KREP

2025

KARNATAKA RADIOLOGY EDUCATION PROGRAM

Anatomy and Applied Radiology Kidneys – 3

Bones can break, muscles can atrophy, glands can loaf about and even the brain can sleep without immediate danger to survival. BUT when the kidneys fail…. Neither bone, muscle gland nor brain could carry on.

Homer William Smith,
"The Evolution of the Kidney", Lectures on the Kidney (1943)

Ultrasound - Kidneys

PREPARATION

- **500mls 1 hour before, avoiding micturition.**
- **Catheter clamped 1.5 hours before.**
- **Fluids by PEG 1.5 hours before.**
- **Operator Dependant**
- **Real Time**
- **Reproducible**
- **Non-invasive**
- **Inspiration**

Protocol

Both Kidneys

- **Urinary Bladder**
- **+/- Residual Volume**
- **Pelvic Surveillance**
- **Aorta**
- **Full bladder**

NORMAL ANATOMY

Renal Ultrasound (Basic Principles) and BMUS Study Case

- **9-12 cm long, 4-5 cm wide, 3-4 cm thick**
- **Gerota's fascia encloses kidney, capsule, perinephric fat**
- **Sinus**

– Hilum: vessels, nerves, lymphatics, ureter
– Pelvis: major and minor calyces

- **Parenchyma surrounds the sinus**

– Cortex: site of urine formation, contains nephrons
– Medulla: contains pyramids that pass urine to minor calyces. Columns of Bertin separate pyramids

RIGHT KIDNEY-TECHNIQUE

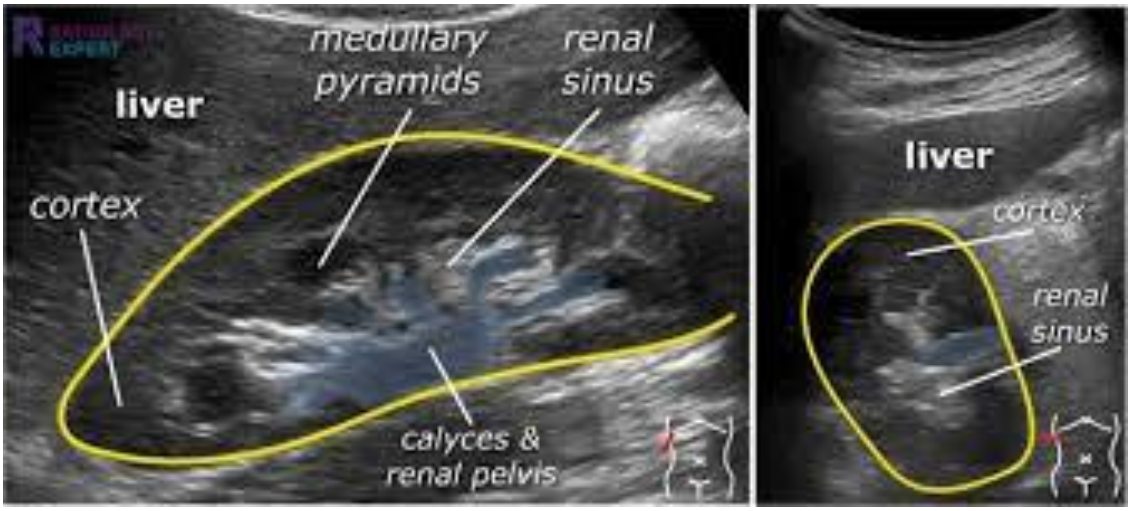
- **A 3.5-5 MHz probe is typically used to scan the kidney.**

For the right kidney, have the patient lie supine and place the probe in the right lower intercostal space in the midaxillary line.
Use the liver as your "acoustic window" and aim the probe slightly posteriorly (toward the kidney).
Gently rock the probe (up and down or side to side) to scan the entire kidney.
If needed, you can have the patient inspire or exhale, which allows for subtle movement of the kidney.

- **Obtain longitudinal (long axis) and transverse (short axis) views.**

Kidneys are retroperitoneal, T12 - L4

- **Right kidney is lower than the left kidney**
- **Right kidney is posterio-inferior to liver & gallbladder.**



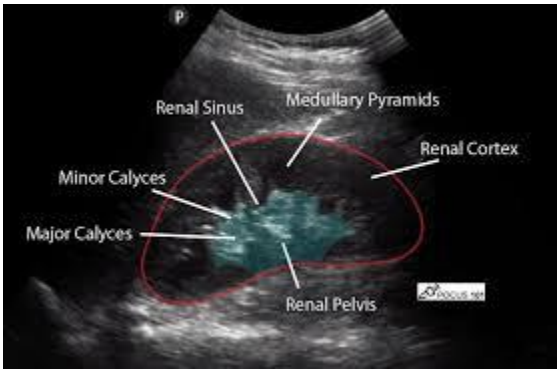
LEFT KIDNEY-TECHNIQUE

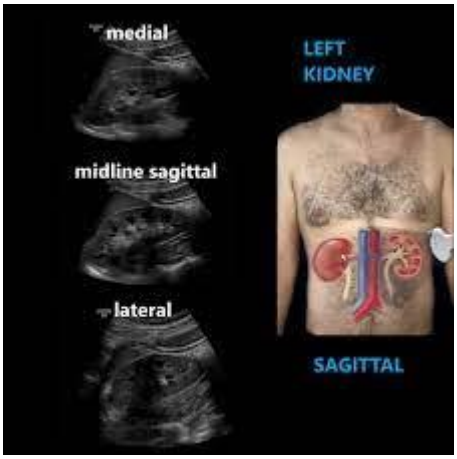
• For the left kidney have the patient lie supine or in the right lateral decubitus position.
Place the probe in the lower intercostal space on the posterior axillary line.
The placement will be more cephalad and posterior than when visualizing the right kidney.
Again gently rock the probe to scan the entire kidney.

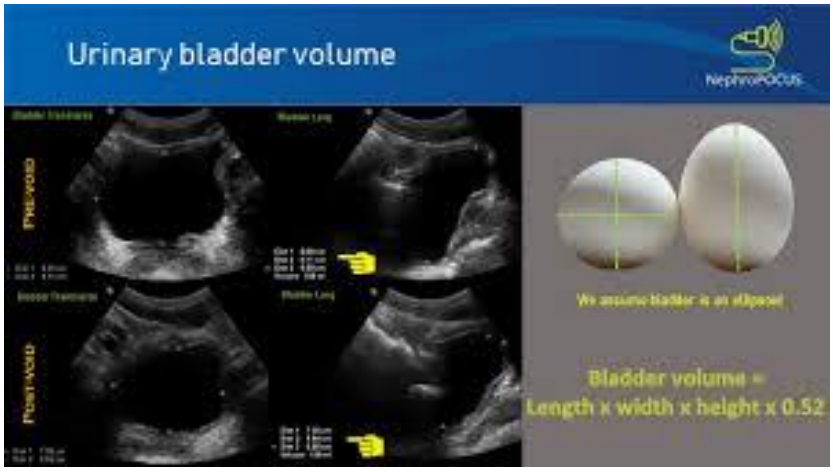
• Obtain longitudinal and transverse views.

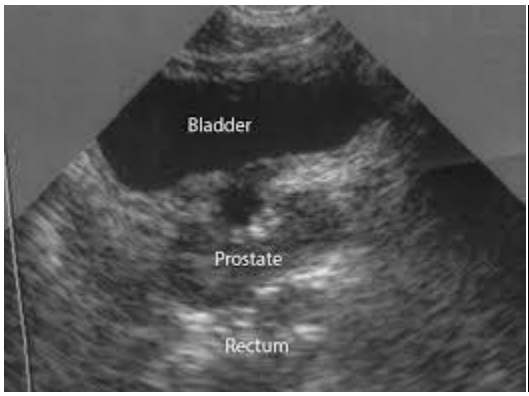
Left kidney is inferior-medial to the spleen

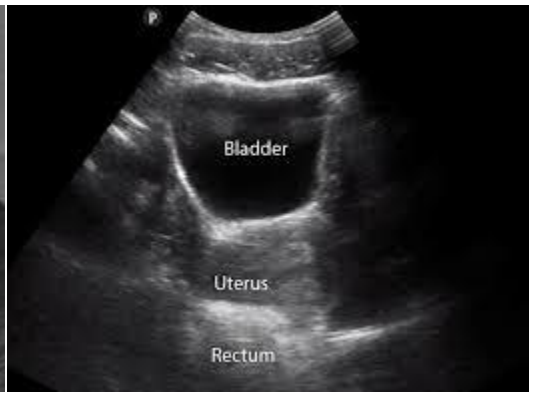
• Adrenal glands are superior, anterior, medial to each kidney











Renal Doppler

Doppler ultrasound (US) is a well-established and useful technique for evaluating the renovascular system and associated pathologic conditions. As with other US examinations, advantages include its noninvasive nature, relatively low-costs, and generally well-tolerated. However, the technique is highly operator-dependent and can be time-consuming. Furthermore, the interpretation of renal Doppler US examinations might be challenging for those with limited experience or those unfamiliar with fundamental concepts and nomenclature.

Nevertheless, due to its benefits, the American College of Radiology (ACR) Appropriateness Criteria guidelines rate renal Doppler US as appropriate or even first-line imaging technique in various clinical scenarios, especially in patients with decreased renal function or renal transplants when contrast administration for computed tomography or magnetic resonance imaging examinations might be problematic

Anterior and frank approaches used to indirectly evaluate the intra-renal (segmental arcuate and interlobar; upper poles, mid poles and lower poles) arterial spectral Doppler waveforms. The renal arteries show normal wall outline/ caliber and also demonstrate low resistance profiles with continuous forward flow throughout the cardiac cycle. The intra-renal arterial waveforms show normal acceleration times and early systolic peak with no pulsus Tardus or pulsus Parvus waveforms.

The renal artery peak systolic velocity is within normal limits bilaterally. The bilateral intra-renal arcuate and interlobar arterial resistive indices of 0.55, 0.56, 0.61, 0.58, ,0.54, and 0.55 for the right kidney and; 0.57, 0.64, 0.65, 0.46, 0.51 and 0.54 for the left kidney noted are within normal limits.

Indications

Doppler US examination of the renal vasculature plays a critical role in the evaluation of native as well as transplanted kidneys.

Indications for Doppler US of native renal arteries include hypertension (particularly when there is strong suspicion for renovascular hypertension), follow-up of patients with the known renovascular disease who are under medical supervision or after the endovascular intervention, evaluation of abdominal/flank bruit, evaluation of a suspected vascular pathology (e.g., aneurysm, pseudoaneurysm, arteriovenous fistula), evaluation of vascular causes of acute renal failure, evaluation of renal blood flow in patients with previously diagnosed abnormalities that may compromise blood flow to the kidneys (e.g., aortic dissection or trauma), evaluation for renal size asymmetry, and evaluation for renal vein thrombosis.

Indications for Doppler US of transplant renal arteries include screening to determine baseline values of hemodynamic parameters, abnormalities such as tenderness, rising creatinine, oliguria/anuria, hematuria, or ureteral dilatation, evaluation of vascular patency, evaluation for iatrogenic complications post-biopsy, and assessment for lymphoproliferative disease.

Ultrasound machines used for Doppler US examinations need to be able to perform Duplex scanning, which refers to the combination of 2D B-mode imaging and pulsed Doppler data acquisition. This usually includes three types of Doppler: color Doppler to obtain flow information (such as direction and magnitude of flow), power Doppler to visualize subtle and slow blood flow (at the expense of directional and quantitative flow information), and spectral Doppler to show blood flow velocity over time as a waveform. Probe selection should be based on body habitus. In general, a lower frequency, the curvilinear transducer, is preferred (typically 3.5 to 5 MHz) in adult patients since both renal arteries and kidneys are in a deep location. However, a 6 to 12 MHz linear transducer might be used to improve flow detection in thin or pediatric patients.

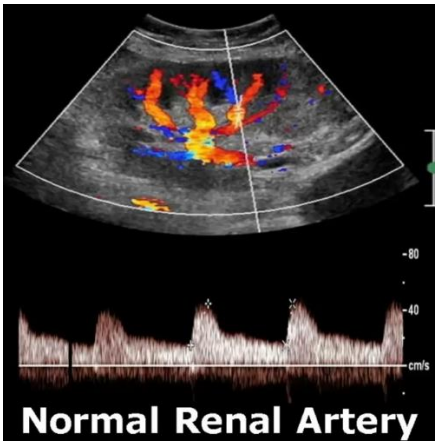
Preparation

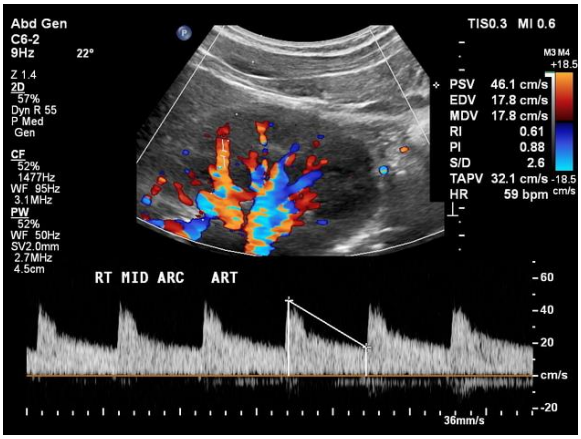
Before a renal Doppler US, patients should remain NPO for eight hours. This includes tobacco products or chewing gums as this promotes the ingestion of air which subsequently limits the examination due to artifacts. However, for renal transplant examinations, patients do not need to be NPO. If patients need to take necessary medications before their exam, this can be achieved with a small glass of water. Simethicone is a well-known emulsifying agent, and prior research has shown its ability to break down large pockets of gas. Hence, Simethicone can be administered to improve sonographic visualization, especially in patients with obesity; however, the cost-effectiveness of the routine use of Simethicone is questionable, and hence this is currently not standard in daily clinical practice.

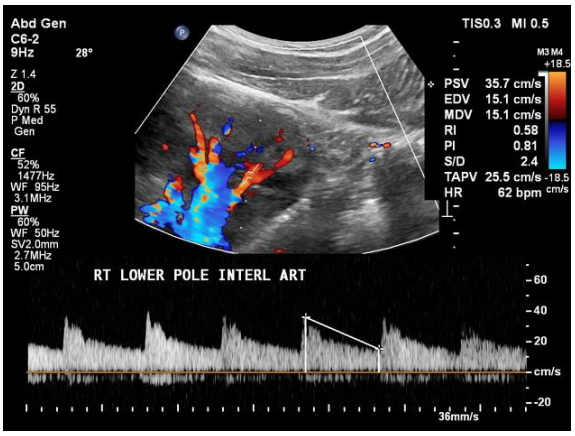
Color Doppler images to evaluate blood flow should be performed in the proximal, mid, and distal renal arteries bilaterally and at the origin of each renal artery from the aorta. In addition, color-coded evaluation of blood flow can assist in the identification of any duplicate renal artery. When high velocities are encountered, specific attention should be paid to an error called aliasing (showing as the projection of color of reversed flow within central areas of a vessel), which indicates turbulent flow, and therefore possible stenosis or arteriovenous fistula. This can be corrected by increasing the velocity scale to exceed the peak velocity of the sampled vessel.

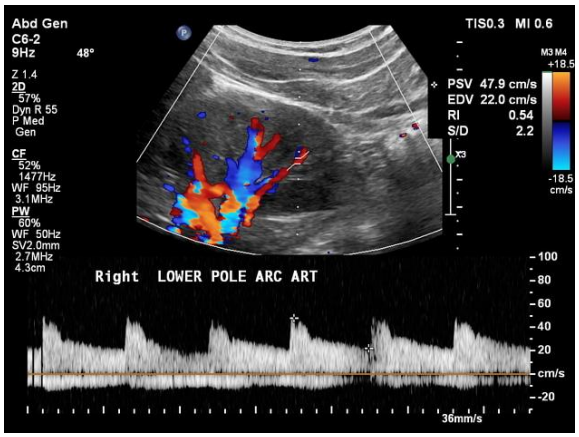
Using Spectral Doppler, the peak systolic velocity (PSV) should be measured in the abdominal aorta at the level of the renal arteries, as well as in the renal artery origin, middle portion, and hilum (in the main renal artery, normal values are 60-100 cm/s). Regardless of transducer position, an angle correct to 60 degrees or less is mandatory to get accurate information. The PSV in the renal artery and PSV in the aorta can also be used to calculate the renal to the aortic ratio, which should be < 3.5. Spectral recording of blood flow is further performed at the intrarenal level using segmental and interlobar arteries, specifically at the upper pole, central part, and lower pole of the kidney. Other criteria evaluated during the examination of intrarenal arteries include acceleration time (AT) (time of the start of systole to peak systole; <70 msec considered normal) and acceleration index (AI) (slope of the systolic upstroke; > 3 m/s considered normal).[3] Finally, with Spectral Doppler evaluation, the resistive index (RI) can be determined by dividing the difference between the PSV and end-diastolic velocity by the PSV (normal range is 0.5 to 0.7).

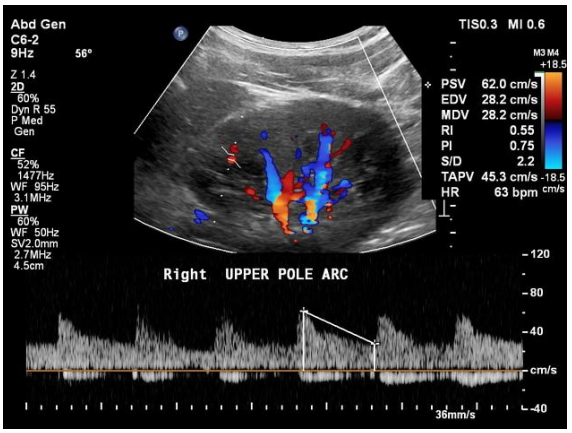
Power Doppler has certain benefits due to its greater sensitivity to flow and reduced angle dependence. This is especially helpful when assessing global renal perfusion and the parenchymal microvasculature to evaluate for cortical perfusion defects.

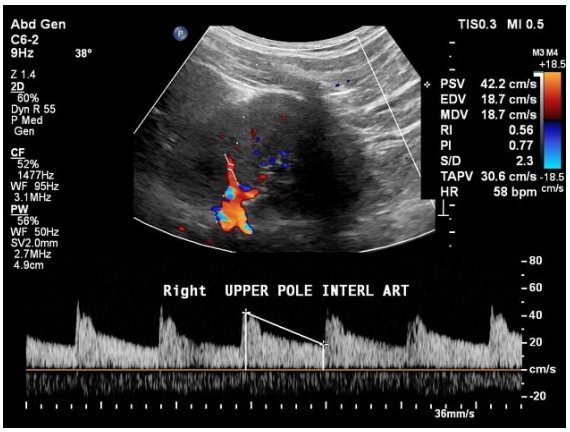

Normal Renal Artery

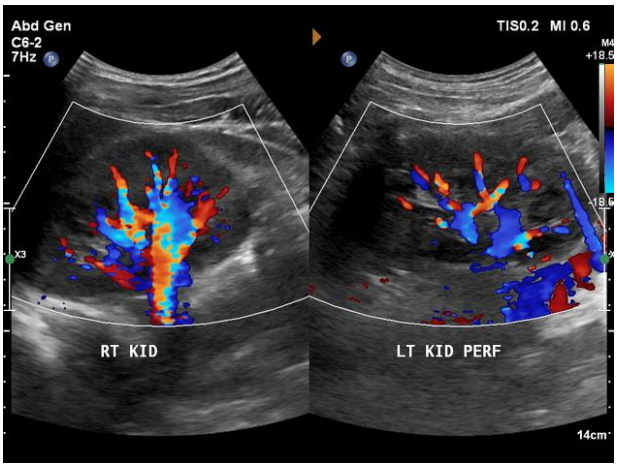

Abd Gen
C6-2
9Hz
TIS0.3 MI 0.6
PSV 46.1 cm/s
EDV 17.8 cm/s
MDV 17.8 cm/s
RI 0.61
PI 0.88
S/D 2.6
TAPV 32.1 cm/s
HR 59 bpm
RT MID ARC ART
cm/s
36mm/s

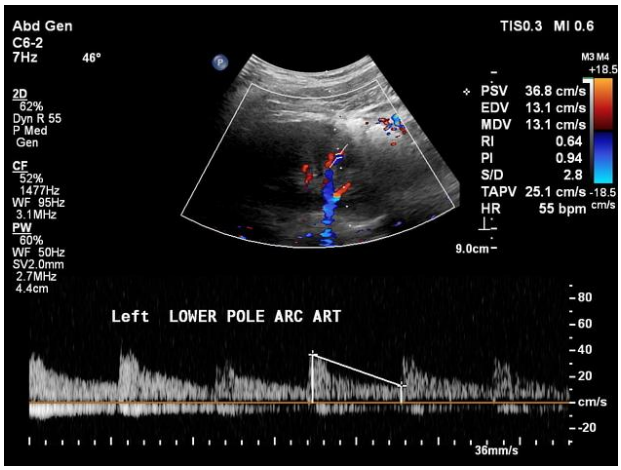

Abd Gen
C6-2
9Hz
TIS0.3 MI 0.5
PSV 35.7 cm/s
EDV 15.1 cm/s
MDV 15.1 cm/s
RI 0.58
PI 0.81
S/D 2.4
TAPV 25.5 cm/s
HR 62 bpm
RT LOWER POLE INTERL ART
cm/s
36mm/s

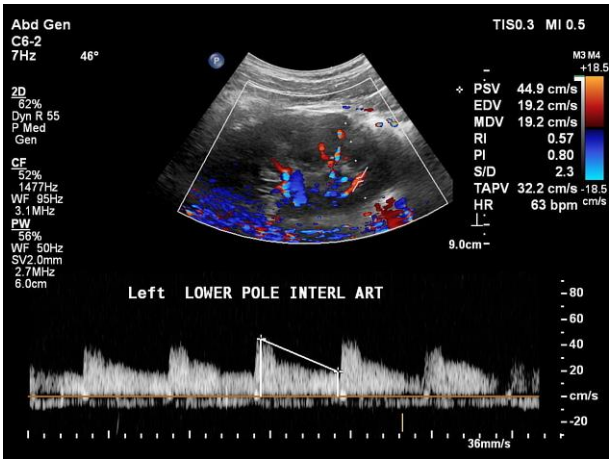

Abd Gen
C6-2
9Hz
TIS0.3 MI 0.6
PSV 47.9 cm/s
EDV 22.0 cm/s
RI 0.54
S/D 2.2
Right LOWER POLE ARC ART
cm/s
36mm/s

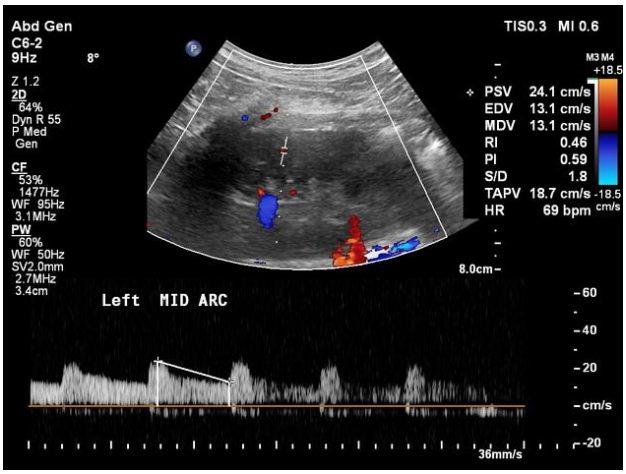

Abd Gen
C6-2
9Hz
TIS0.3 MI 0.6
PSV 62.0 cm/s
EDV 28.2 cm/s
MDV 28.2 cm/s
RI 0.55
PI 0.75
S/D 2.2
TAPV 45.3 cm/s
HR 63 bpm
Right UPPER POLE ARC
cm/s
36mm/s

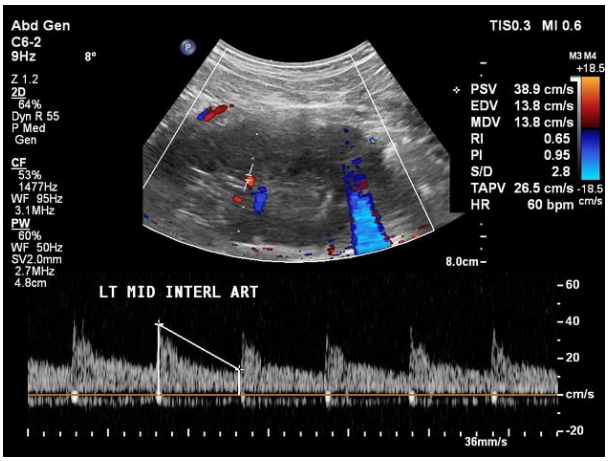

Abd Gen
C6-2
9Hz
TIS0.3 MI 0.5
PSV 42.2 cm/s
EDV 18.7 cm/s
MDV 18.7 cm/s
RI 0.56
PI 0.77
S/D 2.3
TAPV 30.6 cm/s
HR 58 bpm
Right UPPER POLE INTERL ART
cm/s
36mm/s

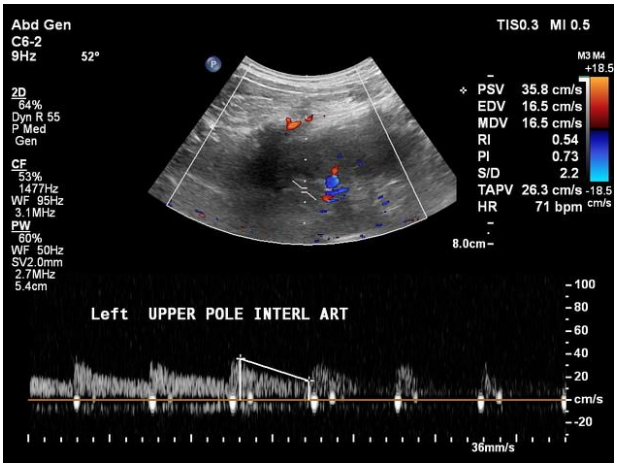












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