

The Mouse Abdominal Imaging Guide

Liver, Hepatic Vessels, Portal Veins, and Gallbladder

A. Anatomy

Liver and Gallbladder

The mouse liver weighs approximately 2g^[1], spans the entire subdiaphragmatic region, and is divided into four main lobes: caudal lobe (located dorsal and ventral to the esophagus), right lateral lobe (subdivided horizontally into anterior and posterior portions), median lobe (subdivided into left and right portions), and the left lateral lobe^[1]. The right lateral lobe has a transverse septum that approximately bisects it. The median lobe sits most ventrally and is the most prominent lobe when the abdominal cavity is viewed from the usual ventral aspect. Its two pyriform wings connected by a narrow central isthmus are present beneath the median lobe, and these produce the ventral sac of the gallbladder. The left lobe is the largest and is a frequent site of sampling for histology. The caudate lobe is small and has two distinct ear-shaped segments^{[2][3]}.

B. Transducer Position and Sonography Procedures

Liver

When imaging the liver the transducer scan head should be moved across the processes xiphoideus gradually toward hind limbs of the mouse (Fig. 1(A)). Because the liver lies just beneath the skin surface, the transducer scan head should be positioned away from the skin surface in order to obtain a focused liver image. A B-mode image is a two-dimensional (2-D) presentation of echo-producing interfaces in a single plane, and it displays shapes, texture, and contours of the body. B-mode imaging is popular for identifying anatomical structure and diagnosing lesions, especially of the abdomen. The liver parenchyma appears echogenic, homogeneous, and of medium texture in a B-mode image. The margin of the liver is bounded by an intensely echogenic curvilinear structure (Fig. 1(B)). The sonographer should examine not only the appearance of the parenchyma but also the margins of the liver, the porta hepatis, and the contour and appearance of the diaphragm. Liver margin evaluation allows detection of protruding nodules and surface irregularities as well as assessment of rounded margins that appear on an enlarged liver.

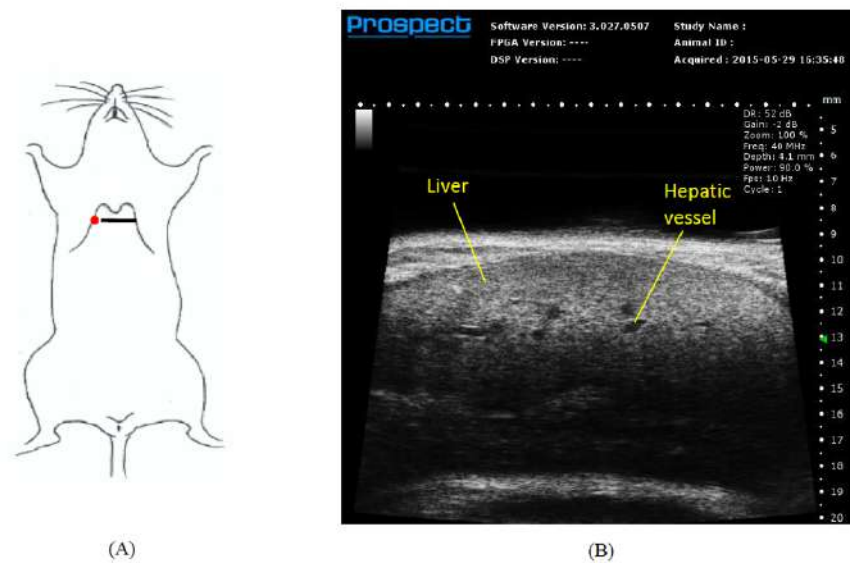


Fig. 1. Mouse liver imaging: (A) transducer position and (B) ultrasound image.

Hepatic Vessels and Portal Veins

When the cross section of the liver is found, anechoic round and tubular vascular structures will simultaneously be noted; these represent hepatic vessels (Fig. 1(B)) and portal veins. The walls of the portal veins are more echogenic due to the more organized connective tissue in the vessel walls scattering more of the ultrasound beam than those of the hepatic vessels. The probe can be moved toward hind limbs to scan all of the liver in an attempt to find more notable vessels or rotated in combination with moving the platform slightly in different directions to obtain a longitudinal-section view of specific vessels (Fig. 2(A) and Fig. 3(A)). Liver vessels can also be identified by using Doppler modes. Two kinds of Doppler modes are provided: color/power Doppler-mode and pulsed-wave (PW) Doppler-mode. The color/power Doppler-mode provides a 2-D color velocity map superimposed on the B-mode image, which facilitates the positioning of the vessels of interest. PW Doppler-mode, on the other hand, represents the spectrum (i.e., the velocity distribution) as a function of time. Employing the triplex function in PW Doppler-mode (i.e., B-mode, color Doppler-mode, and spectral Doppler-mode images displayed simultaneously in the same window) makes it possible to locate the vessels and conduct quantitative flow measurements, as shown in Fig. 2(C)(D) and Fig. 3(C)(D).

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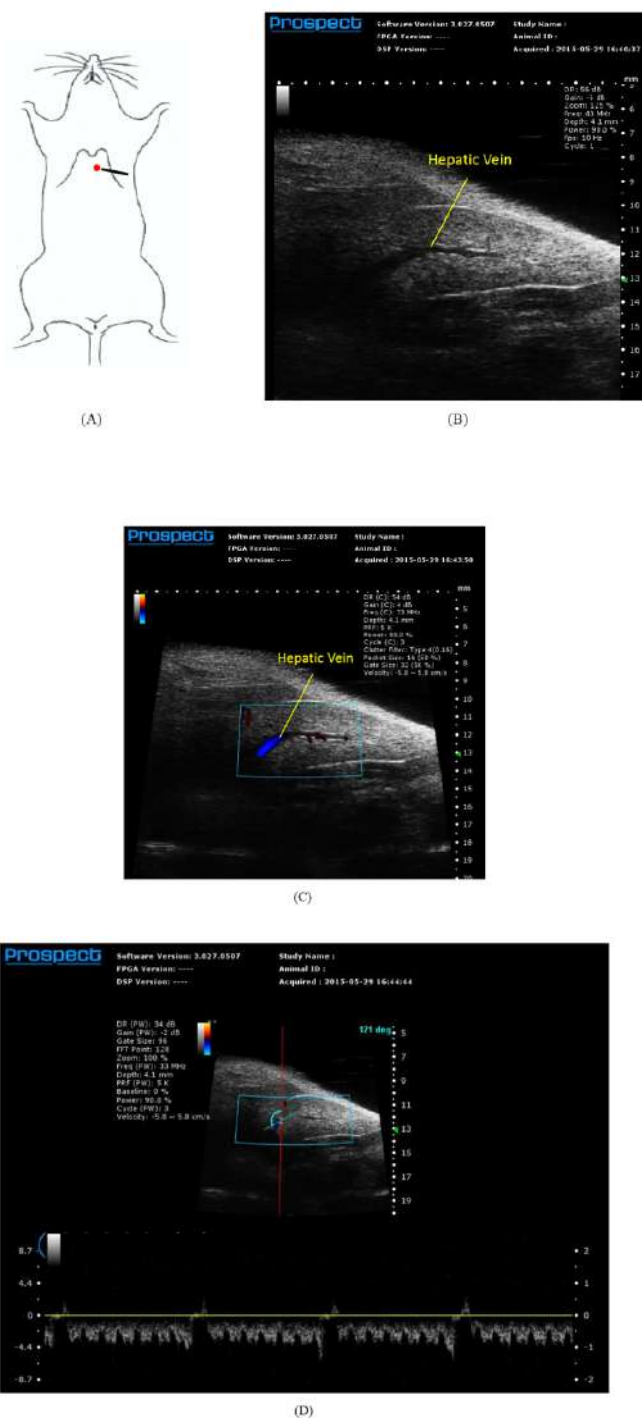
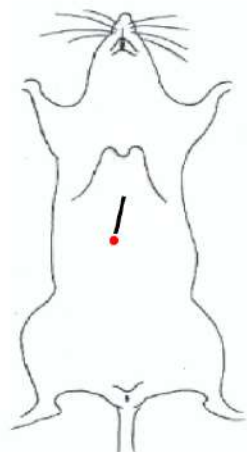
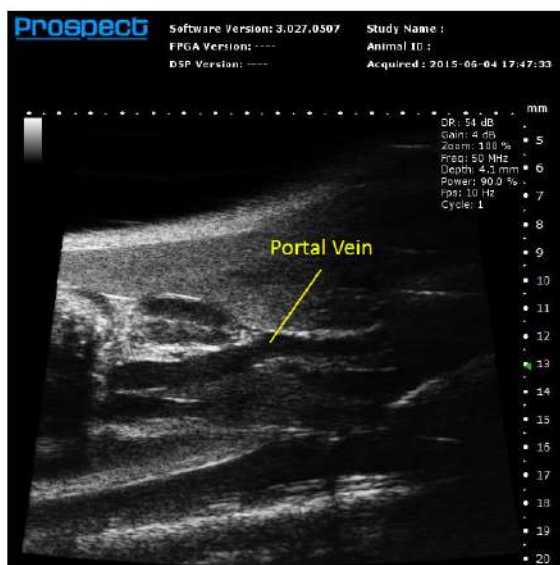


Fig.2. Imaging a hepatic vein: (A) transducer position, (B) B-mode image, (C) Color-mode image, and PW-mode image (the artificial color around the edge of the region of interest edge is due to respiration vibration; this is also evident as regular interruptions in spectral Doppler images).

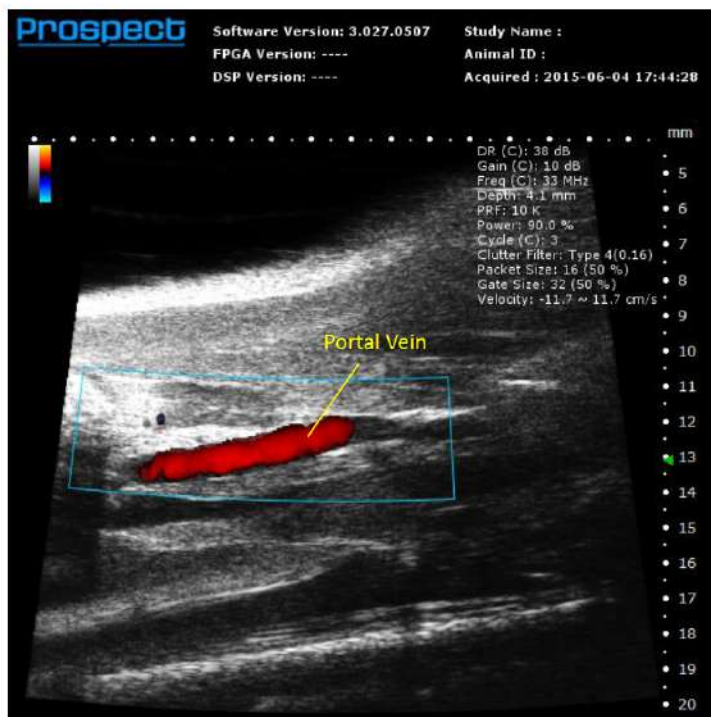
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(A)



(B)



(C)



(D)

Fig.3. Portal vein imaging of the mouse:(A) transducer position, (B) B-mode image,(C) Color-mode image, and (D) PW-mode image.

Gallbladder

As the transducer is moved across the left of the midline (Fig. 4(A)), the gallbladder will appear in the B-mode image as a round or oval anechoic structure with a thin, echogenic wall surrounded by the liver parenchyma (Fig. 4(B)). The normal gallbladder should contain bile and have no space-occupying lesions. The gallbladder should therefore appear anechoic (i.e., be completely black) and be devoid of internal echoes.

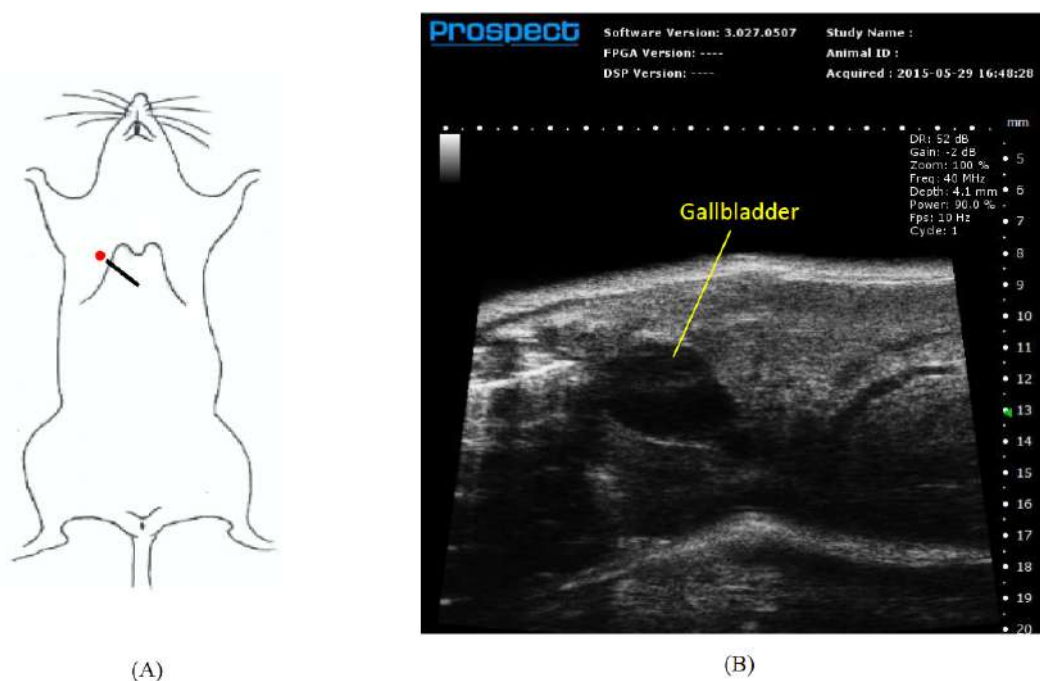


Fig.4. Imaging the gallbladder: (A) transducer position and (B) B-mode image.

II. Inferior Vena Cava and Abdominal Aorta

A. Anatomy

In many instances the blood vessels constituting the venous system are comparable to those of the arterial system. The aortic arch continues as the abdominal aorta, and the aorta passes through the diaphragm and supplies blood to the lower extremities. The inferior vena cava and abdominal aorta are adjacent anatomical structures. The inferior vena cava carries blood from the lower part of the

body to the right atrium. The abdominal aorta branches to the hepatic artery near the liver, and the inferior vena cava passes through the liver where the hepatic vein enters it [6].

B. Transducer Position and Sonography Procedures

B-mode imaging is first used to find the cross section of the liver, and then the probe is moved closer to the surface and adjusted to the appropriate position to display the major abdominal vessels (Fig. 5(A)). The inferior vena cava normally appears beside the abdominal aorta and has walls that are more echogenic than those of the aorta. The portal vein is above both the inferior vena cava and the abdominal aorta, and under the edge of the liver (Fig. 5(B)). Furthermore, the pulse movement is larger for the abdominal aorta than for the portal vein and the inferior vena cava in the B-mode, it is the basis for preliminary identification of an artery and a vein. The longitudinal section of a vessel can be viewed by moving the probe so that the cross section of the vessel appears in the middle of image and then rotating the probe to the appropriate angle, such as Fig. 6(B) and Fig. 7(B).

However, it remains difficult to distinguish the kind of blood vessel using only B-mode imaging; color/power Doppler-mode and PW-mode imaging are useful for identifying the vessel position and distinguishing between an artery and a vein. Color/power Doppler imaging is normally used to confirm whether or not a cavity is a vessel. This is possible since color/power Doppler imaging can detect moving blood cells or other moving structures, with their direction and speed of movement being indicated by the color (Fig. 5(C), Fig. 6 (C) and Fig.7 (C)). Therefore, no color will appear in a color/power Doppler-mode image when the cavity is filled with liquid that is not flowing. After a specific vessel has been selected, the imaging is switched to PW-mode and the obtained PW Doppler waveforms represent the velocity of the blood flowing in a vessel over time. The velocity in a high-resistance arterial vessel will decrease rapidly following the heart systole and will exhibit a low-velocity forward-flow phase in late heart diastole caused by the recoil of the vessel wall (Fig. 6(D)). On the other hand, low-resistance vein is characterized by a low flow velocity and minimal velocity fluctuations (Fig. 7(D)). Furthermore, the velocity is measured using the "Measure tool" tag () by clicking the point icons of the distance type () and then dragging and clicking on the PW-mode ultrasound image window to display the flow velocity data, as shown in Fig. 6(D). It is noteworthy that an appropriate estimate of the angle correction is essential for accurately determining the blood flow velocity. The angle should be less than 60 degrees at all times, since errors in the angle correction will be substantially greater for larger angles.

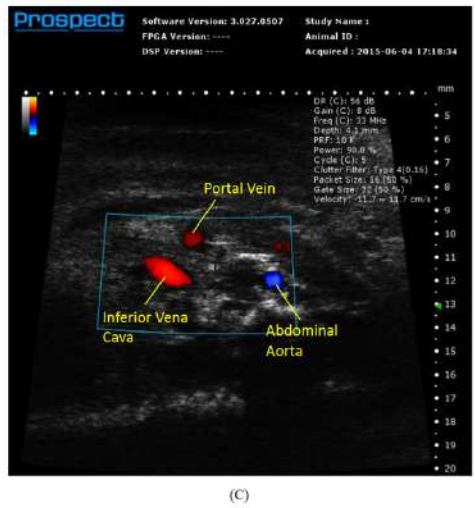
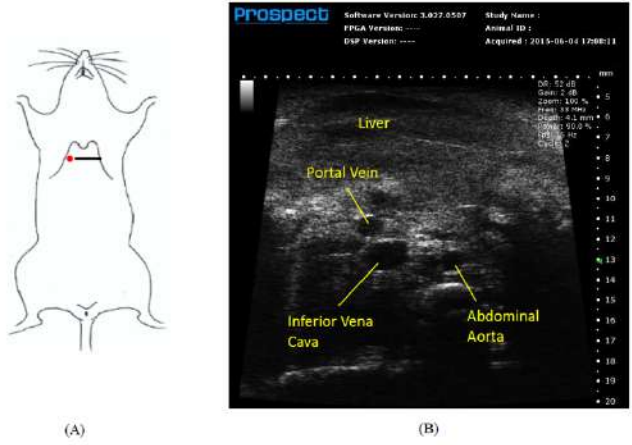


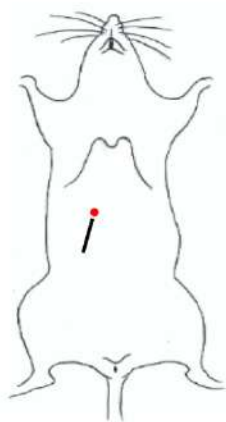
Fig.5. Ultrasound cross-sectional imaging of the mouse portal vein, abdominal aorta, and inferior vena cava: (A) transducer position, (B) B-mode image, and (C) color-mode image.

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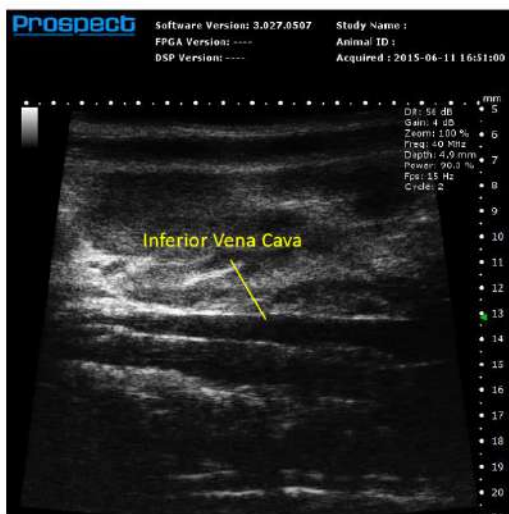


Fig.6. Abdominal aorta imaging of the mouse: (A) transducer position, (B) B-mode image, (C) Color-mode image, and (D) PW-mode

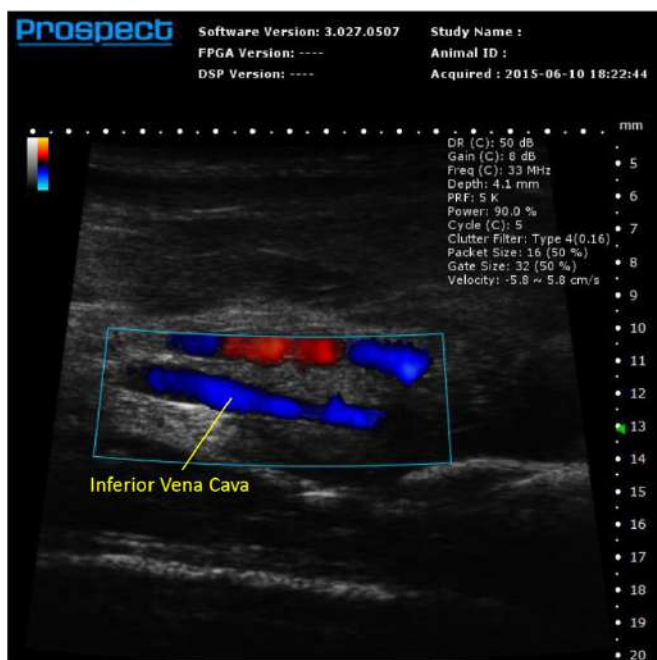
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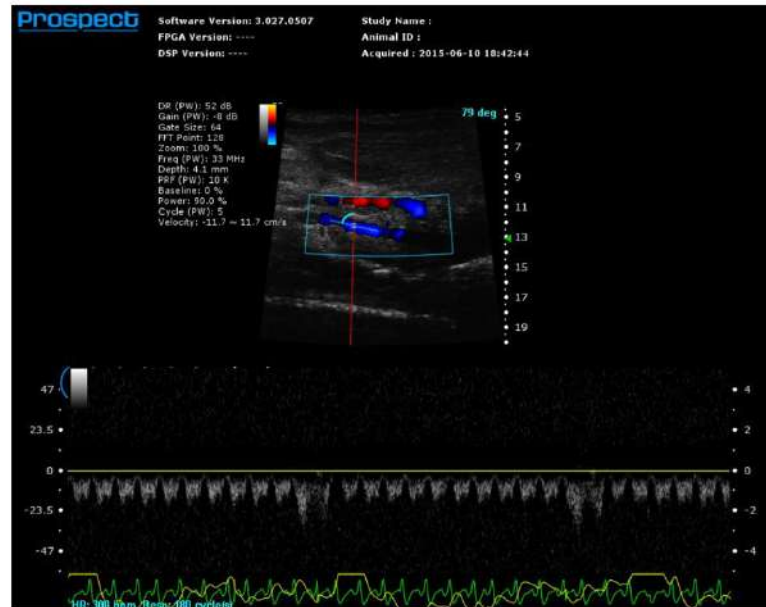
(A)



(B)



(C)



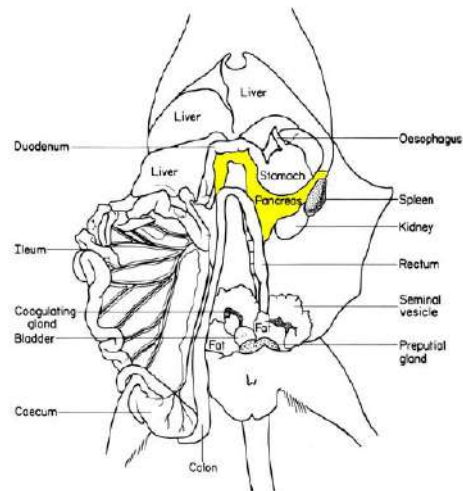
(D)

Fig.7. Inferior vena cava imaging of the mouse:(A) transducer position, (B) B-mode image,(C) Color-mode image, and (D) PW-mode image.

III. Spleen and Pancreas

A. Anatomy

The spleen is the largest organ in the reticuloendothelial system and is located in the left dorsocranial part of the abdominal cavity [1]. It contacts the liver dorsally, and extends between the stomach and the left kidney to the abdominal wall ventrocaudally [5]. The pancreas of an adult mouse is surrounded by the stomach, the duodenum and proximal jejunum, the spleen and kidney, as shown in Fig. 8(B). The duodenum wraps around the head of the pancreas. Rodent pancreas is soft and diffuse compared with the human pancreas, and it is enclosed in the mesenteric adipose tissue completely.



(<http://www.informatics.jax.org/cookbook/figures/figure55.shtml>)

B. Transducer Position and Sonography Procedures

When imaging the spleen the mouse should first be positioned on its right side. After removing the skin hair on the left side, the spleen will be visible as a dark-red object under the skin below the forelimb (Fig.8(A)). A B-mode view of the spleen can be obtained directly by placing the transducer above the spleen, and then the biggest cross section or longitudinal section of spleen would be acquired by adjusting the probe or platform in appropriate position (Fig. 9). The parenchyma of the spleen is homogeneous, and is usually hypoechoic and has a finer texture relative to the liver. Attention should be paid to the fibrous capsule of the spleen that appears as an echogenic margin. About the pancreas imaging, it is difficult to display entire mouse pancreas by ultrasound due to its location. Only portions of the pancreas can be displayed in the same view of the cross section of spleen, as shown in (Fig 9(D)).

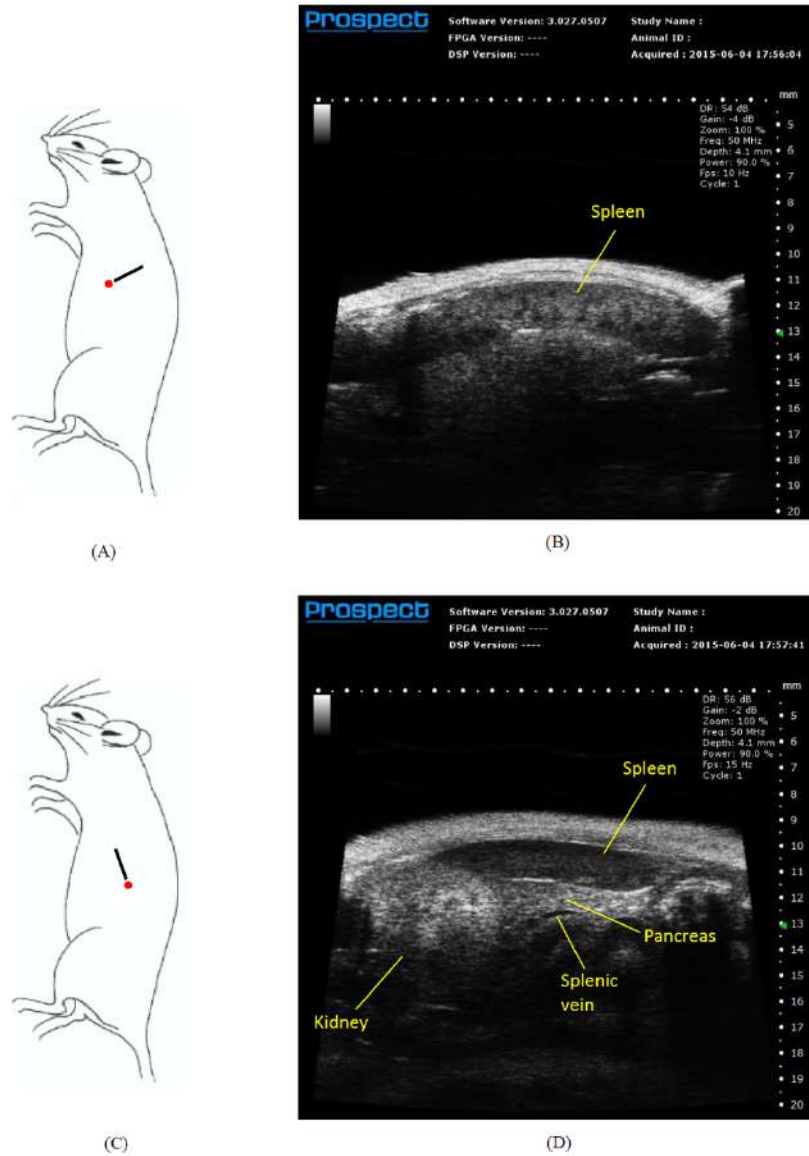


Fig.9. Spleen imaging of the mouse. Transducer position (A) and B-mode image (B) of the spleen longitudinal section. Transducer position (C) and B-mode image (D) of the spleen cross section, and the pancreas and splenic vein also can be displayed in this view.

IV. Kidneys and Adrenal Glands

A. Anatomy

The kidneys represent a paired organ system located in the retroperitoneal space in the dorsal part of the abdominal cavity^[1], and are held securely in place by the tough capsules surrounding them. The adrenal glands are located near the anterior poles of the kidneys and consist of cortex and medulla surrounded by a fibrous connective tissue capsule. The right kidney and adrenal gland are slightly more cranial than the left^[1]. The hilum lies on the concave side of the kidneys, through which the renal artery, renal vein, and lymphatic vessels run. A bisected kidney is characterized by a pale outer region (the cortex) and a darker inner region (the medulla)^{[4][5][7]}

B. Transducer Position and Sonography Procedures

Adrenal Glands

When imaging the adrenal glands the mouse should lie on the platform, with the platform adjusted on one side and the transducer positioned about 1.5cm below the forelimb. Keeping the transducer perpendicular to the midline in B-mode imaging will reveal a hypoechoic concentric structure, which is the cross-section image of the adrenal gland and is adjacent to a larger echogenic one (the kidney), as shown in Fig. 10. The medulla and cortex of the adrenal gland appear in the central and peripheral parts of the adrenal gland, respectively. The longitudinal section of the adrenal gland will be revealed after rotating the transducer to make it parallel to the midline.

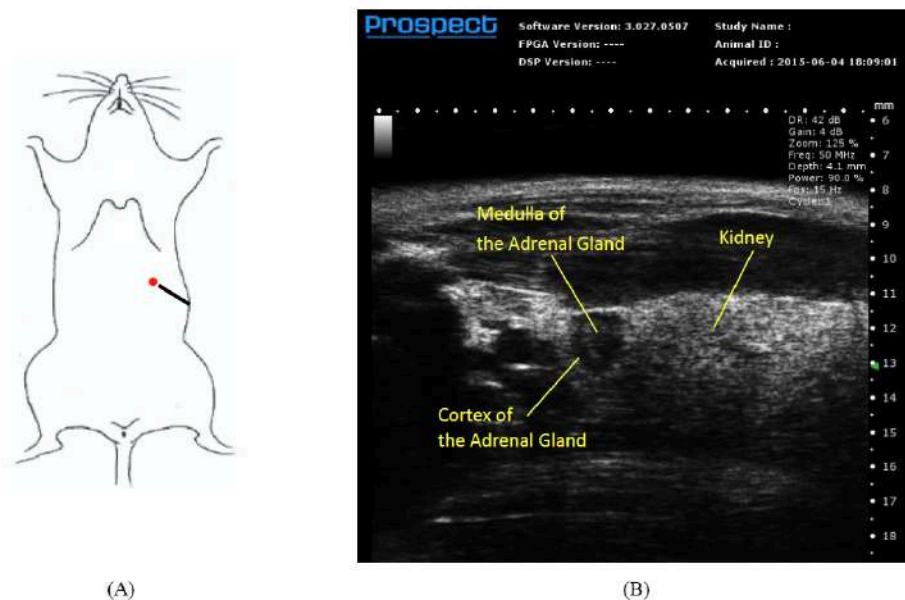
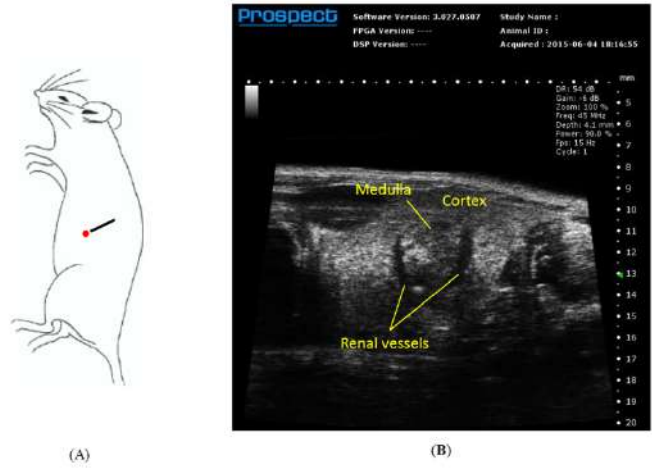


Fig.10. Cross-sectional imaging of the mouse right adrenal gland: (A) transducer position and (B) B-mode image.

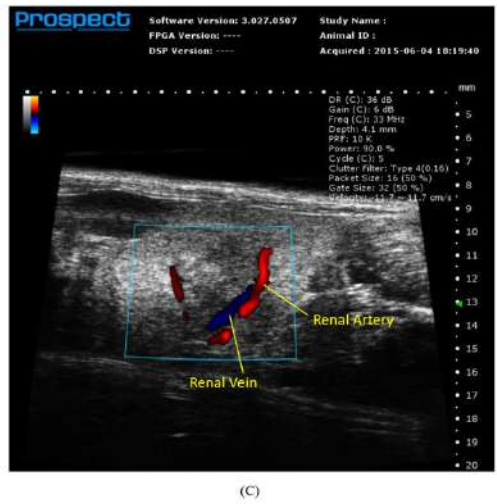
Kidneys

With the mouse on its side, positioning the probe above the side of the abdomen about 1.5 cm below the forelimb will display the kidney in the B-mode image as a substantive bright object (Fig. 11(A)). The kidneys should have a smooth contour with a thin echogenic capsule. Renal cortical and medullary tissues are evaluated based on their relative echogenicity and sonographic distinctions. The cortical tissue is hyperechoic relative to the medulla, and they should be distinctly demarcated (Fig. 11(B)). In addition, the renal vessels are anechoic, which makes them clearly evident (Fig. 11(B) and 12(B)). Color/power Doppler-mode and PW-mode imaging can be used to measure the velocity. The renal artery is a low-resistance artery and, unlike a high-resistance artery with low velocity flow in late heart diastole, some flow occurs therein during diastole, as shown in Fig. 12(D).



(A)

(B)



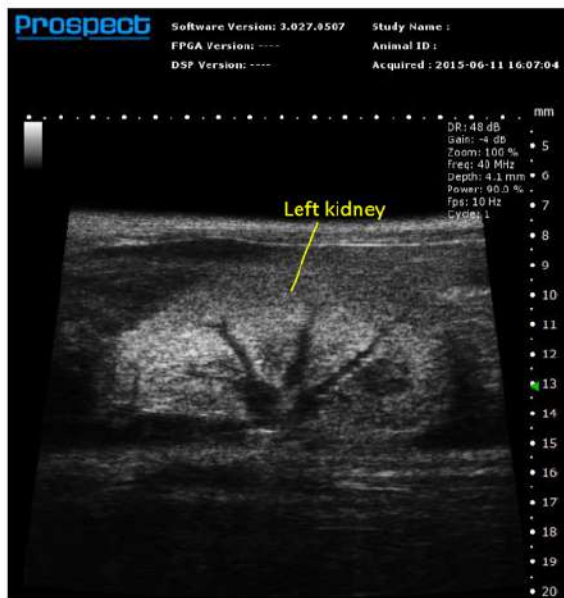
(C)

Fig.11. Cross-sectional imaging of the mouse left kidney: (A) transducer position, (B) B-mode image, and (C) color-mode image.

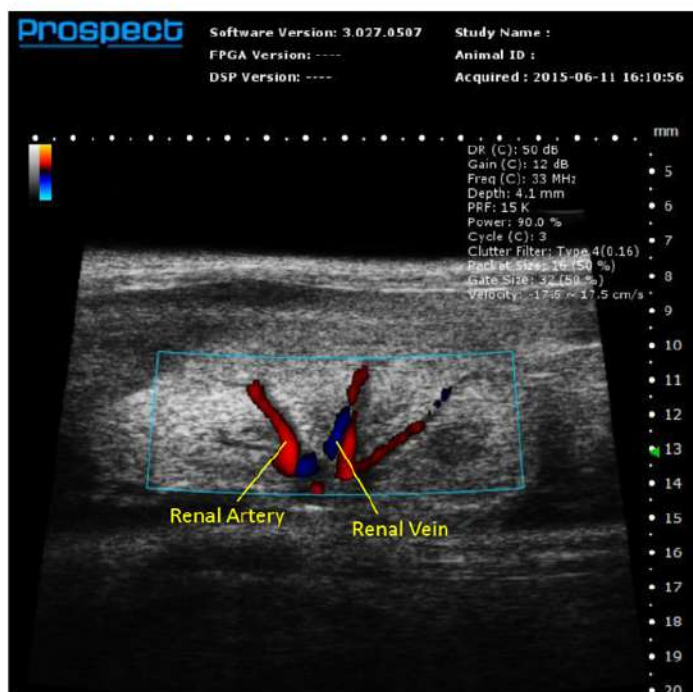
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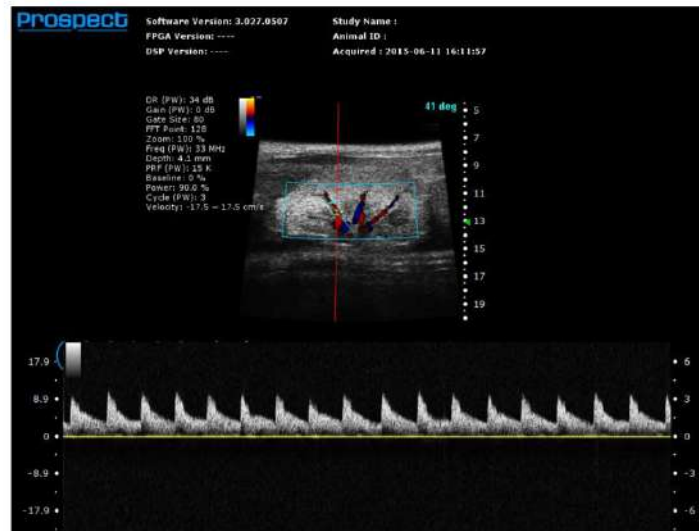
(A)



(B)



(C)



(D)

Fig.12. Longitudinal section imaging of the mouse left kidney: (A) transducer position, (B) B-mode image, (C) color-mode image, and (D) renal artery in PW-mode image.

References:

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3. P. N. Martins and P. Neuhaus, "Surgical anatomy of the liver, hepatic vasculature and bile ducts in the rat," *Liver International*, 27(3), P.384–92, 2007.
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6. http://www.biologycorner.com/worksheets/rat_circulatory.html
7. http://ctrngenpath.net/static/atlas/mousehistology/Windows/endocrine/adrenalgland_young.html

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