MRI APPLICATIONS

Table I. Examples of MRI applications and experiments

Organ or Structure of Interest	Sequence	Examination
Brain	T1w SE (TR =500 ms, TE = 7 ms, FOV = 15 mm)	Anatomy; little differentiation between mouse GM/WM. Applications: T1w CA studies, fat content assessment.
	T2w SE (TR = 1,275 ms, TE = 25 ms, FOV = 15 mm)	Anatomy, good differentiation between mouse GM/WM, excellent for rat. Generally, acquisitions take long time. Acquisitions can be shortened with partial FT, at the expense of decreased signal to noise ratio.
	Echo Planar Imaging (EPI)	For ultra-fast acquisitions, to evaluate perfusion, diffusion, and fMRI (BOLD). Commonly incorporated as the backbone for other sequences. It can consist of a single or multi shot GRE acquisition and include different types of preparation depending on the property of interest: SE (T2), GRE (T2*), IR (T1), DW (ADC). Disadvantages: limited resolution, geometrical artifacts.
	Blood oxygenation level dependent (BOLD)	Monitoring of changes in blood flow, reflective of neuronal activation local field potentials but not spiking activity; most common in rat models. Examples: **SE_EPI_sat**: Spin echo with EPI readout and saturation pulse **T2_TurboRARE**: To generate T2 contrast with SE scheme high spatial resolution. **T2star_FID_EPI_sat**: Fast T2* estimation, low sensitivity to variations of initial magnetization due to blood flow changes in blood vessels… Can be used to assess differences in paramagnetic state of deoxygenated vs. oxygenated hemoglobin (magnetically inhomogeneous environment, causing local signal decrease and T2* decrease)
	Diffusion weighted imaging (DWI)	Standard method to distinguish if water is moving, b-value dependent. The sequence can be modified to acquire multiple b-values and derive ADC (apparent diffusion coefficient) or to include multiple directions and perform image tracing. Sequence can be based on a standard SE (long, mainly for ex vivo) or EPI (faster, for in vivo).
	Diffusion tensor imaging (DTI)	Orientation of white matter (WM) tracts, most common: DtiEpi for in vivo (fast), DtiStandard for ex vivo (low geometric distortions but scans are very long and sensitive to motion).
	T2_TurboRARE	T2w for anatomy; high number of averages recommended; tumors can be visualized.
	Short TI inversion recovery (STIR)	Widely used for fat suppression by adjusting TI to emit 90 RF pulse exactly when fat passes through zero (~200 ms at 3.0 T). Disadvantages: longer acquisition times (the longer the TR).
	Fluid-attenuated inversion recovery (FLAIR)	Fast SE-IR with long TI values (~2000ms) to suppress signal from CSF to better detect brain tissue, tumors, edema, fat… Disadvantages: longer acquisition times (the longer the TR).
	MEMRI T1w SE (TR = 500 ms, FOV = 15 mm)	Anatomical tract tracings from mouse olfactory & visual systems; tracings from striatum & amygdala; activity-dependent tracings in olfactory system; information on anatomical connectivity & enhancement of specific brain nuclei.
Heart	T1 mapping (inversion recovery, IR)	Measure T1 to identify differences between tissues and between normal & diseased areas (deviations from literature values). Example sequences include: RAREVTR, FISP… Respiratory and cardiac gating are recommended, mainly to acquire images at end-diastole to minimize motion artifacts.
	T2 mapping (spin echo, SE)	Measure T2 to identify differences between tissues and between normal & diseased areas (deviations from literature values). Commonly used to identify

		imaging biomarkers such as edema volume quantification. Example sequences include: MSME … Respiratory and cardiac gating are recommended, mainly to acquire images at end-diastole to minimize motion artifacts.
	Fast GRE	T2w, could be used for high-speed image acquisition of the heart to evaluate cardiac perfusion, often utilizing short FA and very short TR; at the expense of poor T1 weighting. Magnetization preparation is recommended (either with a IR pulse or with T2 sensibilization) for cardiac perfusion/viability studies.
	FLASH imaging	Velocity, magnitude, and direction of the myocardium left ventricular volume Coronary artery and heart valve structure.
	Steady-State free precession (SSFP)	Shot TR (2-5 ms, < expected T2) for strong blood signal to get good contrast with respect to myocardium. Fast acquisition with enough signal. Relatively robust to inflow effects.
	Late Gadolinium Enhancement (LGE)	Identify (and quantify size of) acutely infarcted and scar tissue in myocardium (bright = dead) 10-20 minutes after IV administration of CA. Increased contrast is associated with larger extravascular, extracellular volume and/or slower washout. Uses Gadolinium-based CA.
	Manganese enhanced (ME) T1FLASH (TR = 300 ms, FOV = 25 mm)	To evaluate calcium influx and inotropy. Uses magnesium-based CA.
Lungs	Short TE GRE	T2* relaxation times
	PD	Lung parenchyma, lung volume, and lung tumor assessment.
Kidney	T1 with pH-sensitive CA	Measurement of pH.
	3D MRI	Examination of polycystic kidney disease.
	Dynamic ceMRI	Renal tube damage
Tumor	T1 and T2w dynamic ceMRI with Gd chelates	Highlight tumors to monitor size and growth; examination of tumor angiogenesis.
	Rapid acquisition relaxation enhanced sequences (RARE)	SE acquisitions to identify tumors' location, size and shape
Inflammation	T1 and T2w sequences	Highly sensitive MRI imaging of joints can serve to evaluate bone erosion & joint space narrowing, important for rheumatoid arthritis scoring system quantification

MRI, magnetic resonance imaging; T1, spin-lattice relaxation; T2, spin-spin relaxation; Tw, T-weighted image; T2, apparent T2; FLASH, fast low-angle shot; TE, echo time; 3-D, three-dimensional; BOLD, blood oxygenation level dependent; CA, contrast agent; GM, grey matter; WM, white matter; ceMRI, contrast-enhanced MRI; CSF, cerebrospiral fluid; TR, repetition time; FID, free induction decay; sat, saturation*