VERSION 2
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Celiac - SMA - Renals Oh My!

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How Long Have You Been Performing Vascular Ultrasound Exams?

A. 0-2 years
B. 3-5 years
C. 6-10 years
D. Before they had color Doppler!
When you’ve been scanning for a while... You Start Seeing Things...

Does anyone see a Duck?
Does Everybody See A Sloth?
Patrick’s Ultimate Goal Everyday is to...

**Make Duplex Doppler The Gold Standard!**
First Step – Know Anatomy

- **Aorta**
- **IVC**
- **Celiac**
- **SMA**
- **IMA**
- **Renal Arteries**
- **Renal Veins**
2nd Step – Know Normal flow patterns

*Blueprints are essential in complex matters!

Spectral Blueprints
Arterial Flow Patterns
Low Resistance Flow

- Renal arteries
- Celiac and Branches
  - Hepatic, splenic
- ICA
- Vertebral arteries

If high resistance is seen in a low resistance bed, something is usually not right!

High/continual Diastolic Flow
Low Resistive Parenchymal Organs
High Resistant Flow

• Aorto-iliac arteries
• Upper and lower peripheral arteries
• Fasting SMA
• Subclavian artery
• External carotid artery

If low resistance is seen in a high resistance bed, something is usually not right!
Celiac – SMA Arteries

- Left gastric artery
- Splenic artery
- Left hepatic artery
- Right hepatic artery
- Celiac trunk
- Common hepatic artery
- Gastro-duodenal artery
- Stomach
- Spleen
- Left gastroepiploic artery
- Pancreas
- Right gastroepiploic artery

Celiac trunk Flow Distribution
Low Resistive Flow

SMA Flow Distribution
High Resistive Flow
SMA – IMA Arteries

IMA Flow Distribution
High resistive flow

SMA and IMA Flow Distribution
MESENTERIC DOPPLER EXAM
PUTTING THE TRANSDUCER DOWN FOR YOUR DupleX Doppler Patient!

They’ll never know I had Mexican food!
Visceral Duplex Doppler Prep

- Nothing but fluids, Jell-O after 9 pm
- Jell-O is OK for breakfast
- Please take meds!
- No smoking
- Mild laxative (Milk of Magnesia)
- Patients are encouraged to bring a snack for after exam

Research if any prior Duplex Doppler or comparative imaging exams available!
Typical Celiac SMA Examination UNC Rex Healthcare

Celiac Trunk

Superior Mesenteric Artery
Risk Factors

Atherosclerosis of mesenteric vessels affects approx. 18% of adults > 65

• Progressive disease leads to blood flow reduction 2nd to stenosis or occlusion of two or more of major arteries (celiac, SMA, IMA)

• HTN
• Diabetes
• Smoking
• Hypercholesterolemia, obesity, age and genetic factors
• Generalized Atherosclerotic disease (carotid, coronary, renal, extremity arterial, Increased incidence of AAA)

• mesenteric arteries: Females more common
Clinical Presentation

• Post-prandial pain “Food Fear” (sitophobia)
• Recent unexplained weight loss
• Symptoms often delayed if extensive collateral flow
• Negative GI workup
• Patients are commonly misdiagnosed / other suspected diagnoses
  - Eating disorders, Gallbladder
• Diagnosis often delayed (average time to diagnose 12-18 months!)
• CLINICALLY - Abdominal bruit heard
• ACUTE Mesenteric Ischemia — Emboli travels from heart or Ao causing sudden ischemic bowel (SMA most often). Catastrophic event with bowel with becoming infarcted that could lead to death. Needs immediate surgical invention so CT angiography is usually diagnostic modality.
Abdominal Bruit may be heard during Physical Exam

Duplex Doppler is preferred diagnostic test
Patient Positioning

- Supine
- Semi-upright position
- Erect
- Use liver as a window
- Oblique approaches
Mesenteric Doppler Protocol

- Aorta
- Celiac
- Celiac branches
  - Splenic
  - Hepatic*ck direction
- SMA — Prox, mid *distal
- IMA*If visualized
- Evaluate with 2D, color and obtain PSV, EDV Doppler
AORTA

• Identify Vasculature
• Doppler at Level of Celiac Artery
• Use PSV for Ratios
• Normal Ao PSV < 100 cm/sec
Celiac Artery

Classic Celiac Anatomy is seen in 65-75% of the population
Normal Celiac Artery

- **Rapid systolic upstroke**
- **High diastolic flow feeding low resistance vascular bed**
- **Uniform velocities without turbulence**

- **Celiac PSV < 200 cm/sec**
- **EDV 35 cm/sec**
NORMAL SPLENIC ARTERY

LOW RESISTANCE DOPPLER WAVEFORM
HIGH DIASTOLIC FLOW
Normal Common Hepatic Artery

Low resistance Doppler Waveform
High Diastolic Flow
Celiac Artery Stenosis
Diagnostic Criteria

Stenosis 70% or greater
• PSV > 200 cm/sec
• EDV> 55 cm/sec
Post stenotic turbulence

*Important to Obtain a few Dopplers to confirm highest PSV and reproducible

Robert M. Zwolak, MD, PhD et.al JVS 1998
If the celiac is occluded/severely stenotic
Look for retrograde collateral flow in common hepatic artery and antegrade flow in splenic artery

Ref – Textbook of Diagnostic Sonography, Hagen-Ansert, 2018
If increased Celiac PSV consider Celiac Compression Median Arcuate Ligament Syndrome

- Two diaphragmatic crura arise from vertebral bodies on each side
- Pass superior/anterior to surround aortic opening joined by the median arcuate ligament at the aortic hiatus
Celiac Compression
Celiac Compression

- Most commonly affects -
  - Young age (20-40 yrs.)
    - Female
    - Thin
- Characteristic indentation or “hooked” appearance
- Will help to differentiate from atherosclerotic narrowing
- Often intermittent compression
- Evaluate with patient with inspiration/expiration
- Possibly supine and erect
Celiac Compression

- PSV decreases with inspiration
- PSV also decreases with **upright** position
- Some have severe compression that persists during BOTH insp/Exp
- Look for post stenotic dilatation
- SMA rarely involved
- Collateralization can occur from SMA through pancreaticoduodenal arcade (look for retrograde GDA)
Symptomatic Median Arcuate Ligament Patient

Angiogram with Post Stenotic Dilation
Pre and Post Surgical Procedure
SUPERIOR MESENTERIC ARTERY

- Arises 1-1.5 cm below celiac
- Runs parallel to AO
- Just superior to renal arteries
- LRV passes underneath SMA
ANATOMICAL VARIANTS

Separate Origins
Celiac and SMA

Common Origin
Celiac and SMA
Celiac and SMA Common Trunk

Vel A: 243.6 cm/s
Vel B: 49.2 cm/s
Another SMA Vascular Anomaly
Replaced Right Hepatic Artery

Right hepatic artery off the SMA
Common variant noted
Approximately 35%

• Alters flow dynamics (SMA more Low Resistive)
Right hepatic artery off Superior Mesenteric artery
Normal SMA Doppler Waveform

- **Rapid systolic upstroke**
- **Low diastolic flow since feeding a high resistant vascular bed (fasting patient)**
- **Uniform velocities without turbulence**

SMA fasting PSV <275 cm/sec
EDV 14 cm/sec

SMA (postprandial)
Look
CELIAC – SMA Doppler Comparison

CELIAC - Low Resistant

SMA – Higher Resistant
SMA Stenosis Diagnostic Criteria

Stenosis 70% or greater

- PSV > 275 cm/sec
- EDV velocity > 45 cm/sec
- Focal increase in velocity
- Post-stenotic turbulence

*Important to Obtain a few Dopplers to confirm highest PSV and reproducible

Robert M. Zwolak, MD, PhD et al. JVS 1998
Normal IMA Doppler Waveform

- **Rapid systolic upstroke with uniform velocities**
- **Low diastolic flow feeding a high resistant vascular bed in a fasting patient (looks like SMA)**
- **No turbulence**

IMA - No validated criteria for normal PSV 70-200cm/sec
IMA Stenosis
Diagnostic Criteria

Stenosis 70% or greater
• Limited published velocity criteria
• PSV > 200 cm/sec
• EDV velocity > 45 cm/sec
• Focal increase in PSV
• Post-stenotic turbulence

IMA PSV 424.3 cm/sec

*Pellerito JS, Revin MV, Awelrod DJ, Ryoo S, Naidich JB. Comparative Analysis of Doppler Criteria for the Diagnosis of Mesenteric Stenosis. RSNA Presentation, 2006
TREATMENT

• Percutaneous angioplasty
• Stenting
• Embolectomy
• Surgical by-pass
CASE STUDY

68 year old male with Hx of HTN, epigastric pain after eating (cramping sensation) with nausea
Unexplained 50 lb. weight loss in last year
Previous CABG, EVAR and new diagnosis of Parkinson Dz

Presents for Mesenteric Doppler Exam
Mesenteric Doppler Exam

Celiac PSV 367 cm/sec
HEPATIC ARTERY DOPPLER

Reversed Hepatic

CELIAC TRANS
SMA Doppler

SMA PSV 440 cm/sec
Mesenteric Doppler Case Study

- Celiac artery highest PSV 367 cm/sec, EDV 122 cm/sec
- SMA highest PSV 440 cm/sec, EDV 180 cm/sec
- Reversed hepatic artery flow with tardus parvus noted
- PSV Celiac/Aortic ratio = 6.8  PSV SMA/Aortic ratio = 8.1
- > 50% stenosis if ratio is 3 or greater
Renal Duplex Doppler
Renal Artery Anatomy

• Located 1-2 cm below the SMA
• RRA has a longer course and course post to IVC
• LRV travels between Ao and SMA
• Arise from the lateral or posterolateral wall of the abdominal aorta
• ~25% of pts have duplicated renal arteries — limits findings
Renal Artery Anatomy

RRA 9-10 o’clock

LRA 2-4 o’clock
Why Are We Performing Renal Duplex?
**Indications**

- **Evaluate patients with hypertension (renovascular HTN)**
  - Uncontrolled despite optimal medical treatment
  - 6% of patients with uncontrollable or malignant HTN have RAS
  - HTN with progressive decline in renal function
  - Abrupt onset of HTN

- **Follow up renal artery stent or angioplasty**
- **Abdominal or flank bruit**
- **Compare with other imaging modality that suspects vascular abnormality (aneurysm, pseudoaneurysm, AVF)**
- **Evaluate if known aortic dissection to eval if compromise flow**
- **Renal vascular abnormality (renal vein thrombosis, Nutcracker syndrome, congenital renovascular dz)**
Two Major Causes of RAS

**Atherosclerosis** — more than 2/3 of patients
- Primarily affects men over the age of 45
- Usually involves the aortic orifice at proximal main renal artery
- Particularly common in patients with diffuse atherosclerosis, but can occur as a relatively isolated renal lesion.

**Fibromuscular dysplasia** — in comparison to atherosclerosis, fibromuscular dysplasia
- Most often affects younger women and typically involves the mid-distal main renal artery or intrarenal branches
Other Less Common Causes of RAS:

Vasculitis (Takayasu’s arteritis)
Dissection of the renal artery
Thromboembolic disease
Renal artery aneurysm
Renal artery coarctation
Extrinsic compression
Radiation injury
Renal Doppler Protocol

• Complete kidney ultrasound
  – Renal length, Gray scale
• Aorta PSV
• Main renal artery — Prox, Mid, Distal (hilum)
• Intrarenal arteries
• Color and spectral Doppler ≤ 60°
  – PSV, EDV
• Indicate where exam is limited
Renal Duplex Doppler Exam

- Can Be Extremely Difficult Studies
- Skinny is not always easy!
- Experience plays key role
- Know how to optimize equipment settings
- Breathing, CHF, Gas can hinder exam
- Multiple angles of Interrogation Approach (Sag, Trans, Coronal, Supine, RLD, LLD)
Utilization of Probes

• **Standard Convex, Curved**
• **Vector**
• **DO NOT BE AFRAID TO USE NON-STANDARD PROBES FOR INSONATION!**
• **Multiple angles of Interrogation**
• **Patients disserve excellence in image quality and So does your reading Physician**
Know your Tools

- Linear array scanhead
- Curved array scanhead
- Phased array scanhead

Use lots of gel!
Oblique and Lateral Probe Change for Intercostal Interrogation

Curved

Micro Convex
Probe Changes Can Make Large Differences

Curved 6C-

Micro Convex 6MC-1
Flow Direction Does not Change

Supine RRA PROX

LLD RRA DISTAL

This is one of the reasons Why Renal Arteries need To be Interrogated From Multiple Angles!
Don’t Be afraid To **DRAW**...
Tortuous Vessels

Supine
Settings - Settings - Settings ......
RENAL PERFUSION SETTINGS

Directional Power Doppler

Renal Perfusion

Monochrome - SMI
Don’t Forget About Directional Power Doppler!
Color Frequency Change

Poor color flow

Lower color frequency
DIAGNOSTIC CRITERIA
Direct Method – Color + Doppler

Renal / Aortic ratio (RAR) > 3.5

Peak Systolic velocity of RA
Peak Systolic velocity of AO

PSV > 180-200 cm/sec

PSV >225-240 cm/sec (Patrick’s Lab)

Velocities should be reproducible
Look for post stenotic turbulence

Aortic velocities less than
-40-50 cm/sec and greater than 120 cm/sec can skew RAR results
Right Renal Artery

What is the velocity on this baby?
Prox RRA PSV 625 cm/sec
EDV 95 cm/sec
Prox LRA Stenosis

Vel A  413.6 cm/s
Vel B  85.4 cm/s
Diagnostic Criteria
Indirect Method

- **Kidney lengths-cortex assessment for reduced size**
- **Perfusion Kidney** - color Doppler used to assess the perfusion to the edge of the renal cortex
- **Obtain Resistive Index with spectral Doppler of kidney parenchyma at segmental, interlobar arteries and arcuate arteries**
- **Look for signs of Tardus Parvus** (distal to stenosis) “slow to rise, slow to fall” slow systolic upstroke
- **Quantify with Acceleration Time**
  - Acceleration time (AT) > 0.07 sec is ABN
  - Resistivity Index (RI) > 0.7 is ABN
  - Angle correct 0-30°
Doppler upper, mid & lower poles within kidney

INDIRECT METHOD
(QUALITATIVE)
Fibromuscular Dysplasia

Fibromuscular dysplasia are uncommon associated with heterogeneous histologic changes that may affect the carotid circulation as well as the visceral and peripheral arteries.

String of beads is the classic radiographic finding seen in FMD.

FMD usually affects young to middle-aged adults, mostly women, but it can also affect children.
Fibromuscular Dysplasia vs Atherosclerosis

Think Location-Location-Location

FMD (Fibromuscular Dysplasia)
Atherosclerotic (Ostial Lesion)

Drawn By Laura Tastad RVT
Obtain Velocities where aliasing occurs

416 cm/s
322 cm/s
288 cm/s
How to Differentiate FMD

Both cause Renovascular Disease
Atherosclerotic DZ (Proximal)
Fibromuscular dysplasia (Mid-Distal)
Fibromuscular Dysplasia
Clinical Finding

Hear an Acoustic Bruit
Fibromuscular Dysplasia
Pre and Post Angioplasty

Pre Angioplasty

Post Angioplasty
Is this FMD?
LET’S FINISH WITH AN INTERESTING VASCULAR CASE!
Sagitta Aorta — what is next step?
Always Obtain Two views!
Color Images
Color Images

RRA Dissection

SMA Dissection

Aortic Dissection
LEFT SUBCLAVIAN ARTERY
Any Questions?
Thank You!

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