexible design, could be easily adapted to suit other applications.

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References:

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