Diagnosis and Endovascular Approach of Chronic Mesenteric Ischemia

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THE PERIPHERAL EVENT OF THE YEAR
Disclosures

Speaker’s Bureau:
- Abbott
- Boston Scientific
- Cook
- Endologix
- Silk Road Medical

Stockholder:
- none

Medical/Scientific Boards:
- Boston Scientific
- Silk Road Medical
Celiac:

**normal diameter of 6 mm**

comes from the aorta at the level of the crux of the diaphragm

- gives splenic artery, the left and right gastric artery, the gastroduodenal artery, and the common hepatic artery
- It delivers blood to the stomach, the first and second part of the duodenum, the upper part of the pancreas and liver and spleen
- baseline blood flow in CA of mean 450 ml/min increased after meals to 700 ml/min with a peak within 10 min of the meal
SMA:

diameter of 7 mm
originates from the aorta 2 cm below the CA
- gives off jejunal and ileal branches, the right and middle colic artery, ileocolic and appendicular artery
- the lower part of the pancreas, the second part of the duodenum, the small bowel, and the right colon of the transverse colon
- blood flow increases from mean baseline 400 to over 800 ml/min, peaking after 40 min after meal
IMA:

*normal diameter of 2 mm*

- provides the distal part of the colon, usually starting at the splenic flexure.
Mesenteric Artery Stenoses (MAS)

- demonstrates an increasing prevalence with age:
  - 6% at age 40
  - 14% at 60 years
  - 18% - 67% >75 years of age


Chronic Mesenteric Ischemia (CMI)

compare the estimated prevalence:
PAD of 3-10%
CAD of 4.5%
CVD of 2.4%

CMI prevalence of 0.03%
(30 per 100,000) is still very low

The main cause of MAS is *atherosclerotic*.

- Other causes include:
  - vasculitis, FMD, or compression by the median arcuate ligament, referred to as MALS (median arcuate ligament syndrome) - aka celiac axis compression syndrome (CACS) or Dunbar syndrome.
Clinical Presentation

- The most typical complaint is postprandial pain, usually starting after the meal has finished
  - It has been reported in over 90% of patients in most series
  - The duration of pain is usually between 30 min and 2 h
  - Pain for shorter duration, or lasting longer than 4-6 h are rarely seen in CMI
- weight loss
- food fear
- diarrhea

Anatomic Assessment

- degree of stenosis of the artery
- the nature of the stenosis (atherosclerosis, soft plaques, or external compression)
- presence and type of collaterals
Collateral flow

SMA-Celiac: The pancreaticoduodenal arcades described by Rio Branco and Buhler arcades

SMA-IMA: The Riolan, Villemin and Drummond arcades

IMA-IIA: mesenteric artery ends with the superior rectal arteries to middle rectal arteries
### Duplex ultrasound criteria for the diagnosis of SMA/CA stenosis.

<table>
<thead>
<tr>
<th>First author (publication year)</th>
<th>SMA PSV ≥50% stenosis</th>
<th>SMA PSV &gt;70% stenosis</th>
<th>CA PSV ≥50% stenosis</th>
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<th>SMA EDV ≥50% stenosis</th>
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<th>CA EDV ≥50% stenosis</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Bowersox [60] (1991)</td>
<td>&gt;300 cm/s</td>
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<td>-</td>
<td>&gt;45 cm/s</td>
<td>-</td>
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<tr>
<td>Moneta [61] (1993)</td>
<td></td>
<td>≥275 cm/s</td>
<td>-</td>
<td>≥200 cm/s</td>
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</tr>
<tr>
<td>Perko [62] (1997)</td>
<td>≥275 cm/s</td>
<td>≥200 cm/s</td>
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<td>≥50 cm/s</td>
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<tr>
<td>Zwolak [63] (1998)</td>
<td>≥300 cm/s</td>
<td>≥200 cm/s</td>
<td>-</td>
<td>≥55 cm/s</td>
<td></td>
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</tr>
<tr>
<td>Lim [64] (1999)</td>
<td>≥275 cm/s</td>
<td>≥200 cm/s</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>AbuRahma [57] (2012)</td>
<td>≥295 cm/s</td>
<td>≥400 cm/s</td>
<td>≥240 cm/s</td>
<td>≥45 cm/s</td>
<td>≥70 cm/s</td>
<td>≥40 cm/s</td>
<td>≥100 cm/s</td>
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<tr>
<td>Van Petersen [20] (2013)</td>
<td>≥220 cm/s</td>
<td>≥268 cm/s (expiration)</td>
<td>≥280 cm/s (expiration)</td>
<td>≥62 cm/s</td>
<td>≥101 cm/s</td>
<td>≥64 cm/s</td>
<td>≥57 cm/s (expiration)</td>
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</tr>
</tbody>
</table>

**SMA** = Superior Mesenteric Artery, **CA** = Celiac Artery, **PSV** = Peak Systolic Velocity, **EDV** = End Diastolic Velocity, **Sens** = sensitivity, **Spec** = specificity.
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<th>CA PSV ≥50% stenosis</th>
<th>CA PSV ≥70% stenosis</th>
<th>SMA EDV ≥50% stenosis</th>
<th>CA EDV ≥50% stenosis</th>
<th>CA EDV ≥70% stenosis</th>
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<tr>
<td>Bowersox [60] (1991)</td>
<td>&gt;300 cm/s sens 63% spec 100%</td>
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<tr>
<td>Moneta [61] (1993)</td>
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<td>≥275 cm/s sens 92% spec 96%</td>
<td>-</td>
<td>≥200 cm/s sens 87% spec 80%</td>
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<td>-</td>
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<tr>
<td>Perko [62] (1997)</td>
<td>≥275 cm/s sens 93% spec 80%</td>
<td>-</td>
<td>≥200 cm/s sens 94% spec 94%</td>
<td>-</td>
<td>≥50 cm/s sens 100% spec 100%</td>
<td>-</td>
</tr>
<tr>
<td>Zwolak [63] (1998)</td>
<td>≥300 cm/s sens 60% spec 100%</td>
<td>-</td>
<td>≥200 cm/s Sens 93% Spec 94%</td>
<td>-</td>
<td>≥45 cm/s sens 90% spec 100%</td>
<td>≥55 cm/s spec 93% spec 100%</td>
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<tr>
<td>Lim [64] (1999)</td>
<td>-</td>
<td>≥275 cm/s sens 100% spec 98%</td>
<td>-</td>
<td>≥200 cm/s sens 100% spec 87%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>AbuRahma [57] (2012)</td>
<td>≥295 cm/s sens 87% spec 89%</td>
<td>≥400 cm/s sens 93% spec 83%</td>
<td>≥240 cm/s sens 87% spec 83%</td>
<td>≥320 cm/s sens 80% spec 89%</td>
<td>≥45 cm/s sens 79% spec 89%</td>
<td>≥70 cm/s sens 84% spec 91%</td>
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<tr>
<td>Van Petersen [20] (2013)</td>
<td>≥220 cm/s (expiration) sens 84% spec 76%</td>
<td>≥268 cm/s (expiration) sens 86% spec 80%</td>
<td>≥268 cm/s (expiration) sens 75% spec 66%</td>
<td>≥280 cm/s (expiration) sens 66% spec 77%</td>
<td>≥62 cm/s (expiration) sens 75% spec 74%</td>
<td>≥101 cm/s (expiration) sens 78% spec 83%</td>
</tr>
<tr>
<td></td>
<td>≥277 cm/s (inspiration) sens 68% spec 93%</td>
<td>≥205 cm/s (inspiration) sens 78% spec 84%</td>
<td>≥243 cm/s (inspiration) sens 68% spec 71%</td>
<td>≥272 cm/s (inspiration) sens 72% spec 77%</td>
<td>≥52 cm/s (inspiration) sens 76% spec 93%</td>
<td>≥52 cm/s (inspiration) sens 93% spec 81%</td>
</tr>
</tbody>
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SMA = Superior Mesenteric Artery, CA = Celiac Artery, PSV = Peak Systolic Velocity, EDV = End Diastolic Velocity, Sens = sensitivity, Spec = specificity.
Overview of sensitivity and specificity rates of CTA in diagnosing AMI and CMI.

<table>
<thead>
<tr>
<th>First author (publication year)</th>
<th>CTA sensitivity</th>
<th>CTA specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taourel [65] (1996)</td>
<td>64%</td>
<td>92%</td>
</tr>
<tr>
<td>Kirkpatrick [58] (2003)</td>
<td>96%</td>
<td>94%</td>
</tr>
<tr>
<td>Wiesner [66] (2004)</td>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>Zandrino [67] (2006)</td>
<td>92%</td>
<td>100%</td>
</tr>
<tr>
<td>Aschoff [68] (2008)</td>
<td>93%</td>
<td>100%</td>
</tr>
<tr>
<td>Ofer [69] (2008)</td>
<td>89%</td>
<td>97%</td>
</tr>
<tr>
<td>Akyildiz [70] (2009)</td>
<td>93%</td>
<td>90%</td>
</tr>
<tr>
<td>Menke [71] (2010)</td>
<td>93%</td>
<td>96%</td>
</tr>
<tr>
<td>(Meta-analysis [58,66–70])</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yikilmaz [72] (2011)</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Schaefer [48] (2013)</td>
<td>CA 100%</td>
<td>CA 95%</td>
</tr>
<tr>
<td></td>
<td>SMA n.a.</td>
<td>SMA 98%</td>
</tr>
</tbody>
</table>
### Overview of sensitivity and specificity rates of MRA.

<table>
<thead>
<tr>
<th>First author (publication year)</th>
<th>Pathology</th>
<th>MRA sensitivity</th>
<th>MRA specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holland [73] (1996)</td>
<td>Mesenteric stenosis ≥50%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Meaney [59] (1997)</td>
<td>CMI &gt;75% stenosis</td>
<td>100%</td>
<td>95%</td>
</tr>
<tr>
<td>Kreft [74] (2000)</td>
<td>Portal venous thrombosis</td>
<td>100%</td>
<td>98%</td>
</tr>
<tr>
<td>Schaefer [48] (2013)</td>
<td>Mesenteric stenosis ≥50%</td>
<td>CA 92%</td>
<td>CA 84%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SMA n.a.</td>
<td>SMA 95%</td>
</tr>
</tbody>
</table>
Ischemia Functional Testing

Selecting those patients who will benefit from treatment is a task which will not get easier in the coming years.

PCO2 tonometry
- can be used with a provocative test (eating or exercise)
- laborious
- sparsely available

VLS (Visual Light Spectroscopy)
- widely available
- can be used during endoscopy
- poor specificity
- reproducibility?
- provocative testing complicated.
DSA

- femoral, brachial or radial approach
- Femoral or radial access is first choice as brachial access has a higher complication rate
- In case of a steep angle of the mesenteric arteries with regard to the aorta, a radial approach may be more appropriate than a femoral approach
- Sheath diameter should be chosen according to expected intervention and material used (generally six or seven French)
- Ultrasound guided puncture of the artery reduces the number of attempts and time required for acquiring access especially in the radial approach
- Selective angiography is performed with <15-20 ml iodine contrast medium for both the CA and the SMA
- The femoral access site is closed by manual hemostasis or a closure device
- The radial access site closed by manual pressure or TR band


multiple oblique projections of the abdominal aorta and of the origin and outflow of the mesenteric arteries

- At least AP and lateral views should be obtained
- Selective angiography and views during ex- and inspiration are optional and of diagnostic importance in patients with MALS
- Early imaging is necessary for visualizing the origins of the CA and the SMA
- Late imaging is required to evaluate the retrograde flow, delayed filling and collateral pathways
- Dynamic imaging also provides information on flow direction, which may be valuable interpreting collateral circulation
Non-selective DSA (AP plane) in a patient with CA and SMA stenosis showing collateral from IMA through the arc of Riolan

- (white arrows indicate collateral with flow direction from large to small arrow)
Non-selective DSA in a patient with CA stenosis
• (black arrow) and SMA stenosis (white arrow) in lateral plane
Treatment Scenarios

(1) the symptomatic single-vessel MAS and MALS patient
(2) the symptomatic multivessel MAS patient
(3) the patient with chronic NOMI
(4) the asymptomatic MAS patient
treatment indicated in patients with:

- typical complaints
- functional test showing ischemia

IF a functional ischemia test NOT available:

- exclude more common causes of abdominal complaints
- patient is informed that the treatment is more or less a shot in the dark with success rates up to 50% (would not recommend)
symptomatic multivessel MAS patient

- should be treated urgently
- choice of treatment depends on vessel anatomy and age and comorbidity of the patient

• percutaneous mesenteric artery stenting (PMAS) will be the first choice (high success rate, low morbidity)
• retrograde operative mesenteric stenting (high success rate, moderate morbidity)
• operative surgical mesenteric artery repair (OSMAR) (high success rate, high morbidity) can be first choice in “fit” patients because the open approach still has the most convincing long-term primary patency results.
the patient with chronic NOMI

- normal vessel anatomy and mesenteric ischemia
- vasospasm of the mesenteric circulation, or abdominal migraine
- patients with varying degrees or heart or respiratory failure
- patients with all symptoms of irritable bowel syndrome, and ischemia may be secondary to bowel spasm
- individuals who develop ischemia during exercise; in most cases the type of exercise was very extensive (marathon running, competitive biking, triathlon, etc.)

MEDICAL MANAGEMENT
the asymptomatic MAS patient

- IN GENERAL: “no complaints, no ischemia, no treatment”
- exception #:
  - multi vessel MAS - significant proportion develop AMI (high mortality)
  - proceed if reasonable risk:benefit (otherwise good physical condition)


- exception #:
  - single vessel CA or SMA stenosis and major abdominal surgery
  - may consider for pancreatic, gastroduodenal or colonic surgery

Most patients with abdominal discomfort and significant (>70%) stenoses of both SMA and CA have CMI, and are candidates for vascular treatment.

A minority of patients with single-vessel MAS have CMI; patient selection for vascular treatment is therefore crucial, and an ischemia function test highly desirable.

Patients with subtotal stenosis or occlusions of SMA and CA may progress from chronic to acute mesenteric ischemia. Complaints become less typical with prolonged periods of pain, even during fasting (vascular abdominal rest pain), diarrhea and abdominal fullness. Urgent referral and treatment is indicated.
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