Guide to Small Animal Abdominal Imaging using the Vevo 770™

Course Objectives:

After completion of this module, the participant will be able to accomplish the following:

• Recognize abdominal organs and vessels in mice,
• Position micro-ultrasound RMV scanhead to acquire the necessary views
• Discuss the physiological functions and relevance to in vivo imaging.

This Guide to Small Animal Abdominal Imaging includes imaging of the following structures: liver, spleen, pancreas, gallbladder, kidneys, and the adrenal glands.

A Note on RMV Scanhead Selection for Abdominal Imaging:

Appropriate selection of RMV scanheads for abdominal imaging is critical to the resolution and definition obtained. For the Vevo 770, recommended RMV scanheads are the RMV 704 and the RMV 708.
I. Imaging the IVC and Abdominal Aorta

A. Imaging in Transverse (cross-sectionally)

First, position the scanhead in transverse (i.e., the notch of the probe is placed to the left of the mouse). The scanhead is placed in the midline of the mouse just below the rib cage. Two dark circles will be visualized in the midline which will represent the IVC (Inferior Vena Cava) to the right of midline and the aorta, which is slightly to the left of midline.

A trick to assist in identifying the IVC (a vein) is to apply pressure to the abdomen of the mouse: a vein will collapse when an artery will not. This is represented below:

**Figure 1:** Transverse B Mode image of the compressed IVC and aorta using the Vevo 770 with the RMV 704 at a center frequency of 40MHz.
Without compression the Aorta and IVC will appear as below:

![Image](image_url)

**Figure 2:** Transverse B Mode image of the uncompressed IVC and aorta using the Vevo 770 with the RMV 704 with a center frequency of 40MHz.

As with all vascular anatomy, the vein will always be larger than its correlating artery.

**B. Imaging in longitudinal axis**

To image the aorta or IVC in longitudinal axis, rotate the scanhead 90 degrees (notch towards the head of the mouse). The IVC will be imaged as shown below. Remember to use compression to identify the IVC because the aorta is just to the left of this vessel.
**Figure 3:** Longitudinal B Mode image of the IVC and aorta using the Vevo 770 with the RMV 704 at a center frequency of 40MHz.

With the scanhead moved slightly to the left of midline you will visualize the aorta. As seen below:
Figure 4: Longitudinal B Mode image of the aorta and the superior mesenteric artery using the Vevo 770 with the RMV 704 at a center frequency of 40MHz.

II. Imaging the liver and hepatic vessels

Anatomy: The liver is located in the right upper quadrant of the abdomen and extends into the midline and the left upper quadrant of the abdomen. It adheres to the diaphragm, and its inferior concave surface is in contact with the stomach and duodenum.

Scanhead Position: Maintain position at the midline and move the scanhead slightly to the mouse's right to image the liver. It is a large structure with smooth texture, and contains many vessels and ducts.

Image Characteristics: The texture of the liver is normally uniform. Any variations in the texture would be indicative of a disease process. The brightness of the liver image can also indicate some pathology. The mouse liver has four large lobes: a medial lobe, two lateral lobes (left and right) and a caudate lobe with dorsal and ventral portions. The left and right side of the liver are separated by the falciform ligament and the ligamentum teres.
**Figure 5:** B Mode image of the liver using the Vevo 770 with the RMV 704 at a center frequency of 40MHz.

The hepatic vessels are located near the diaphragm and branch off of the IVC. The hepatic vessel walls are less bright and smooth as compared to the organ. The portal vessels come from below the liver (from the bowel) and the walls are echogenic.
Figure 6: B Mode image of the liver and hepatic artery using the Vevo 770 with the 704 RMV at a center frequency of 40MHz

Using the aorta as a landmark, the left lobe of the liver extends to the left of midline. The left lobe may extend as far as the spleen on the left upper quadrant of the mouse.

Figure 7: B Mode image of the aorta and the left lobe of the liver using the Vevo 770 with the 704 RMV at a center frequency of 40MHz
III. Imaging the Gallbladder

Anatomy: The gallbladder is located in the dome of the liver closer to the diaphragm. It contributes to the digestive process and contains bile. The bile produced by the liver reaches the gallbladder via the hepatic duct, and leaves the gallbladder (to the intestine) via the cystic and common bile ducts. The bile is a liquid which will appear dark on the ultrasound image. Mice eat constantly so if your study requires visualization of the gallbladder, it is recommended to have the mouse fast for a few hours. This allows the to gallbladder fill up with bile, which facilitates successful imaging.

Scanhead Position: To successfully image the gallbladder, angle the scanhead or the mouse or both. The liver is located under the ribs, requiring the scanhead to be angled upward toward the liver to reach the level of the diaphragm and to visualize the gallbladder. Angle the scanhead toward the head of the mouse (keep the scanhead in the same plane that you started with: the notch to the mouse's left). If angling of the scanhead alone is not sufficient, angle the mouse on the mouse handling platform, with the head lower then the rest of the body.

![Figure 8: B Mode image of the right lobe of the liver, gallbladder and diaphragm using the Vevo 770 and the RMV 704 with a center frequency of 40MHz.](image-url)
IV. Imaging the Kidneys

Anatomy: The kidneys are paired organs, located on the posterior wall of the abdomen beside the vertebral column. Kidneys are "bean shaped" and the medial margin of the organ is concave. In this concavity, the hilum of the kidney exists. The hilum houses the renal artery and vein, nerves and the ureter. The hilum is also called the renal pelvis. In the mouse, the right kidney is slightly larger than the left, and is positioned slightly higher than the left. The ureters are two thin small ducts that connect the kidneys to the bladder, and they transport the urine produced by the kidney to the bladder.

Scanhead Position: Continue to investigate the right side of the abdomen. Move the scanhead caudally (towards the feet of the mouse) and apply a small amount of pressure to allow the upper pole of the right kidney to be visualized. Medial positioning will visualize the adrenal gland which lies in the perirenal space antero-medial to the kidney.

The adrenal gland consists of a medulla (secretes epinephrine) and cortex (secretes aldosterone, corticosteroids and sex hormones). The medulla, which is the centre of the gland, will appear brighter than the outer portion of the gland which is the cortex. These are joined to the kidneys by fibrous and fatty tissue and are approximately the size of a pinhead.

Figure 10: B Mode image of the adrenal gland using the Vevo 770 and the RMV 704 with a center frequency of 40MHz.
**Figure 11:** B Mode image of the right adrenal gland and the IVC using the Vevo 770 and the RMV 704 at a center frequency of 40MHz.

### A. RIGHT KIDNEY

With a more caudal scanhead position, the kidney can be visualized. The renal artery and vein can be seen at the midline or the hilum (or renal pelvis). The ureter also inserts at this point but is not seen unless it is diseased.
**Figure 12:** B Mode image of the right kidney with its renal vein using the Vevo 770 and the RMV 704 at a center frequency of **40MHz**

The renal vein usually appears larger than the artery, and the artery travels posterior to the vein. One can distinguish the renal vein and artery from each other by performing a PW Doppler. The renal artery will present a wave form as follows:

**Figure 13:** Doppler image of the renal artery using the Vevo 770 and RMV 704 with a **40MHz** center frequency
The Doppler waveform for the renal vein is represented by the picture below:

**Figure 14:** Doppler image of the renal vein using the Vevo 700 and the RMV 704 with center frequency of 40MHz.

The kidney consists of two layers: the medulla and the cortex. When viewed under ultrasound, the medulla is darker than the cortex and it is in the medial portion of the kidney. The cortex is the outer layer where tumors and cysts will generally appear.

**B. LEFT KIDNEY**

To visualize the left kidney, move caudally (towards the mouse's feet), and apply a little more pressure. The anatomy is the same as the right kidney and you can find the left adrenal gland in the same Position, antero-medially, as with the right kidney.
**Figure 15:** B Mode image of the pancreas, spleen and left adrenal gland using the Vevo 770 and the RMV 704 at a center frequency of 40MHz.

**Figure 16:** B Mode image of the left kidney and its renal vein using the Vevo 770 and the RMV 704 at a center frequency of 40MHz.
**Figure 17:** B Mode image of the kidney displaying the cortical and medullary tissues using the Vevo 770 and the RMV 704 with a center frequency of 40MHz.

If you turn the scanhead with the groove toward the head of the mouse, all of these organs can be visualized in the longitudinal plane.

**Figure 18:** Longitudinal B Mode image of the right kidney using the Vevo 700 and the 704 RMV at a center frequency of 40MHz.
V. Imaging the Pancreas

**Anatomy:** The pancreas of the mouse is located in the midline of the abdomen and extends into the left upper quadrant. It runs parallel to the duodenum and is completely enclosed in the mesenteric adipose tissue. It does not appear as a true compact organ as in the human being.

The entire pancreas is difficult to see due to its size and location. With the Vevo 700, it is possible to visualize portions of the pancreas, particularly the left lobe.

**Scanhead Position:** To locate the left lobe of the pancreas, start in the midline with visualization of the IVC and aorta. With the scanhead in transverse plane, move to the left of midline slightly (to the mouse's left), and you will see tissue above the upper pole of the kidney, distal to the stomach and medial to the spleen.

You should also visualize the splenic vein, on the posterior surface of this tissue.

*Figure 20:* B Mode image of the aorta, splenic vein, pancreas, spleen and left kidney using the Vevo 770 and the RMV 704 with a center frequency of 40MHz.
The portion of the pancreas that extends to the right of midline (right lobe of pancreas) also travels caudally. To visualize it properly, stay in midline and move slightly to the right while angling the scanhead towards the head of the mouse with a slight angle.

The tissue of the pancreas is less substantial on the right than it is on the left. As you will see from the anatomy illustration, the pancreas is quite vast but not all lobes are visible.

VI. Imaging the Stomach

**Location:** The stomach sits in the left upper quadrant of the mouse and is usually filled with contents and some fluid. It is a large structure and may inhibit visualization from time to time when gas-filled.

**Scanhead Position:** Place the scanhead in the midline and move toward the left of midline. You will still see liver tissue, and you will see the stomach with fluid/contents. You may also see a lot of "noise" posteriorly which would represent air artifact as there may be air in the stomach. If you are not sure if you are imaging the stomach, just remain in your position and watch the structure. The stomach will move due to peristalsis.

*Figure 22: B Mode image of the stomach using the Vevo 770 and the RMV 704 with a center frequency of 40MHz.*
VII. Imaging the Spleen

**Location:** The spleen is located lateral to the stomach in the left upper quadrant. It is crescent shaped and contains two different tissues. The parenchyma of this organ contains:

   a) red pulp which is tissue with erythropoietic function consisting of vessels and cords of various types of red cells, and

   b) a lymphoid tissue called white pulp.

The ventral portion is smooth and convex, and the dorsal side is slightly concave. It contains the hilum, through which the splenic vessels enter the organ. Its appearance is that of "Swiss cheese".

The function of the spleen is to produce antibodies to fight infection or disease; it rarely develops tumors. However, the spleen's texture and size will change with certain disease processes.

The young adult mouse spleen measures approximately 15mms in length, 3mms in width and 2mm in thickness.

**Scanhead Position:** Using the RMV 704 there are two ways to approach imaging of the spleen. The first is to start with your scanhead in the midline and then move to the left until you visualize the spleen. However, this approach may put too much pressure on the ribs of the mouse so you may want to image from the left lateral side of the mouse. Bring the scanhead over to the left lateral portion of the mouse and angle inward toward the mouse; you should see the spleen, and you may use this position for either sagittal or transverse scanning.
VIII. Imaging the Gastrointestinal Tract

**Anatomy:** The intestine is approximately 40 cm long and is comprised of the small and large intestine. The small intestine includes the duodenum, jejunum, and ileum. The duodenum starts from the stomach and has a horseshoe shape. The longest portion on the small intestine is the Jejunum. The ileum follows and ends at the caecum.

The large intestine includes the caecum, which consists of a small bag located in the right lower quadrant of the abdomen. Also included are the ascending colon, the transverse colon, the descending colon, and the rectum at the end of the large intestine.

*Figure 24: B Mode Image of the spleen using the Vevo 770 and the RMV 704 with a center frequency of 40MHz.*
IX. Imaging of lymph Nodes

**Anatomy:** The lymphatic and cardiovascular systems are closely related structures that are joined by a capillary system. Lymphatic vessels are located anywhere there are blood vessels.

Lymph nodes are part of the body's defense mechanism. They filter out organisms that cause disease. They produce certain white blood cells and generate antibodies. They are also important for the distribution of fluids and nutrients in the body because they drain excess fluids and proteins to prevent tissues from swelling.

Lymph is a milky body fluid that contains white blood cells (lymphocytes), proteins and fats.

The lymph nodes are numerous and vary in size depending on the different strains of animals. They can be shaped like a small pea or bean. According to where they are situated, they can be classified as superficial or deep. Superficial lymph nodes are located in the subcutaneous area and near the skeletal muscle masses. They are bilateral. The deep nodes are located inside the thoracic and abdominal cavities close to the organs.

**Scanhead Position:** Use the RMV 704 for the deep lymph nodes and use the RMV 708 for imaging the superficial nodes. Please look at the anatomical diagram for the location of the lymph nodes.
Figure 25: B Mode image of a superficial lymph node using the Vevo 770 and the RMV 704 with a center frequency of 40MHz.

For more information or assistance with any imaging procedures, please contact VisualSonics at: support@visualsonics.com