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Dynamic Contrast Enhanced MRI of mouse Abdomen

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Animal Preparation

1 This SOP includes a brief DCE protocol that consists of following major steps:

1. Animal Preparation for tail vein catheterization

2. MRI calibration, acquisition of B1, T1 and DCE perfusion MRI

3. Animal recovery

Note: The technical details for the acquisition of B1, T1 and DCE perfusion MRI can be

found in the ISMRM 2022 abstract (Pickup S et al. “Abdominal DCE-MRI in mice with stack of stars sampling and KWIC image reconstruction”)

Animal should be transferred from the home cage to anesthesia box connected to isoflurane.

1.1 Induction of general anesthesia

1.Keep the animal under the isoflurane in an anesthesia box for sedation (Figure 1 (A)).

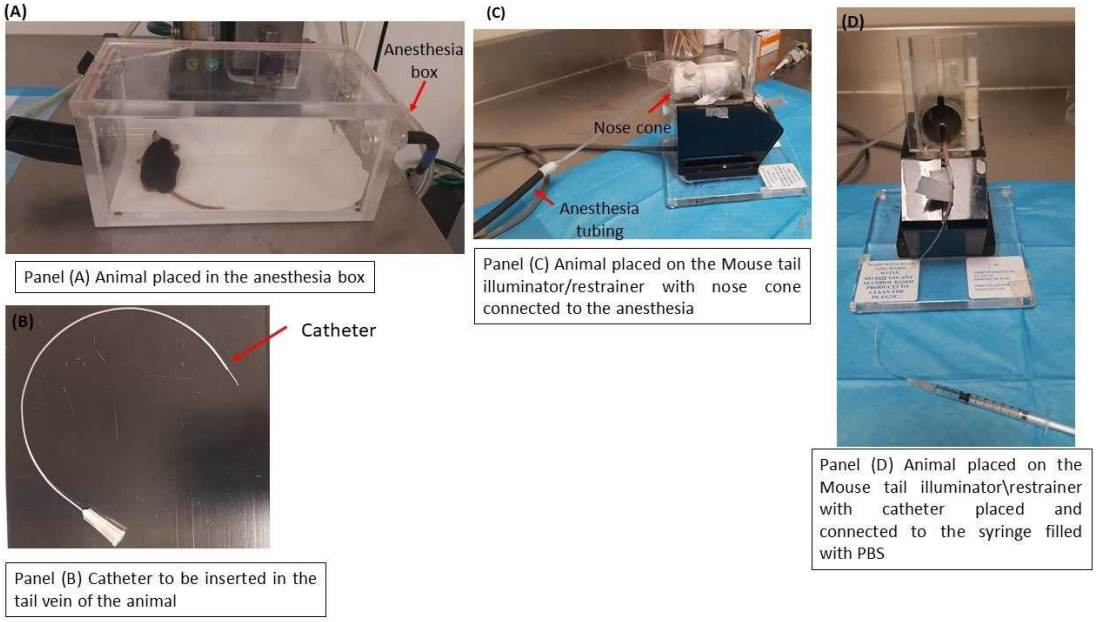

Figure 1: Mouse is placed in anesthesia box and placed on Mouse tail vein illuminator/restrainer with catheter inserted in the tail vein secured with tape and connected to the syringe filled with PBS

2. Connect the Mouse tail illuminator/restrainer nose cone (Braintree Scientific, Inc.) to the anesthesia tubing (Figure 1 (C)).

3. Animal should then be transferred to the Mouse tail illuminator/restrainer.

1.2 Preparing the animal for tail vein catheterization

1. Prepare a small needle (30 gauge) tubing connected to the catheter (PE10 - Polyethylene, Braintree Scientific) and insert it into lateral vein parallel to the tail (Figure 1 (B), (D)).

2. Connect one side of the catheter to the syringe filled with PBS (Figure 1 (D)).

3. To verify proper injection slowly inject the PBS filled in the syringe. If there is resistance and/or a blister or white area appears above the needle on the tail, remove and reinsert again.

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4. Secure the needle using the tapes (Figure 1(D)).

5. Remove the syringe and hup of the syringe and connect the catheter with an approx. 30 cm extended catheter to inject the contrast agent outside the magnet manually with a tape (Figure 2 (A), (B)).

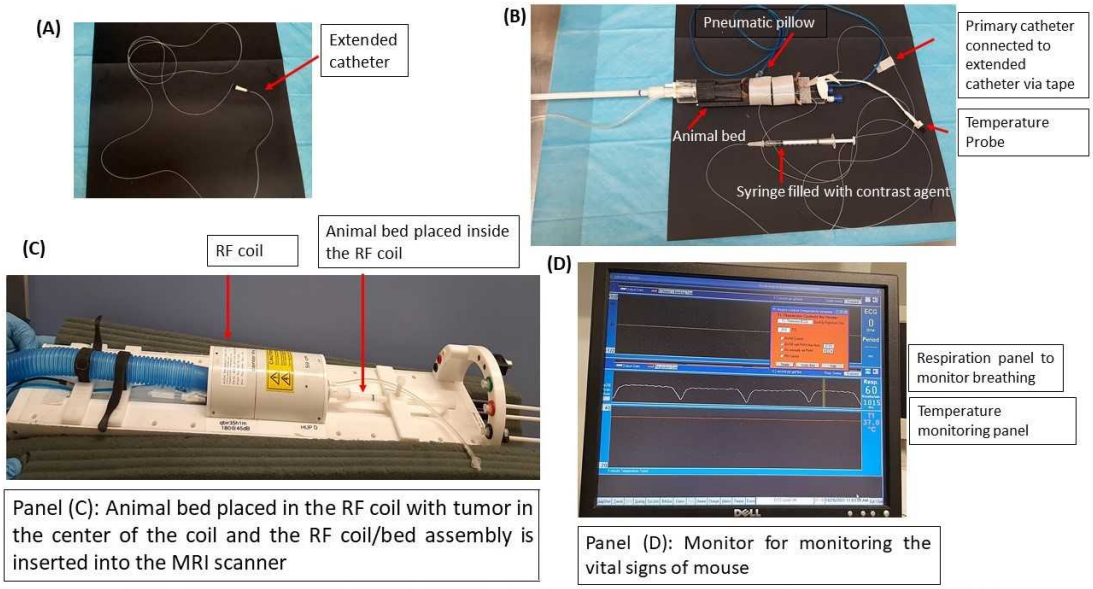

Figure 2: (A) Extended Catheter (B) Extended catheter connected to the primary catheter via tape and connected to the syringe filled with contrast agent and mice placed on the animal bed with Pneumatic pillow and temperature probe (C) Animal bed placed in the RF coil and monitor to monitor the vital signs (D) Monitor for monitoring the vital signs of mouse

6. An FDA-approved contrast agent for clinical MRI, Prohance (Bracco diagnostic Inc., Germany) was diluted (50×) in PBS to 10 mmol/L gadolinium (Gd) for injection in mice. We refer this diluted contrast agent as gadolinium-based contrast agent (GBCA).

7. The extended catheter should be prefilled with GBCA.

1.3 Place the mice in with the vital signs monitoring

1. Place the sedated animal on the animal bed and secure it properly with tape, secure the pneumatic pillow under the thorax of the animal to record proper breathing (Figure 2 (B)).

2. Insert the temperature rectal probe into the animal rectal using a lubricant for monitoring the temperature (Figure 2 (B)).

3. Position the animal bed in the coil in a position which exposes the tumor-bearing region in the center of the magnet by measuring from the center line printed on the top of the coil (Figure 2 (C)).

4. Now place the RF coil in center of the magnet using a non-metal yardstick and connect the temperature probe and respiration probe to the ERT module.

Note: *Remember to always continue monitoring the animal vitals when it is on the scanner*

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(Figure 2 (D)).

2 MRI Scanner Calibration, Scout, T2W MRI and DCE

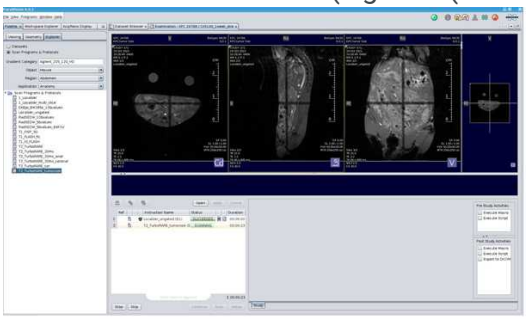
Open ParaVision 6.0.1 for generating a new study.

2.1. Localizer initiation

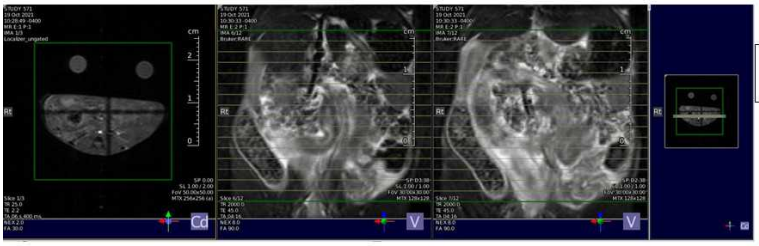
1. After generating a new study, a localizer can be selected from the scan programs and protocols drop down menu.

2. For initiating a localizer, locate the appropriate protocol in the scanner interface/software.

3. Generally, a simple short T1-weighted image with a single slice in each orthogonal direction can provide enough spatial information to ensure that the animal is properly placed underneath the coil (Figure 3 (Panel (A)).



Panel (A) Showing a simple T1-weighted image with a single slice in each orthogonal direction.



Panel (B) Setting of T2_Turbo with RARE technique scan

Figure 3: A simple T1-weighted image with a single slice in each orthogonal direction and setting of T2_Turbo with RARE technique axial scan.

4. Prior to initiating the scan, a series of calibration/shimming is performed automatically by the scanner including the following steps:

I. Wobble -tuning and matching of the RF coil.

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ii. Set the basic frequency
iii. Perform auto shimming
iv. Set the reference power

2.2 Select T2_Turbo with RARE technique (Tumor staging and reference image for DCE)

1. Select T2_Turbo with RARE technique (FOV=30x30, Slice thickness=1.00 mm, no. of averages=8) to obtain the coronal images.

2. Click on apply to run the scan.

3. Duplicate the first scan and increase the number of slices to cover the entire tumor with (number of averages=12) in axial direction for calculating the tumor size.

4. Click on apply to run the scan.

5.The third scan T2_Turbo with RARE technique in axial plane can be set using the images obtained from the first scan. The T2_Turbo with RARE technique scan will serve as reference scan for the DCE. A preset FOV, NA, Slice thickness (1.5 mm), number of slices (16) were used according to the protocol (Figure 3 (Panel (B)).

6. Turn on Autoshim then Mapshim and tick the automatic shim volume.

7. In this study under geometry the read offset and phase offset were kept as zero.

8. Click on apply to run the scan.

9. Before running the third scan the Bo inhomogeneity map can be obtained.

2.3 Acquire B1 map with outer volume suppression (OVS)

1. Under application tab choose perfusion and then the custom developed radial K-space stack of star sampling (SPSOS 3d AF02) with OVS to acquire the B1 map.

2. Copy the T2_Turbo with RARE technique in axial plane sequence parameter to SPSOS 3d AF02 sequence from the drop-down menu.

3. To set the OVS following steps can be done:

i. Tick the FOV saturation under contrast.
ii. There should be at least 1 slice gap between the acquisition slice and saturation slice.
iii. Set the thickness fraction to 0.85. Check the geometry again and then click on apply to start the sequence.

4. Click on apply to run the scan.

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2.4 Acquire T1 map with OVS using variable flip angle method

1. Under application tab choose perfusion and then the custom developed SPSOS3d01_ T1 with OVS to acquire the T1 map.

2. Copy the T2_Turbo with RARE technique in axial plane sequence parameter to SPSOS3d01_ T1 with OVS sequence from the drop-down menu.

3. To set the T1 with variable flip angle following steps can be done:

i. Right click SPSOS3d01_ T1 with OVS sequence and multiply the instruction.
ii. Click on the hand icon and choose ExcPulse1 and then Flip angle.
iii. Set the Flip angles to 5, 8, 12, 16, 20.

4. Check all the SPSOS3d01_ T1 with OVS for all the flip angles and geometry.

5. Click on apply to run the scans.

2.5 Acquire the DCE series

1. Under application tab choose perfusion and then the custom developed golden angle stack of stars sampling (SPSOS3d01_ DCE) to acquire the perfusion maps.

2. Copy the T2_Turbo with RARE technique in axial plane sequence parameter to SPSOS3d01_ DCE from the drop-down menu.

3. Click on apply to run the scan.

4. After 2 mins of baseline scan inject 200ul of GBCA manually in 10 secs to acquire the post contrast perfusion maps.

3 Remove and Recover Mice

1. Upon completing the scan, the RF coil/animal bed assembly are removed from the scanner.

2. Vital sign probes and tail vein catheter are removed from the mice before anesthesia is turned off.

3. The mice should be recovered from the anesthesia by keeping it warm either using the warm pads or preheated operation table warmed at 37°C.

4. After the mice is recovered well it can be returned to its home cage.

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