Re: Recommended MRI protocol for Day-2 stroked mice

To all SPAN sites:

As the MRI “shakedown” run approaches, the MRI group, coordinating center, and central repository have continued to revise the imaging protocol and our plans for analysis. The overall goal is to enable a fully automated pipeline for stroke lesion segmentation, brain hemispheric volumes, and midline shift. Because we will be imaging so many animals, it is important that each site employ methods that are best suited to the hardware and sequences at that site, subject to very specific restrictions. Below, we outline the basic imaging protocol, an explicit example protocol specific to a Bruker scanner (used by 5 of 6 sites), and some best practices and potential pitfalls.

## Basic Imaging protocol

We will collect 4 types of scans:

1. Anatomical T2-weighted imaging using FSE/TSE/RARE method (fast spin echo)
   * **Purpose:** normalization/segmentation and comparison with later time point at 29 days
   * Use a long TR (e.g., 6000) and an effective echo time of 60 ms or longer
2. A series of spin-echo images in order to create T2 maps
   * **Purpose:** lesion segmentation
   * Use a minimum echo time of 15 ms or shorter to provide a low-contrast volume for analysis
   * Use a maximum echo time of 70 ms or longer (lesion T2 will be about 70 ms)
   * Suggested echo times for multi-echo imaging using a volume transmitter: 0 to 100 ms in steps of 10 ms
   * Suggested echo times for single-echo imaging using a surface coil transmitter: 15, 45, 75 ms
3. A series of diffusion-weighted images in order to create ADC maps
   * **Purpose:** lesion segmentation and CSF discrimination
   * Suggested b-values: 0, 500, 1000 along the z direction
4. A series of gradient-echo images in order to create T2\* maps
   * **Purpose:** detection of hemorrhage
   * Suggested echo times: 3 to 15 ms

All scans except for #1 above should use “conventional” imaging with one readout per excitation in order to avoid distortions. Furthermore, all image data above should use the same matrix, resolution, and geometry:

|  |  |
| --- | --- |
| Field of view | 19.2 mm in-plane x 15 mm in slice direction |
| Matrix | 128 x 128 x 30 slices |
| Resolution | 150 x 150 um with 500 um slice thickness |
| BW | 50k |

Individual sites have some latitude to use methods appropriate to their hardware and sequences. In particular, some sites will want to use multi-echo imaging for the generation of spin-echo T2 maps, whereas other sites may not have an available sequence or may need to use single-echo imaging due to the use of a surface coil for RF transmission and reception. Importantly, once each site defines their protocol, it should remain fixed for the duration of the SPAN study.

## Explicit example protocol on a Bruker scanner (numbering scheme matches basic protocol above)

Hardware: 9.4T magnet, Bruker volume transmit coil, Bruker 4-channel phased array surface receiver coil

Software: PV5.1

The numbering scheme below matches the “Basic Imaging Protocol” above. The time per animal, including all setup, should be less than 1 hour.

1. Setup (these setup scans are not needed in the upload)
   * Sagittal localizer (sequence = FLASH) to position animal accurately along bore
   * Tri-plane localizer with large FOV = 30 mm (sequence =RARE) for adjustments
   * Tri-plane localizer with small FOV = 15 mm (sequence =RARE) for geometry planning
2. Anatomical T2-weighted image volume (3.5 min)
   * Sequence = RARE (rapid acquisition with relaxation enhancement)
   * TR/TE=6000/15, 8 segments, 4 averages, effective TE=60
3. Multi-echo (spin-echo) scan to enable T2 map (6.5 min)
   * Sequence = MSME (multi-slice multi-echo); TR = 4500
   * 10 spin echo times from 10 to 100 ms
4. Diffusion-weighted scan to enable ADC map (9.5 min)
   * Sequence = DtiStandard (\*), TR/TE=1500/25
   * 3 b-values: 0, 500, 1000
5. Multi-echo (gradient-echo) scan to enable T2\* map (2.5 min)
   * Sequence = MGE (multi-gradient-echo), TR=1500
   * 4 gradient echo times from 3 to 15 ms

(\*) Note that sequence DtiStandard enforces a minimum inter-slice delay time to prevent high gradient duty cycles during long runs (at least this is true on PV5.1). This delay can lead to excessively long TR values, so it may be necessary to edit the sequence to shorten this delay, which is not necessary for short diffusion scans.

## Potential pitfalls and best practices

|  |  |
| --- | --- |
| Pitfall | Some scans are not co-aligned with others within a single dataset. |
| Best practice | After defining the geometry on the first scan (e.g., RARE anatomical), always copy geometry from the first scan to other scans. |
|  |  |
| Pitfall | Image volumes within a given “mapping” dataset (e.g., multi-echo data) do not have a consistent scale factor. |
| Best practice | 1. When possible, collect all data within a mapping series using a single scan that collects multiple time points (e.g., multiple TE values or b values) to ensure self-consistent scaling 2. If hardware warrants the use of multiple scans (e.g., a multiple spin-echo sequence like MSME should not be used with a transmit surface coil), then take special care to ensure that each scan has the correct relative signal (\*). |
|  |  |
| Pitfall | The stroke lesion appears on the wrong side of the brain, complicating analysis. |
| Best practice | Ensure that all animals are registered correctly during the initiation of the scan. Using “feet first” when the animal is “head first) will cause a parity change in the image coordinate system. |
|  |  |
| Pitfall | A surface coil provides insufficient spatial coverage or signal to noise ratio (SNR) across the whole brain, leading to a failed segmentation. |
| Best practice | While surface coils provide excellent SNR in general, ensure that 1) the surface coil in use is large enough to provide full brain coverage under optimal conditions, and 2) there is reproducible method to accurately position the coil on the animal head. If initial images indicate poor volume coverage due to a shifted coil or animal head, remove the animal and reposition the coil before continuing the scan. |

(\*) On Bruker scanners, set the parameter “Reco\_map\_mode = ABSOLUTE\_MAPPING”

Thank you – the MRI working group.