SPAN STANDARD OPERATING PROCEDURE

#1	INFORMATION

Procedure Title	MRI Acquisition
Originators	SPAN Coordinating Center
Creation/Revision Date	7/02/2020;**10/06/2020**

SOP: 35 **Version No: 1.0** **Effective Date: TBD**	**Supersedes** **Document:** **Effective Date:**

#2	POLICY

The SPAN study MRI scans will be uploaded, collected, and viewed in the Image Data Archive (IDA) hosted by the USC Laboratory of Neuroimaging (LONI). The LONI IDA is a secure repository for sharing and long-term preservation of neuroimaging and biomedical research data. This repository securely manages data and protects data ownership. The IDA utilizes a data de-identification engine and encrypted file transmission to help ensure compliance with subject-privacy regulations. SPAN MRI acquisition will follow a common protocol.

#3	SCOPE

This procedure applies to all study sites.

#4	ROLES AND RESPONSIBILITIES

Coordinating Center: draft all SOPs
Study Site Principal Investigator: read and distribute all SOPs to relevant study team members

#5	APPLICABLE REGULATIONS AND GUIDELINES

#6	REFERENCES TO OTHER APPLICABLE SOPS

SOP 33 MRI Upload

#7	ATTACHMENTS AND REFERENCES

Toga AW, Crawford KL, Neu SC. The image and Data Archive at the Laboratory of Neuro Imaging. Neuroimage. 2017 Jan 1; 124(0): 1080-1083

IDA User Registration and Archive Instructions document

#8	TERMS AND ABBREVIATIONS

SOP: standard operating procedure
NINDS: National Institutes for Neurological Disorders and Stroke
SPAN: Stroke Preclinical Assessment Network
IDA: Image and Data Archive
LONI: Laboratory of Neuroimaging
INI: Institute for Neuroimaging and Informatics

#9	TRAINING REQUIREMENTS

General Training:

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Location Where Records Maintained:	Site

#10	SPECIFIC PROCEDURES

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 30 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

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, now that each site has defined 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.

0. 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
1. Anatomical T2-weighted image volume (3.5 min)

- Sequence = RARE (rapid acquisition with relaxation enhancement)
- fTR/TE=6000/15, 8 segments, 4 averages, effective TE=60

2. 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
     Or
   - Sequence = MSME using 1 echo per scan
   - 3 spin-echo TE values = 15, 45, 75 ms
3. Diffusion-weighted scan to enable ADC map
   (9.5 min)
   - Sequence = DtiStandard (*), TR/TE=1500/25
   - 3 b-values: 0, 500, 1000

(*) 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”

Upload to LONI Repository

MRI Data will be uploaded to LONI in DICOM format. These files will contain much of the information that is needed to analyze the data, but unfortunately some information will be missing. For instance, Bruker DICOM files do not incorporate b-values. Moreover, it would simplify identification of each image series if it was labeled in some manner. To help facilitate, please include the following text strings into your “protocol name”, which is a standard DICOM field that will be carried along with the data.

1. RARE anatomical image volume: protocol name includes “RARE_anatomy”
2. T2-weighted image scan(s): protocol name includes “T2_map”
3. Diffusion-weighted image scan(s): protocol name includes “ADC_map”

Additionally, specific information describing items 2-3 above should be copied into a text file or data structure template to accompany each dataset upload. See an example below for the text file. Note: This data structure template should be emailed to the CC during the pilot study.

T2 information
Sequence = multi-echo multi-slice or single-echo multi-slice
TE = specify 10 values for multi-echo or 3 values for single-echo (in units of ms)

ADC information
Sequence = DtiStandard or whatever was used
b-values = specify 3 values used (in units of s/mm2)

Protocol must remain fixed for the duration of the SPAN study.

Example Data Structure template

Each experiment will have a folder SS3691_Ya_d2_1_1)

SS3691**: ear tag id**
Ya: Yale
d2: day 2 scan

a. RARE anatomical image volume: **RARE_anatomy**
b. T2 map:

If using Single echo multi slice

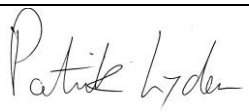
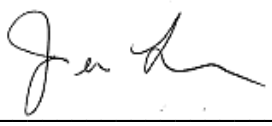
c. T2_map_15ms
d. T2_map_45ms
e. T2_map_65ms

If using multi echo multi slice

T2_map (10 to 100 ms)

f. Diffusion weighted image scan: **ADC map**
Sequence= DtiStandard
b values: 0, 500, 1000

#11	REVIEWED AND APPROVED BY

Patrick Lyden, Principal Investigator	
(Printed Name/Title)	*(Signature)*
Jessica Lamb, SPAN Manager	
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