
*The Fenestra™ line of imaging products provide flexible, long-lasting contrast enhancement for a wide range of computed tomography imaging applications, including vascular and hepatobiliary anatomy and function.*

# Imaging Vascular Anatomy in SD Rats with Fenestra VC and GE Healthcare's eXplore Locus microCT Scanner

This case study provides guidance and recommendations for conducting vascular imaging studies in normal SD rats with Fenestra VC and GE Healthcare's eXplore Locus microCT scanner. You should note that other examples of the capabilities of Fenestra and a selection of additional case studies are available on the ART website at *www.art.ca/en/imaging-agents/*.

## Animal Model

### Strain
Sprague-Dawley rats (180 to 230 g females).

### Model
Normal rats.

## Animal Preparation

### Anesthesia
Animals received 5% isoflurane in oxygen during rapid inhalation induction (1 to 2 minutes) of anesthesia Maintenance of anesthesia during scanning was achieved using 2 to 2.5% isoflurane in oxygen.

### Administration and Dosage
Fenestra VC was injected intravenously into the lateral tail vein of anesthetized rats at a dose of 7.5 to 15 ml per kg body weight over a period of 2 to 4 minutes. A 1 ml disposable syringe fitted with a 27-gauge needle was used to inject the contrast agent. Prior to injection the tail vein was immersed in warm water for 30 to 60 seconds to increase blood flow to the tail and dilate the vessels.

**NOTE** Refer to the ART publication ***Using Fenestra Contrast Agents*** (PMK-UG001-E) for recommendations and detailed instructions related to dosage, animal preparation, and administration.

## Image Acquisition

### Equipment

GE Healthcare eXplore Locus microCT scanner.

### Animal Placement

Anesthetized rats were placed on the scanner bed with heads positioned and secured in an anesthesia mask connected to the gas line. Tails were pointed into the gantry. The desired body region was selected from the scout view as the anatomic landmark for image acquisition.

### Settings

The settings selected for this medium resolution contrast-enhanced study were as follows:

#### X-Ray Camera

| Parameter | Setting |
|---|---|
| Bin-mode | 4 |
| CDS-gain | 1 |
| Camera-gain | 0 |
| Scan-bright-first | No |
| Bright | Yes |
| Dark | Yes |
| Multiple-bright | No |
| Trigger | Internal |
| Exposure Time Per Frame | 5 |
| Warp Correction | Yes |
| Defect Map Correction | No |

#### X-Ray Tube

| Parameter | Setting |
|---|---|
| X-Ray Voltage | 80.0 kVp |
| Anode Current | 450.0 μA |

#### CT Scan

| Parameter | Setting |
|---|---|
| Rotation Stage Start Position | 0.000 degrees |
| Stage Position | 210.002 mm |
| Total Rotation | 360 degrees |
| Number of Rotation Steps | 400 |
| Number of Acquired Calibration Exposures | 10 |
| Raw Data | Written to File |
| Real Time Reconstruction | No |
| Total Scan Time | 22 minutes |
| Resolution | 0.094355 mm |

Images were acquired at T = 10, 120, 240, 360, and 1440 minutes post-injection. Beginning at T=10, vascular contrast rapidly increased to a level that was sustained for several hours. The liver showed a slight increase in CT density due to its significant vascular supply. The highly vascular structure of the spleen resulted in a high level of contrast enhancement. Beyond the 6-hour time point, vascular contrast enhancement declined gradually as Fenestra VC underwent hepatobiliary elimination, resulting in a substantial increase in CT density of the liver.

## Data Reconstruction and Analysis

### Data Reconstruction

Reconstructed image files can be stored as a VFF or DICOM files. You should note that down-sampling was unnecessary for the selected resolution in this experiment.

**NOTE** DICOM files can be exported to Visage Imaging's Amira image presentation and analysis software for viewing as axial, coronal, and sagittal images, in addition to a number of other image representations.

| Parameter | Setting |
|---|---|
| Mini Volume Reconstruction | 10 × 10 (X/Y and Z-bin size) × 10 (view increments) |
| Full Resolution Reconstruction | 1 × 1 (X/Y and Z-bin size) × 1 (view increments) |
| Reconstruction Filter | Shepp-Logan |
| Reconstruction Algorithm | Fledkamp cone-beam |

### Volumetric ROI Measurement

Relative tissue density of a region of interest (ROI) can be calibrated to represent Hounsfield Units (HU) through the use of the CT Calibration or Bone Mineral Density tool in GE Healthcare's MicroView imaging application.

### Data Visualization

Data is routinely imported into Amira from the GE Healthcare's reconstruction program as raw CT image data or as DICOM files windowed to a vascular contrast setting. Data can be viewed in Amira using the Standard Display format with simultaneous display of the axial, coronal, and sagittal images, or as 3D isosurface images that can be manipulated to view anatomic structure with or without orthoslice display of 1, 2, or all 3 of the planar slices. The isosurface image can also be cropped to eliminate extraneous data and saved as an Amira map file, which can accelerate isosurface viewing and save file space.

Using Amira's image capture feature, planar and 3D images can be captured for presentations or publication purposes, while movies can be created for fly-through of 3D image data sets.

## Representative Images

A series of representative images from a study conducted in normal SD female rats using Fenestra VC and GE Healthcare's eXplore Locus microCT scanner are provided in the figures below. You should note that dosing of Fenestra VC was calculated at 15 ml/kg body weight in all contrast-enhanced images.

### Precontrast Exam

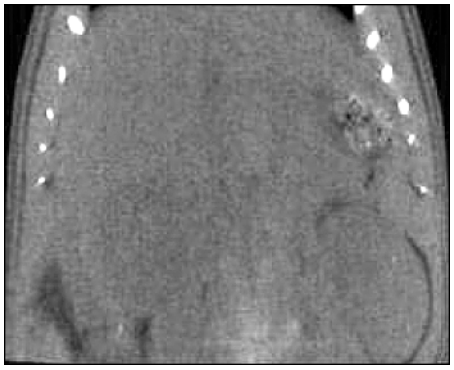

***Figure 1.*** *Non-contrast coronal scan of a female rat. Poor soft-tissue contrast is evident in the thoracic and abdominal cavities. The bright spots in the intestines are caused by minerals in the rodent chow that attenuated the X-ray beam.*

### Fenestra VC Exam

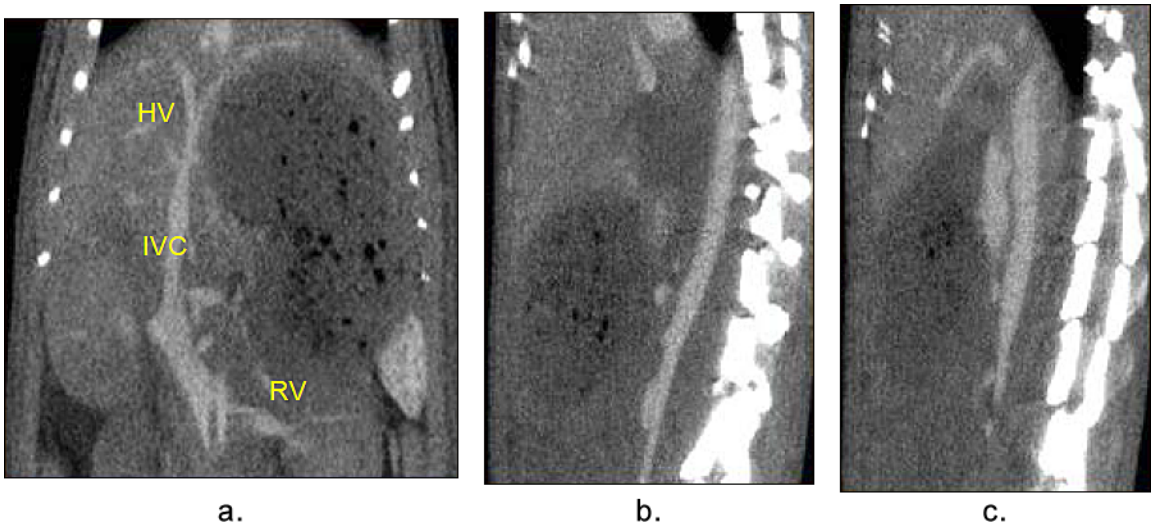


***Figure 2.*** *Coronal and sagittal views of a female rat 10 minutes after IV injection of Fenestra VC.* ***a.*** *This coronal image shows the inferior vena cava (IVC), the renal veins (RV), and hepatic vasculature (HV). The spleen (adjacent to the left kidney) is enhanced due to its high degree of vascularity.* ***b.*** *This sagittal view shows the descending aorta in proximity to the spine and a short segment of the IVC in the upper abdominal area.* ***c.*** *This image shows both the inferior vena cava and portal vein below the dome of the liver and several other vessels in the liver.*

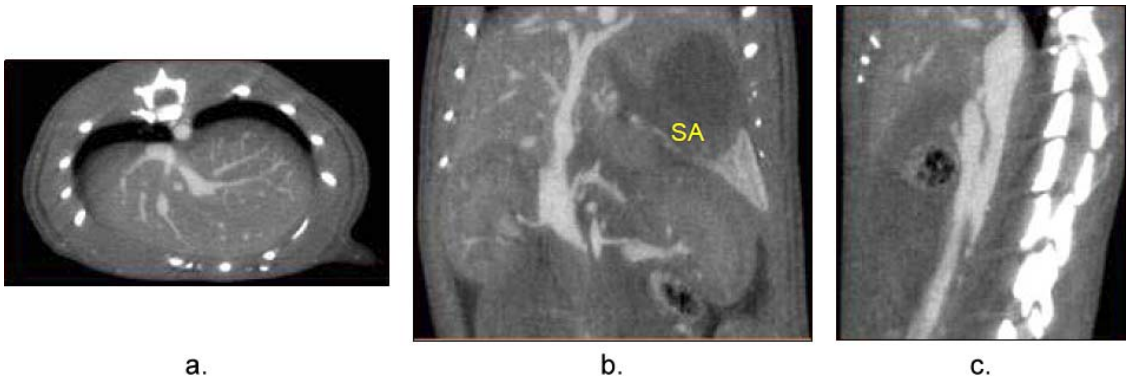


***Figure 3.*** *Axial, coronal, and sagittal scans of a female rat obtained 10 minutes after IV administration of Fenestra VC.* ***a.*** *Axial view shows the aorta and inferior vena cava, as well as major vessels traversing diagonally through the liver. A number of smaller vessels are also seen in cross section.* ***b.*** *In the coronal view, the inferior vena cava and the left renal vein and artery are significantly enhanced. The renal cortex and renal medulla of the left kidney can be clearly seen at this dose of Fenestra VC. The splenic artery (SA) is clearly observed, as is the spleen (adjacent to the left kidney) owing to its high degree of vascularity.* ***c.*** *Sagittal image shows both the inferior vena cava and portal vein in the abdomen. Chow-induced artifacts in the intestines are evident in the coronal and sagittal images.*

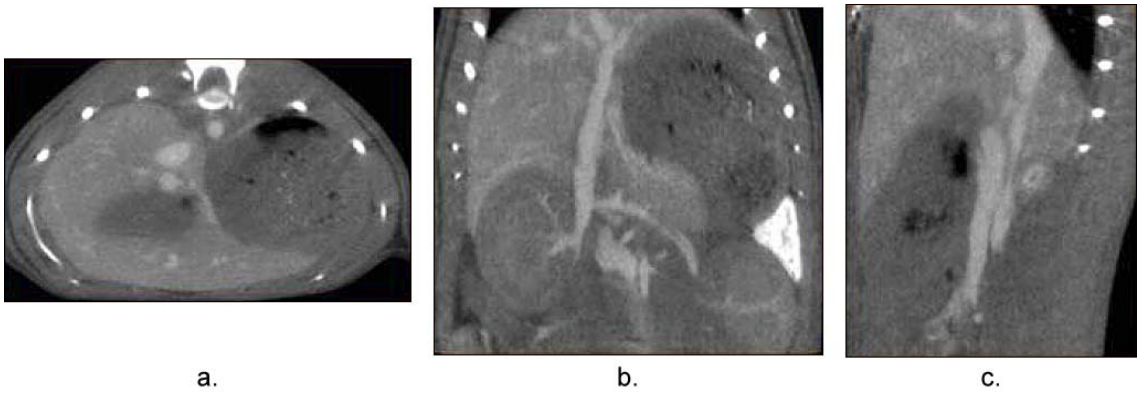


***Figure 4.*** *Axial, coronal, and sagittal scans of a female rat obtained 6 hours after IV administration of Fenestra VC.* ***a.*** *Axial image shows the aorta and inferior vena cava, as well as small vessels in cross section. Increased enhancement is observed in the liver due to the elimination of the contrast agent.* ***b.*** *Coronal image shows Fenestra VC continues to produce vascular contrast 6 hours after injection.* ***c.*** *Sagittal image shows both the inferior vena cava and portal vein in the abdomen, as well as the liver.*

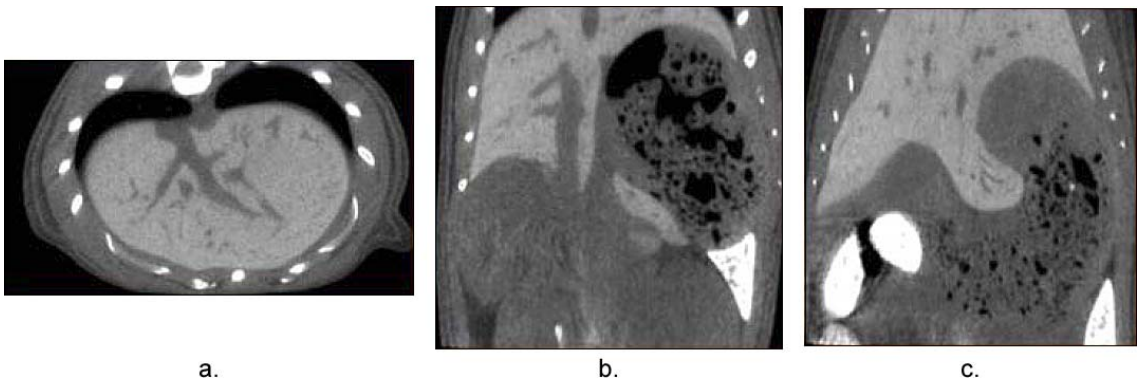


***Figure 5.*** *Axial and coronal scans of a female rat obtained 24 hours after IV administration of Fenestra VC.* ***a.*** *Axial image shows the liver is significantly enhanced due to the accumulation of metabolites as the contrast*

*undergoes hepatobiliary elimination. The aorta and inferior vena cava, as well as hepatic vasculature, become visible due to the negative contrast effect.* ***b.*** *Coronal view shows the contrast agent was totally eliminated from the vasculature system after 24 hours as the inferior vena cava appeared black. The spleen (adjacent to the left kidney) remained enhanced.* ***c.*** *This coronal image shows enhanced liver and gastrointestinal tract (seen on the bottom left corner of the image) as the contrast agent was eliminated from the body.*

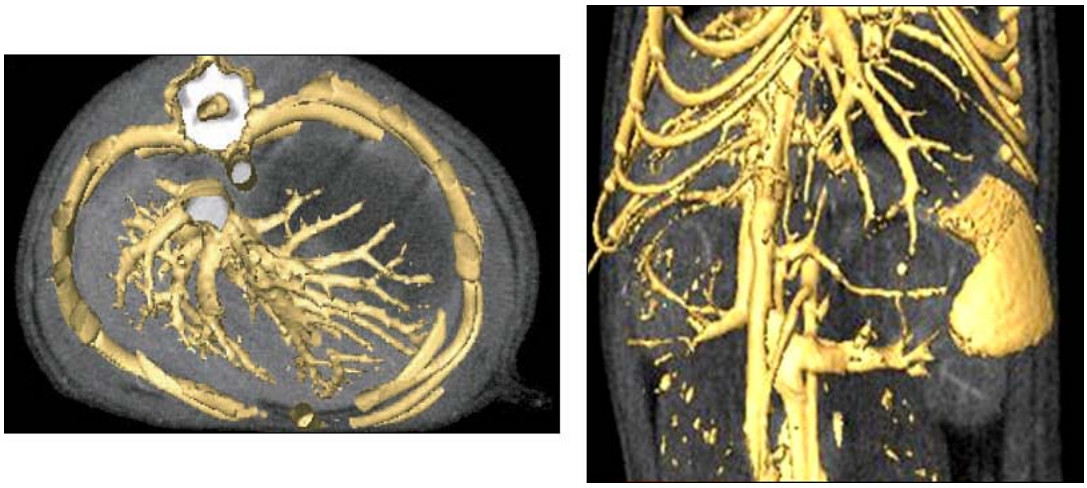

***Figure 6.*** *Volumetric representations of vascular enhancement from scans of a normal female rat obtained 10 minutes after IV administration of Fenestra VC. Fenestra VC can produce vascular contrast enhancement throughout the entire body from a single peripheral injection.*



PMK-UG005-E02

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