Duplex Scanning and Color Flow Imaging of the Abdominal Vessels

Chapter 14

Diagnostic Imaging of the Abdominal Vessels

Capabilities

- *Aortoiliac vessels:* Determines presence/absence of significant stenosis, supports follow up of bypass grafts, evaluated aneurysms
- *Renal artery:* Determine if significant stenosis is present
- *Kidney:* Determines presence/absence of nephrosclerotic disease, evaluates and supports follow-up of transplants
- *Mesenteric arteries:* Determines presence/absence of stenosis causing mesenteric bowel ischemia
- *Liver:* Evaluates for portal hypertension and pre/post liver transplants

Limitations

- Patient body habitus
- Bowel gas
- Previous surgeries/scar tissue
- Shortness of breath or rapid respirations
- Non-fasting patient

General Technique

- Patient can be placed supine with minimal head elevation for most exams
  - LLD and RLD are also helpful when assessing renal arteries
- 3-5 MHz transducer to duplex vessels of interest
- Use a 60-degree angle of insonation to assess Doppler waveform qualities and velocities

Aorto-iliac Arteries

Technique

- Examine:
  - Proximal, mid, and distal aorta to the bifurcation
  - Common iliac arteries bilaterally
  - Proximal, mid, and distal external iliac arteries bilaterally
  - Internal iliac arteries bilaterally
  - Brief evaluation of the celiac artery, superior mesenteric artery and renal arteries

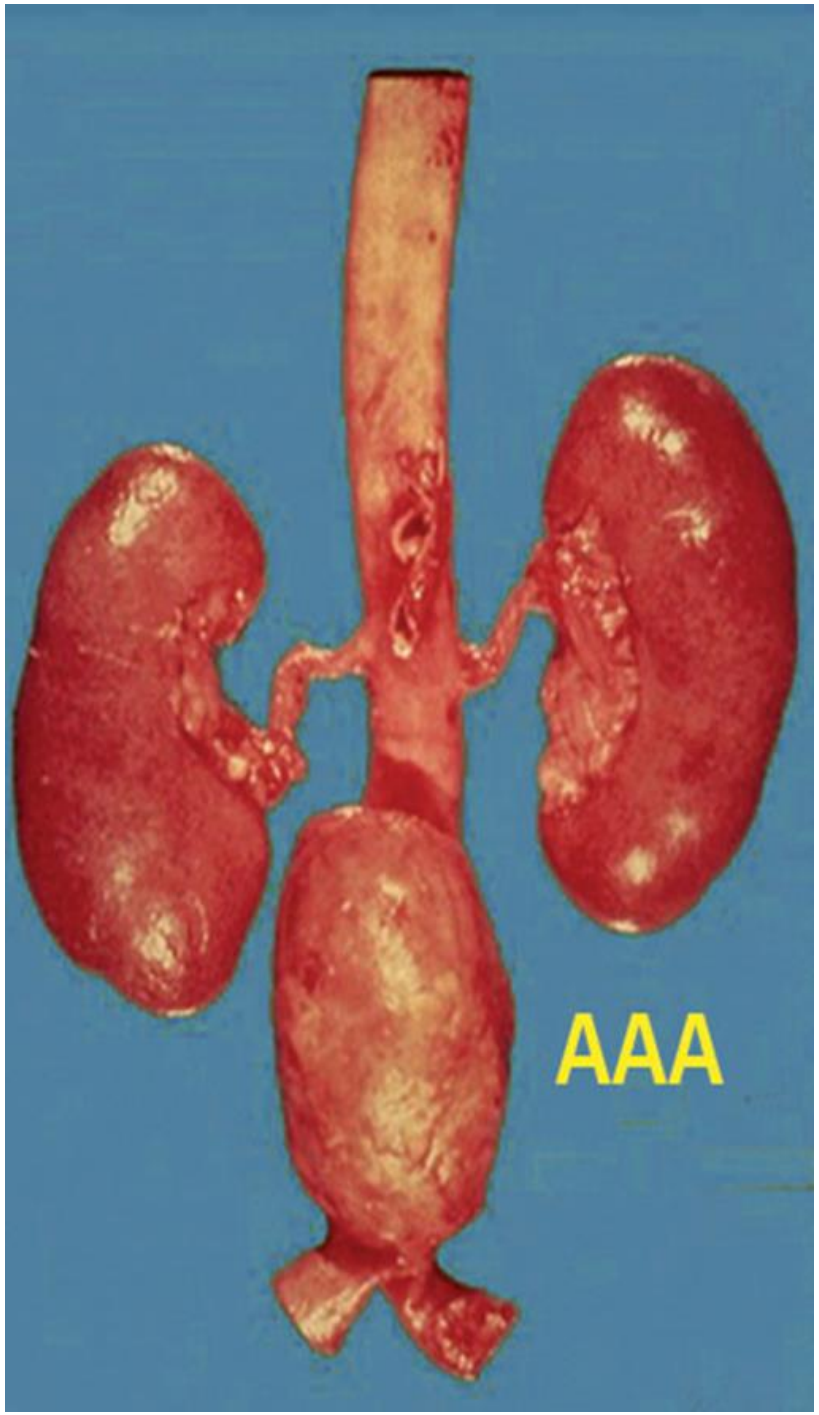
When imaging aneurysms, measurements need taken at the maximum diameter of the aneurysm

Interpretation

- Aneurysm:
  - For the aorta, a dilatation >3cm
  - In general – an increase in diameter of >50% qualifies an artery as aneurysmal
  - Majority are infrarenal
  - Identify the type (fusiform, saccular, false, dissecting)
  - Pay close attention to thrombus or clot formation
    - May embolize

Risk Factors

- Tobacco abuse
- Hereditary/family history
- Advanced age
- Male gender (men are 5 times more likely to develop AAA than women)
- High cholesterol
- Obesity

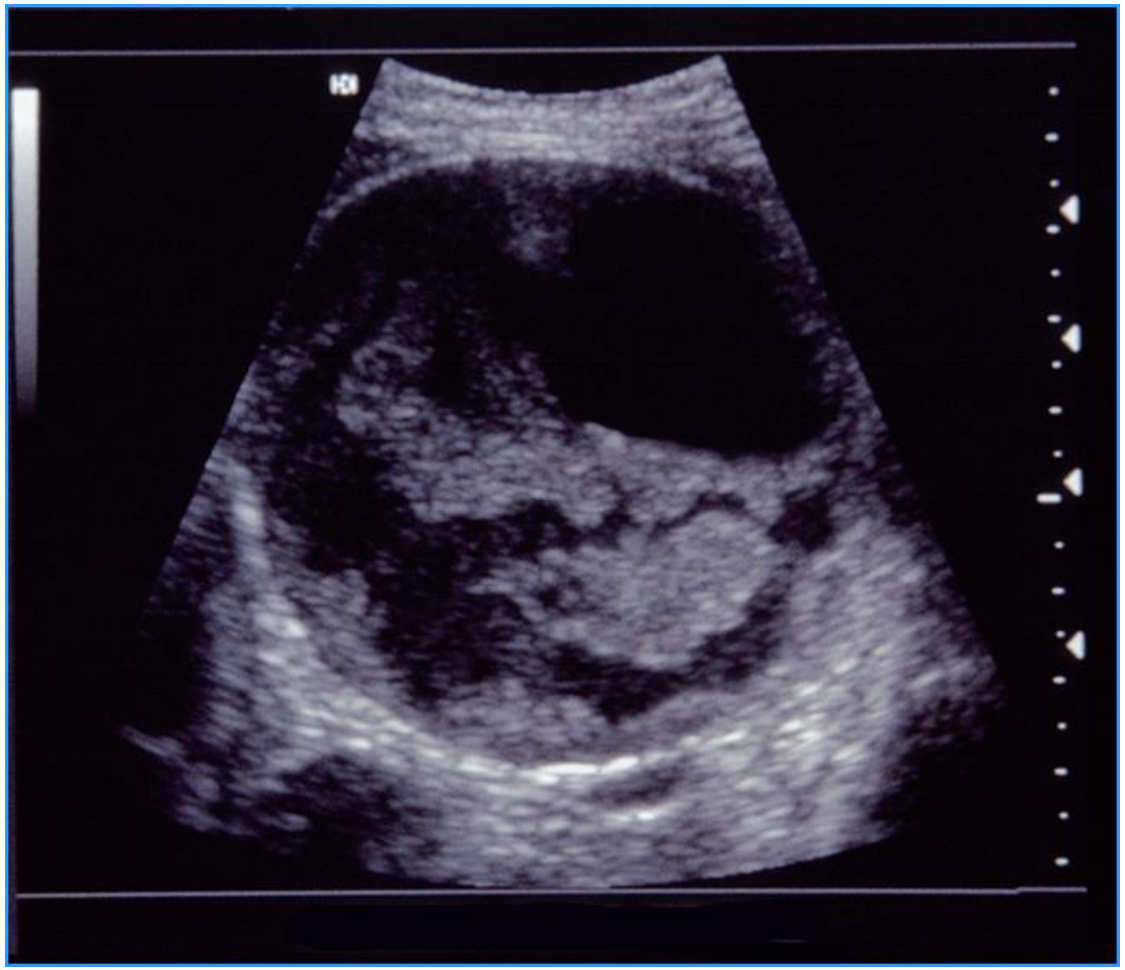


Symptoms

- Most intact aortic aneurysms do not produce symptoms
- Palpable pulsatile mass in abdomen on examination
- Back pain
- Abdominal pain

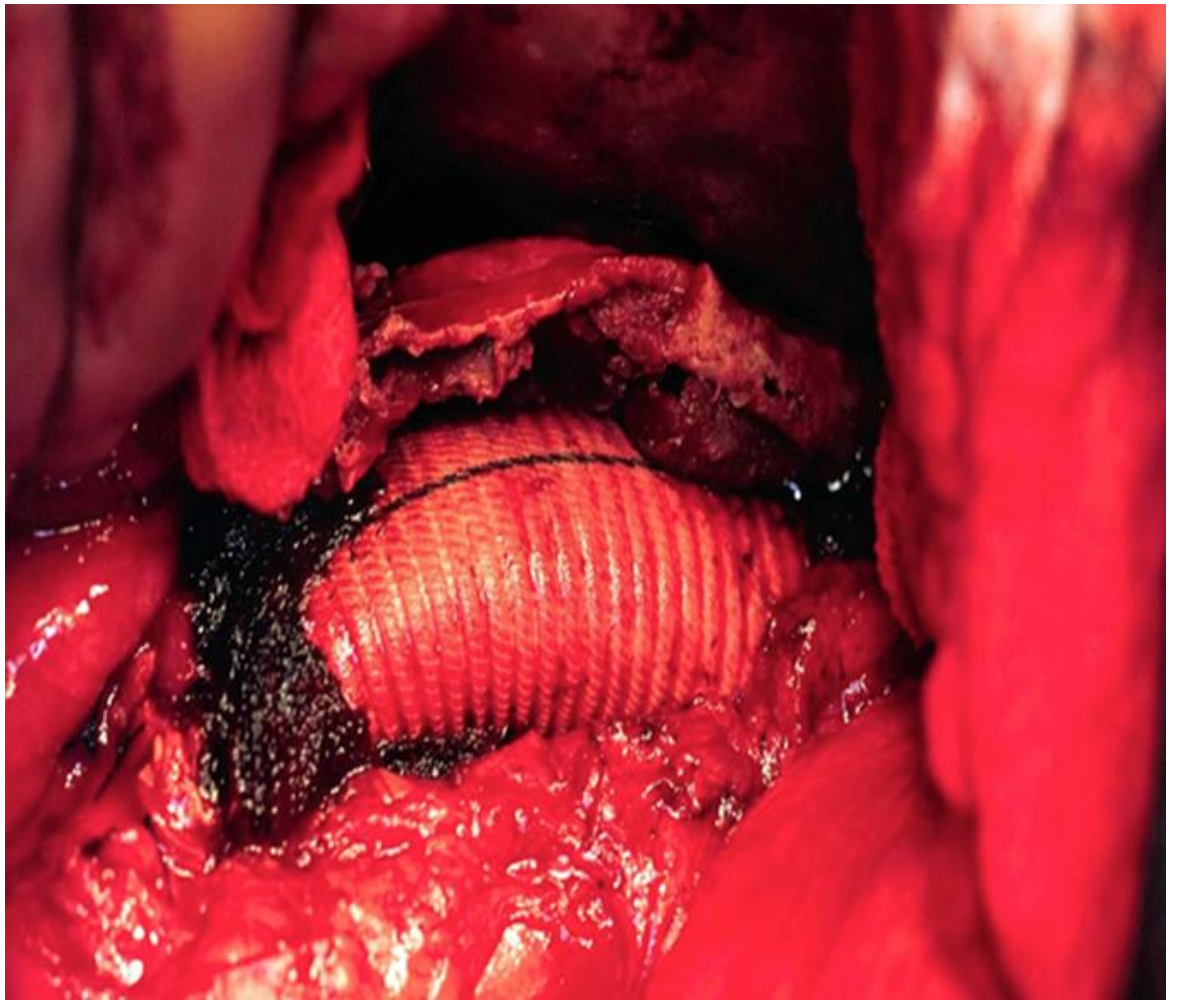
AAA Complications

- Rupture
  - Risk is high if AAA diameter is ≥ 5 cm
- Thrombosis
- Embolization
- Males over 60 yrs. old– highest risk group



Treatment for AAA

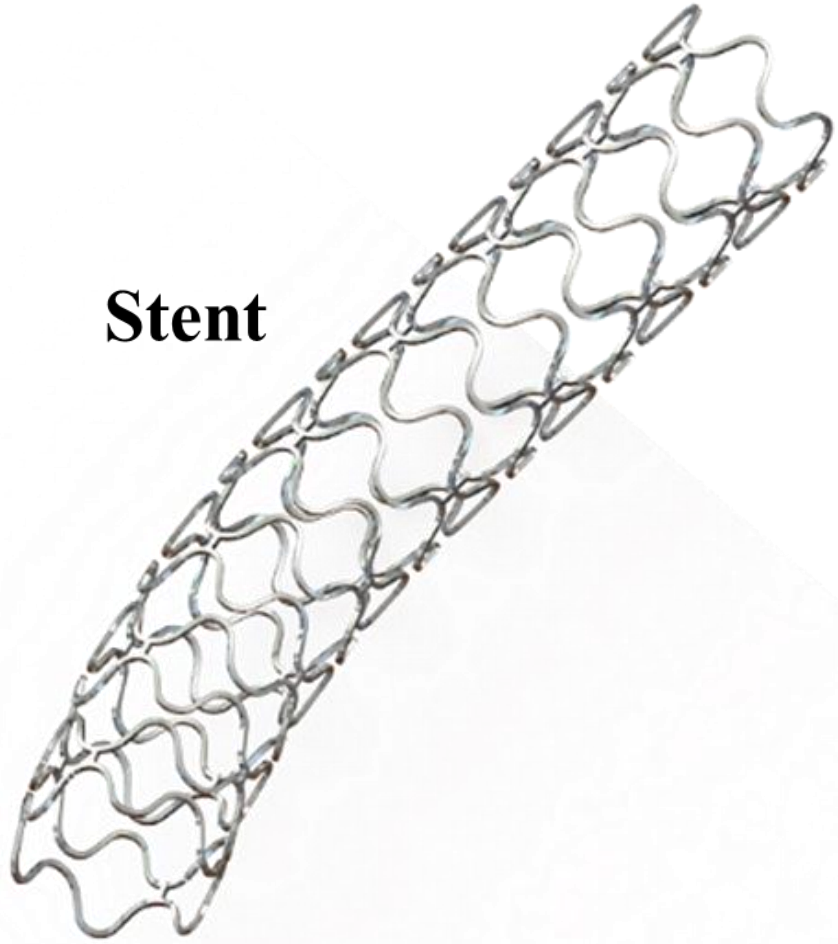
- Open Repair of AAA:
  - Surgical repair for patients who are not suitable for EVAR (anatomical reasons)
    - Aneurysmal sac is opened and depressurized
    - Graft is sewn in as an inlay
    - Aneurysmal sac is closed over the graft

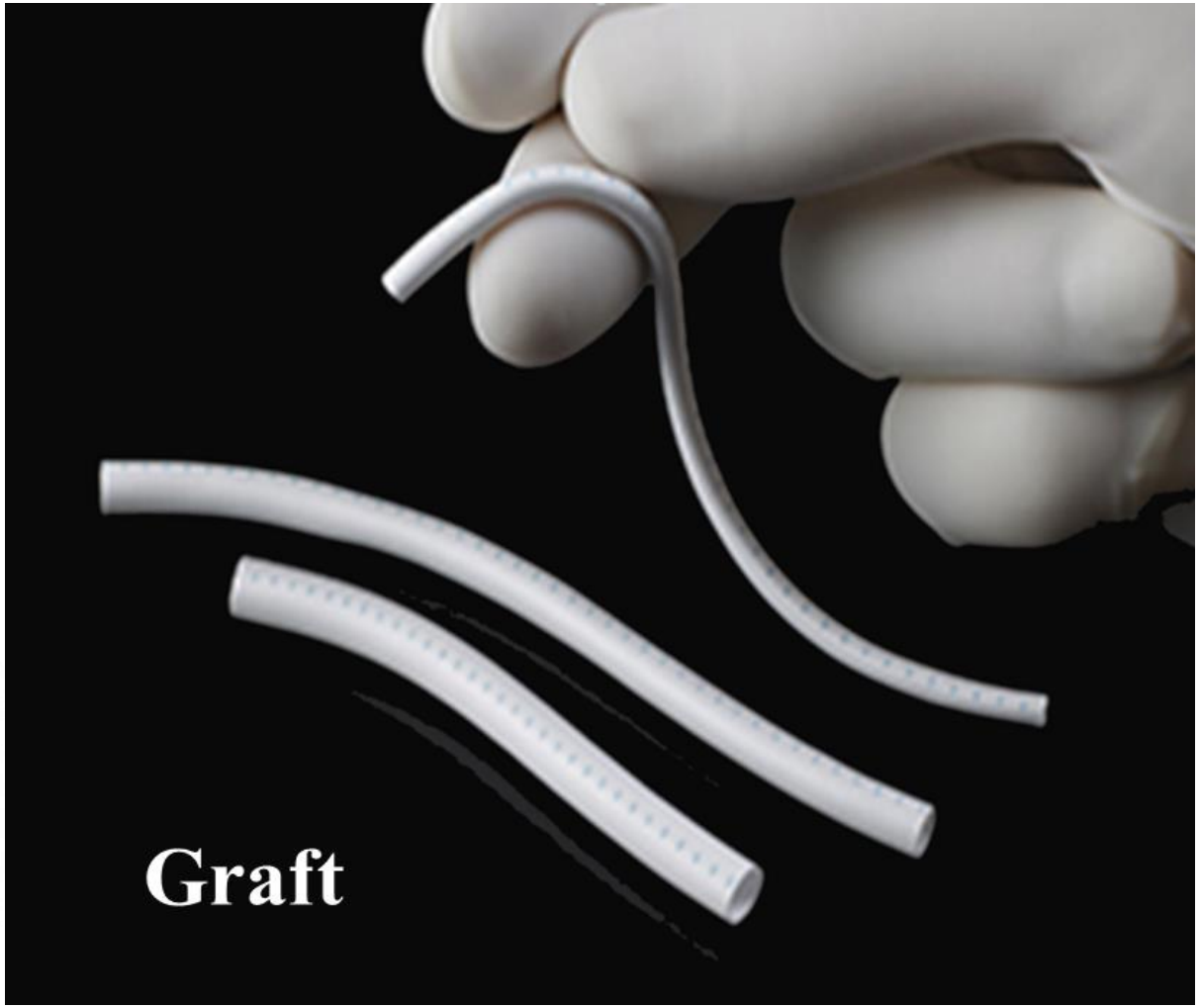


Treatment for AAA

- Endovascular Repair of AAA:
  - Introduced in 1991 for repair of AAA in high-risk patients
  - Combination of intravascular stent and prosthetic graft
    - "Stent" acts as anchoring component and is fixated to the aneurysm
    - Graft component acts a new conduit or vessel to de-pressurize the aneurysm

Vascular Stent vs. Graft

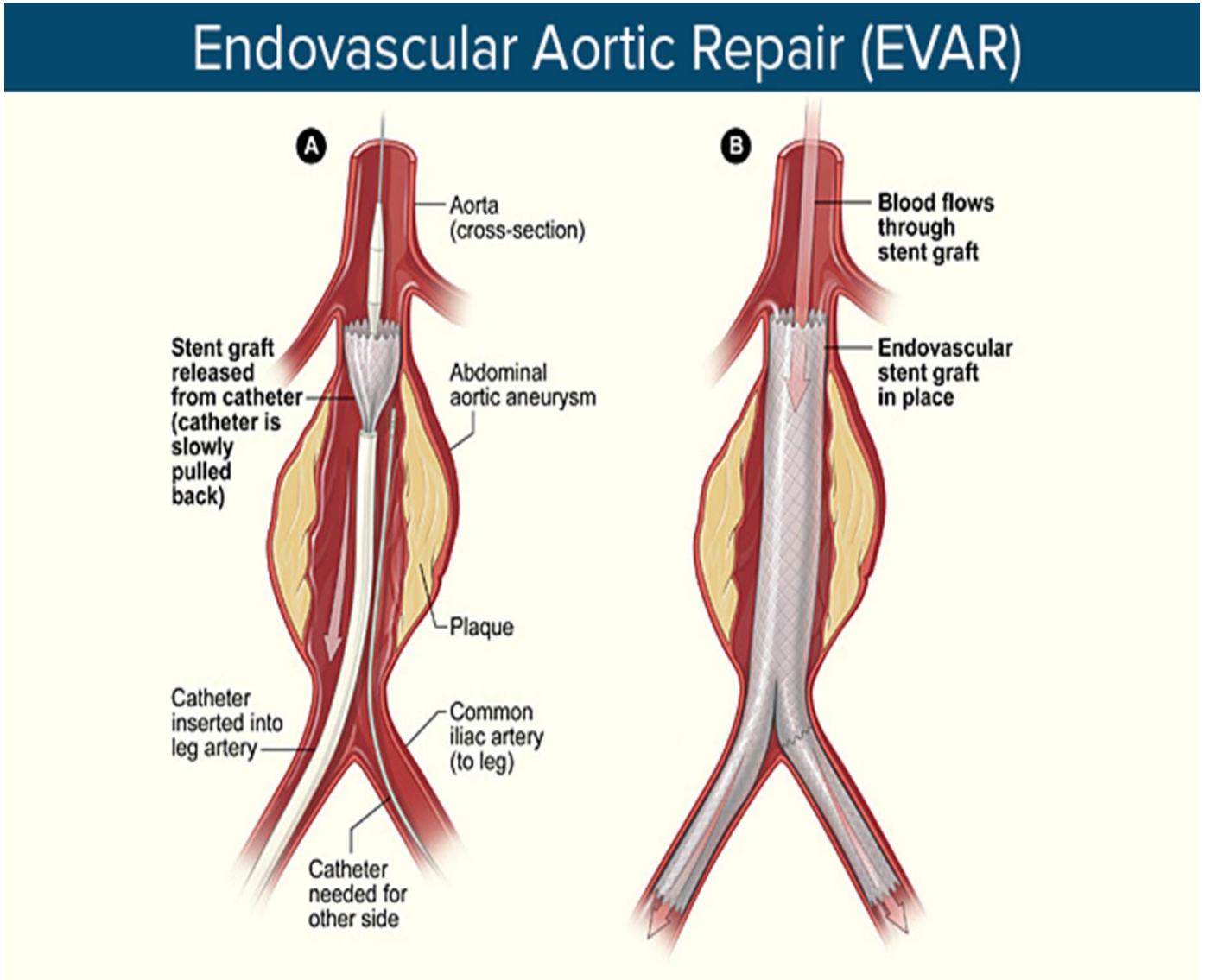




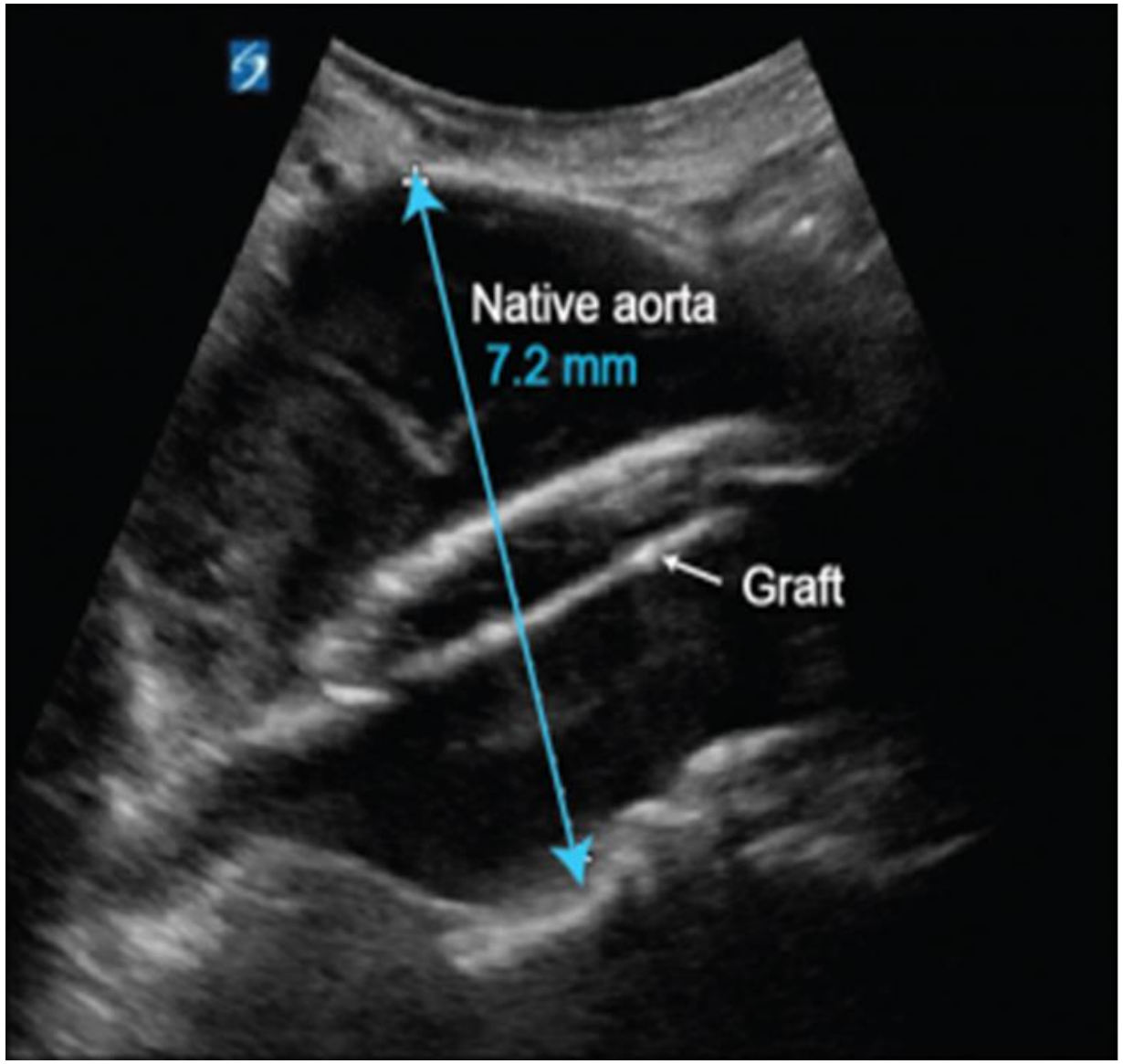
Endovascular Graft

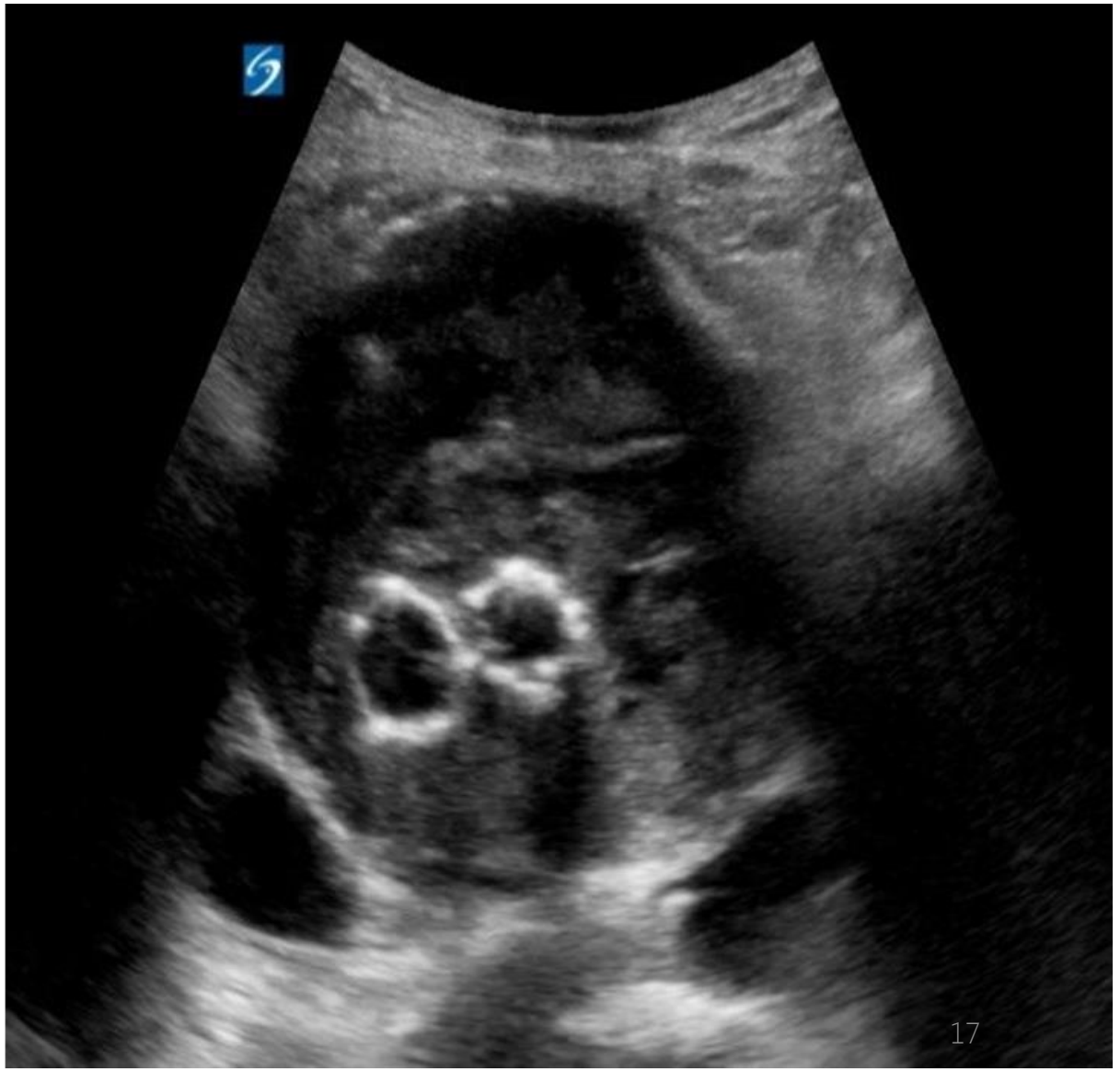
Endovascular Graft

- Flow is only permitted through the endovascular graft
  - Avoids flow within the native artery
- Grafts are deployed immediately distal to the lowest renal artery and as close to the iliac bifurcation



Endovascular Graft

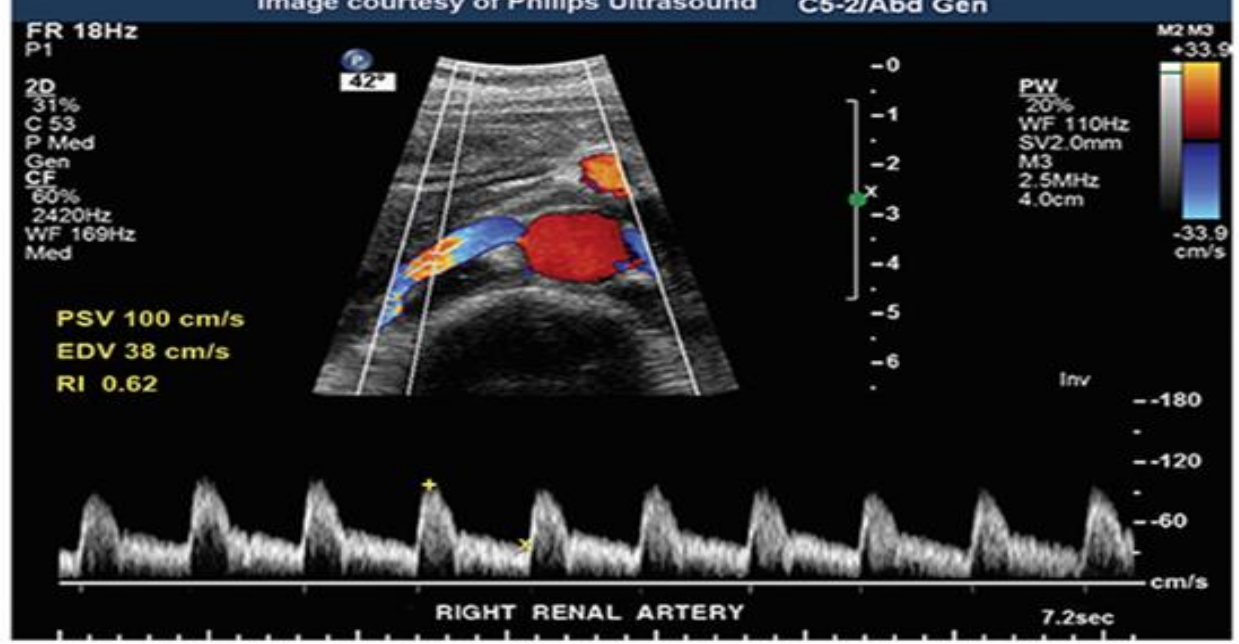




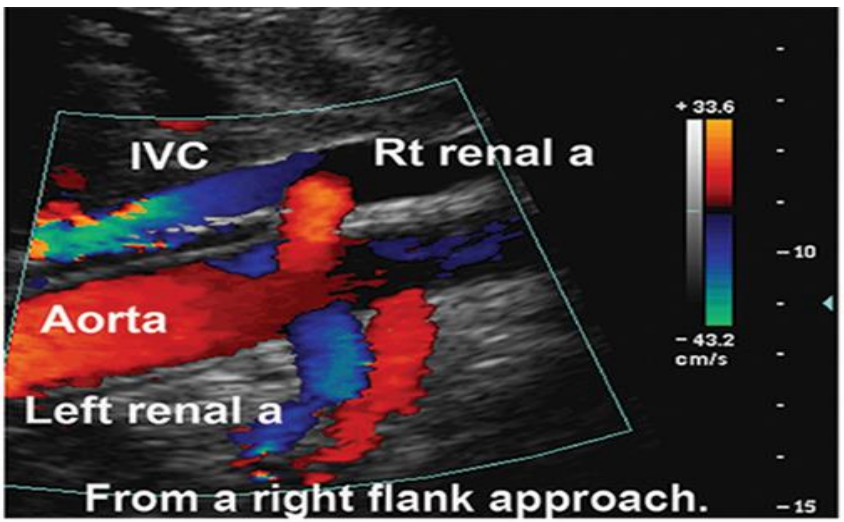
Renal Artery and Kidney

Technique

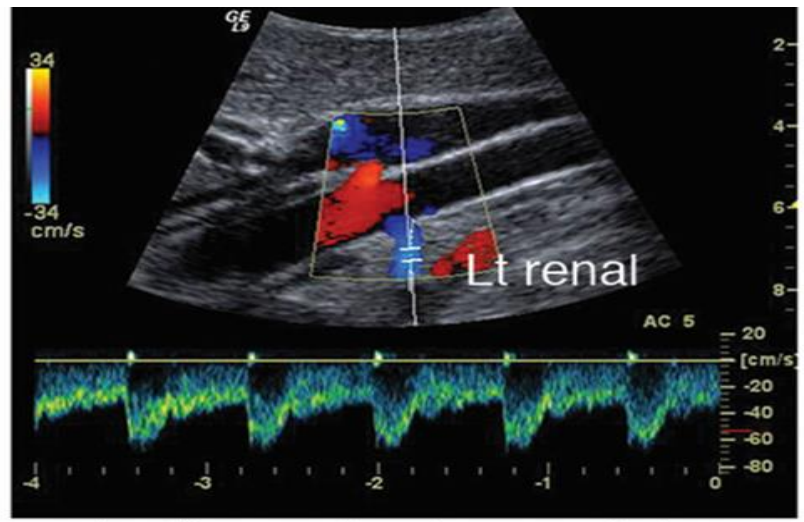
- Renovascular hypertension – secondary form of high blood pressure often caused by renal artery stenosis
- Examine:
  - Peak systolic velocity of the aorta
  - Using transverse approach, investigate the bilateral renal arteries obtain PSV and EDV at prox, mid, and distal levels
  - Obtain PSV and EDV of the segmental arteries and interlobar arteries
  - Evaluate each kidney size and morphology



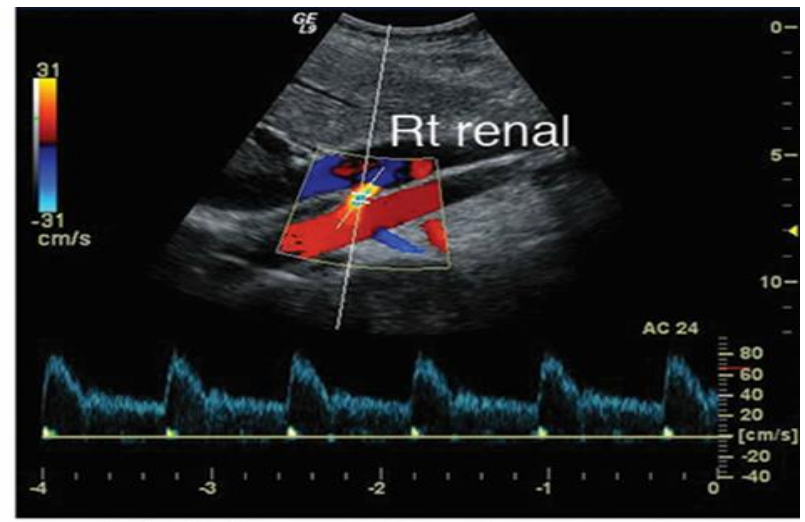
Rt renal a. from transverse abdominal anterior approach



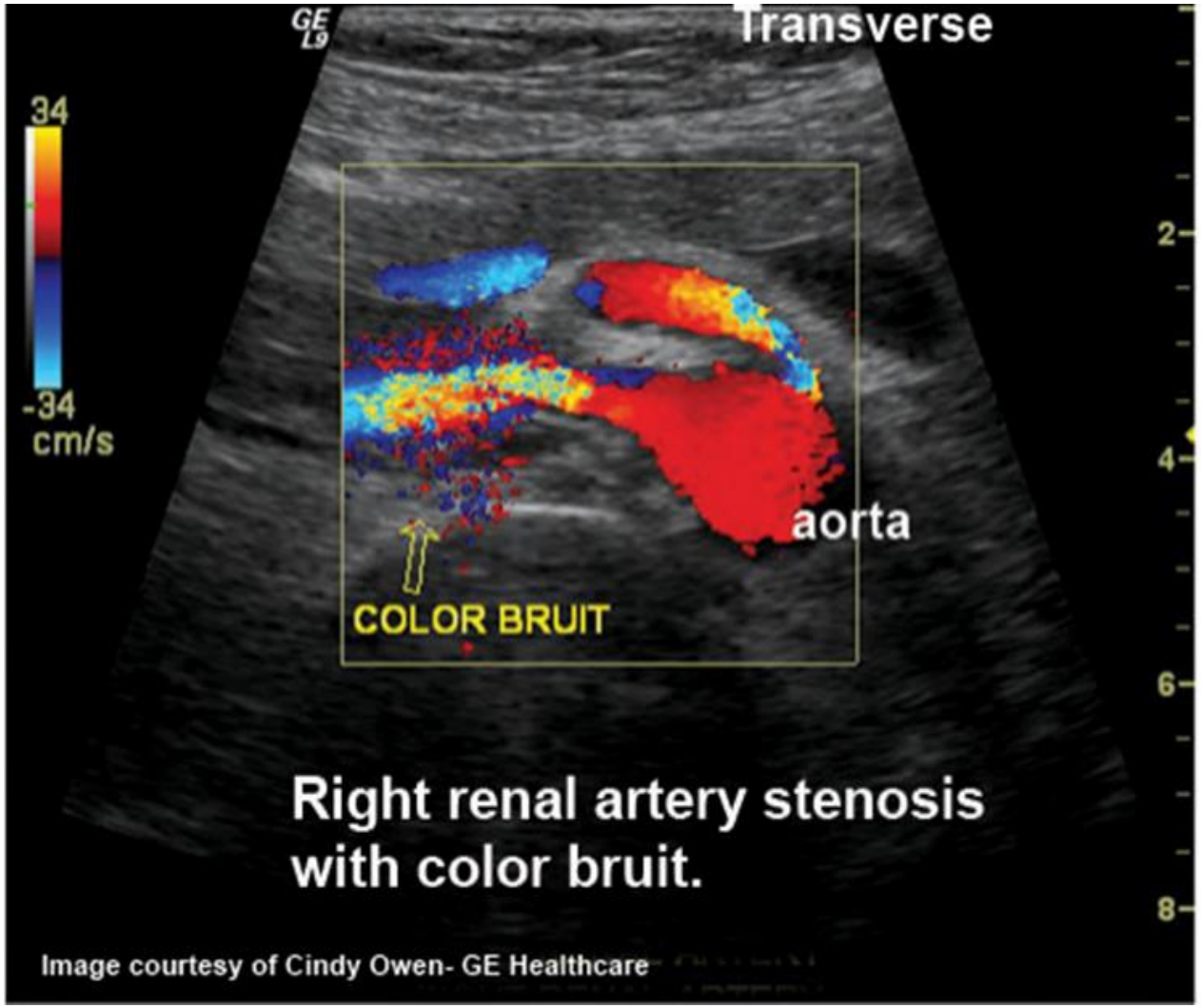
Rt & Lt renal origins imaged from right flank approach.

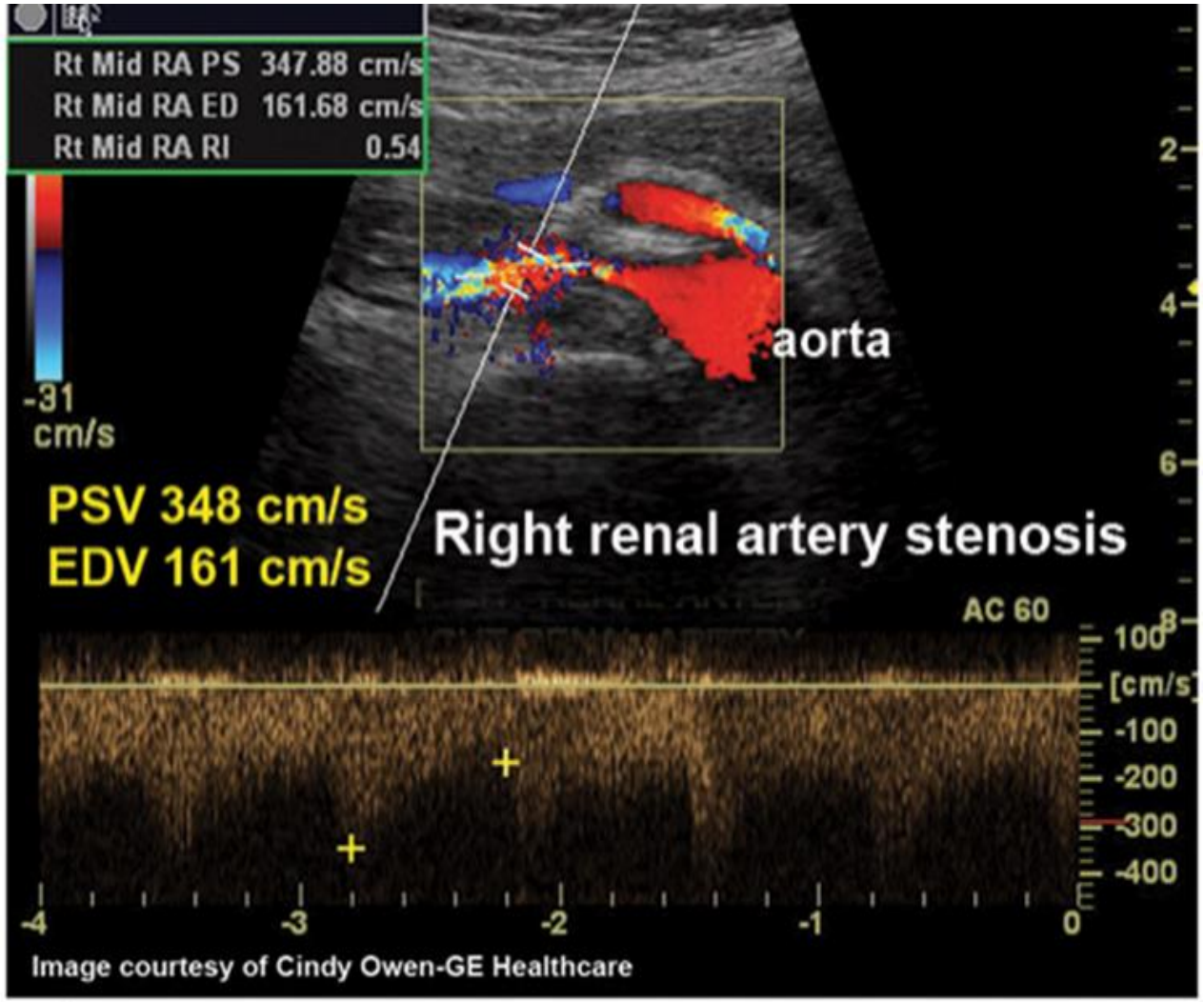


Left renal artery origin



Right renal artery origin

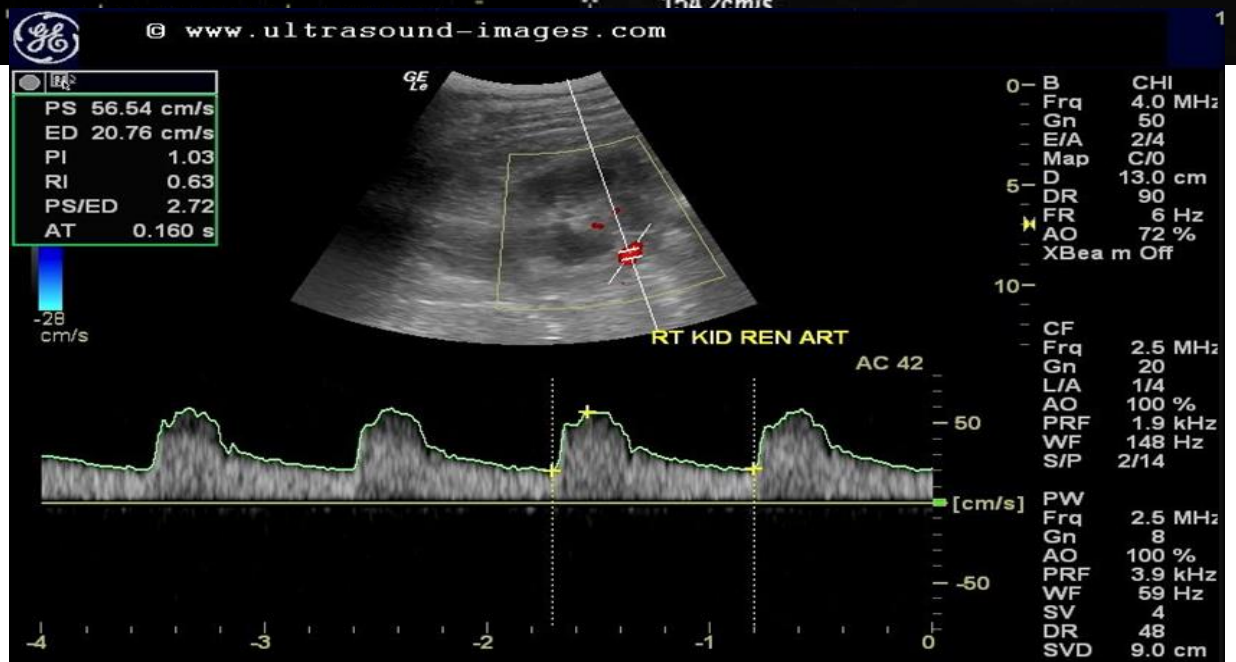

GE
L9
Transverse
34
-34
cm/s
aorta
COLOR BRUIT
Right renal artery stenosis
with color bruit.
Image courtesy of Cindy Owen- GE Healthcare


Rt Mid RA PS 347.88 cm/s
Rt Mid RA ED 161.68 cm/s
Rt Mid RA RI 0.54
-31
cm/s
aorta
PSV 348 cm/s
EDV 161 cm/s
Right renal artery stenosis
AC 60
100
[cm/s]
-100
-200
-300
-400
-4
-3
-2
-1
0
Image courtesy of Cindy Owen-GE Healthcare

Interpretation

- Renal arteries and kidney arteries are characterized as low-resistance vessels
- Aortic flow is normally low resistance above the renal bifurcation and high-resistance below renal arteries
- Significant stenosis will demonstrate spectral broadening


PS 106.0 cm/s
ED 19.0 cm/s
1 Vel 106.0 cm/s
-23 cm/s
AC 60
150
100
50
[cm/s]
-50
Aorta proximal to renals
HDI 5000
C5-2 Abd/Aorta
11 Nov 04
1:24:52 pm
Fr #64
10.0cm
Col 71% Map 1
WF Med
PRF 3000 Hz
Flow Opt: Med V
BW 0 Pg 0
Col 0 Pg 0
+ 46.1
- 46.1 cm/s
SV Angle 68°
Dep 5.1 cm
Size 2.0 mm
Freq 2.5 MHz
WF Med
Dop 61% Map 2
PRF 5000 Hz
Aorta below renals
AORTA
100
cm/s
-100


© www.ultrasound-images.com
PS 56.54 cm/s
ED 20.76 cm/s
PI 1.03
RI 0.63
PS/ED 2.72
AT 0.160 s
-28 cm/s
RT KID REN ART
AC 42
50
[cm/s]
-50
B CHI
Frq 4.0 MHz
Gn 50
E/A 2/4
Map C/0
D 13.0 cm
DR 90
FR 6 Hz
AO 72 %
XBea m Off
CF
Frq 2.5 MHz
Gn 20
L/A 1/4
AO 100 %
PRF 1.9 kHz
WF 148 Hz
S/P 2/14
PW
Frq 2.5 MHz
Gn 8
AO 100 %
PRF 3.9 kHz
WF 59 Hz
SV 4
DR 48
SVD 9.0 cm

Interpretation

- Calculation of RAR (Renal-to-Aortic Ratio) is important:

$$\frac{\text{Renal Artery PSV}}{\text{Aortic PSV}}$$

- Normal RAR = <3.5
- Abnormal RAR = ≥3.5 (indicates a 60% or greater diameter reduction)

- Renal-to-aortic ratio (RAR) may not be accurate if there is an AAA or when PSV in the aorta are <40 cm/sec or >90-100 cm/sec

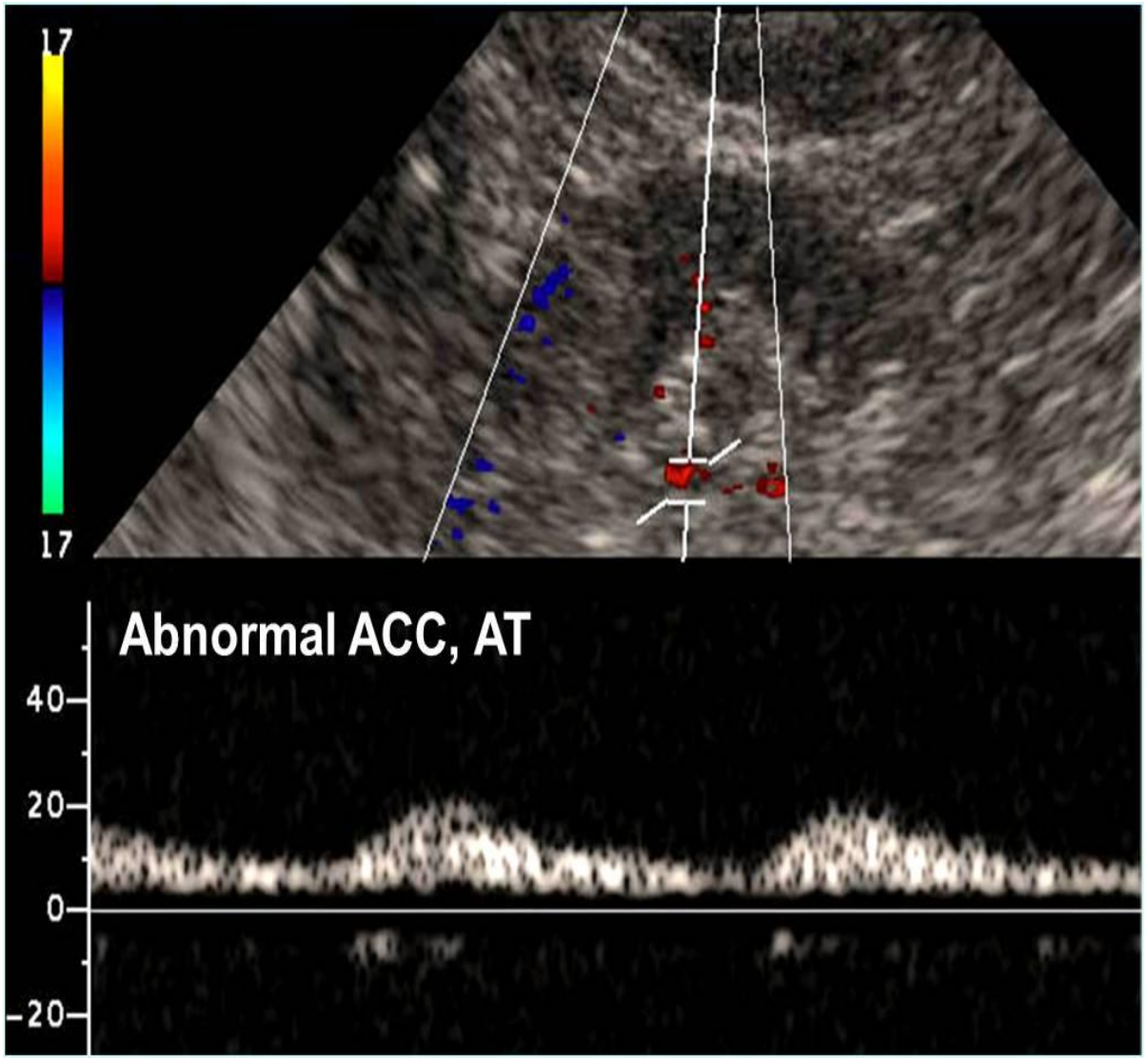
Interpretation

- Resistance of the renal arteries is also evaluated using Pourcelot's Resistive Index (RI):

$$\frac{\text{PSV-EDV}}{\text{PSV}}$$

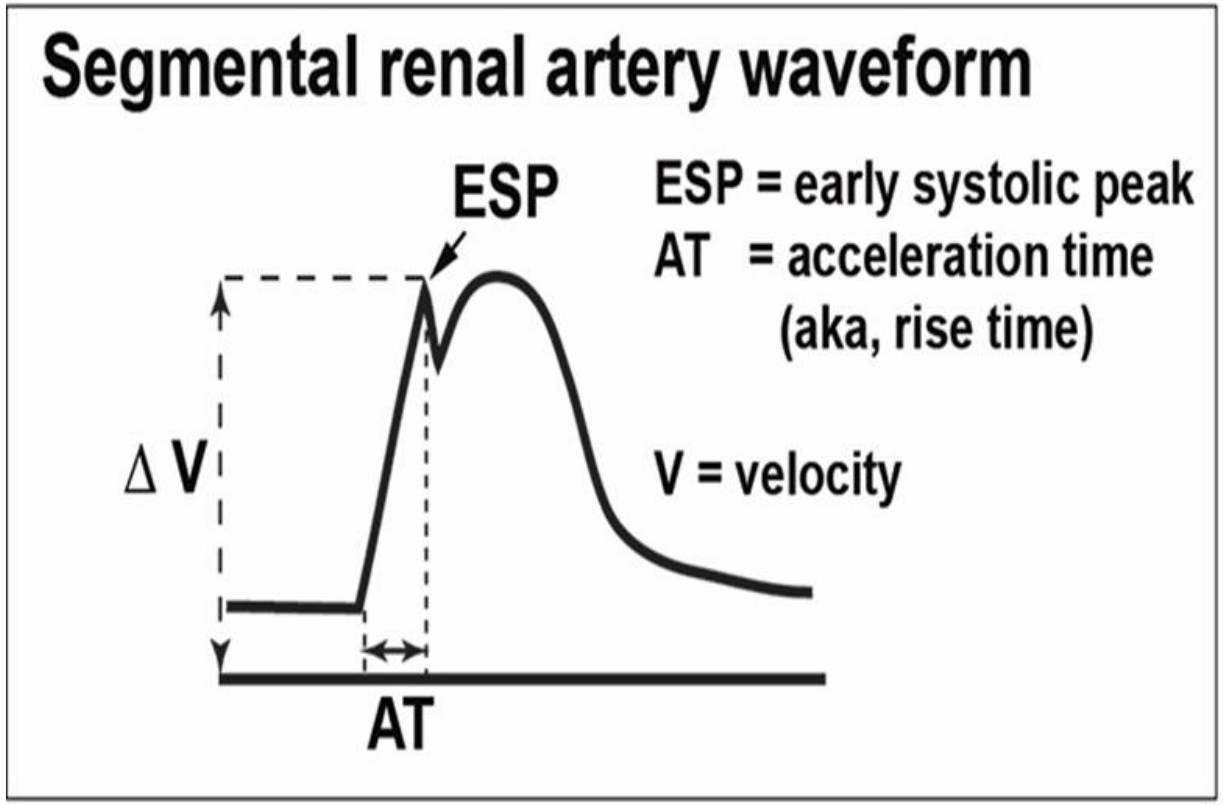
- Normal RI = <0.7
- Abnormal (increased resistance) = ≥ 0.7

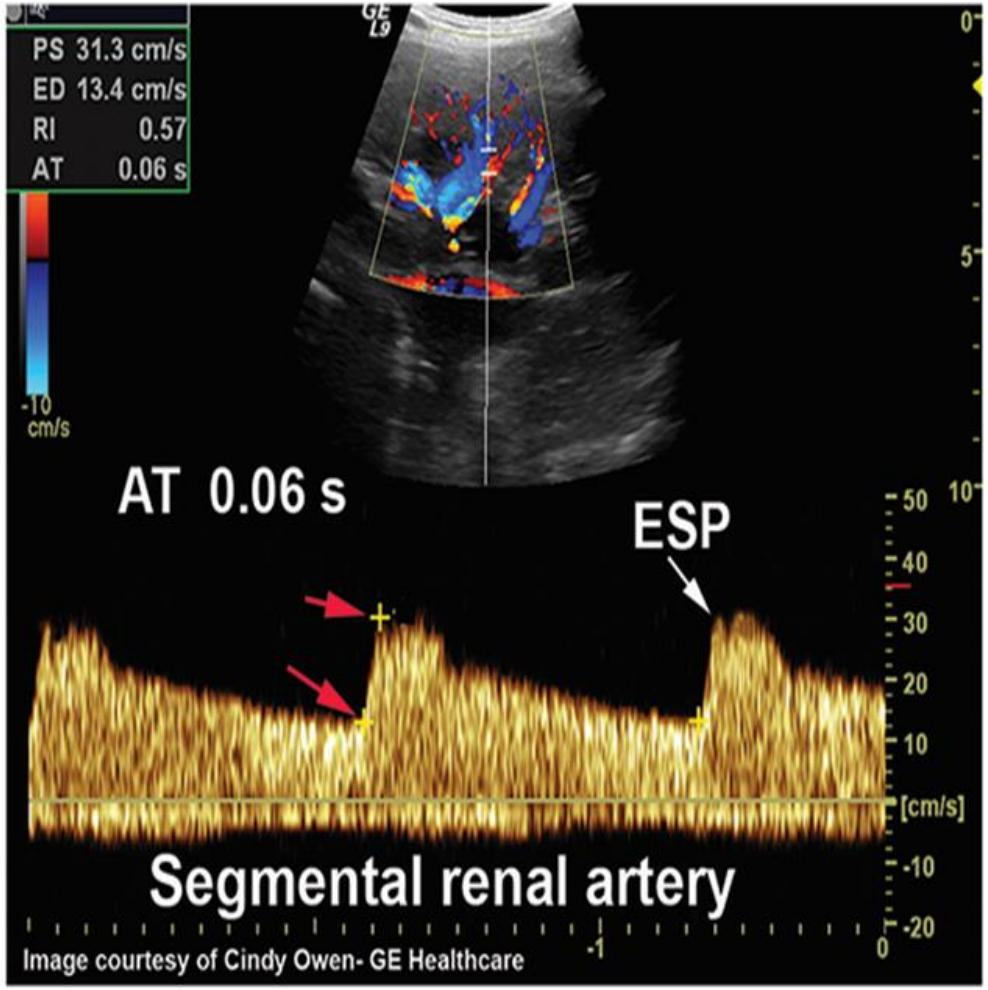
Interpretation



- Proximal high-grade stenosis or occlusion of the renal artery may result in a dampened (prolonged upstroke) but still low resistance waveform
  - Called a tardus-parvus waveform
- Acceleration time (AT) can be measured to evaluate arterial flow in the kidneys
  - Abnormal AT = ≥100 msec

Acceleration Time (AT)



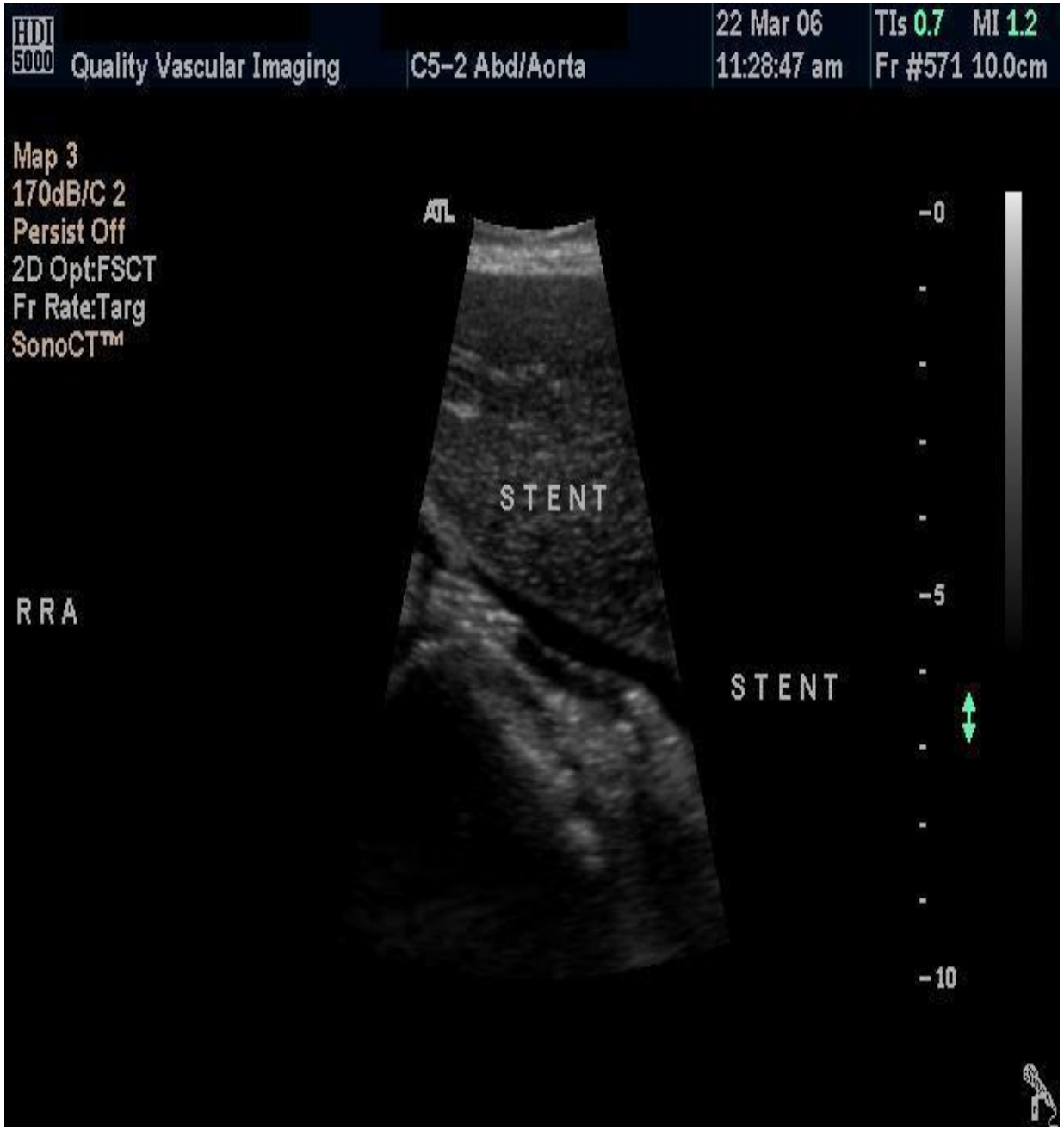


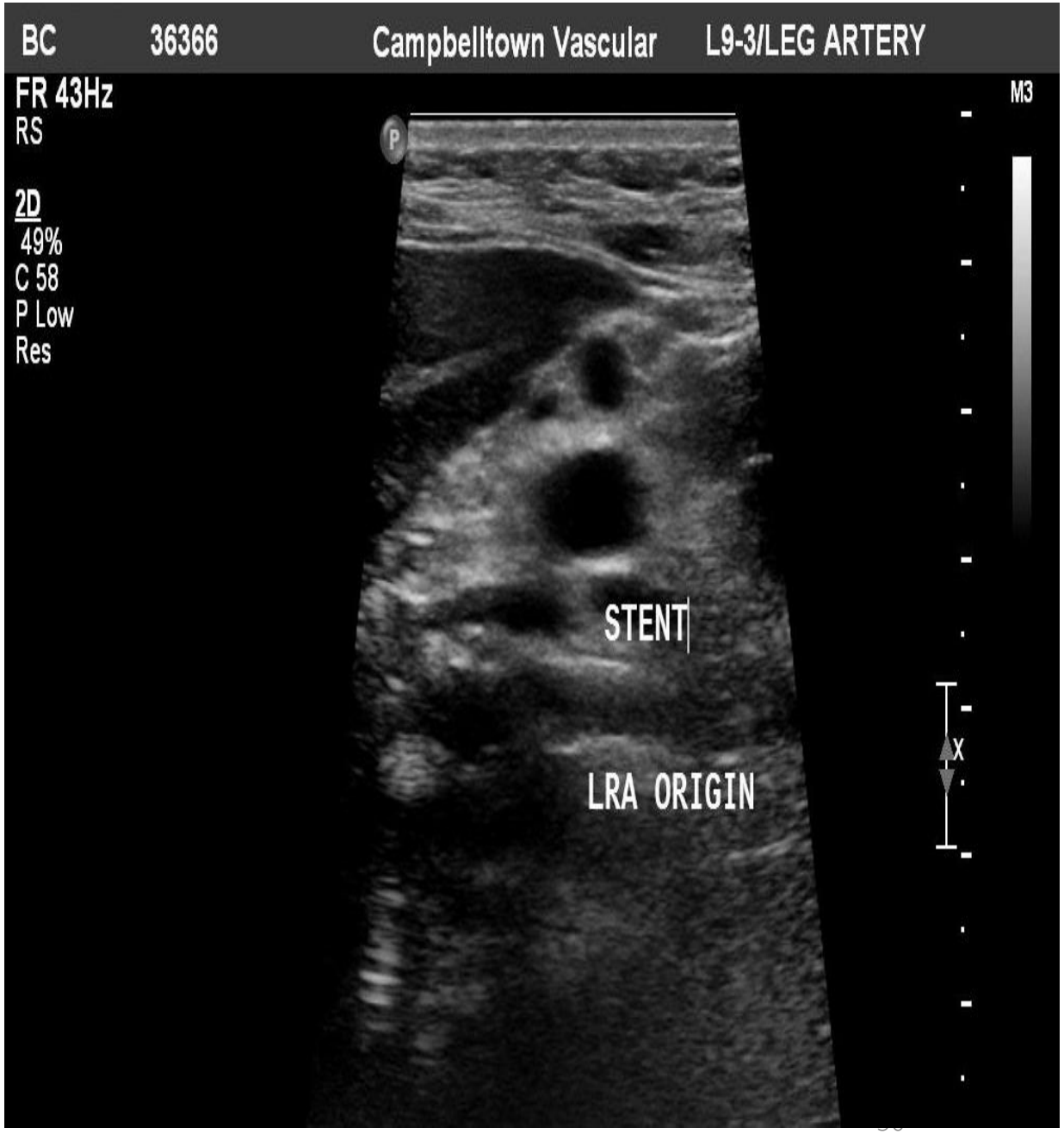
Renovascular HTN Causes

- Atherosclerosis, usually in proximal renal artery
- Fibromuscular dysplasia (FMD)
- Dissection and/or extension of aortic dissection
- Renal artery stenosis must be $\geq$70% before it is likely to cause hypertension

Treatment for RA Stenosis

- Renal angioplasty and stenting
  - Widening of the narrowed renal artery
  - Stent placed inside the vessel to hold it open and promote better blood flow
- Renal artery bypass
  - Substitute blood vessel is grafted to act as a new conduit for blood to reach the kidneys

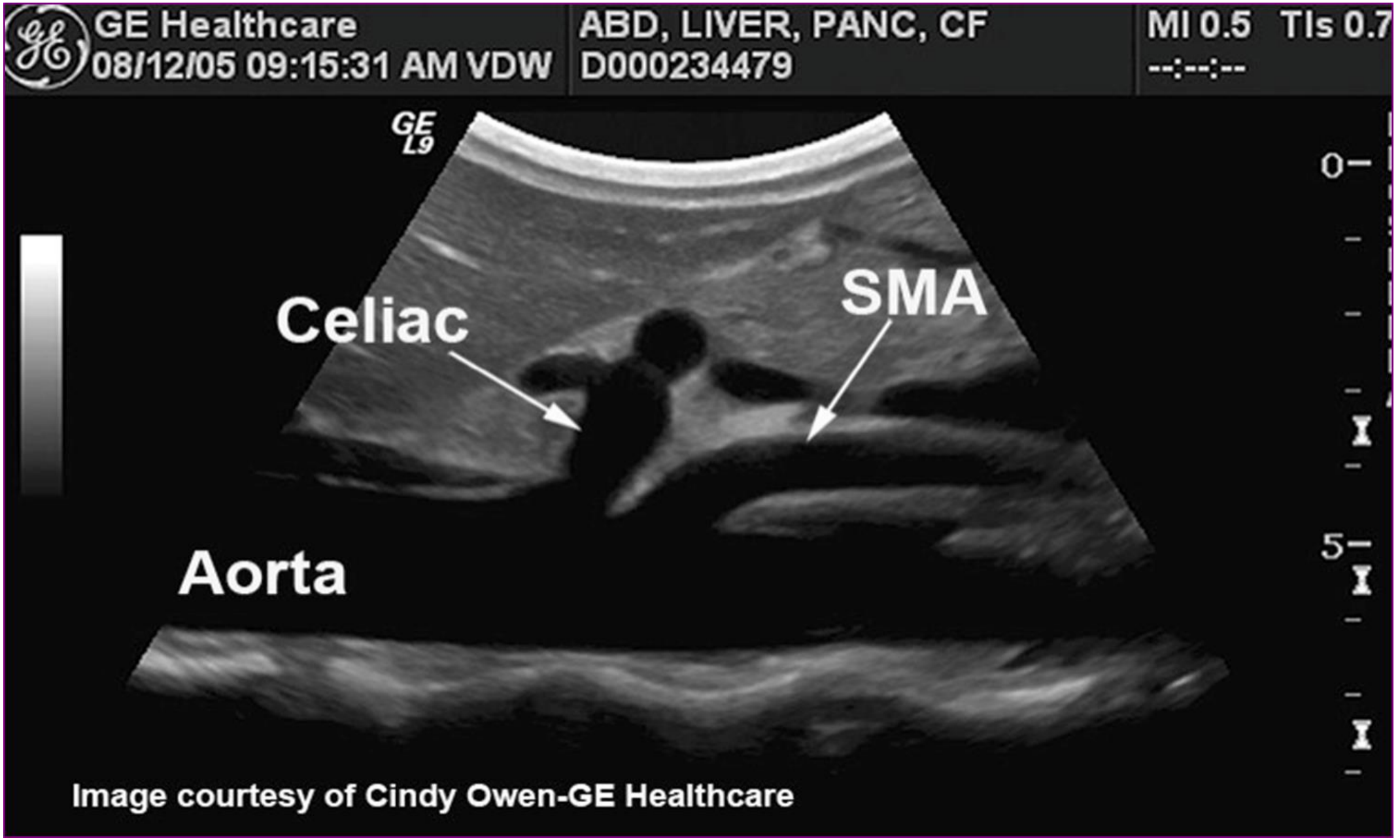

HDI 5000
Quality Vascular Imaging
C5-2 Abd/Aorta
22 Mar 06
11:28:47 am
TIs 0.7 MI 1.2
Fr #571 10.0cm
Map 3
170dB/C 2
Persist Off
2D Opt:FSCT
Fr Rate:Targ
SonoCT™
ATL
STENT
STENT
RRA
-0
-5
-10


BC
36366
Campbelltown Vascular
L9-3/LEG ARTERY
FR 43Hz
RS
2D
49%
C 58
P Low
Res
M3
STENT
LRA ORIGIN
X

Mesenteric Arteries

Technique

- Patient history:
  - Dull, achy, or crampy abdominal pain 15-30 minutes after meals may suffer from *mesenteric ischemia*
  - Diarrhea
  - Weight loss
- Causes by athero occlusive disease at vessel origins
- Celiac, superior mesenteric artery (SMA), and inferior mesenteric artery (IMA) must be all involved for bowel ischemia to occur


GE Healthcare
08/12/05 09:15:31 AM VDW
ABD, LIVER, PANC, CF
D000234479
MI 0.5 TIs 0.7
--:--:--
GE
L9
Celiac
SMA
Aorta
0
5
Image courtesy of Cindy Owen-GE Healthcare

Technique

- Exam must be performed on a fasting patient
- Obtain PSV and EDV from the following vessels:
  - Celiac trunk, hepatic artery, and splenic artery
  - Proximal, mid, and distal SMA
  - IMA, if possible
  - Aorta (to rule out aortic abnormalities)
- Patient is then given a high-caloric drink and rescanned after 20-30 minutes (or sooner if the patient begins experiencing symptoms)
  - *Post-prandial*

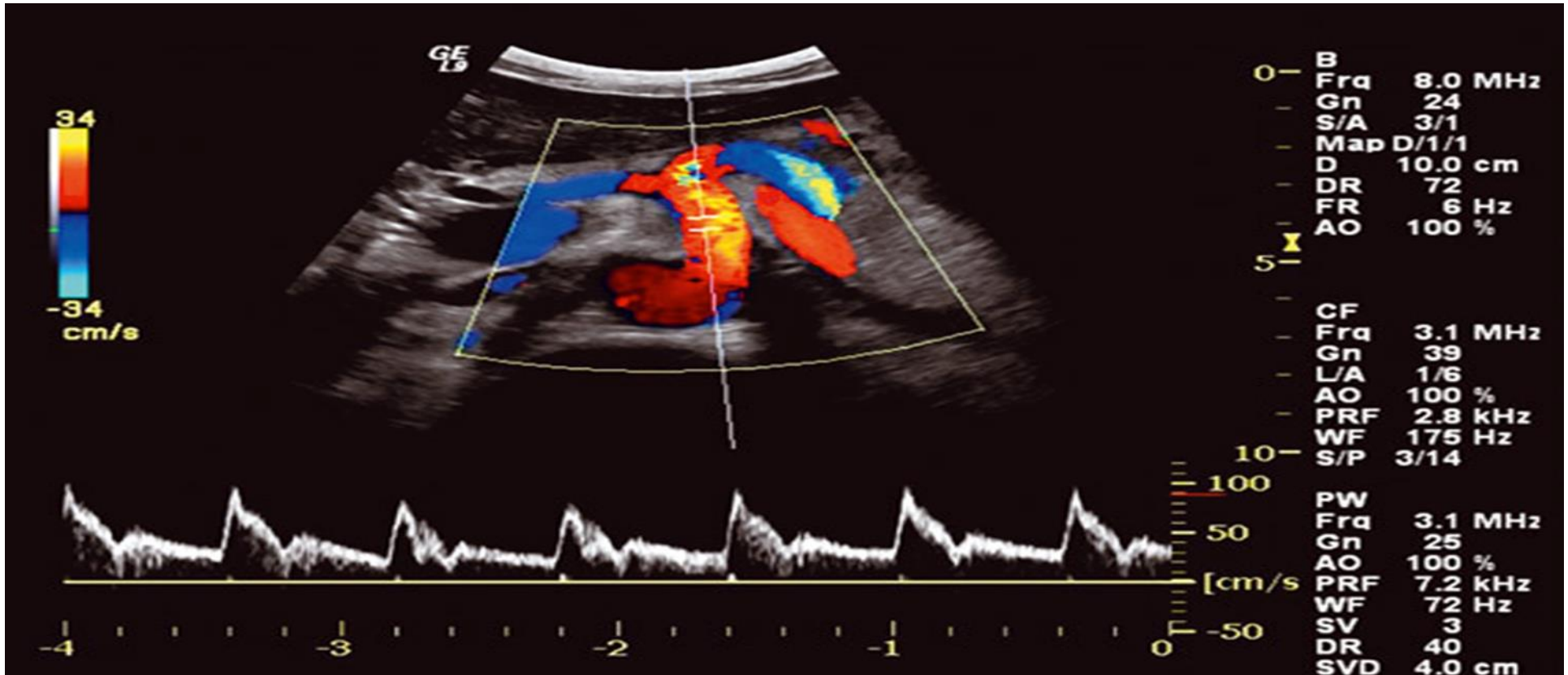
Interpretation

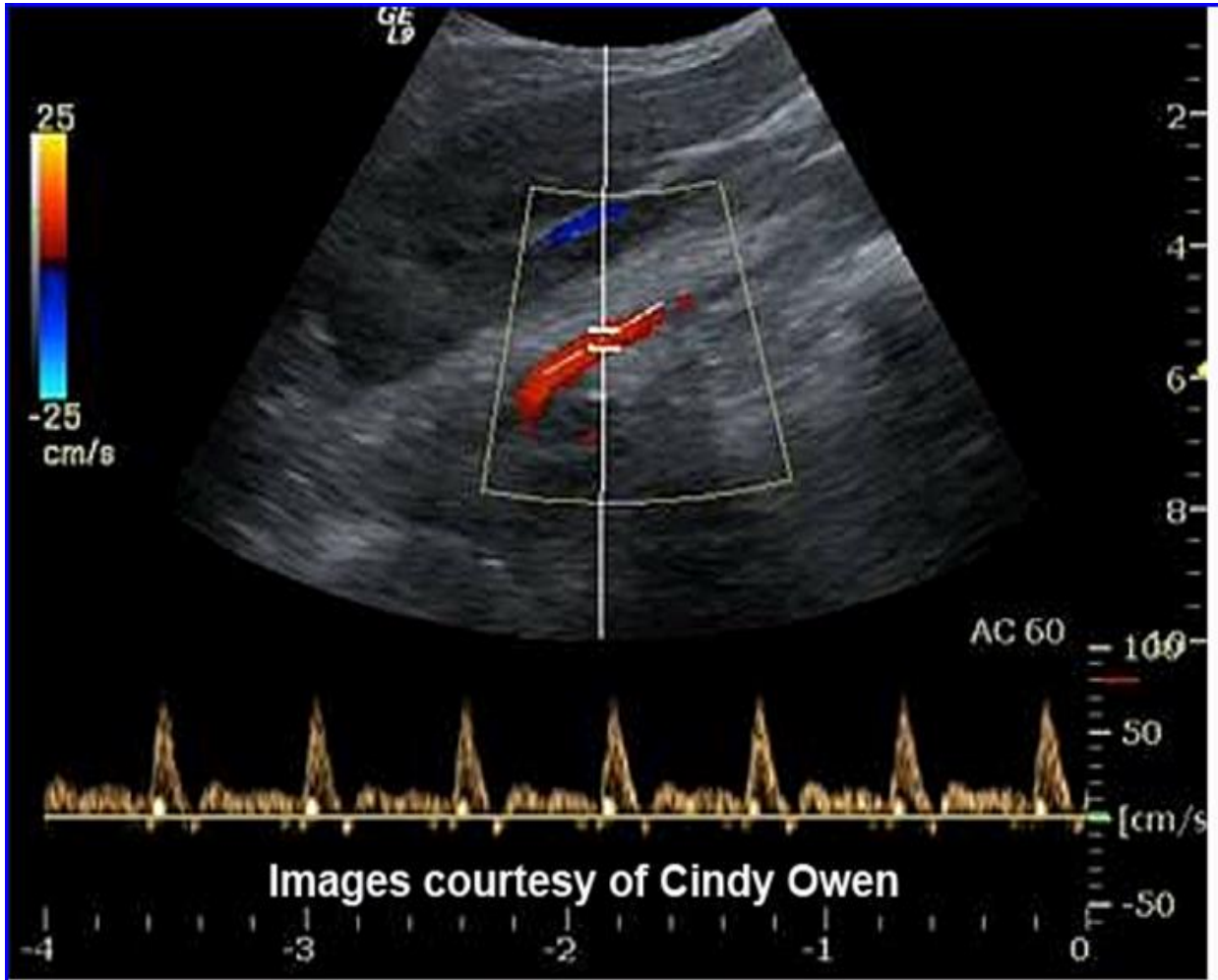
- Superior mesenteric artery and Inferior Mesenteric Artery:
  - Pre-prandial – high-resistance flow
  - Post-prandial – low-resistance flow
  - An SMA stenosis may be present
- Celiac artery:
  - Pre-prandial – low-resistance
  - Post-prandial – low-resistance

  ****No response to high-caloric liquid intake****
  - A celiac stenosis may be present

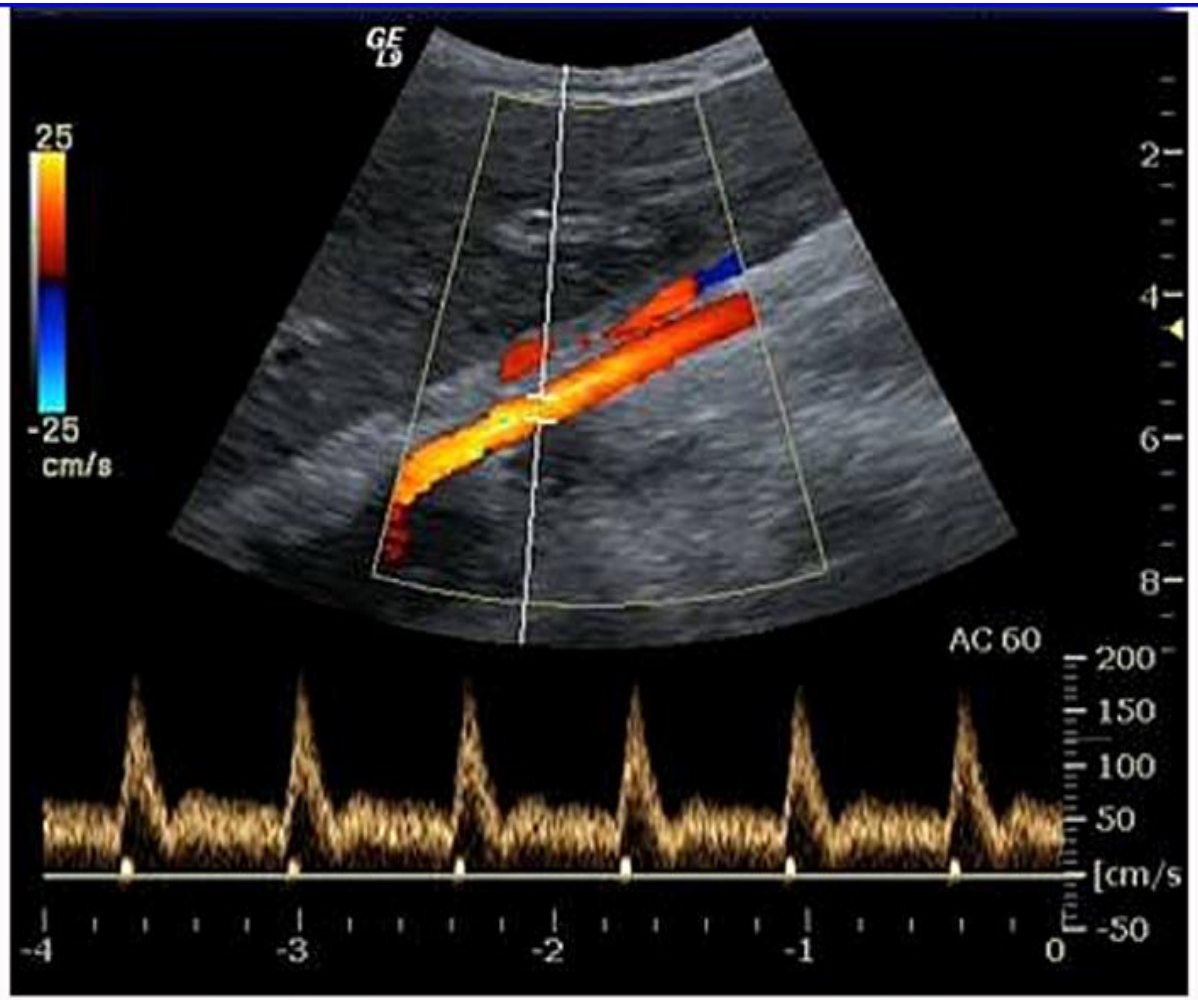
Interpretation

- Celiac, Splenic, and Hepatic
  - All should demonstrate a low-resistance flow pattern

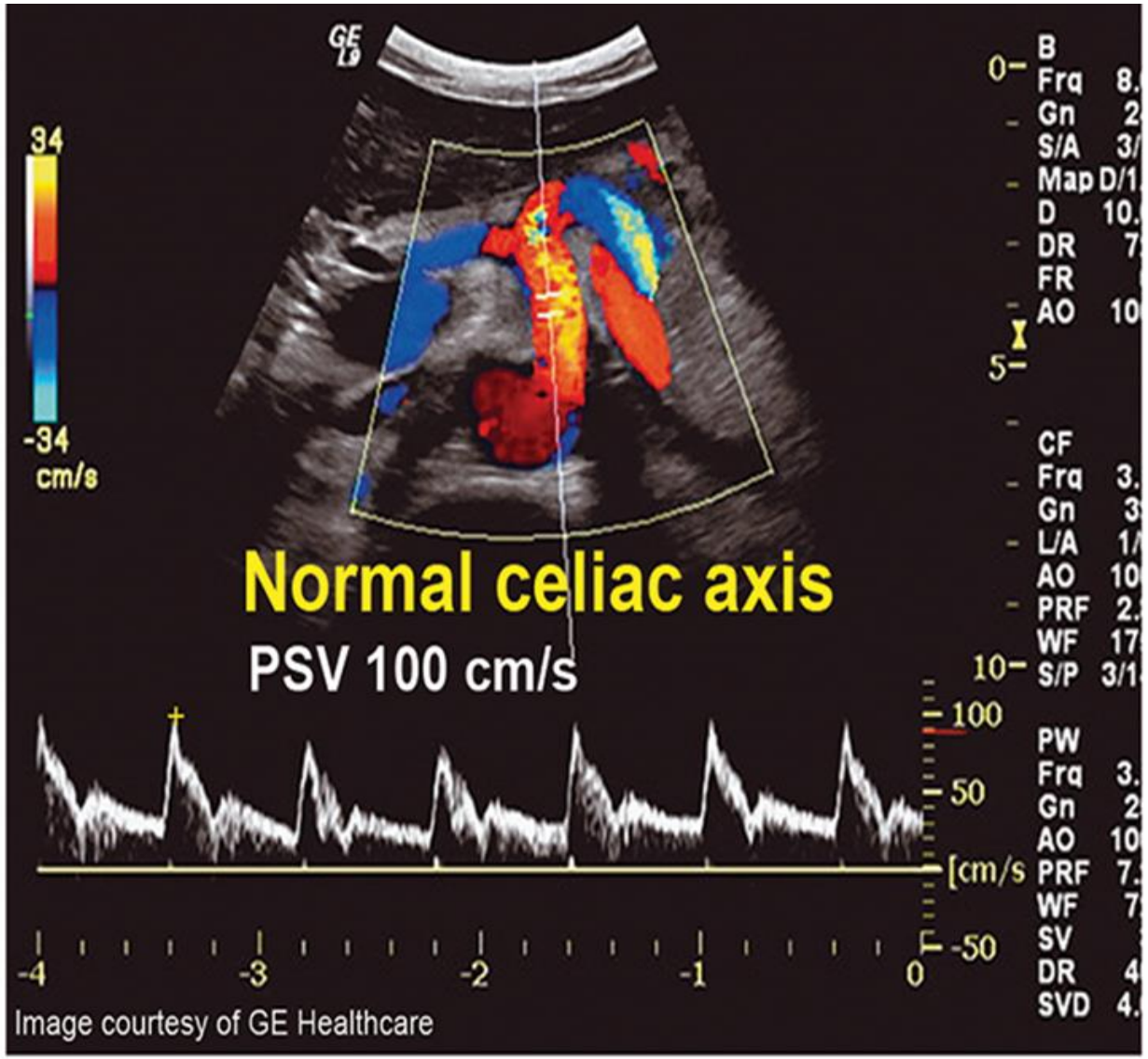


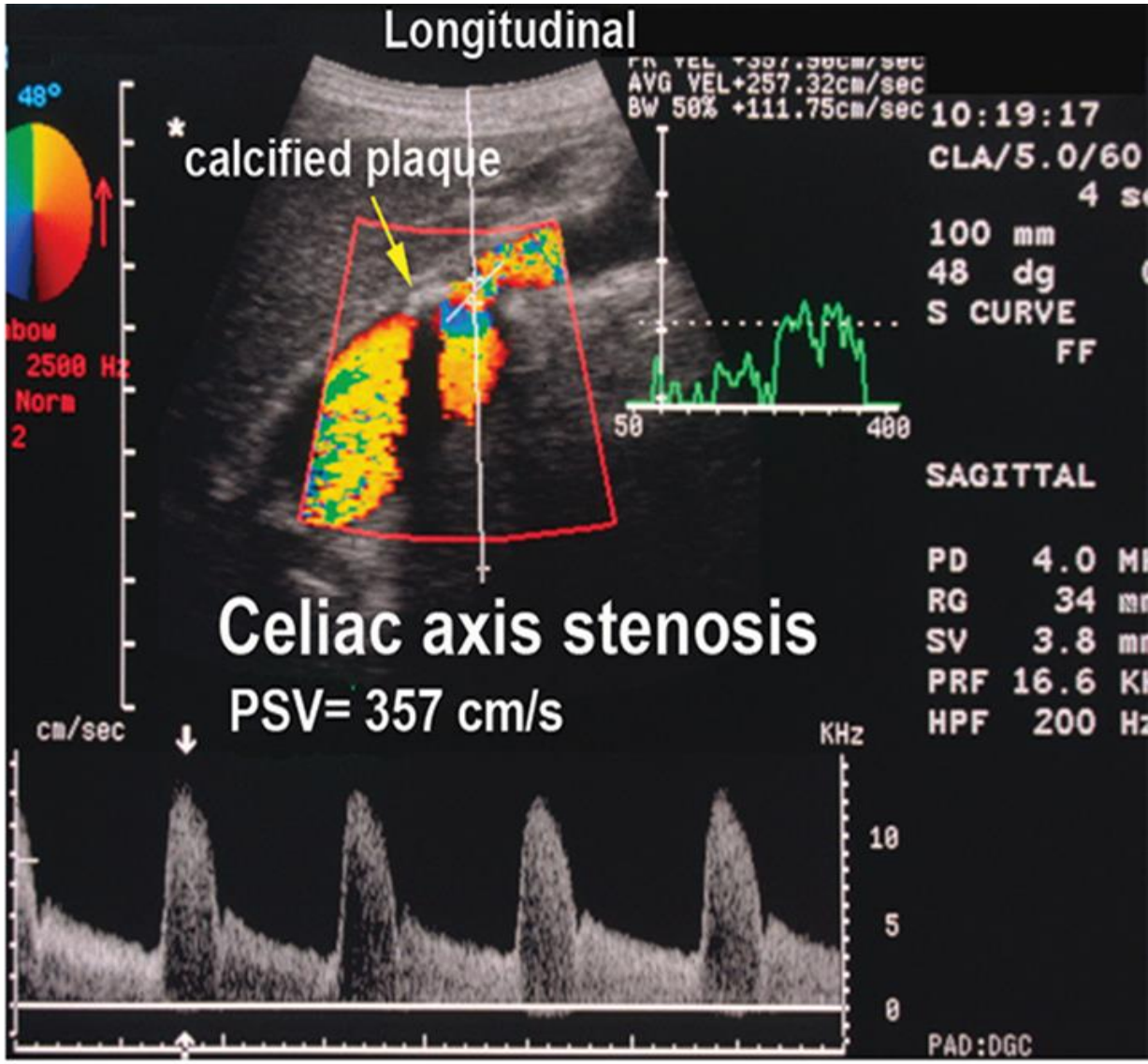


SMA Fasting



SMA post prandial


34
-34
cm/s
Normal celiac axis
PSV 100 cm/s
100
50
-50
[cm/s
-4
-3
-2
-1
0
Image courtesy of GE Healthcare


Longitudinal
calcified plaque
AVG VEL+257.32cm/sec
BW 50% +111.75cm/sec
10:19:17
CLA/5.0/60
100 mm
48 dg
S CURVE
FF
SAGITTAL
PD 4.0
RG 34
SV 3.8
PRF 16.6
HPF 200
2500 Hz
Norm
50
400
Celiac axis stenosis
PSV= 357 cm/s
cm/sec
KHz
10
5
0
PAD:DGC

Treatment for Mesenteric Ischemia

- Medical treatment with anti-coagulation is used for patients who are unable to tolerate surgical treatment
- Endovascular repair using angioplasty/stenting
- Thrombectomy
- Bypass the occluded artery
- Surgical removal of damaged intestines

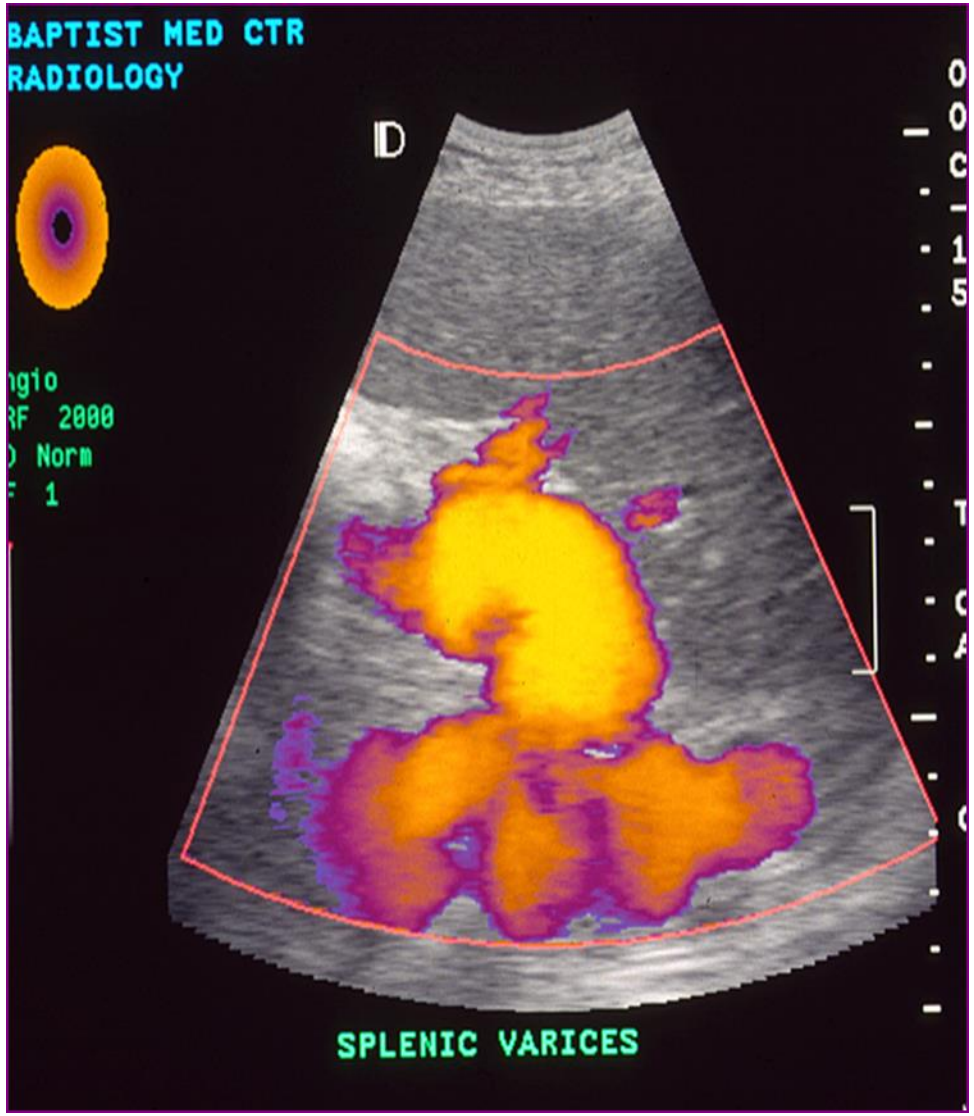
Portal Hypertension

Portal Hypertension

- Elevated pressure in the portal venous system due to increased impedance of flow through the liver
- May be:
  - Pre-hepatic – thrombosis of portal or splenic v.
  - Intra-hepatic – Cirrhosis, hepatic fibrosis
  - Post-hepatic – IVC obstruction, hepatic v. obstruction

Portal Hypertension

- May lead to:
  - Ascites
  - Splenomegaly
  - GI – esophageal varices and bleeding
  - Jaundice
  - Signs of hepatic failure

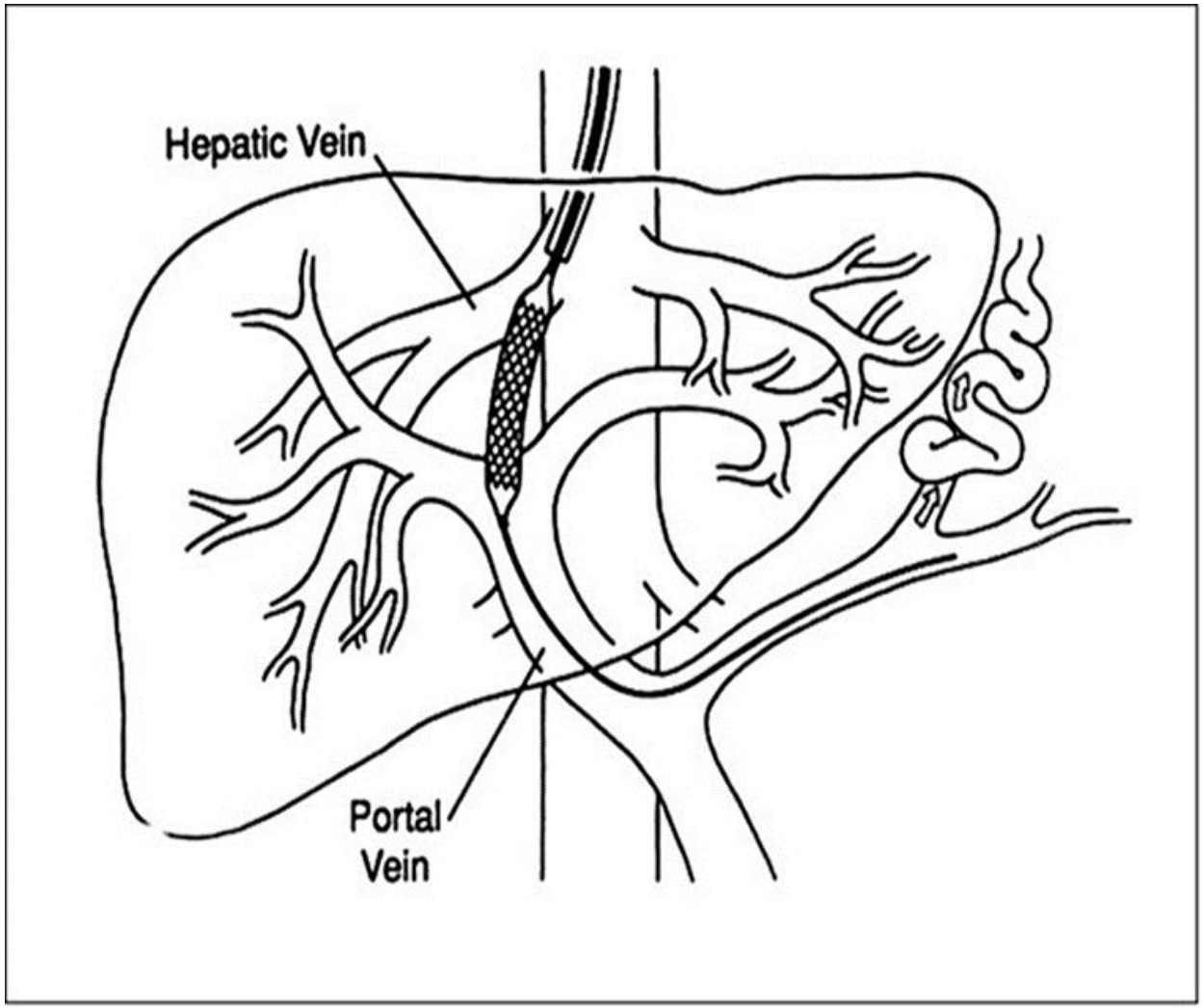


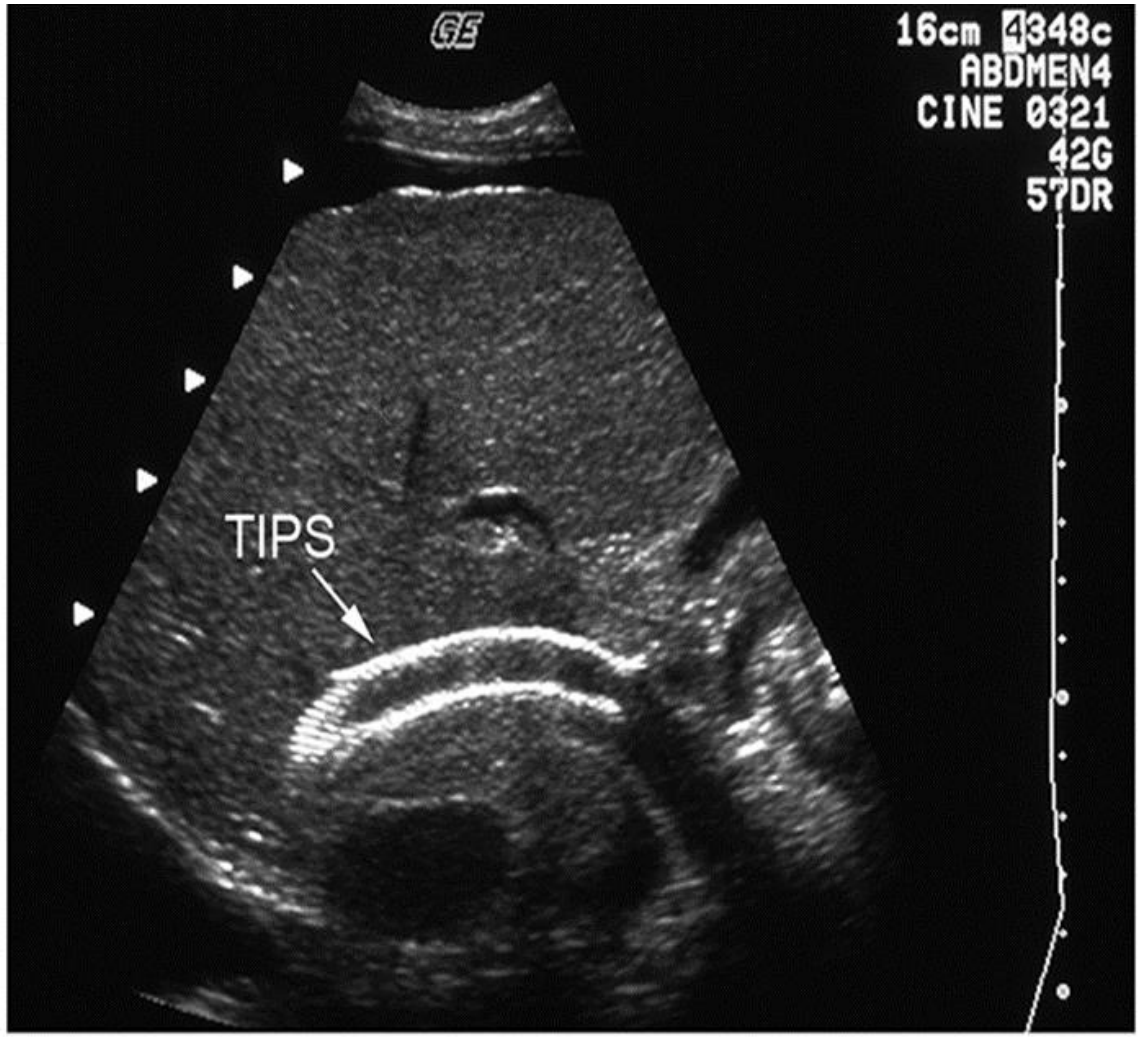
Technique

- Measure Portal v. diameter (normal is <13mm)
- Use low PRF and wall filter settings
- Assess Portal vein velocity and direction
- Evaluate Portal vein and branches for thrombus and look for collaterals
- Measure the spleen (normal is <13cm)
- Rule out extrinsic compression of the Portal vein
- Evaluate IVC for obstruction

Treatment for Portal HTN

- Transjugular Intrahepatic Portosystemic Shunts (TIPS)
  - Stent placement in the liver parenchyma between portal vein and hepatic vein
  - Purpose: decompression of the portal system
  - Does not address the cause of portal hypertension





Transjugular Intrahepatic Portosystemic Shunt (TIPS)