Method for Cardiac Localization in Multiple Mouse MRI

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Introduction Multiple mouse magnetic resonance imaging has recently been introduced for high-throughput imaging of large numbers of mice [1]. In cardiac imaging, it is often preferred to set a double-oblique imaging plane to show the heart in a long or short axis orientation. During the scan prescription process, localizer images must be prospectively gated in order to accurately locate the heart in three-dimensional space. However, in the case of multiple mouse imaging, the ECG's of the mice are asynchronous. In this abstract, we show how double-oblique localization in multiple mice can best be performed given this restriction. These localization images allow the scan volume to be prescribed for each mouse in a subsequent retrospectively gated cine acquisition.

Materials and Methods Localization for double-oblique short-axis slices requires prospective gating for motion artifact control and compatibility with manufacturer's online image reconstruction software. Prospectively gated acquisition can only be obtained from one mouse at any given moment in time. Localization images could simply be acquired from each mouse sequentially, but to optimize the duration of the localization acquisition, the combined multi-slice multi-mouse data set is obtained in an interleaved fashion (figure 1).

The asynchronous gating signals are directed to separate bits of an 8 bit I/O port on the scanner. Within the realtime portion of the pulse sequence, the I/O port is read every 9 msec within a polling loop. If a gate signal is present and matches the current mouse, the sequence is triggered for the coil containing that mouse. The I/O pin selection is then immediately updated to correspond with the ECG of the next mouse, and the polling loop re-entered. Thus the data acquisition iteration ordering is [phase encoding, slice selection, mouse selection] from slowest to fastest. When the scan is complete, the data are compatible with the manufacturer's online reconstruction software, and may be displayed in a montage format to permit the graphical assignment of oblique rotation angles.

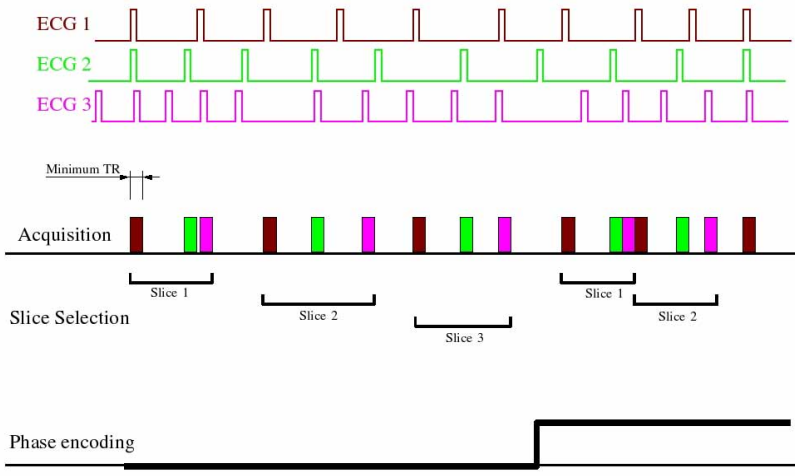

Figure 1. Schematic illustration of multi-mouse multi-slice interleaving.

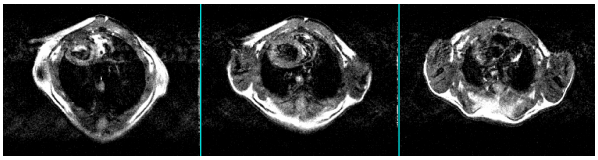

Figure 2. Three axial slices from one mouse obtained using conventional prospective cardiac gating.

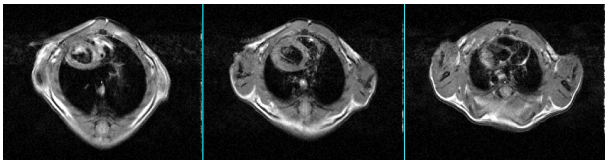

Figure 3. Three axial slices from the same mouse obtained using interleaved prospective cardiac gating (windowing level not identical to figure 2).

Four normal mice were anaestheized with ~1.0% isofluorane gas and imaged with a 7 Tesla MRI scanner (Varian NMR System, Palo Alto CA). ECG respiration and temperature were monitored with commercial hardware (SA Instruments Inc, Stoneybrook, NY), and each mouse was double-gated for cardiac and respiration using TE = 15 ms, field of view = 30x30 mm and matrix = 256x256. Three axial slices through the heart were obtained per mouse. In the first experiment, the four mice were scanned sequentially one a time in the conventional manner. In the second experiment, the interleaved scheme shown in figure 1 was used.

Results In figure 2, three axial slices from one of four mice obtained using prospective cardiac gating are displayed. In figure 3, the same data acquired using interleaving are displayed. The interleaved scan for all four mice took 10:50 min, while the sequential single mouse scans took a total of 11:35 min not counting a brief switchover time. In addition, the interleaved scan resulted in a factor of two increase in SNR due to longer effective TR per mouse. The results for the other three mice were qualitatively similar.

Conclusions We have shown an interleaved acquisition scheme by which spin-echo multi-slice localizer images may be obtained in multiple mice in a time efficient manner while still maintaining compatibility with the manufacturer's online reconstruction software.

References

[1] Bock NA, Konyer NB, Henkelman RM. Multiple-mouse MRI. Magn Reson Med 2003; 49:158-167.