

Ultrasound – Mesenteric Artery Protocol

PURPOSE:

To determine the absence or presence of stenosis or aneurysm of the central visceral arteries. Duplex also used to determine location, severity, and type of pathology present.

SCOPE:

Applies to all studies performed in:

- UT Southwestern Zale-Lipsky University Hospital, William P. Clements Jr. University Hospital, and all University Hospital-based Clinics Imaging Services (UTSW)
- Parkland Health and Hospital System Department of Radiology (PHHS)

INDICATIONS:

- Abdominal pain associated with eating
- Persistent diarrhea
- Significant weight loss
- Bruit
- Postoperative evaluation
- Suspected celiac artery compression; median arcuate ligament syndrome (MALS)
- Suspected aneurysm of the mesenteric, hepatic, or splenic arteries
- Suspected vascular insufficiency of the intestines (SMA stenosis)

CONTRAINDICATIONS:

- Open wounds; abdominal drains
- Overlying sutures/staples or bowel gas that completely limits visualization
- Rapid breathing, inability to hold breath, uncooperative patients
- Post-prandial state (Not NPO)

EQUIPMENT:

- Curvilinear transducer with a frequency range of 1-9 MHz that allows for appropriate penetration and resolution depending on patient's body habitus

PATIENT PREPARATION:

- Patient should be NPO for 6-8 hours prior to study

EXAMINATION:

GENERAL GUIDELINES:

- A complete examination includes evaluation of the entire course of the accessible portions of the abdominal aorta and major visceral arteries including the celiac artery, superior mesenteric artery (SMA) and inferior mesenteric artery (IMA).

EXAM INITIATION:

- Review prior imaging, particularly previous CT, MR, or catheter angiograms
- Introduce yourself to the patient and explain test
- Verify patient identity using patient name and DOB

- Obtain patient history including symptoms. Enter and store data page
- Place patient in supine position.

TECHNICAL CONSIDERATIONS:

- Always review any prior imaging, making note of abnormalities or other findings requiring further evaluation. Note relevant history (example: fibromuscular dysplasia)
 - For **MALS**, review CT or other imaging noting focal narrowing of the proximal celiac artery by the Median Arcuate Ligament of the diaphragm. Is usually associated with post-stenotic dilatation.
 - Evaluate prior imaging for dilated left renal or left gonadal veins, which may indicate Nutcracker (left gonadal vein entrapment by the SMA), for which a different order/assessment/protocol is available.
 - For suspected SMA syndrome, review CT or other imaging noting a decrease in the SMA-Aorta angle. This narrowing is often due to a reduction in mesenteric fat (the tissue cushioning the intestine) and compression of the duodenum. This can occur after significant weight loss from various causes, including eating disorders, malabsorption, or other illnesses.
- Optimize gain and display setting with respect to depth, dynamic range, and focal zones on greyscale imaging first
- Optimize color Doppler setting to show optimal flow
 - Adjust scale and gain to maximally fill the vessel of interest without artifact
 - Light color in the middle of the vessel lumen
 - Areas of aliasing due to turbulent flow should be documented
 - Use Power Doppler or MicroFlow if suspect absent flow with color Doppler
- Optimize spectral Doppler
 - Place time-gate centrally within the vessel of interest
 - Adjust scale to extend spectral waveform (amplitude adequate for interpretation)
 - Reduce aliasing for high flow evaluation
- As much as possible, utilize angle correction of $\leq 60^\circ$ to measure velocities
 - Angle correction should always be parallel to the vessel wall
 - For certain anatomy, may need to try from different approaches to optimize angle
- Areas of suspected stenosis or obstruction will include spectral Doppler waveforms and velocity measurements recorded at and distal to the stenosis or obstruction
- Sites of intervention (stent) will include spectral Doppler waveforms and velocity measurements within the proximal, mid, and distal stent as well as interrogation of the native vessel proximal and distal to the stent.
- Plaque should be assessed and characterized (smooth vs irregular; calcified vs non-calcified)
- Attempt to visualize inferior mesenteric artery (IMA) as a prominent IMA may indicate significant compromise of the celiac axis and/or SMA flow.
- The gastroduodenal artery should be evaluated if celiac occlusion is suspected. Normal gastroduodenal artery blood flow direction is towards the feet, therefore, flow towards the head can confirm celiac disease.

- If ruling out **MALS** (Median Arcuate Ligament Syndrome), obtain velocities on inspiration and expiration.
 - Spectral Doppler with PSV at both deep inspiration and complete expiration.
 - Document celiac artery excursion between deep inspiration and complete expiration.
 - Calculate deflection angle (DA):
 $DA = (\text{angle between celiac and aorta at inspiration}) - (\text{angle at expiration})$
 - Repeat measurements in erect position.
 - If ruling out SMA syndrome, include AOM⁺ angle/Aorta-SMA angle (see appendix for example). Identify the aorta, celiac artery, and superior mesenteric artery (SMA) in the longitudinal plane.
 - The aortomesenteric angle is formed by the SMA as it branches off the aorta.

IMAGE DOCUMENTATION:

Anatomy	Grey Scale	Color Doppler	Waveform	PSV/EDV	Angle [^]	Angle [±]
Mesenteric Doppler:						
Trans Aorta: At Celiac Artery	X	X				
Trans Aorta: At SMA	X	X				
Long Aorta: At Celiac (Mid)	X	X	X	X		
Celiac Artery: Origin	X	X	X	X		
Common Hepatic Artery (CHA): Origin	X	X	X	X		
Splenic Artery: Origin	X	X	X	X		
SMA: Origin	X	X	X	X		
SMA: Prox	X	X	X	X		
SMA: Mid	X	X	X	X		
SMA: Distal	X	X	X	X		
IMA: Origin	X	X	X	X		
If concern for MALS*, ALSO obtain the following:						
Celiac Artery: Supine Origin w/ Deep Inspiration	X	X	X	X	X	
Celiac Artery: Supine Origin w/ Complete Expiration	X	X	X	X	X	
Celiac Artery: Erect Origin w/ Deep Inspiration	X	X	X	X	X	
Celiac Artery: Erect Origin w/ Complete Expiration	X	X	X	X	X	
If concern for SMA Syndrome, ALSO obtain the following:						
AOM angle: Aorta-SMA angle	X	X				X
*MALS = Median Arcuate Ligament Syndrome [^] Calculate Deflection Angle (DA) between Inspiration and Expiration in each position ⁺ Calculate the AOM (Aortomesenteric angle): the angle between Aorta and the SMA (see appendix).						

- Data Page

PROCESSING:

- Review examination data
- Export all images to PACS
- Confirm data Imorgon (UTSW only)
- Note any study limitations in Epic Study Note

REVISION HISTORY:

SUBMITTED BY:	David T. Fetzer, MD	Title	Medical Director
APPROVED BY:	David T. Fetzer, MD	Title	Medical Director
APPROVAL DATE:	11-15-2015		
REVIEW DATE(S):	11-12-2018		Julie Champine, MD
REVISION DATE(S):	01-02-2019	Brief Summary	Updated diagnostic criteria
2/24/24	Skye Smola, David Fetzer, MD		Updated Protocol documentation and removed CMA inspiration & expiration
08/27/2025	Jana Smith, RDMS, RVT		Added information and images for evaluation of SMA syndrome

REFERENCES:

- ACR-AIUM-SPR-SRU Practice Guideline (Revised 2017)
- IAC Guidelines (Updated 8/2018)
- Mesenteric/Splanchnic Artery Duplex Imaging. (2010, January 25). Society for Vascular Ultrasound. Retrieved from: McPharlin, M., Rumwell, C., (n.d.). Vascular Technology. Education for the Sonographic Professional.
- Gruber H et al. Ultrasound of median arcuate ligament syndrome: a new approach to diagnosis. *Medical Ultrasonography* 2012;14(1):5-9.
- Rumwell, C., McPharlin, M., (2000) Vascular Technology. (p 47). Pasadena, California: Davies Publishing.
- Zierler, R. (2010). Strandness’s Duplex Scanning in Vascular Disorders 4th edition. Philadelphia, Pennsylvania: Lippincott Williams & Wilkins.
- Daigle, R. (2009). Techniques in Noninvasive Vascular Diagnosis An Encyclopedia of Vascular Testing 3rd edition. Littleton, Colorado: Summer Publishing, LLC. Liu Y, Zheng H, Wang X, Wang Z, Zhu Q, Wen C and Tong Y (2023) Ultrasound characteristics of abdominal vascular compression syndromes. *Front. Cardiovasc. Med.* 10:1282597. doi: 10.3389/fcvm.2023.1282597

US MESENTERIC DOPPLER DIAGNOSTIC CRITERIA

Description	SMA	Celiac Axis
Pre-prandial		
PSV	High	High
EDV	Low	High
Flow reversal	Yes	No
Post-prandial		
PSV	Marked increase	No change
EDV	Marked increase	No change
Loss of flow reversal	Yes	N/A
Velocity criteria		
Normal PSV	80-200 cm/s	50-160 cm/s
Stenosis Criteria	<ul style="list-style-type: none"> • PSV > 275 cm/s, predicts 70% diameter reduction • No flow, occluded • EDV > to 45 cm/sec, predicts 50% stenosis (may be elevated if replaced right hepatic artery, in which case SMA waveform will be low resistance biphasic) 	<ul style="list-style-type: none"> • PSV > 200 cm/s predicts 70% diameter reduction • No flow, occluded • EDV ≥ to 55 cm/sec, predicts up to 50% stenosis

Duplex Criteria for Mesenteric/Splanchnic Arteries:

- If ruling out compression syndrome, the SMA and IMA have a high resistance flow pattern in a fasting patient due to the relatively high capillary bed resistance. This pattern usually changes after meals during which the capillary beds are wide open and flow pattern will be noted of low resistance form.
- In a normal or mildly obstructed (<50%) SMA, peak systolic velocities range from 80-200 cm/s, and end diastolic flow velocity is < 45 cm/s.
- Occlusion of the SMA is diagnosed by ultrasound when blood flow is absent in a portion of the vessel during color or spectral Doppler evaluation.
 - Anomalous mesenteric artery anatomy must be considered when a low-resistance flow pattern is found in an otherwise normal proximal SMA. The most common finding is a right hepatic artery originating from the SMA.
- Celiac artery flow pattern demonstrates low resistance form because the majority of flow volume is directed to the liver and spleen where capillary beds are wide open with or without food ingestion.
 - In a normal or mildly obstructed (< 50% Celiac artery, peak systolic flow velocity is 50-160 cm/s and end diastolic flow velocity of < 55 cm/s).

Median Arcuate Ligament Syndrome (MALS):

- Increase in PSV during expiration (>210% change)
- >350 cm/s PSV during expiration
- 3:1 ratio of PSV (during expiration, celiac to abdominal aorta PSV)
- Deflection angle > 50° between inspiration and expiration:



Fig 1. Doppler ultrasound scan of a 21 year old female patient with a positive deflection angle (DA+) of the celiac trunk (arrows) of about 80° during maximum expiration.



Fig 2. The same case as in fig 1 during maximum inspiration.

(Modified from Gruber et al. Medical Ultrasonography 2012)

Aortomesenteric (AOM) / Aorta-SMA angle

