Mesenteric ischemia: A pictorial review

Poster No.:	C-1594
Congress:	ECR 2010
Type:	Educational Exhibit
Topic:	GI Tract
Authors:	C. Ruivo, M. A. Portilha, J. F. Costa, L. Curvo Semedo, J. Ilharco, A. Bernardes, F. Caseiro Alves; Coimbra/PT
Keywords:	acute mesenteric ischemia, chronic mesenteric ischemia, emergency
DOI:	10.1594/ecr2010/C-1594

Learning objectives

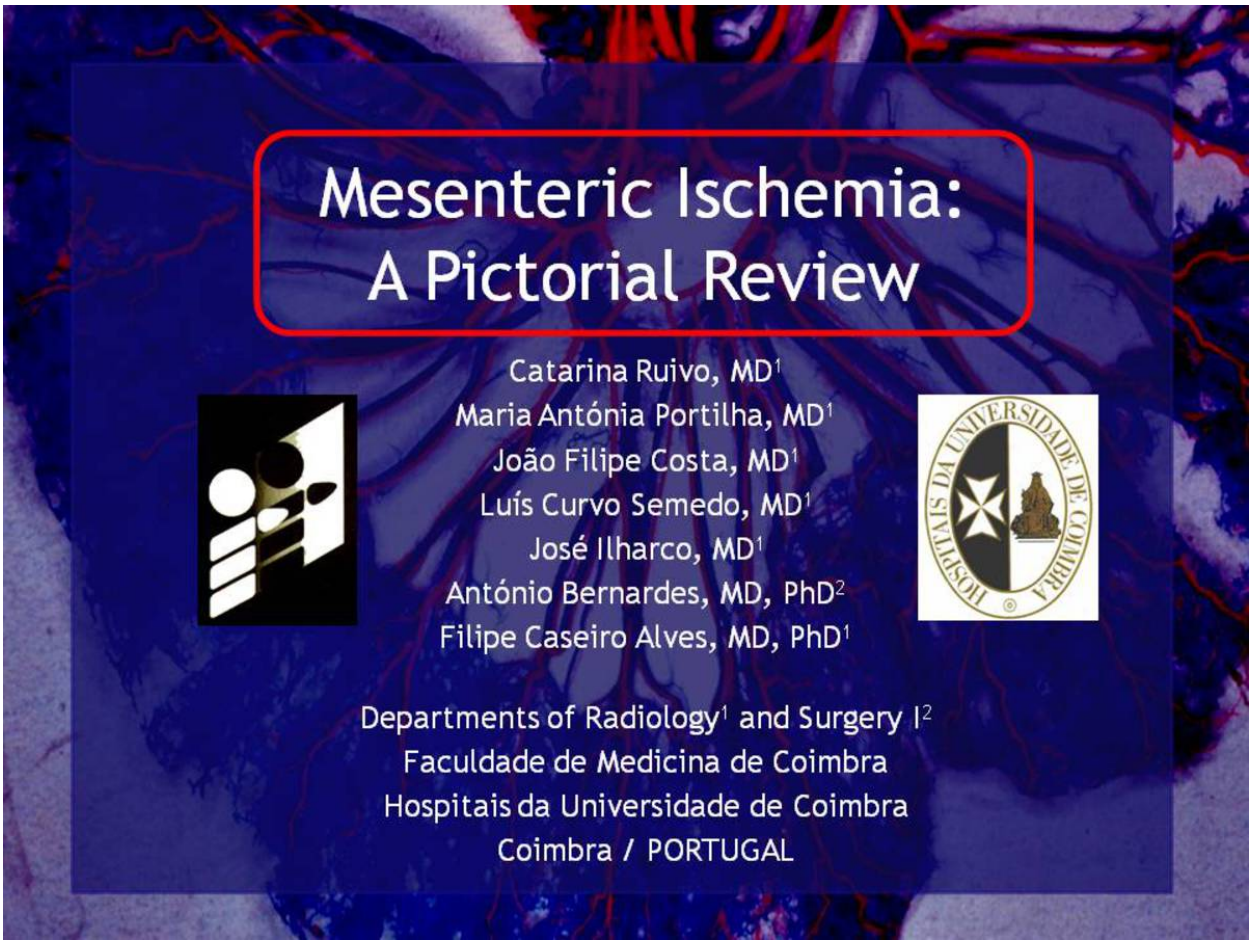

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

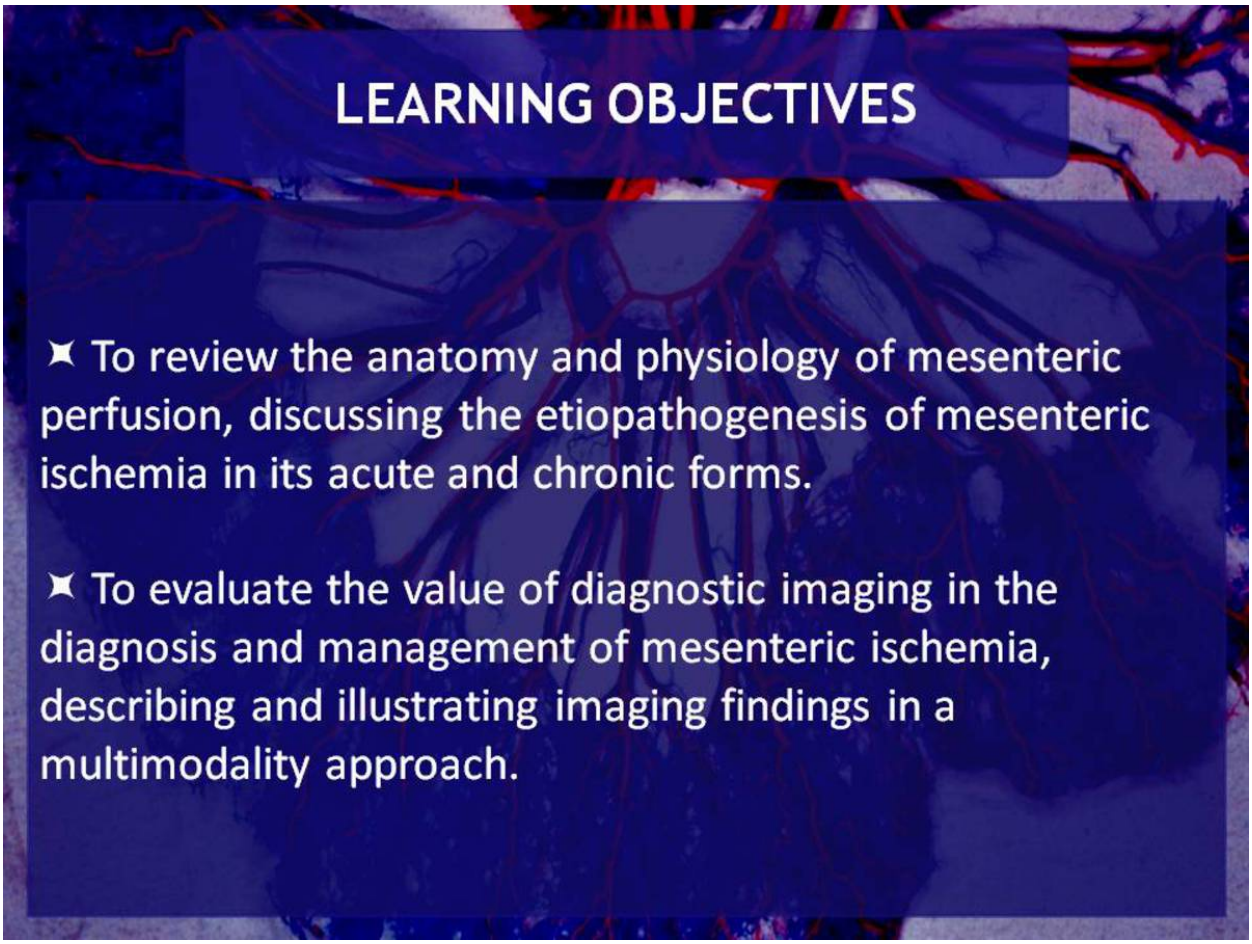

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

Images for this section:

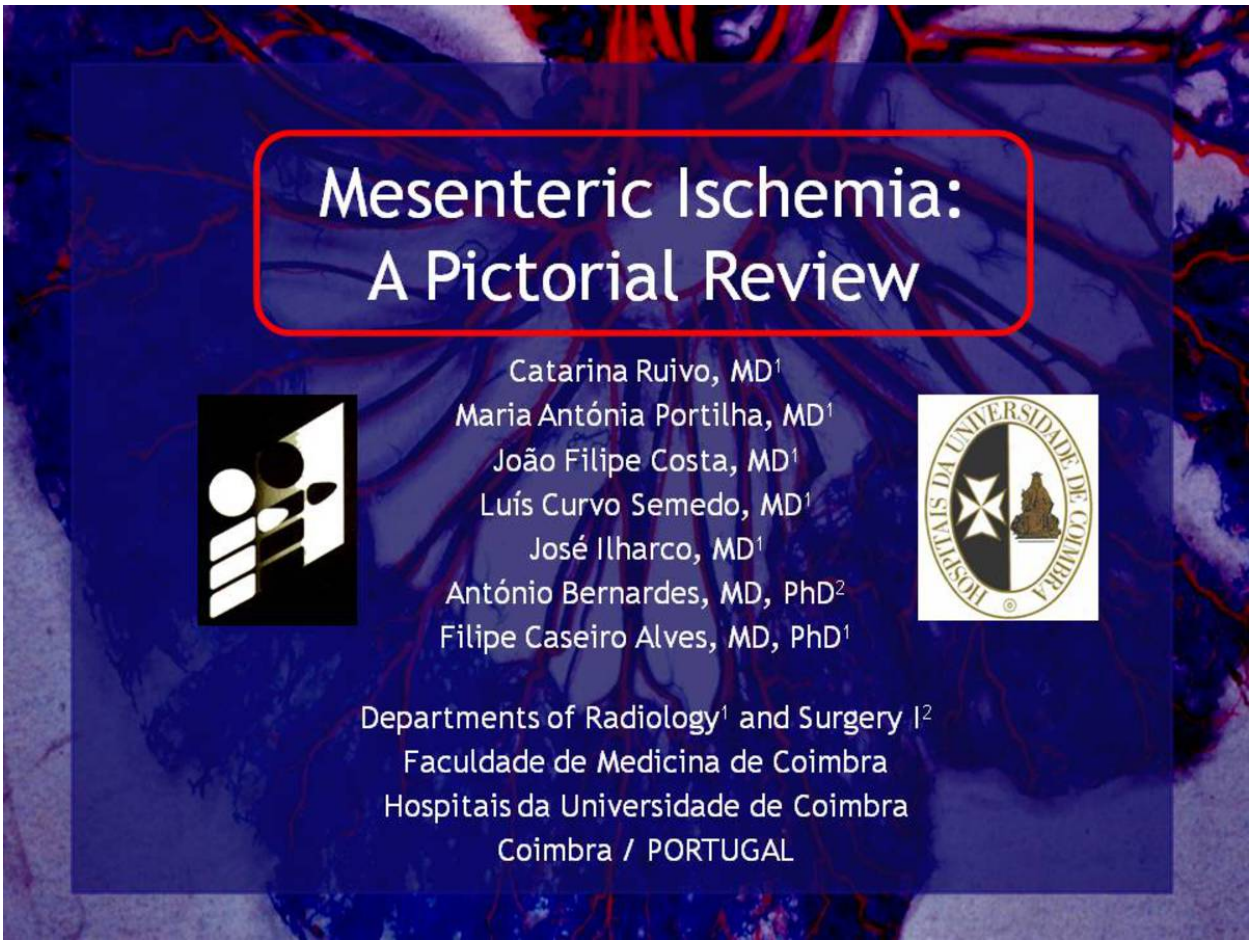
Mesenteric Ischemia:
A Pictorial Review
Catarina Ruivo, MD[1]
Maria Antónia Portilha, MD[1]
João Filipe Costa, MD[1]
Luís Curvo Semedo, MD[1]
José Ilharco, MD[1]
António Bernardes, MD, PhD[2]
Filipe Caseiro Alves, MD, PhD[1]
Departments of Radiology[1] and Surgery I[2]
Faculdade de Medicina de Coimbra
Hospitais da Universidade de Coimbra
Coimbra / PORTUGAL

Fig. 1

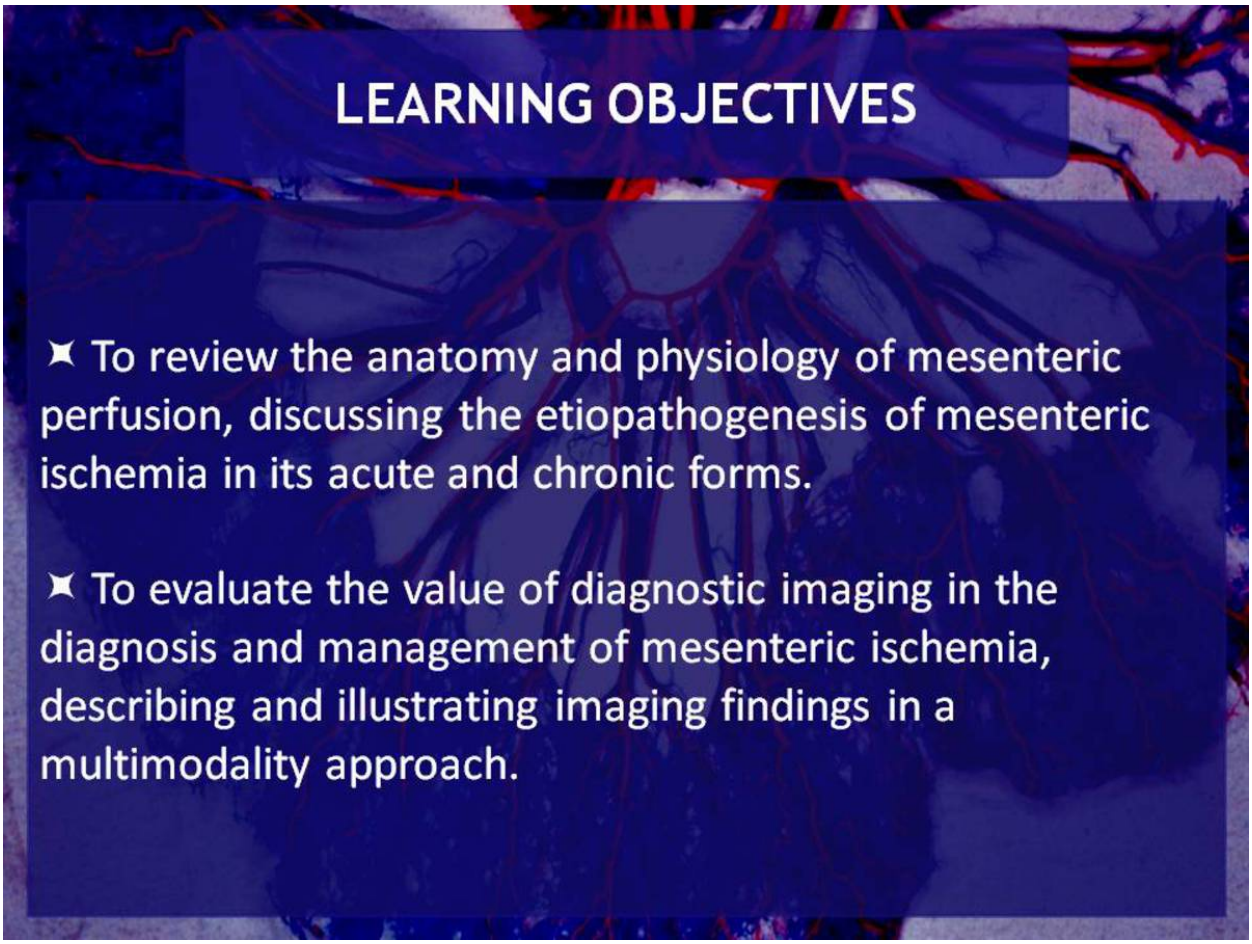
LEARNING OBJECTIVES
To review the anatomy and physiology of mesenteric perfusion, discussing the etiopathogenesis of mesenteric ischemia in its acute and chronic forms.
To evaluate the value of diagnostic imaging in the diagnosis and management of mesenteric ischemia, describing and illustrating imaging findings in a multimodality approach.

Fig. 2

Background

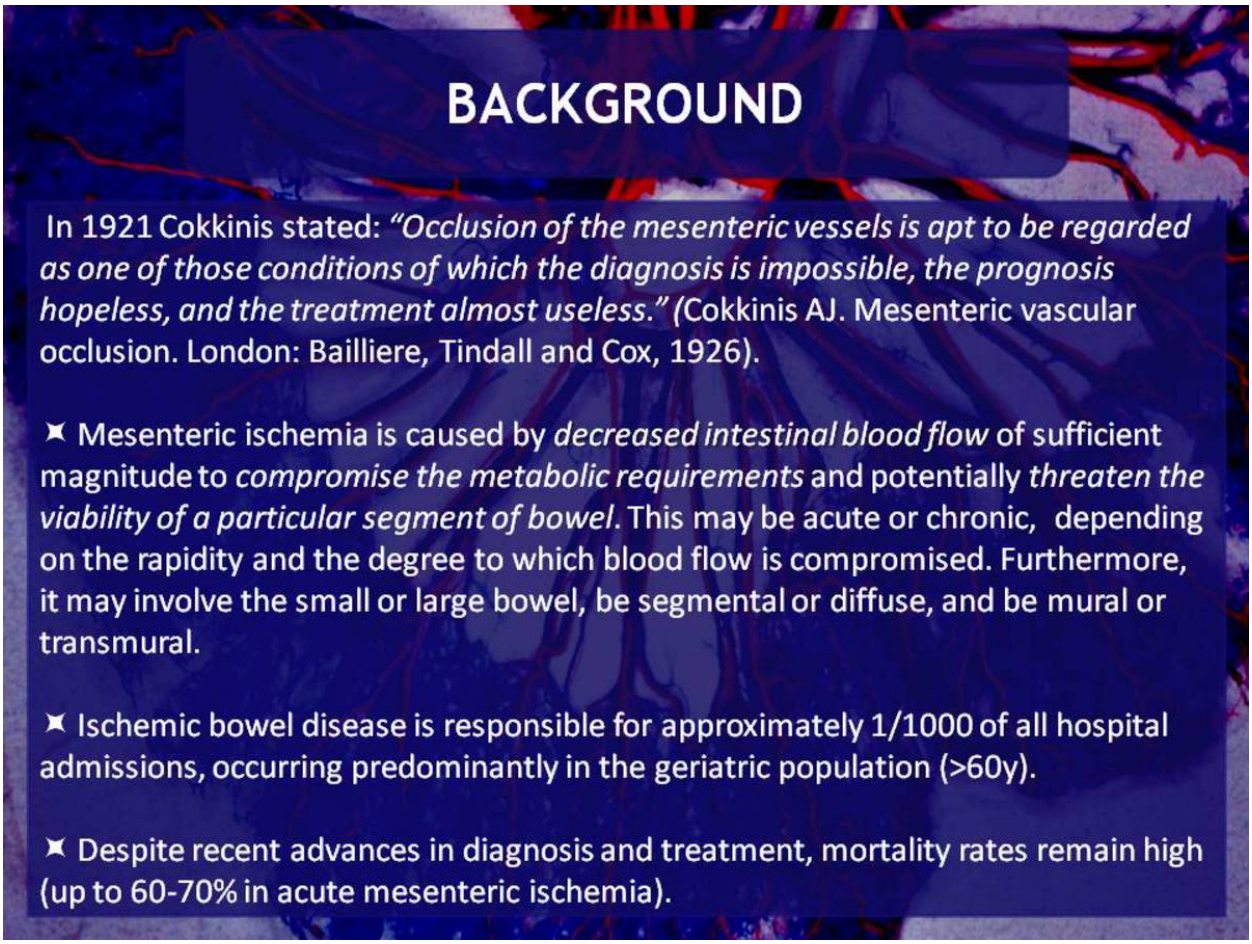

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

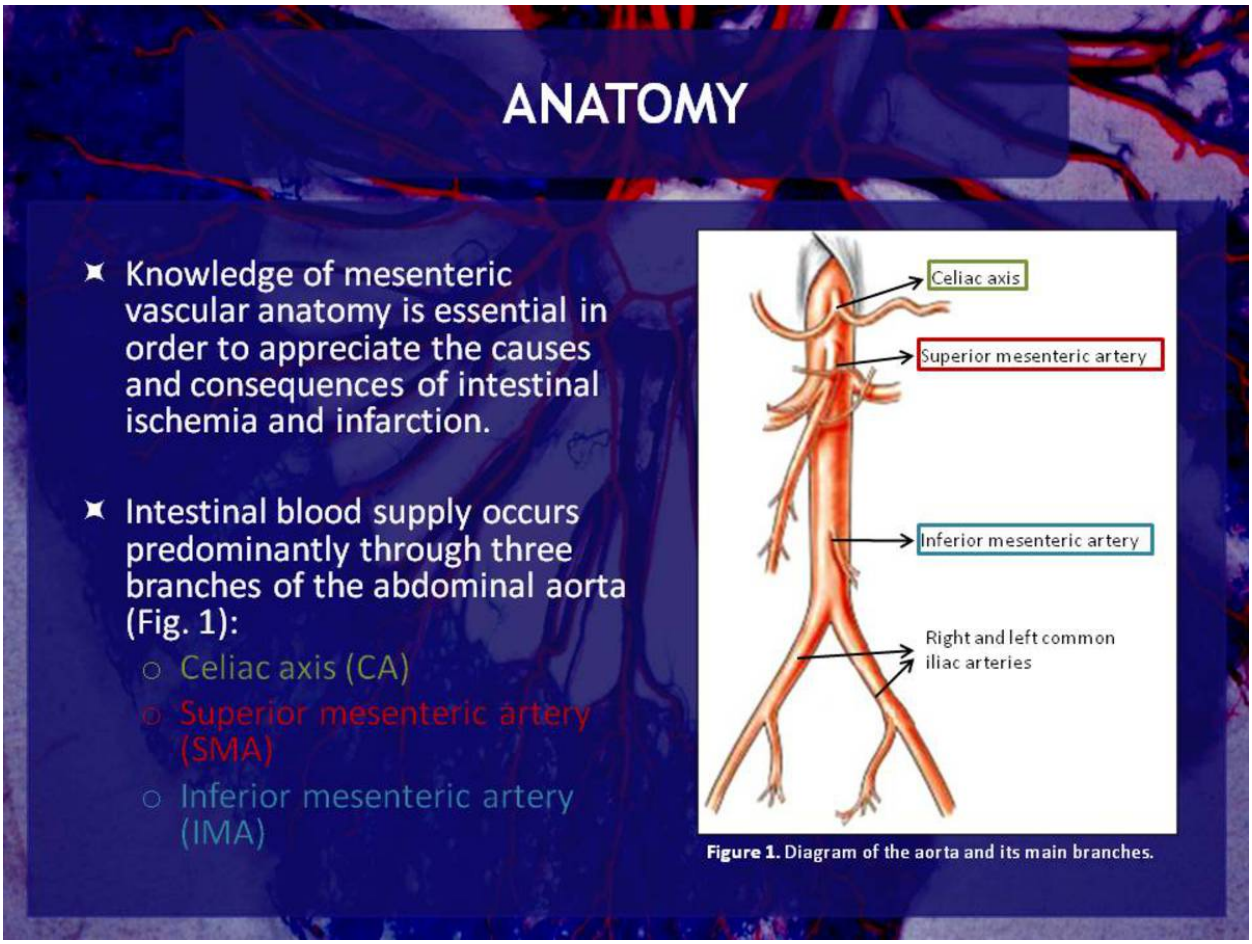

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

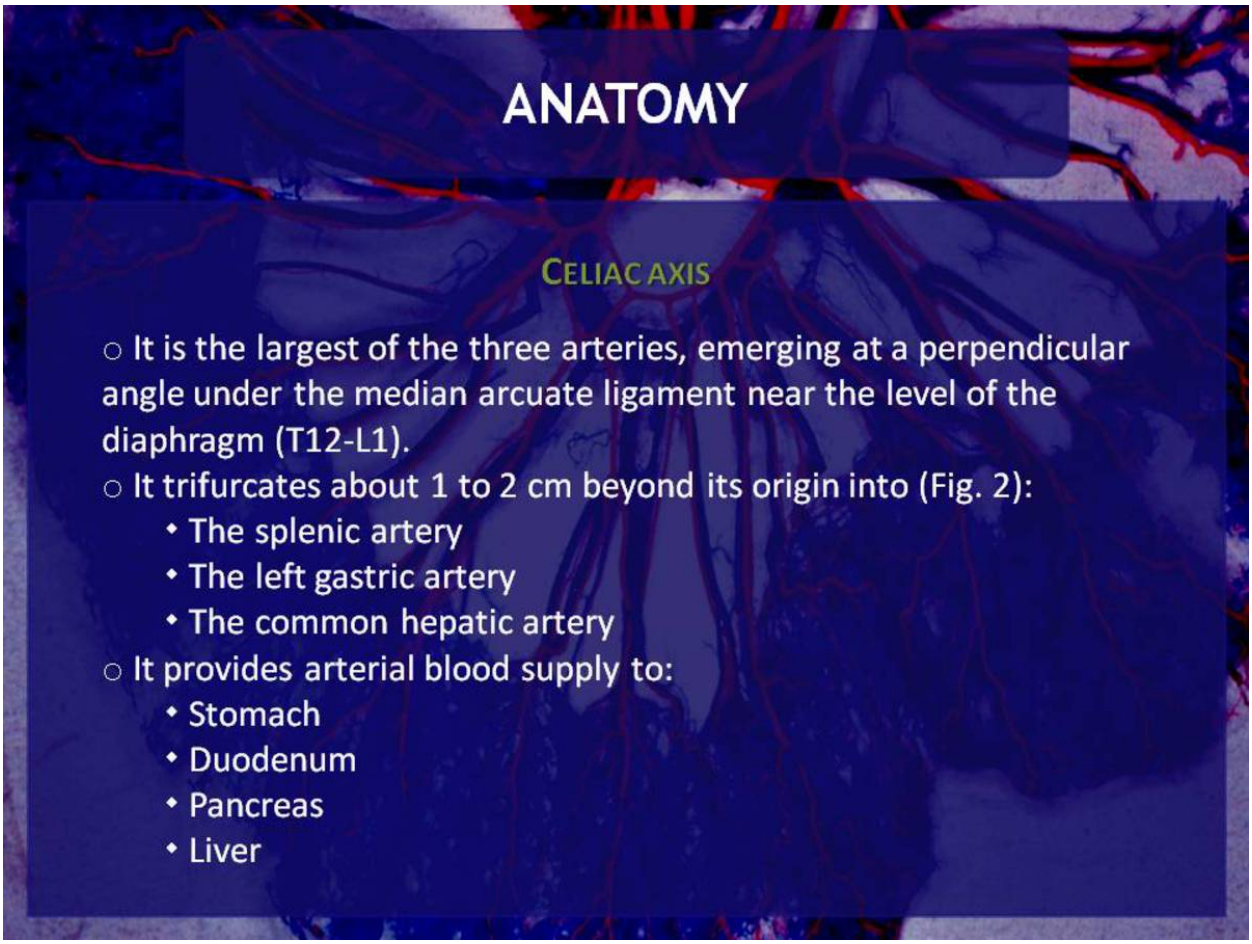

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

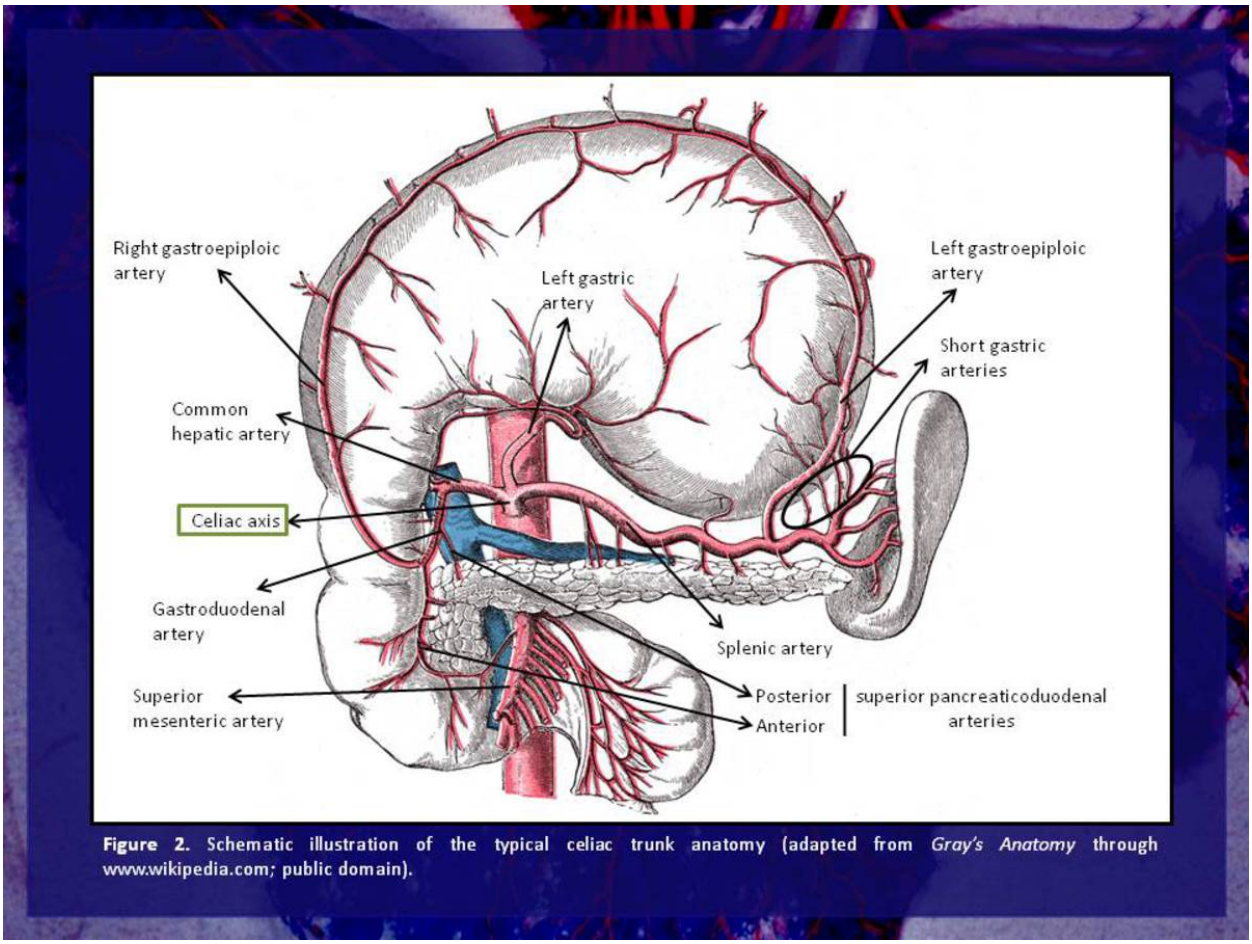

Figure 2. Schematic illustration of the typical celiac trunk anatomy (adapted from *Gray's Anatomy* through www.wikipedia.com; public domain).

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

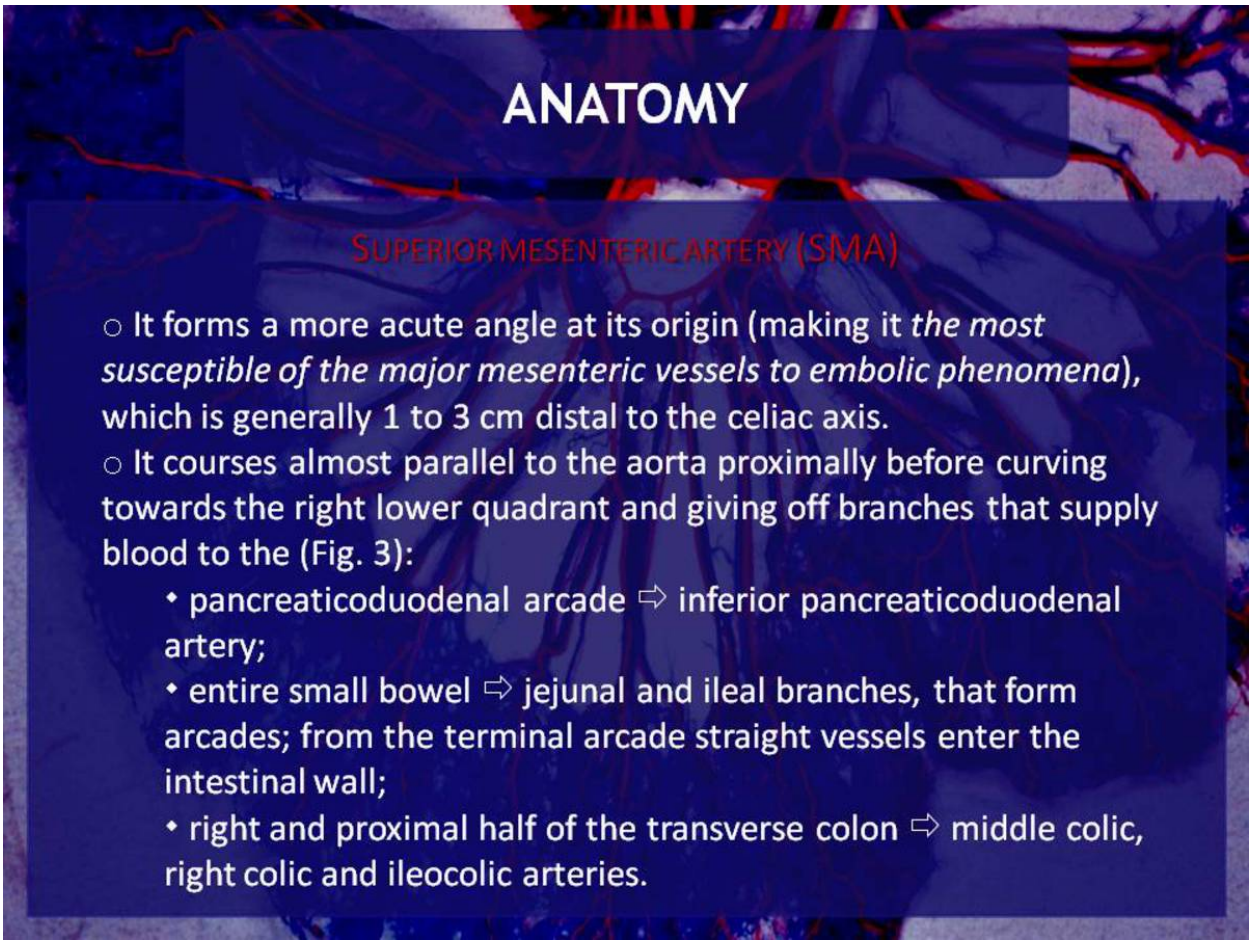

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

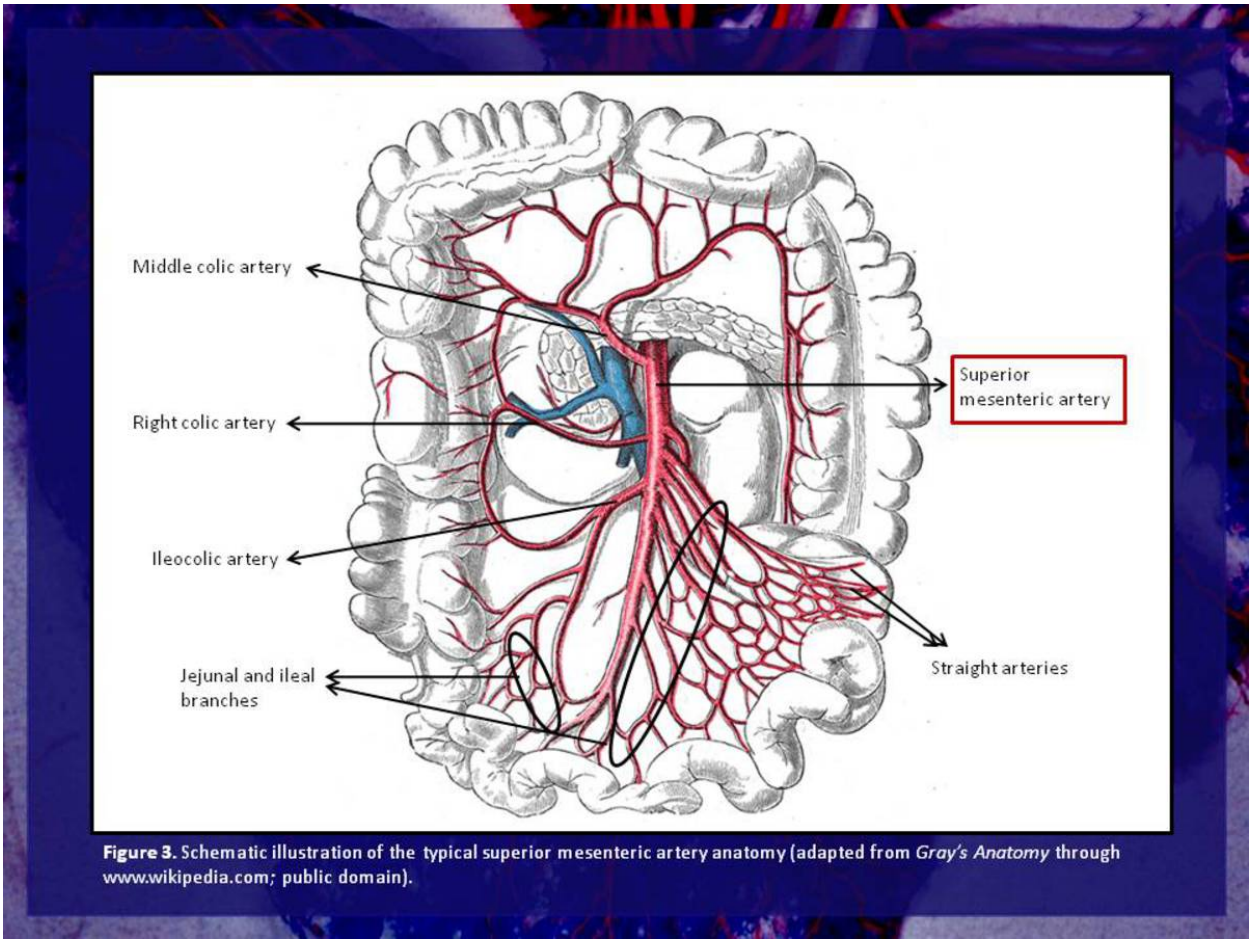

Figure 3. Schematic illustration of the typical superior mesenteric artery anatomy (adapted from *Gray's Anatomy* through www.wikipedia.com; public domain).

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

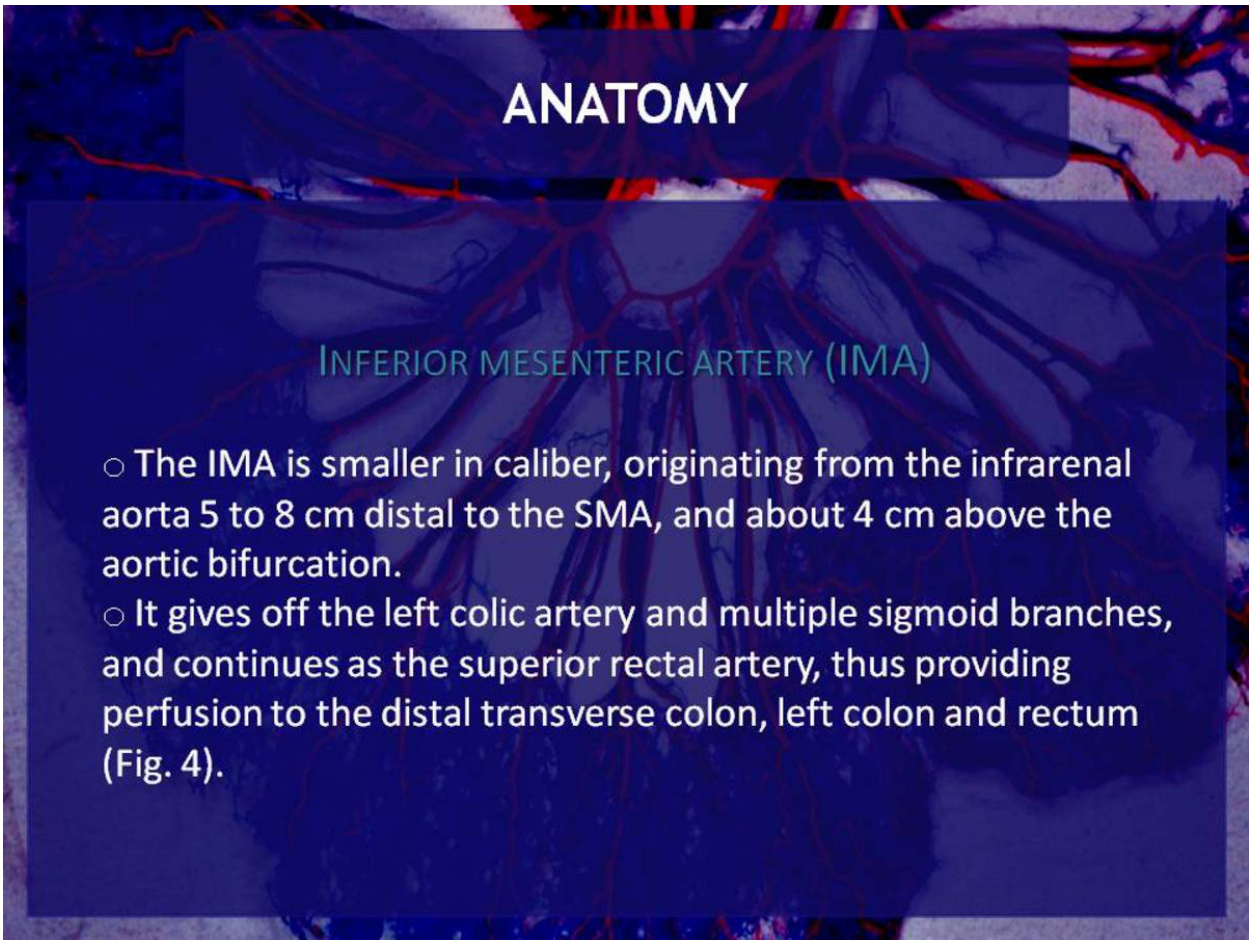

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

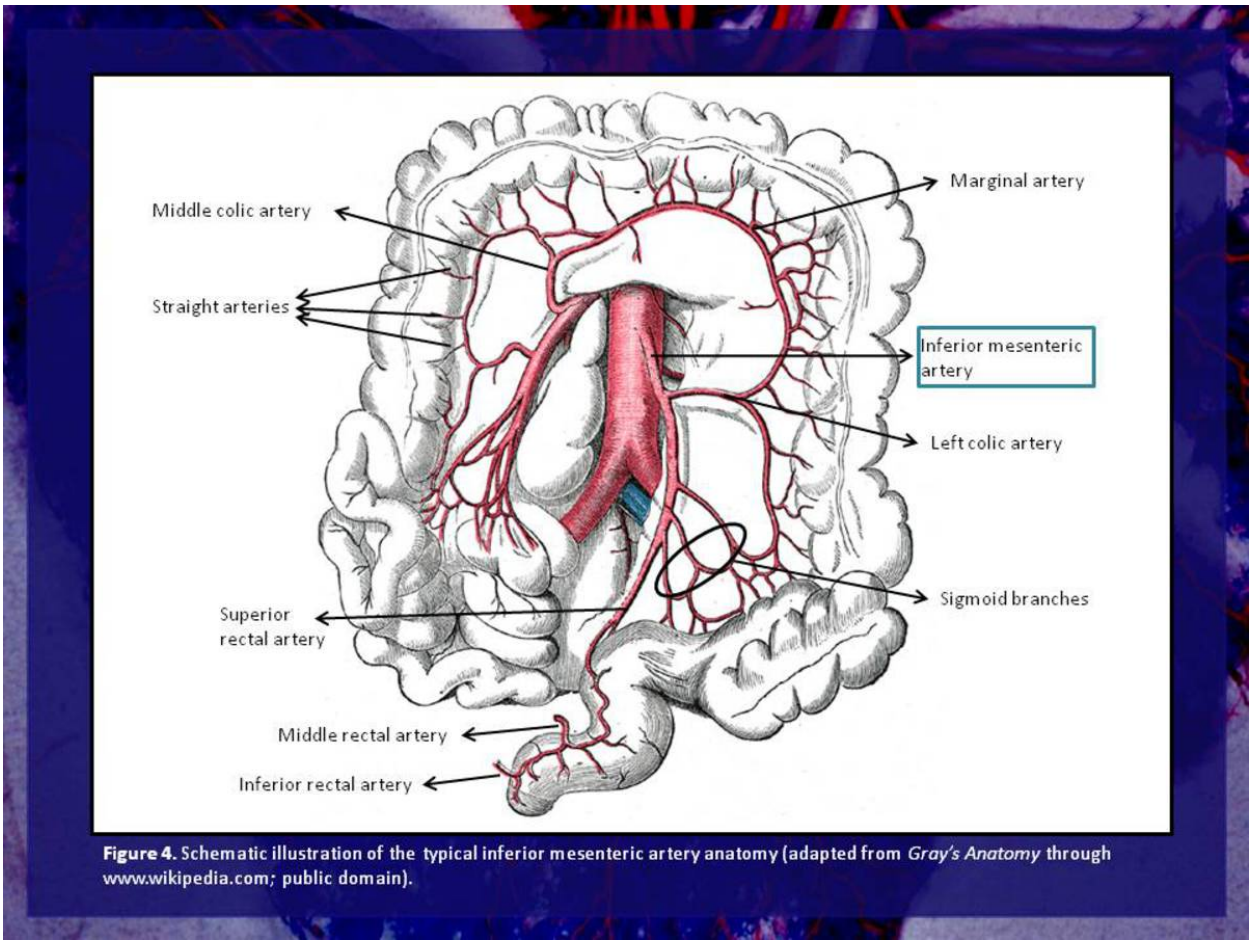

Figure 4. Schematic illustration of the typical inferior mesenteric artery anatomy (adapted from *Gray's Anatomy* through www.wikipedia.com; public domain).

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

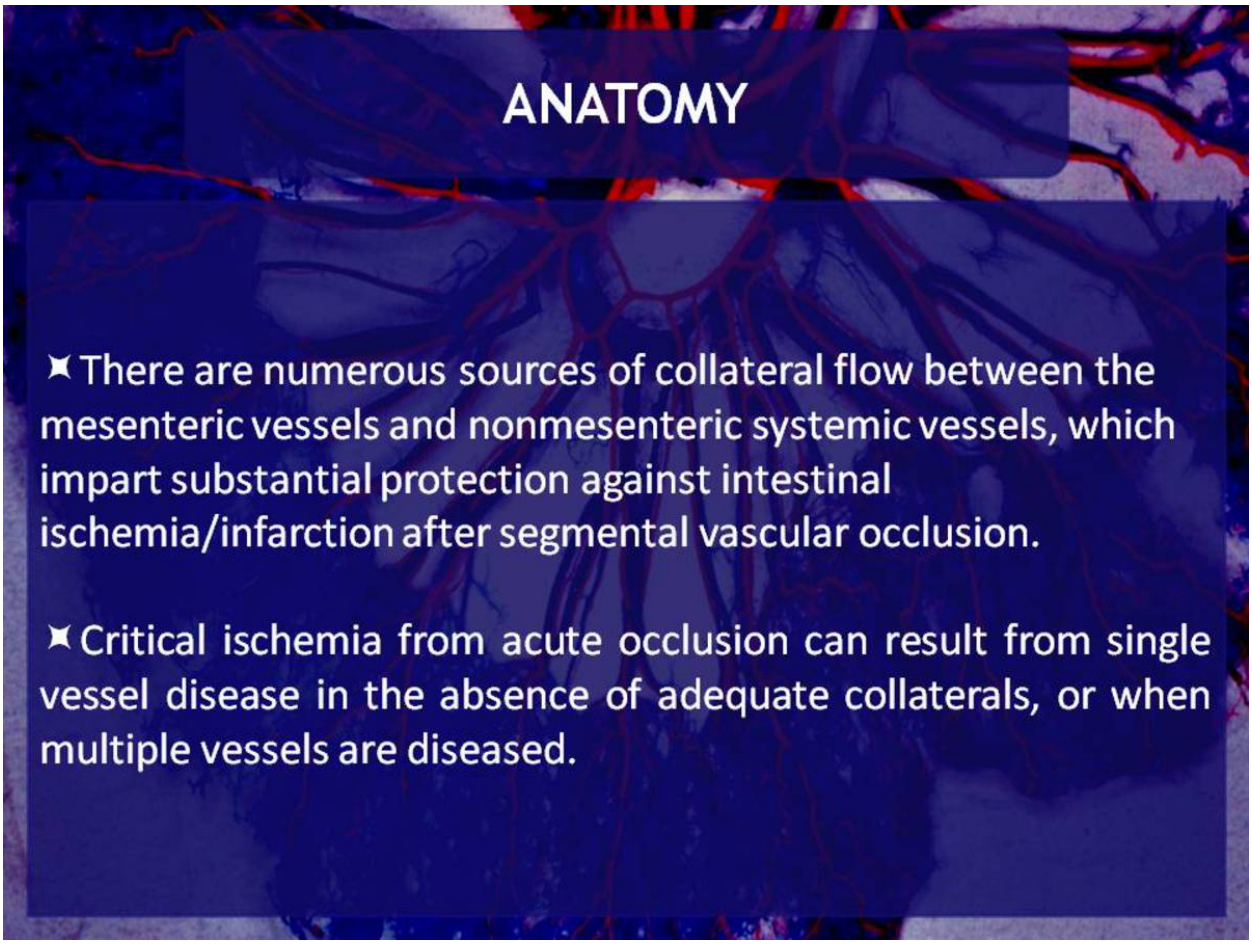

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

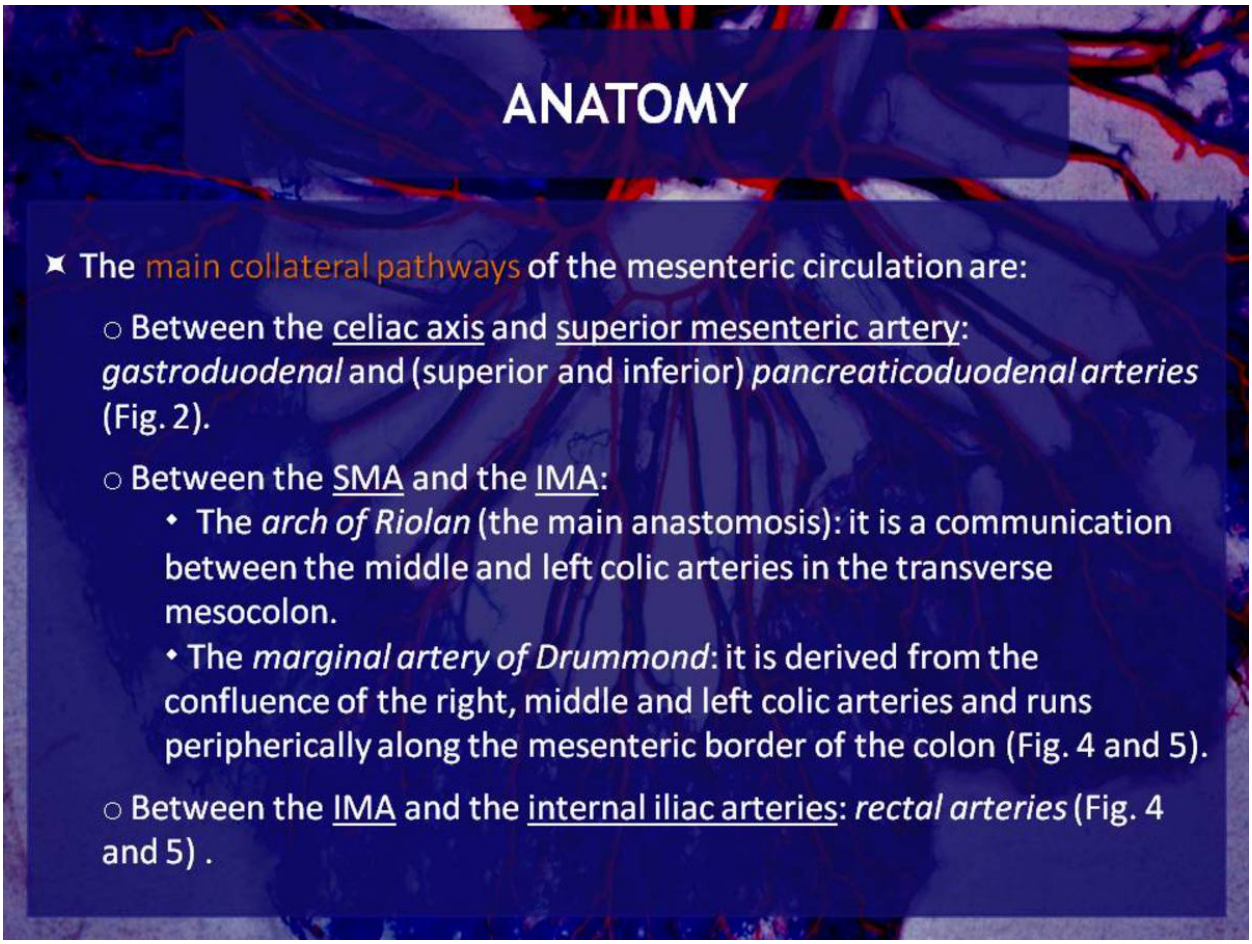

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

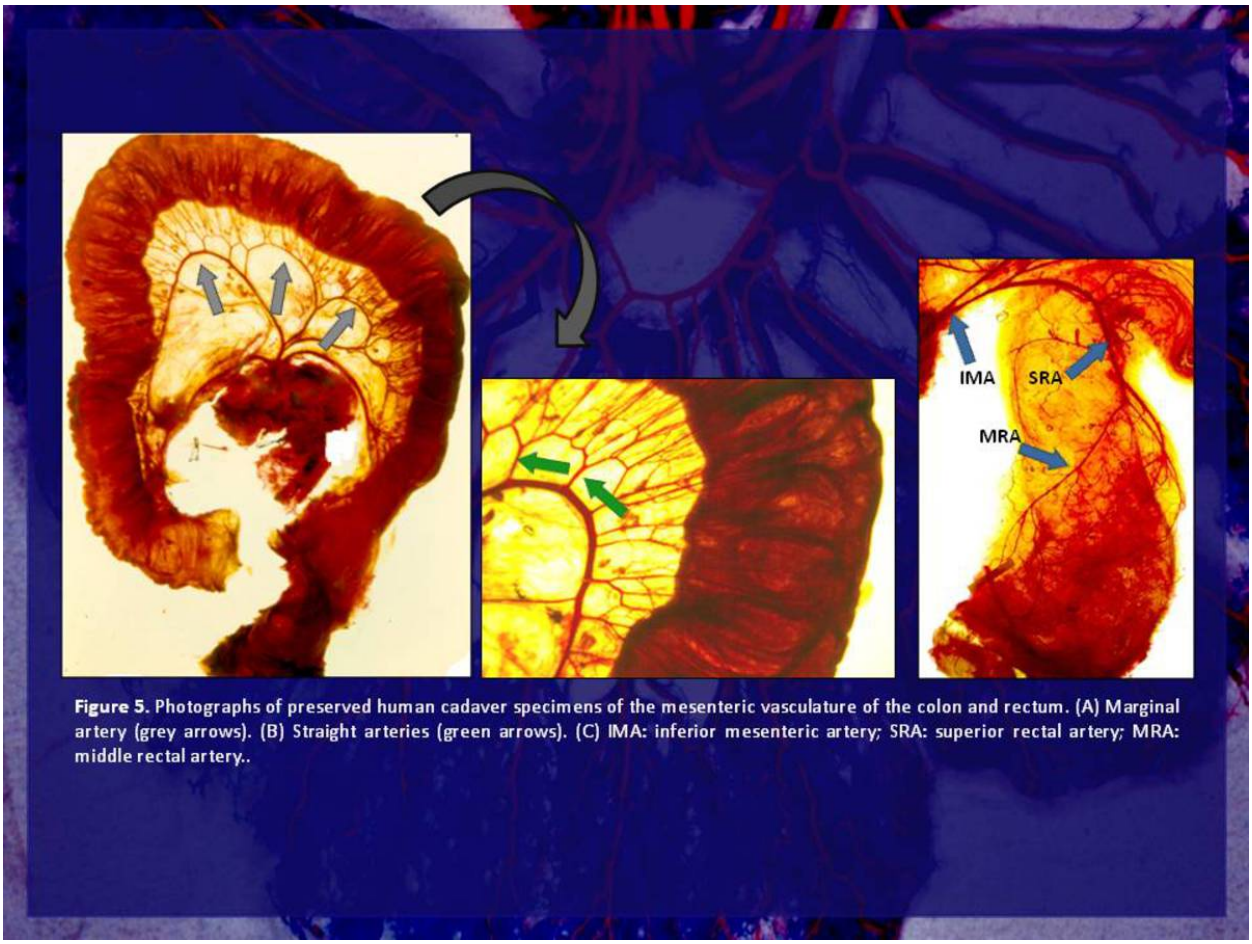

Figure 5. Photographs of preserved human cadaver specimens of the mesenteric vasculature of the colon and rectum. (A) Marginal artery (grey arrows). (B) Straight arteries (green arrows). (C) IMA: inferior mesenteric artery; SRA: superior rectal artery; MRA: middle rectal artery..

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

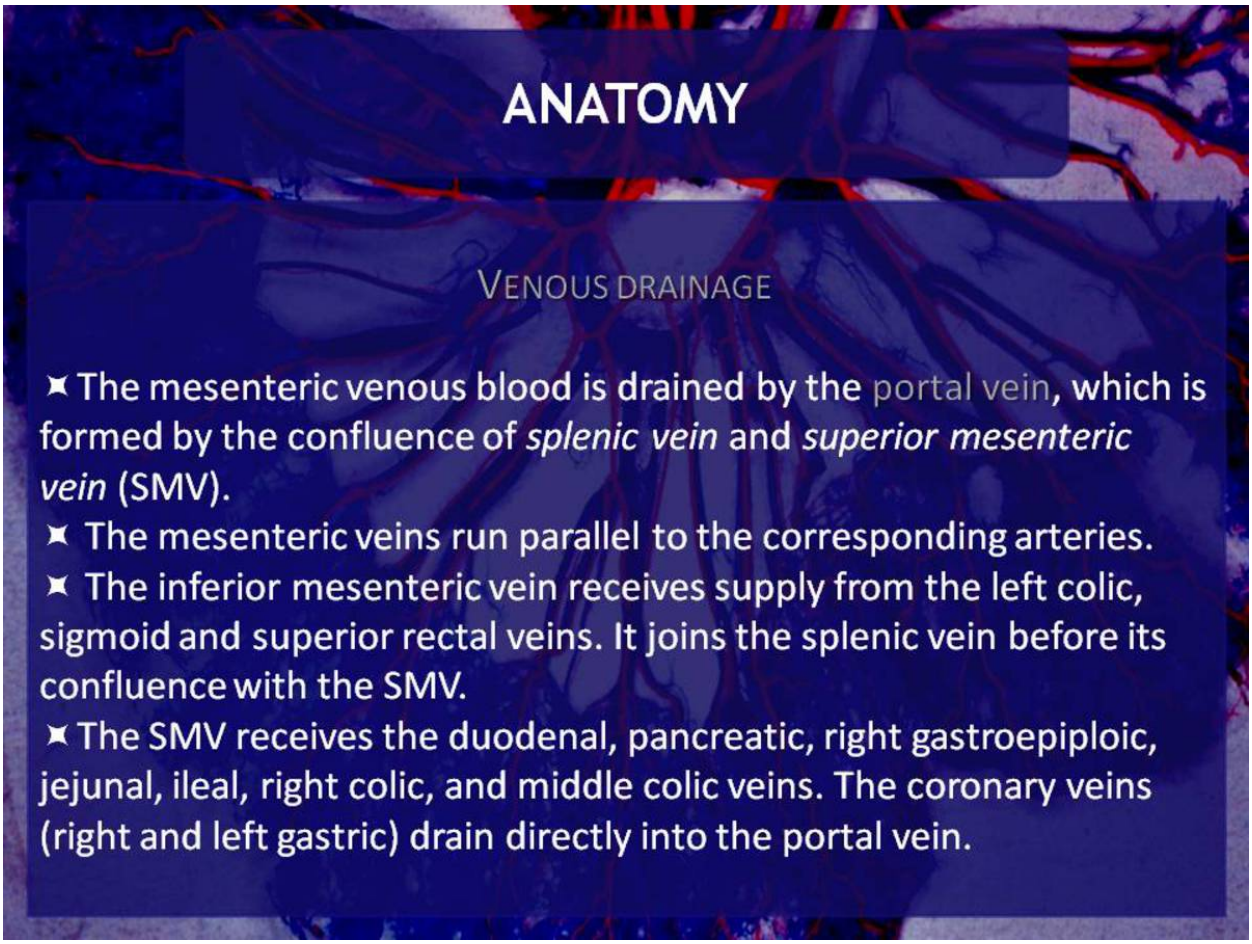

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

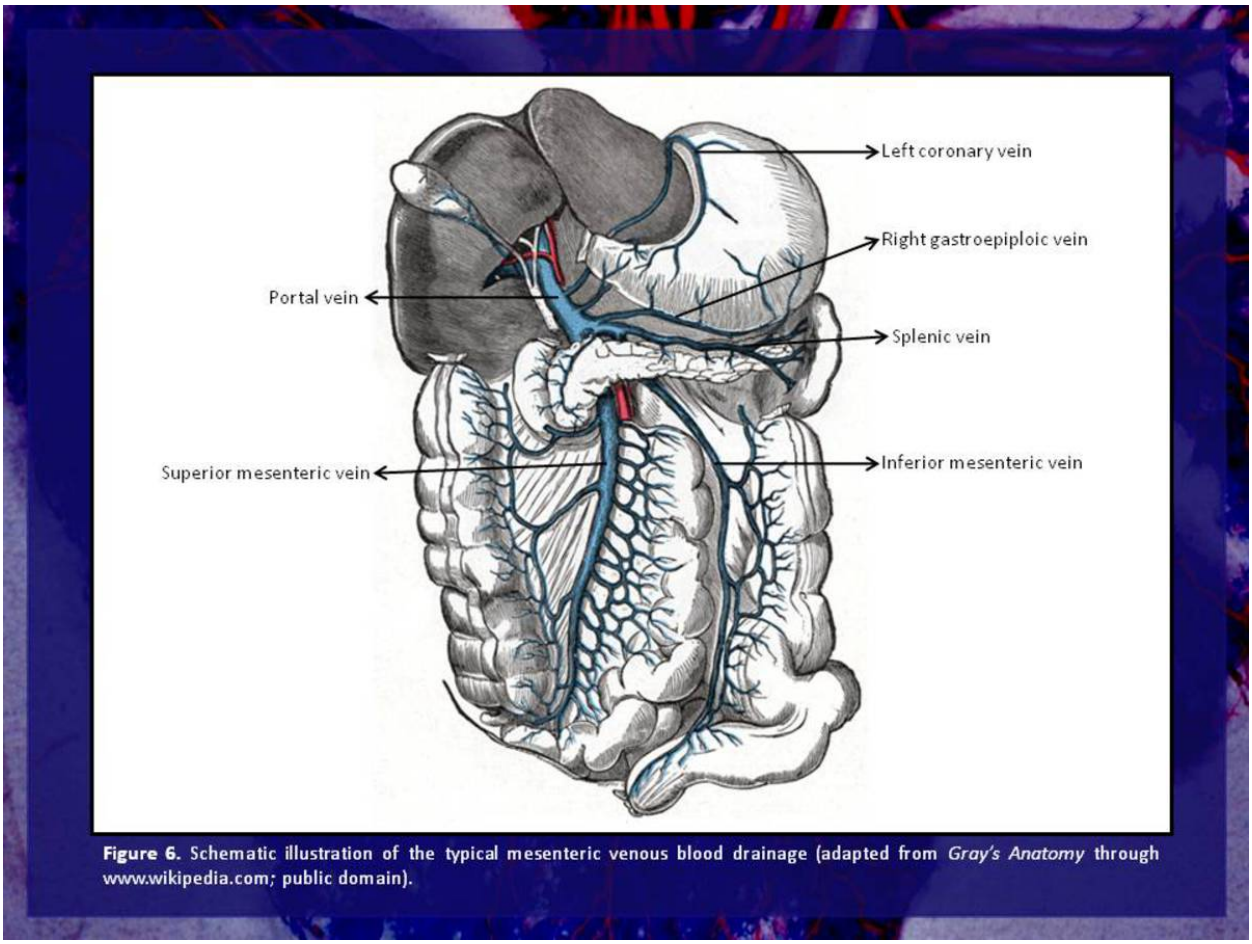

Figure 6. Schematic illustration of the typical mesenteric venous blood drainage (adapted from *Gray's Anatomy* through www.wikipedia.com; public domain).

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

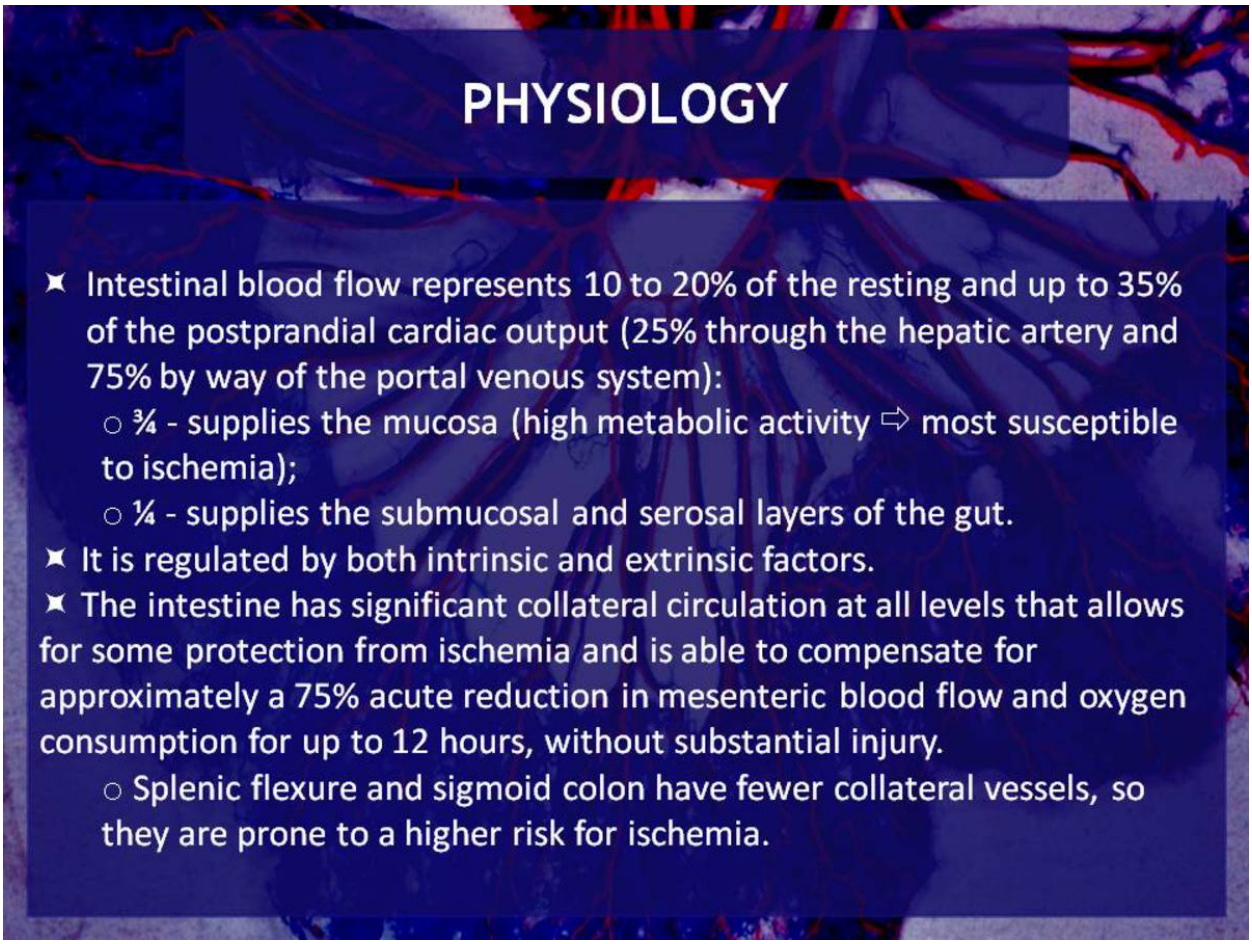

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

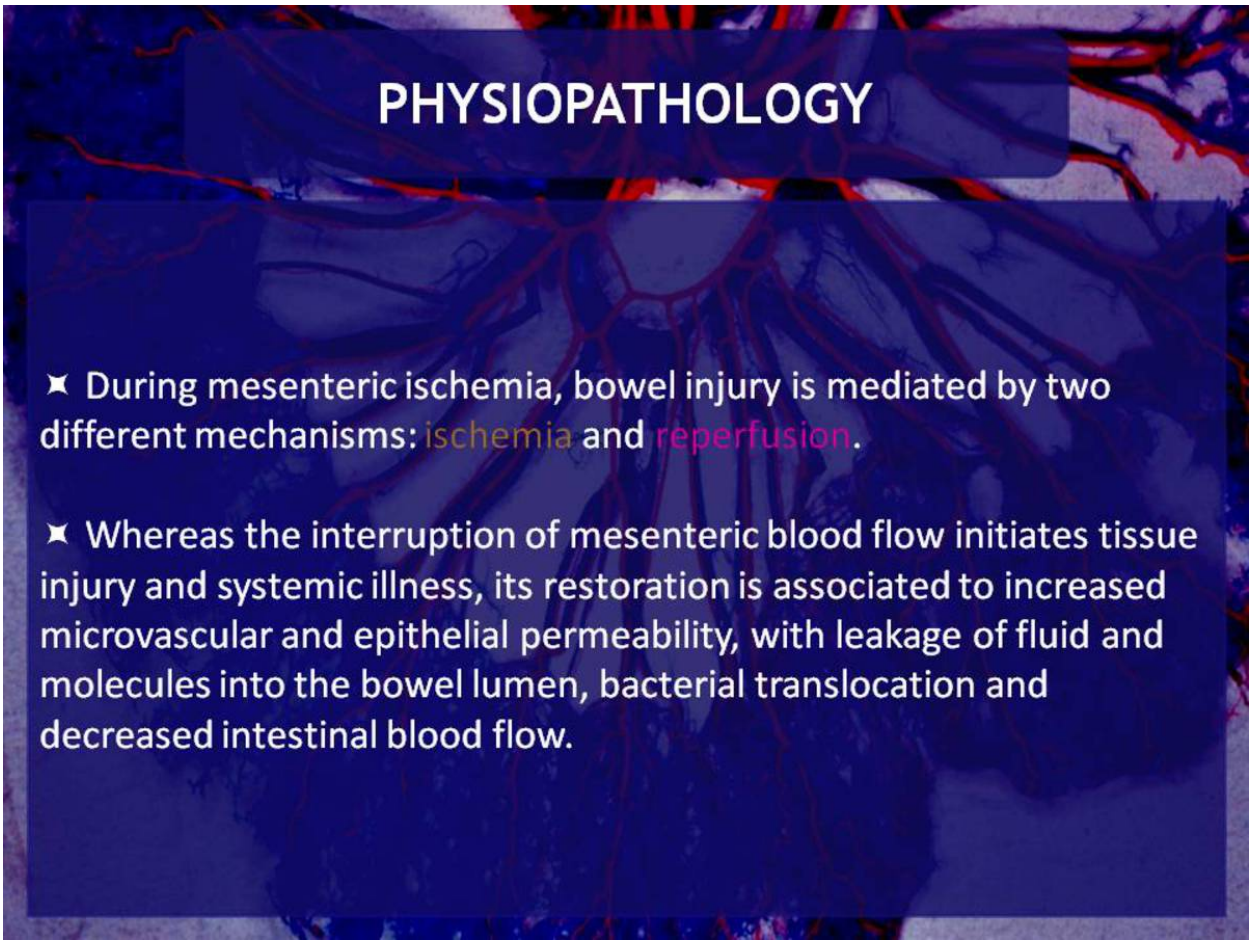

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

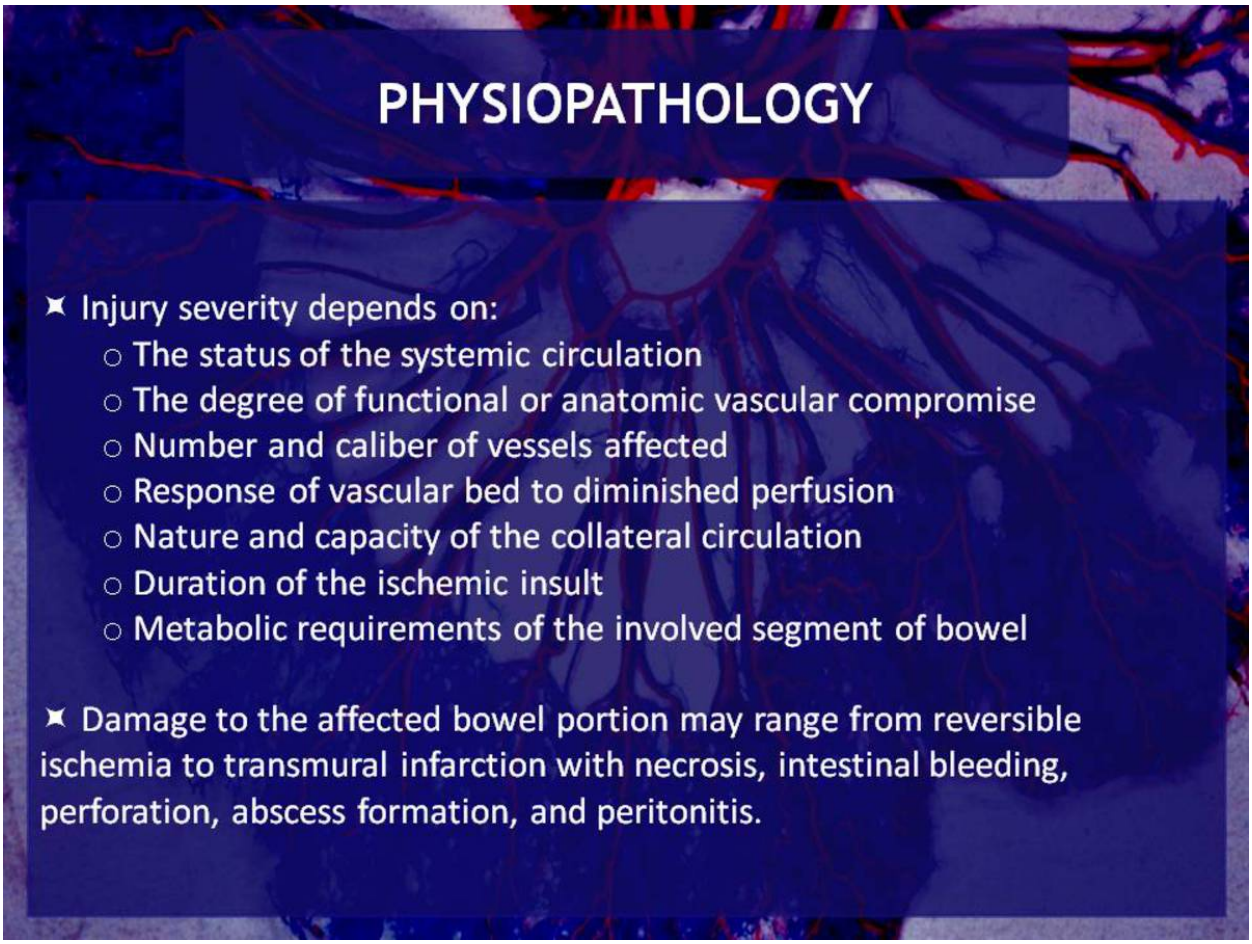

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

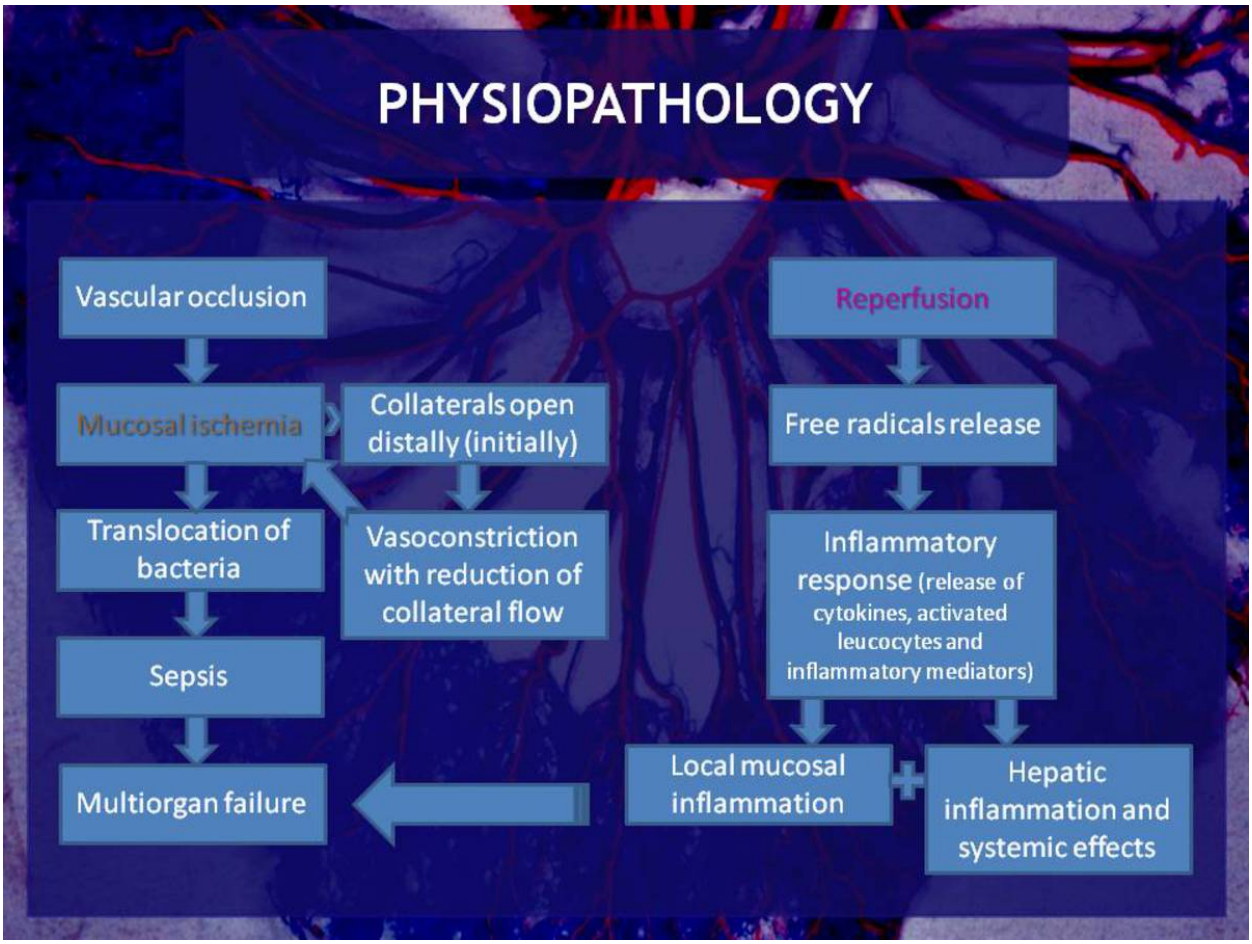

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

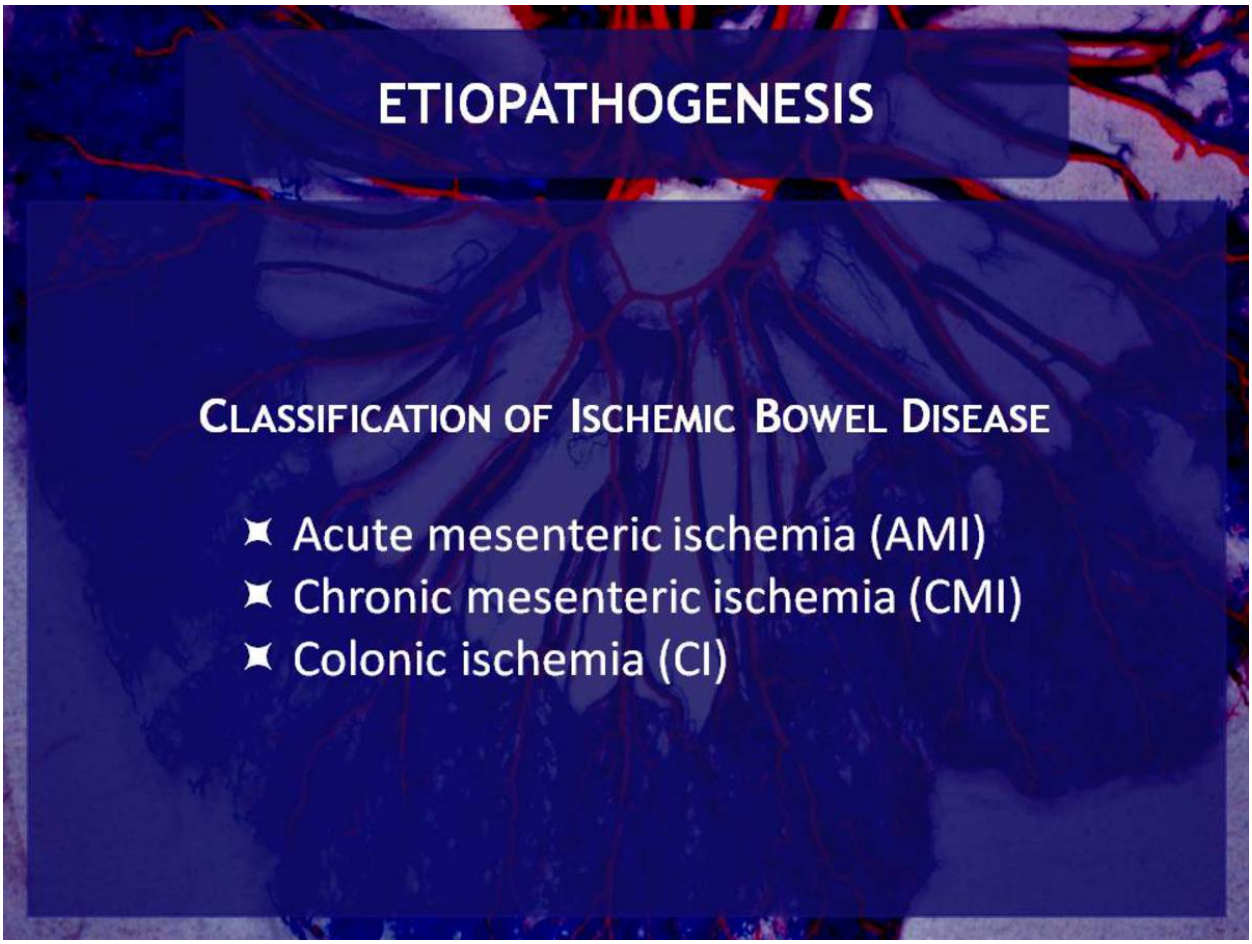

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

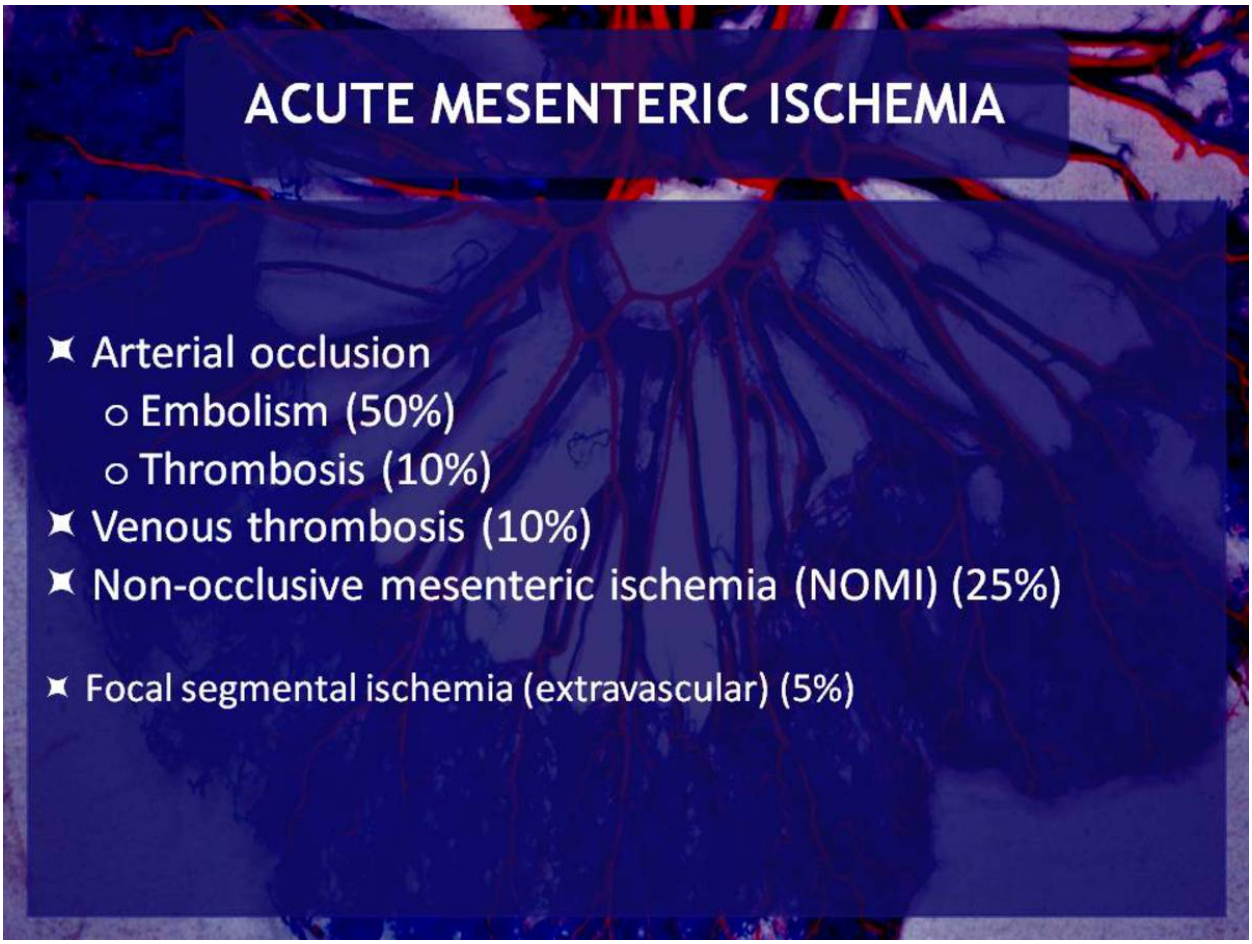

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

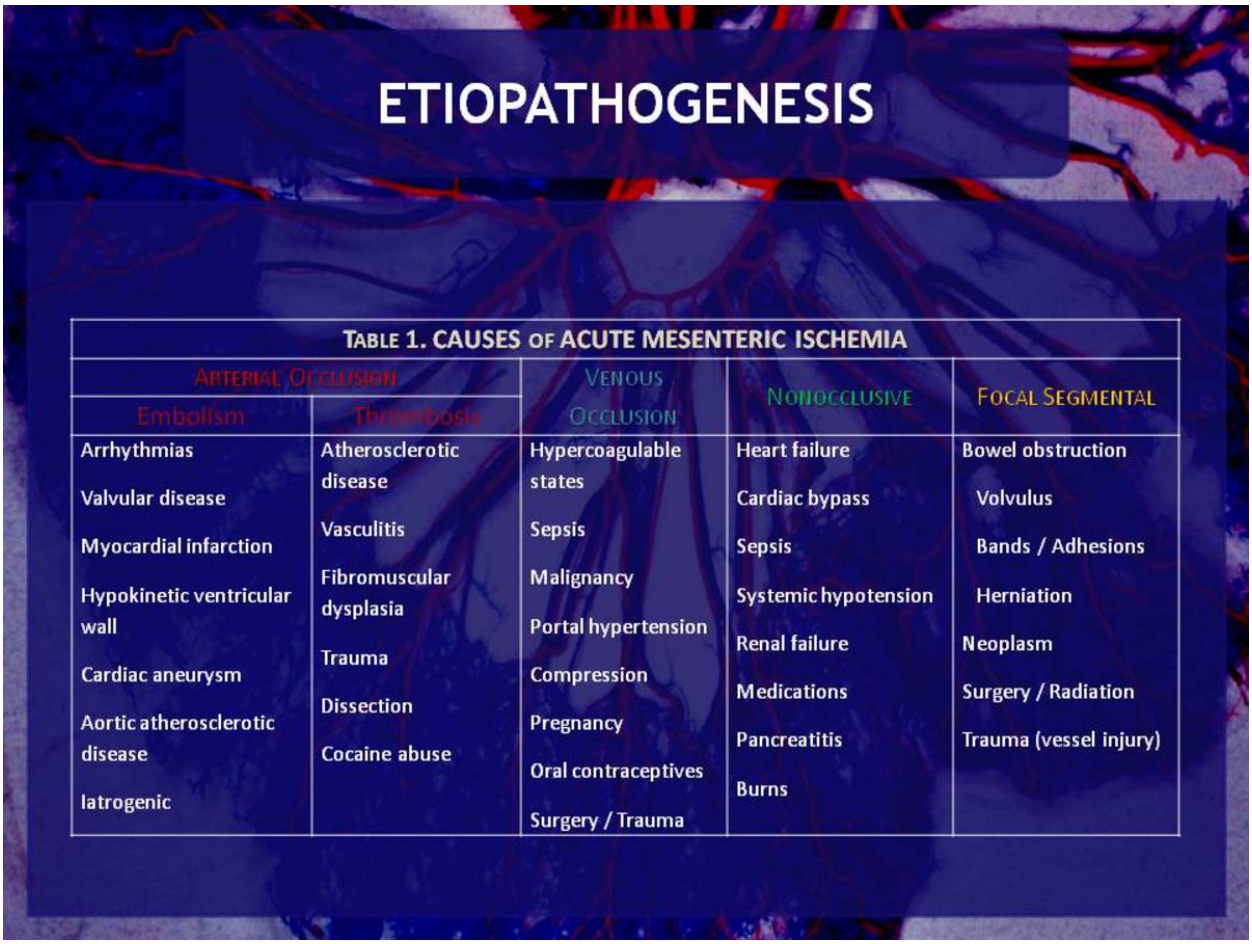

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

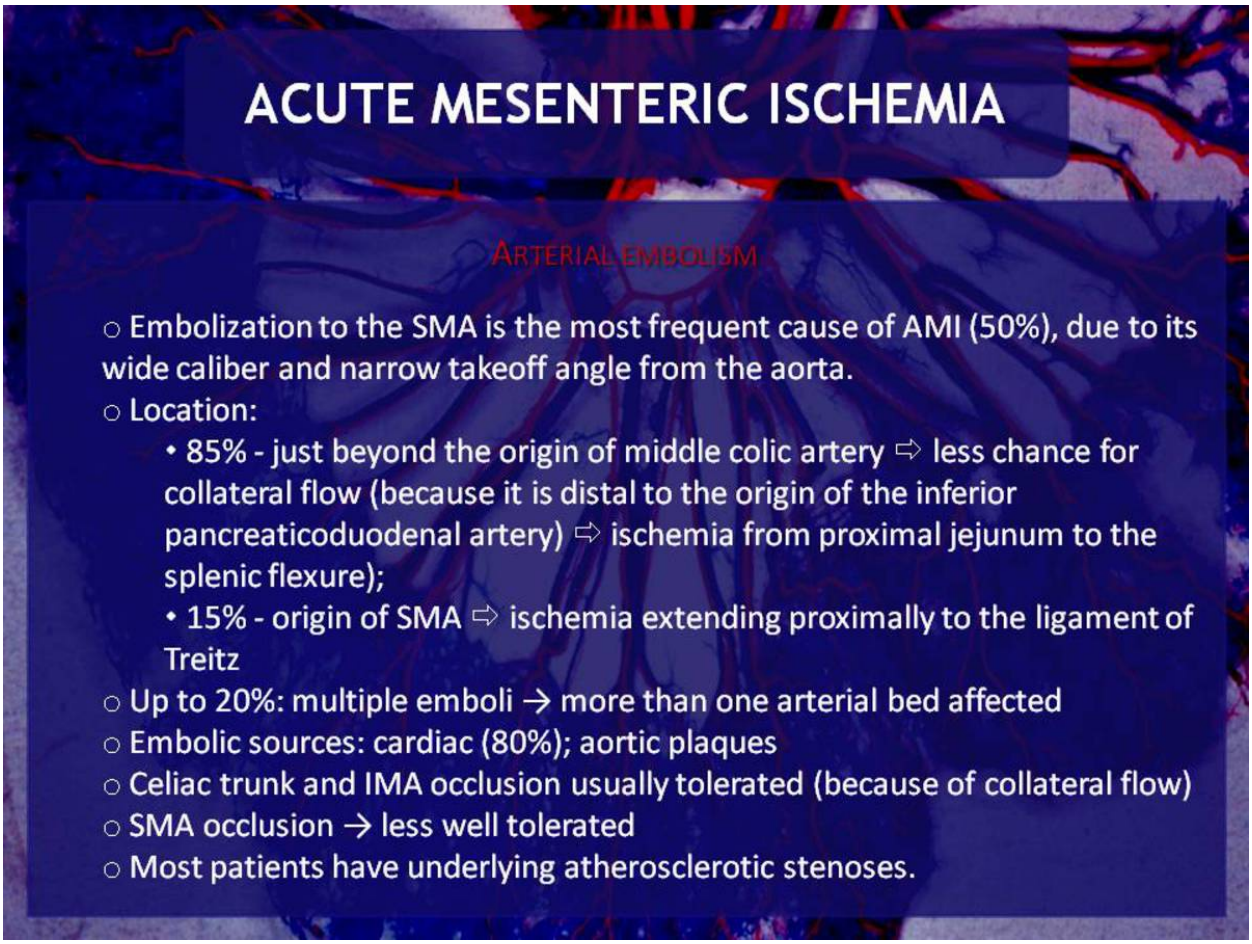

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

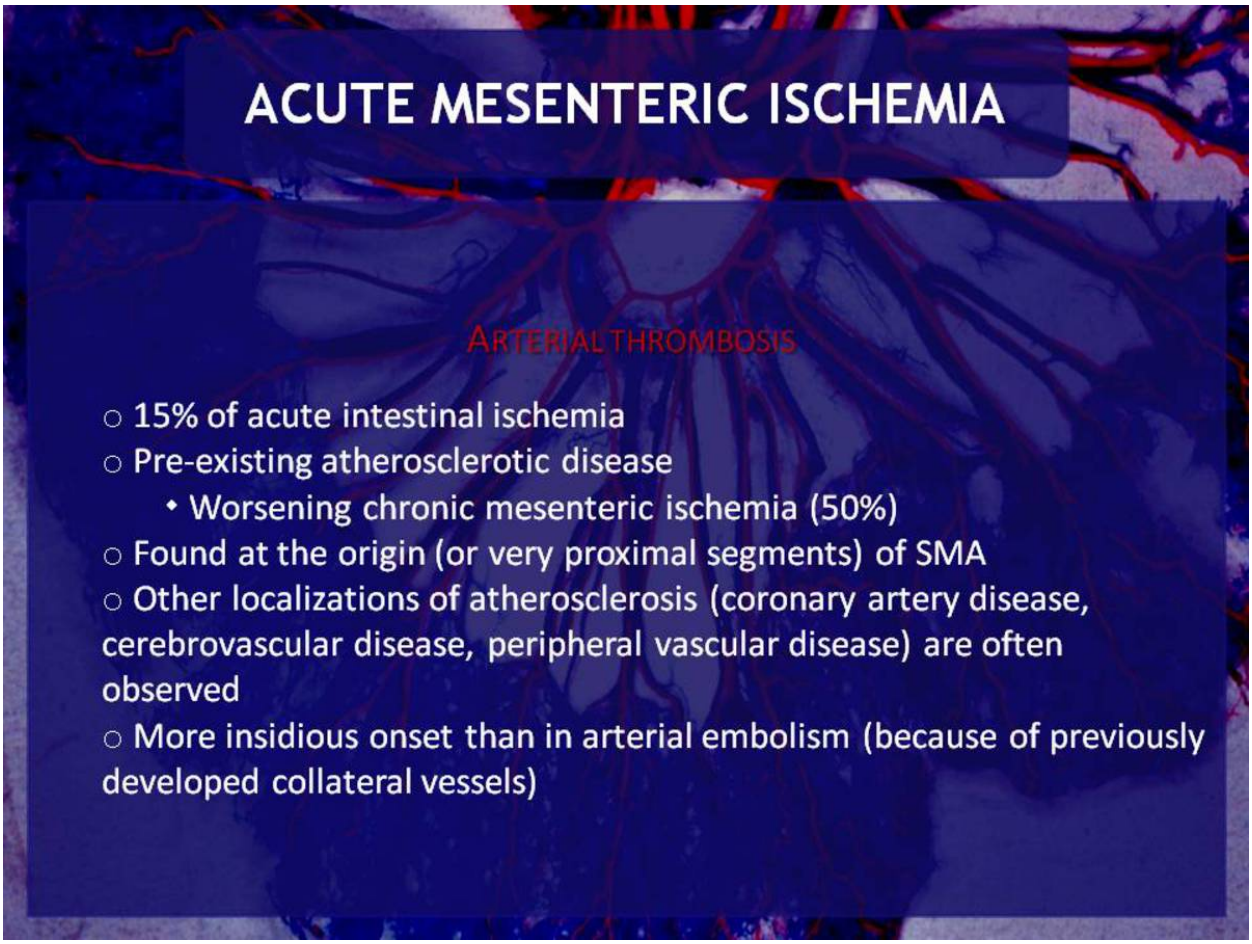

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

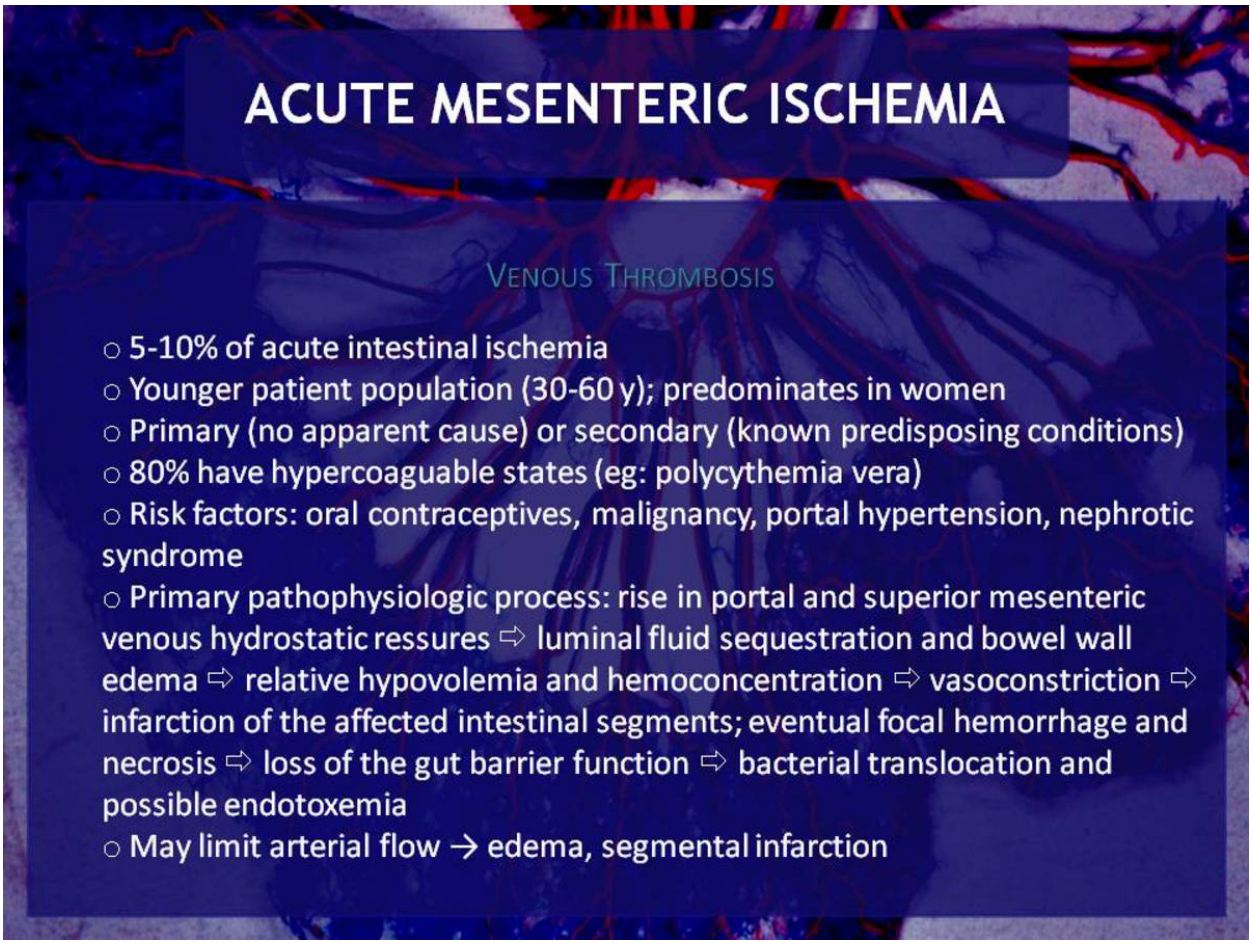

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

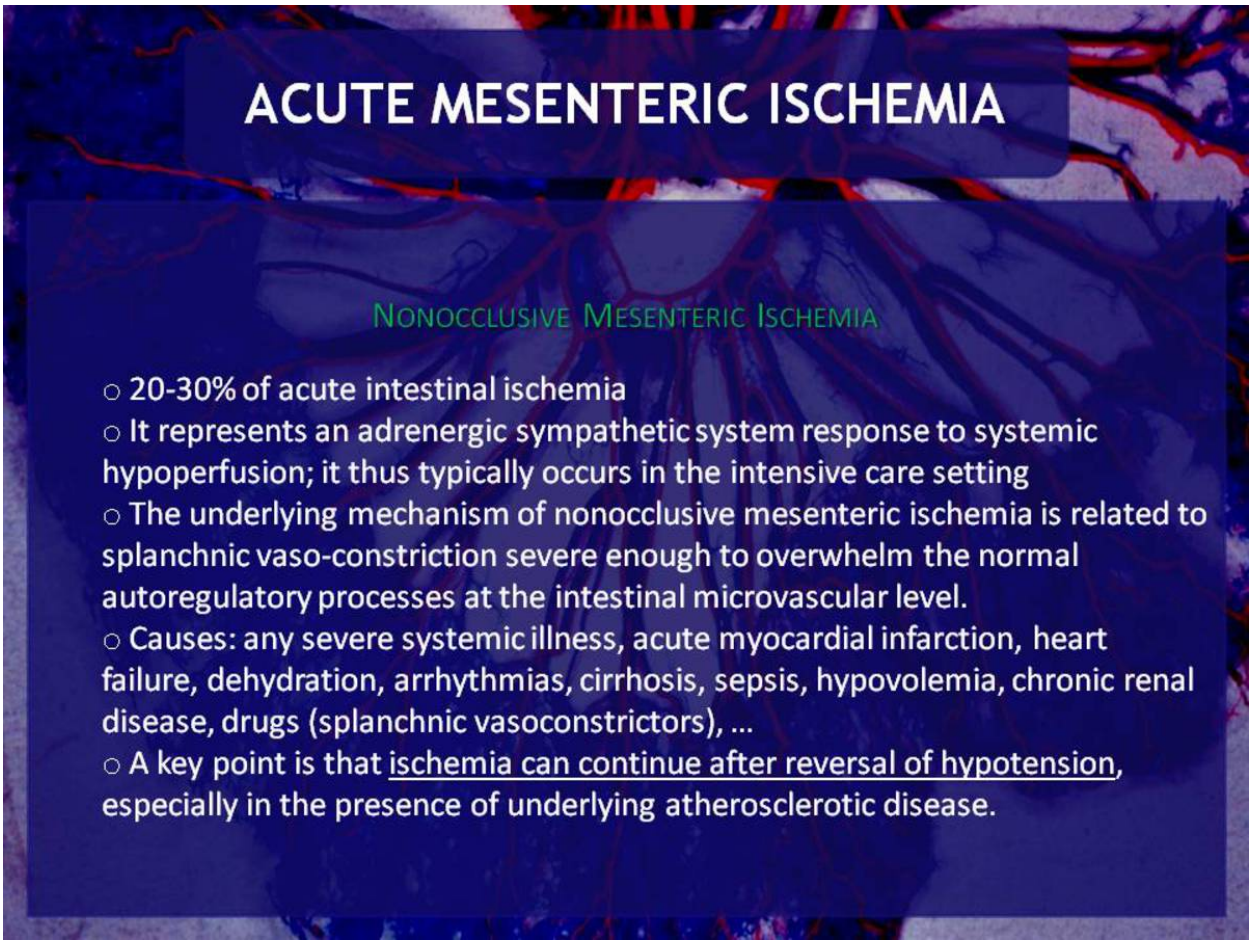

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

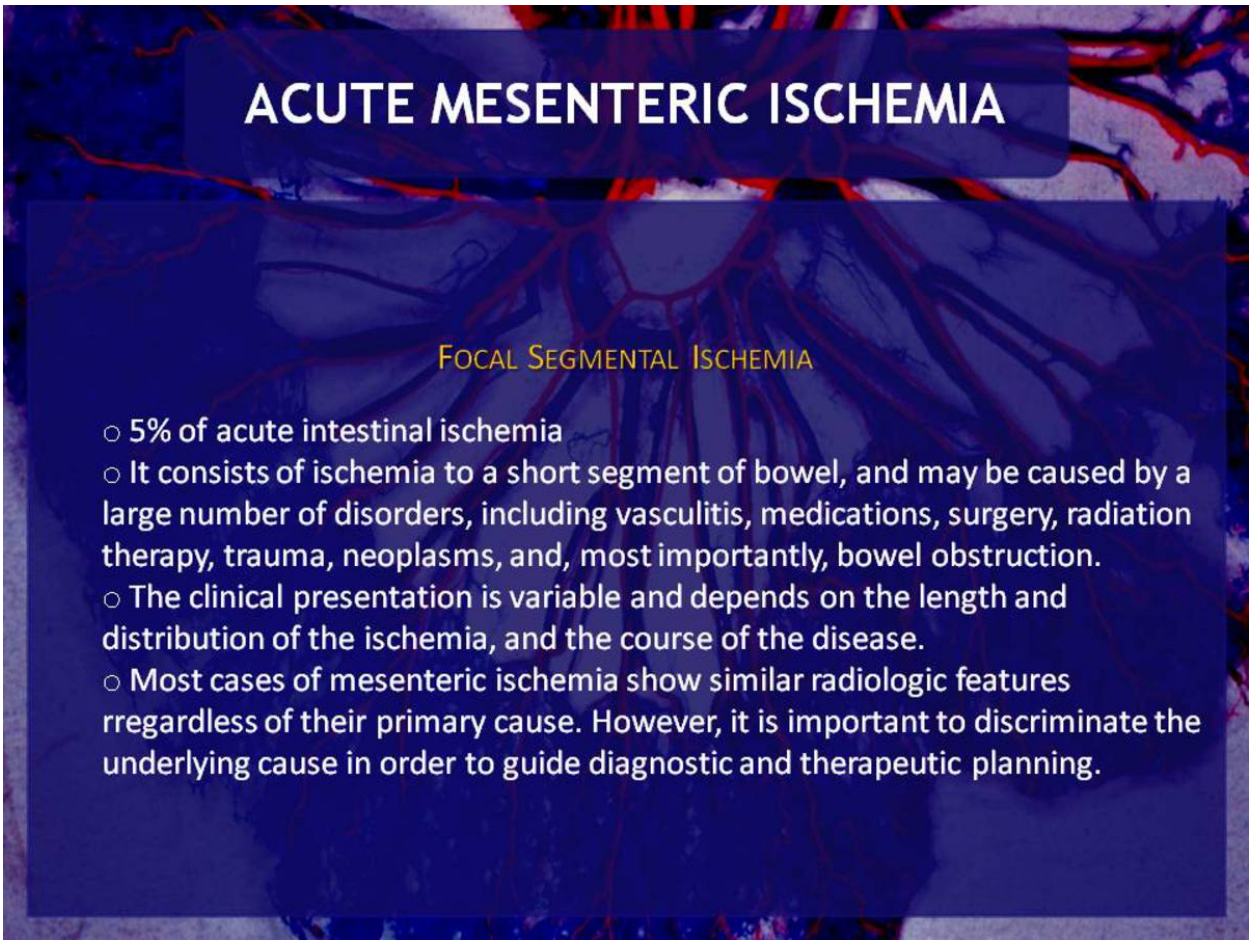

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

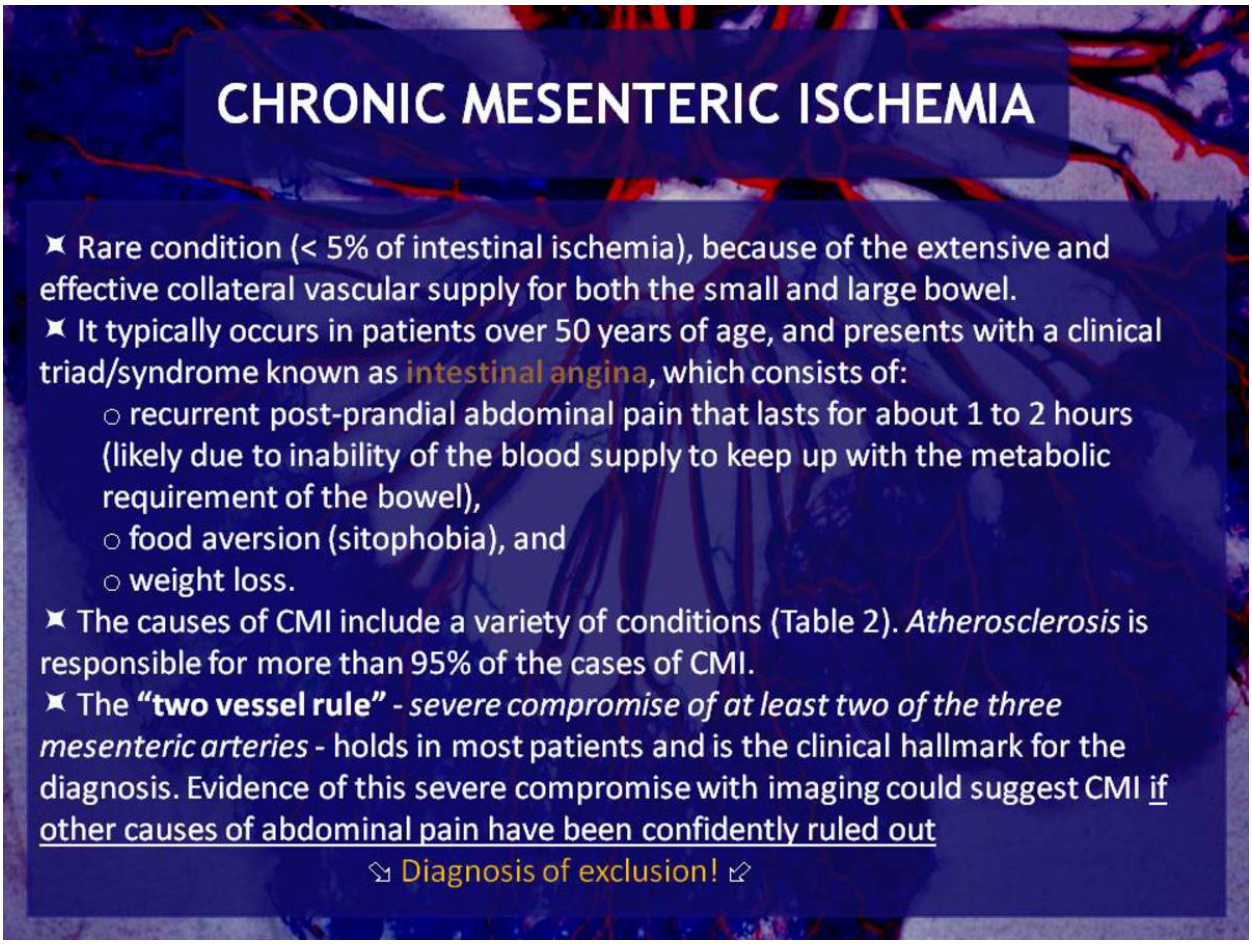

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

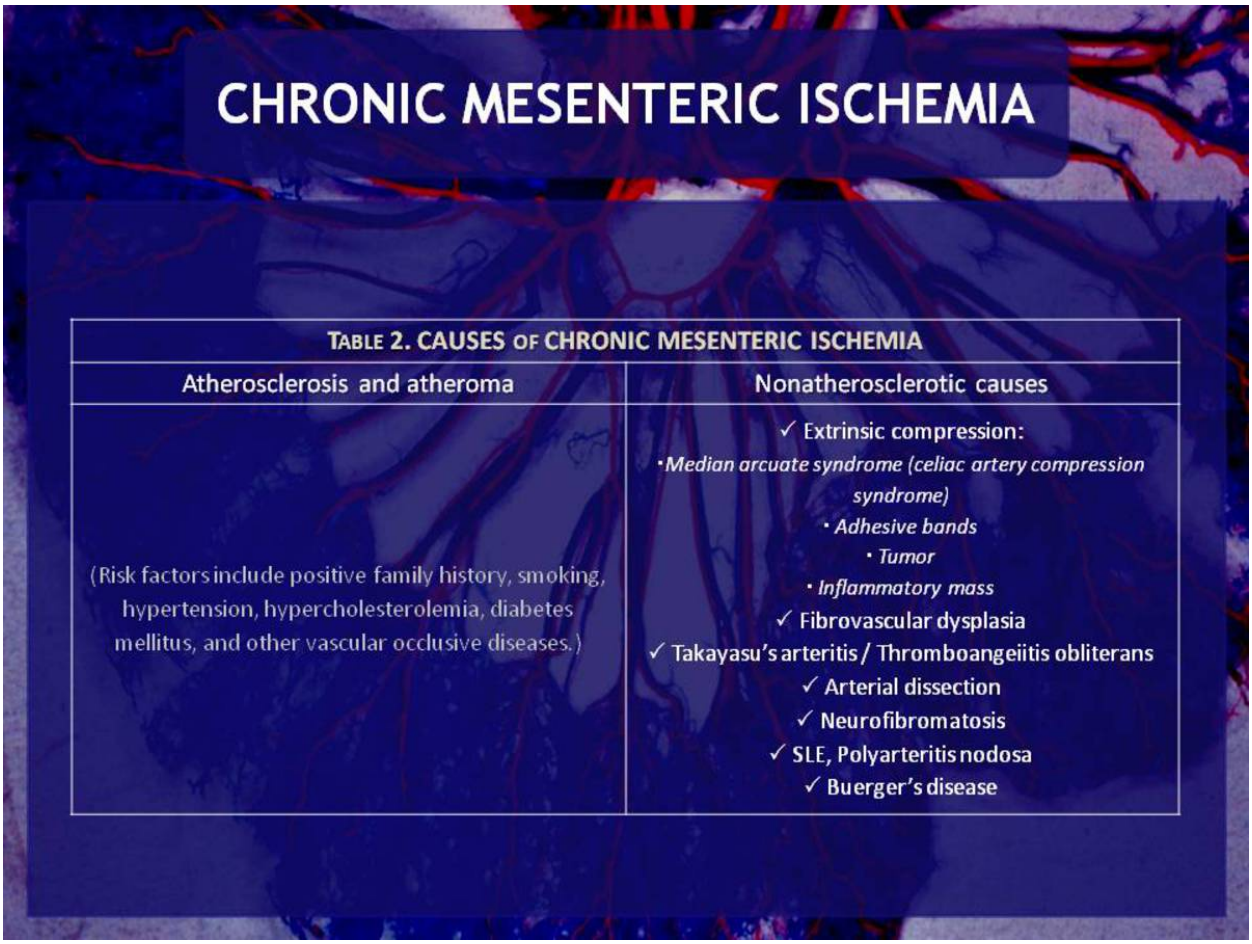

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

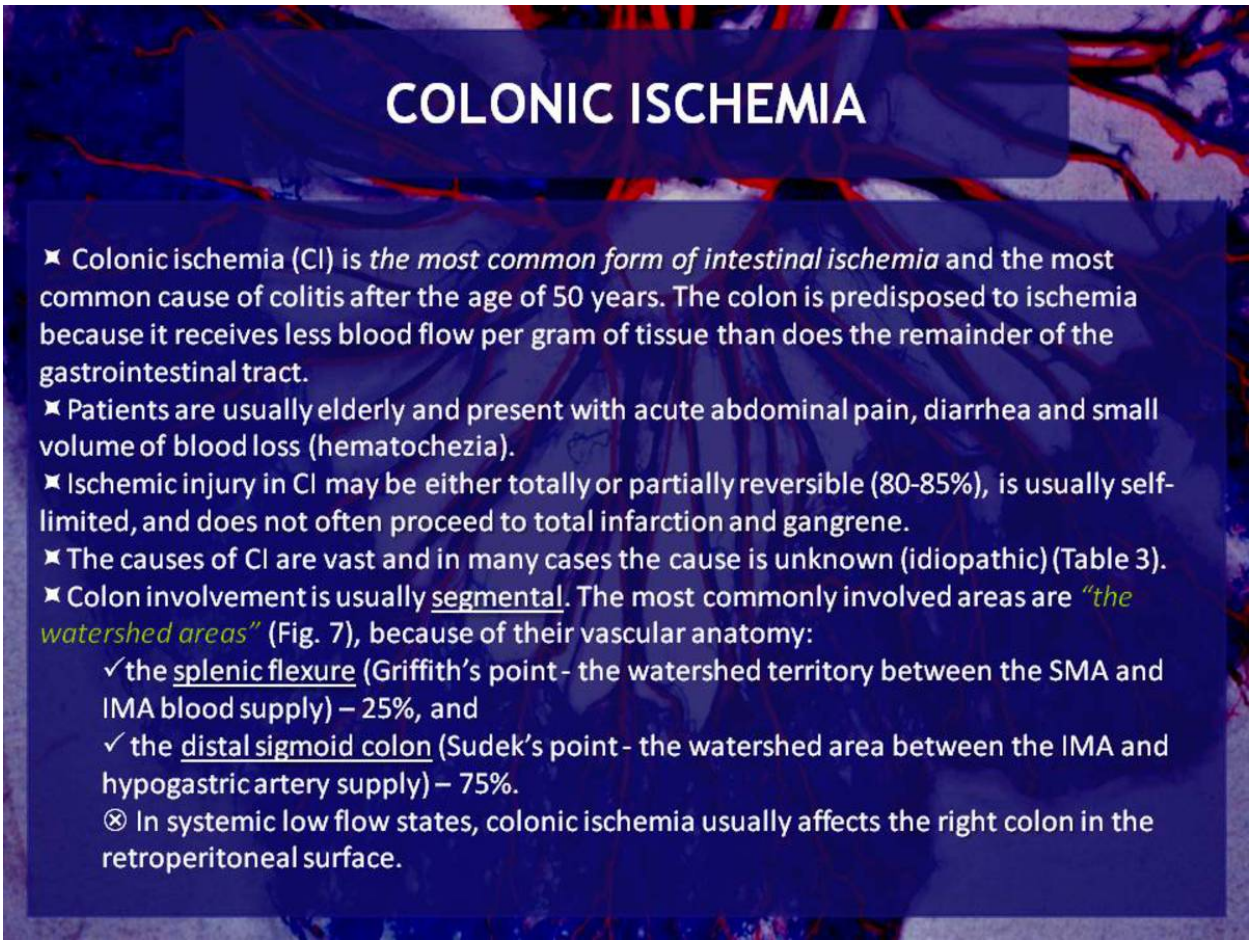

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

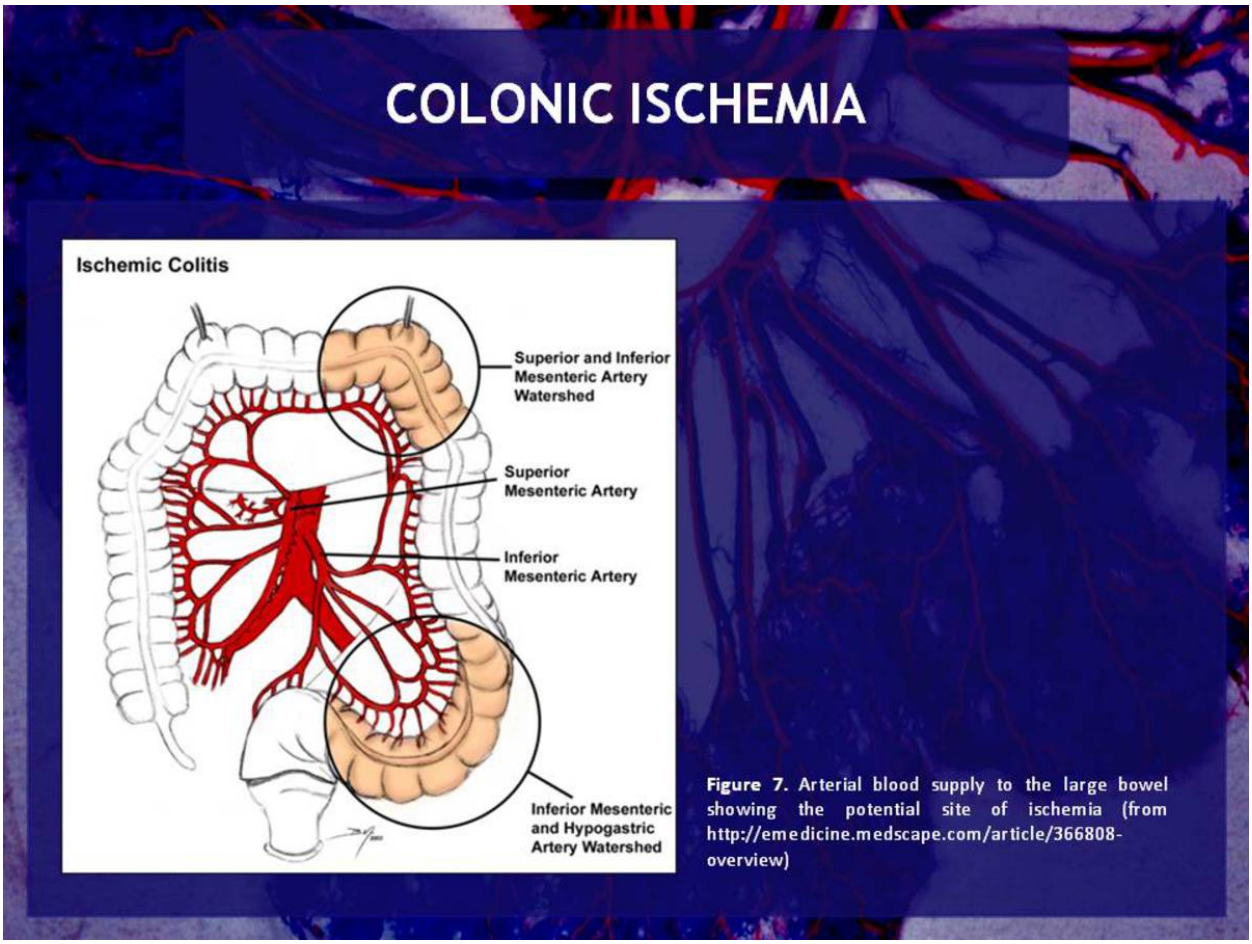

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

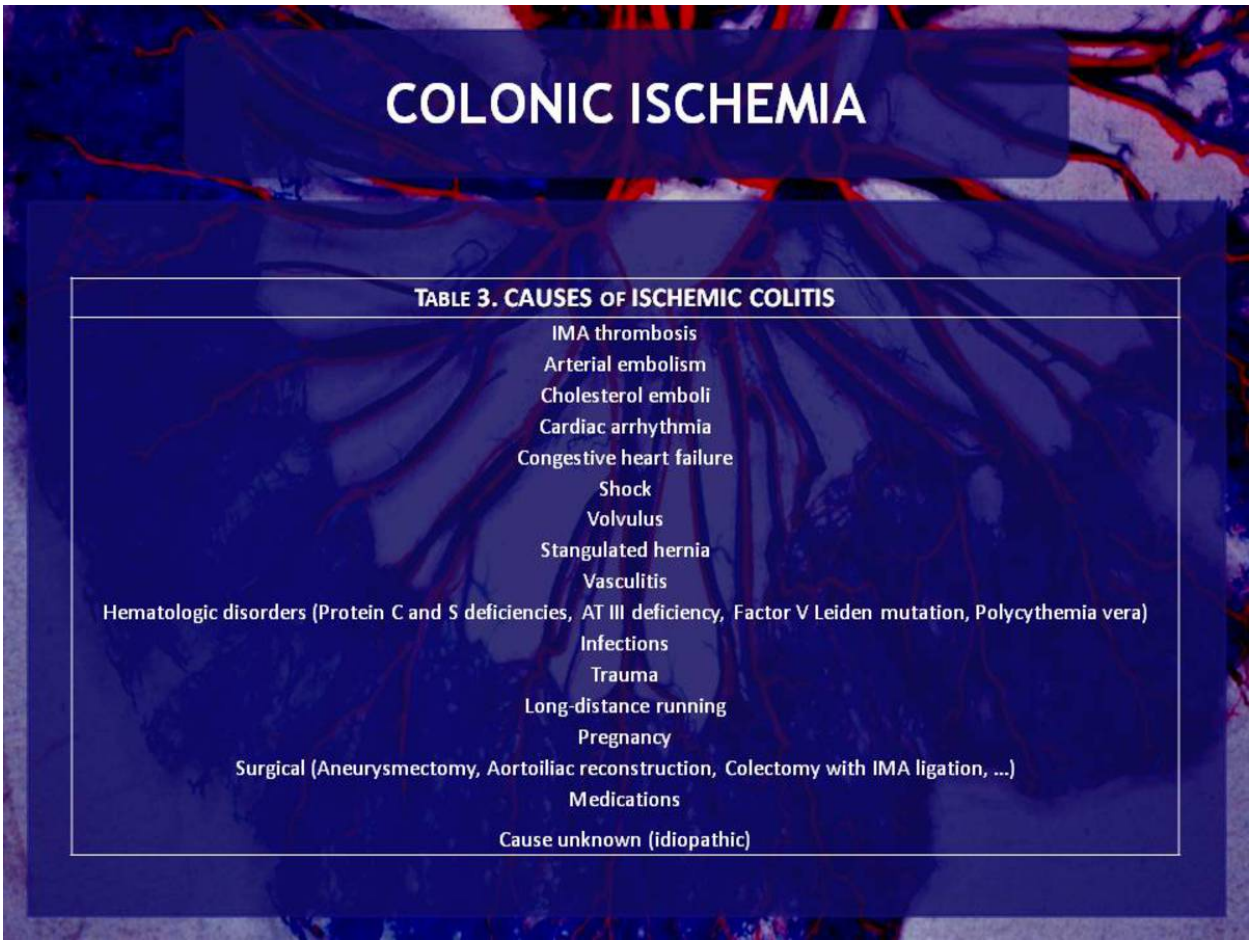

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

Images for this section:

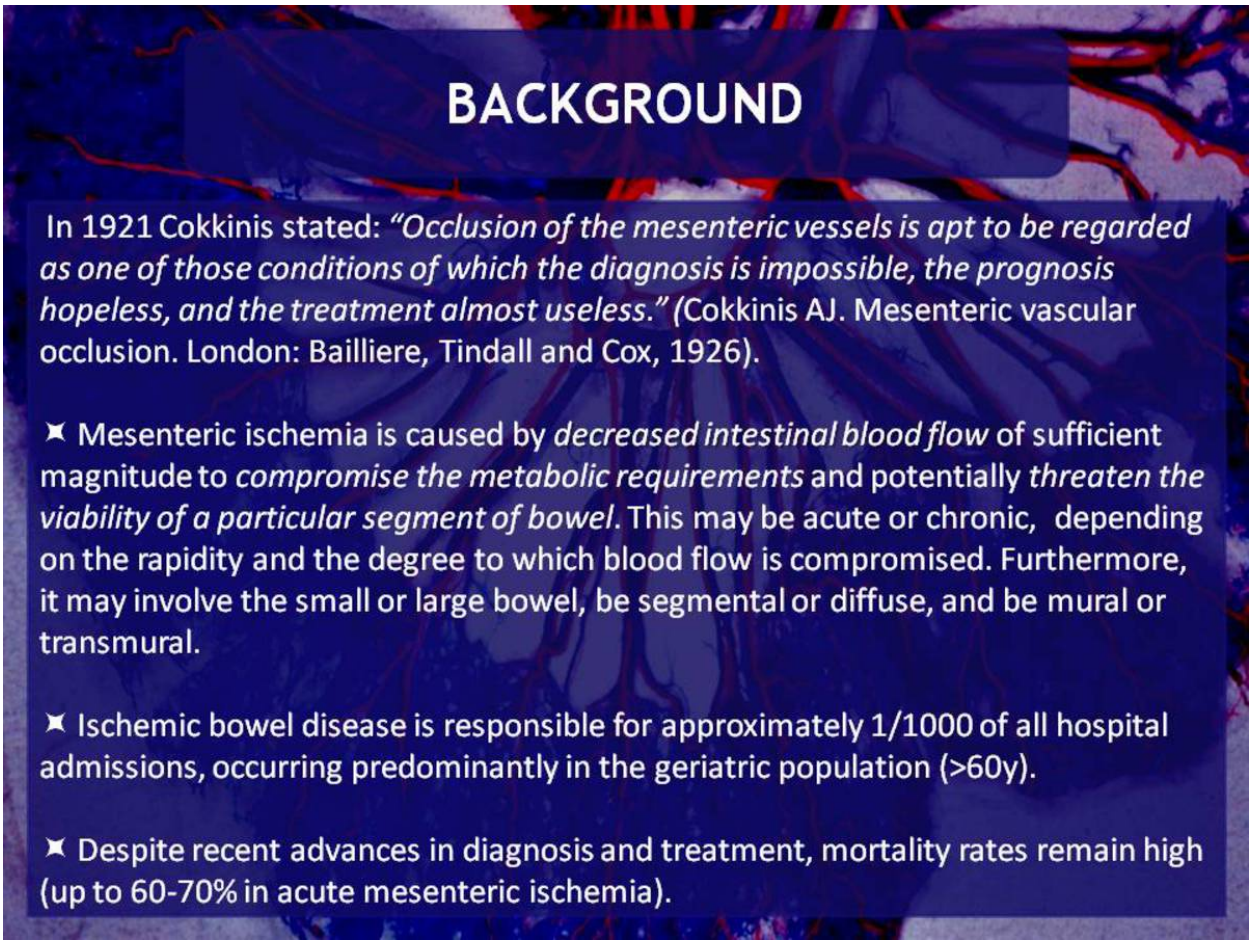
BACKGROUND
In 1921 Cokkinis stated: "Occlusion of the mesenteric vessels is apt to be regarded as one of those conditions of which the diagnosis is impossible, the prognosis hopeless, and the treatment almost useless." (Cokkinis AJ. Mesenteric vascular occlusion. London: Bailliere, Tindall and Cox, 1926).
Mesenteric ischemia is caused by decreased intestinal blood flow of sufficient magnitude to compromise the metabolic requirements and potentially threaten the viability of a particular segment of bowel. This may be acute or chronic, depending on the rapidity and the degree to which blood flow is compromised. Furthermore, it may involve the small or large bowel, be segmental or diffuse, and be mural or transmural.
Ischemic bowel disease is responsible for approximately 1/1000 of all hospital admissions, occurring predominantly in the geriatric population (>60y).
Despite recent advances in diagnosis and treatment, mortality rates remain high (up to 60-70% in acute mesenteric ischemia).

Fig. 1

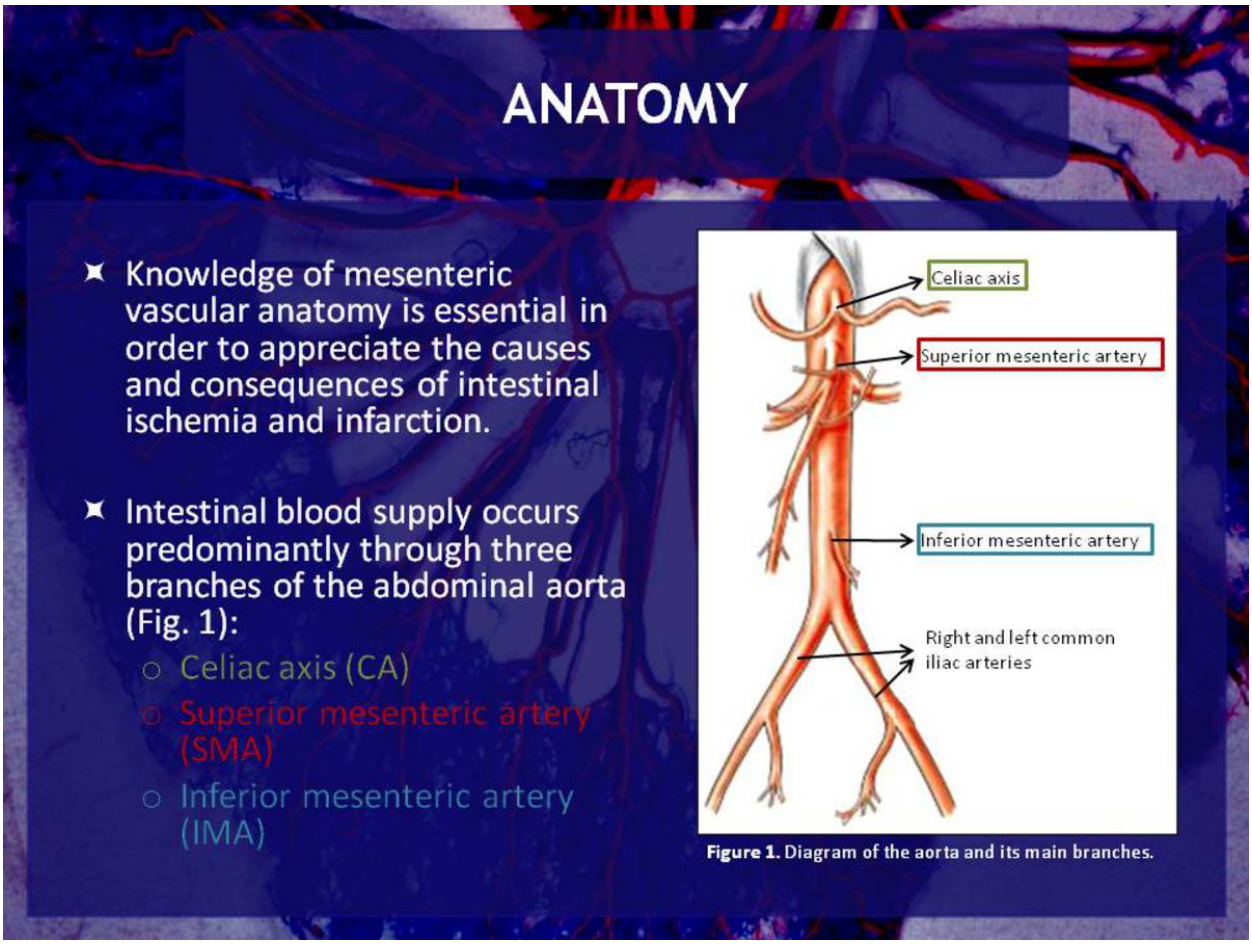
ANATOMY
Knowledge of mesenteric vascular anatomy is essential in order to appreciate the causes and consequences of intestinal ischemia and infarction.
Intestinal blood supply occurs predominantly through three branches of the abdominal aorta (Fig. 1):
Celiac axis (CA)
Superior mesenteric artery (SMA)
Inferior mesenteric artery (IMA)
Celiac axis
Superior mesenteric artery
Inferior mesenteric artery
Right and left common iliac arteries
Figure 1. Diagram of the aorta and its main branches.

Fig. 2

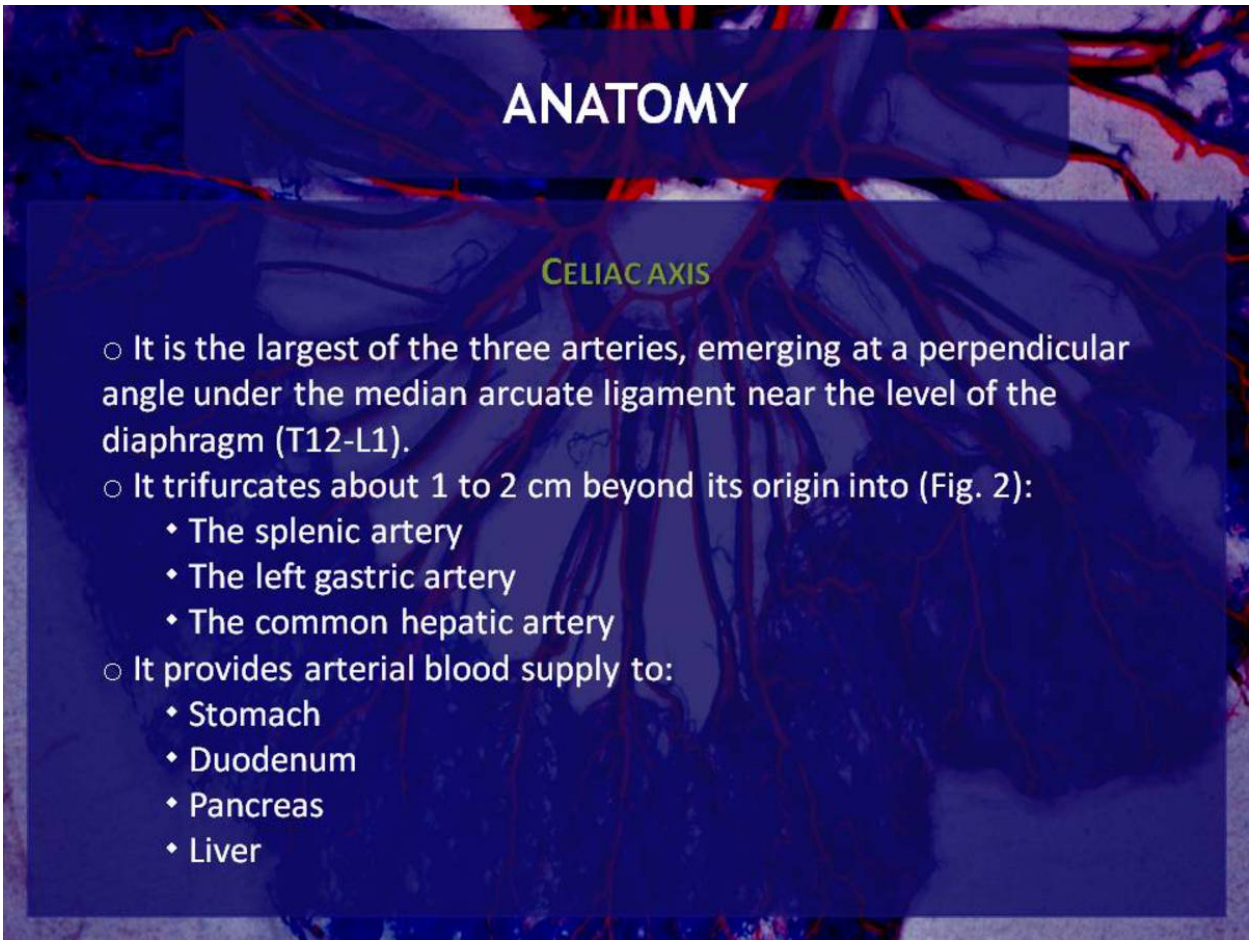
ANATOMY
CELIAC AXIS
It is the largest of the three arteries, emerging at a perpendicular angle under the median arcuate ligament near the level of the diaphragm (T12-L1).
It trifurcates about 1 to 2 cm beyond its origin into (Fig. 2):
The splenic artery
The left gastric artery
The common hepatic artery
It provides arterial blood supply to:
Stomach
Duodenum
Pancreas
Liver

Fig. 3

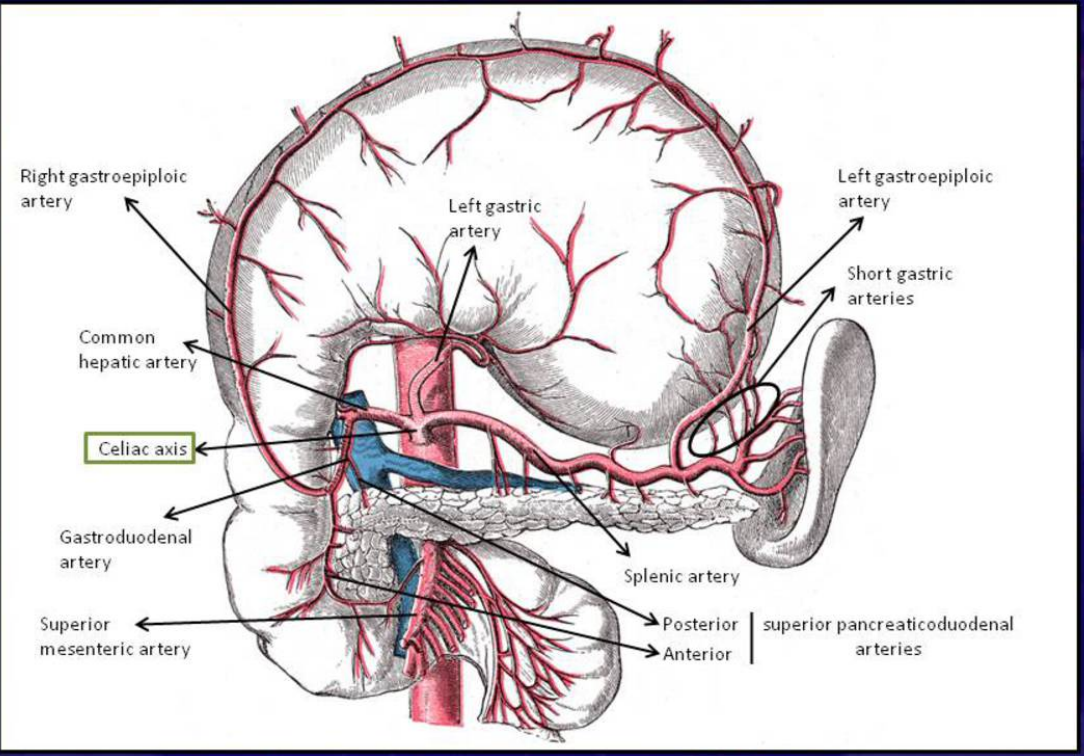

Figure 2. Schematic illustration of the typical celiac trunk anatomy (adapted from *Gray's Anatomy* through www.wikipedia.com; public domain).

Fig. 4

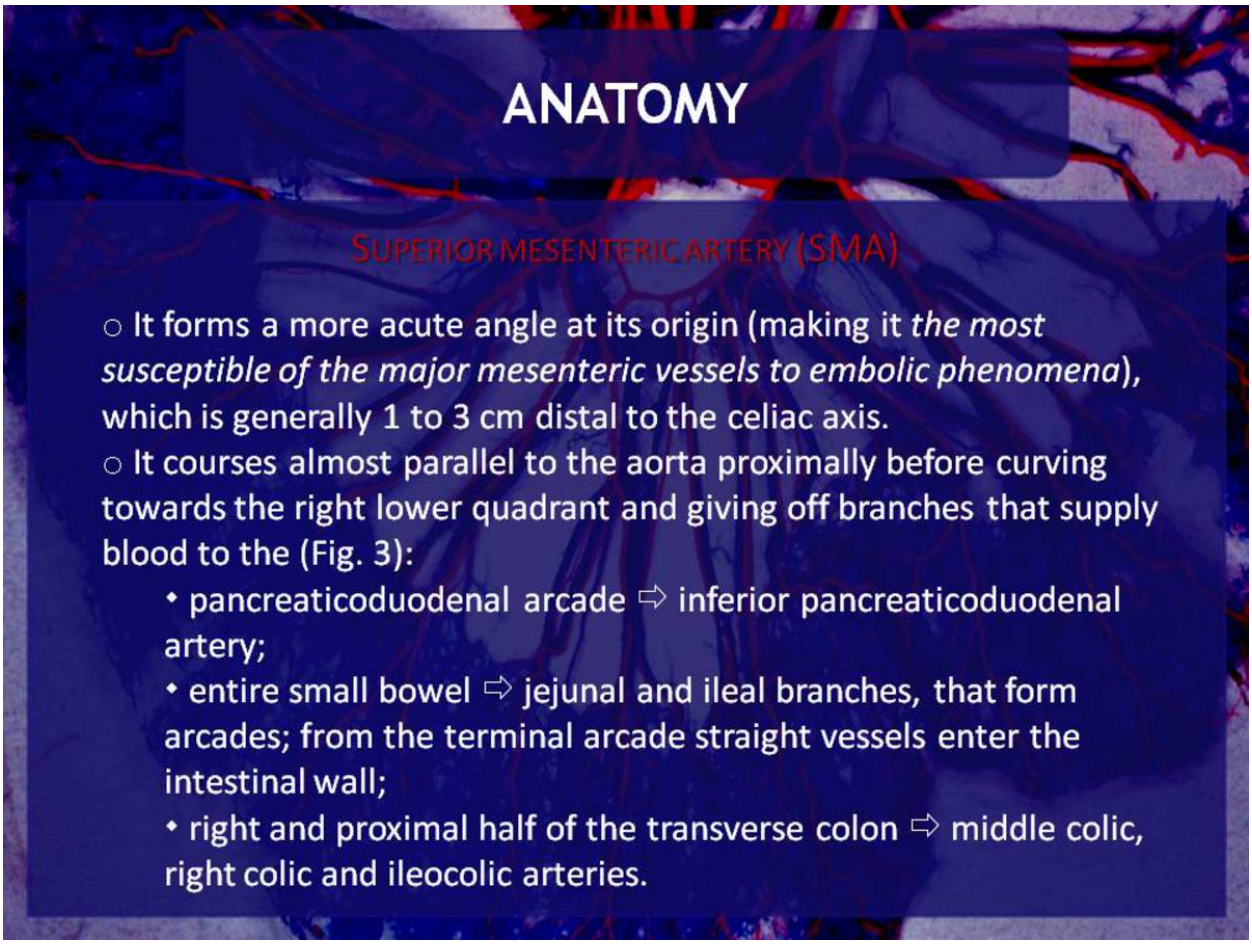
ANATOMY
SUPERIOR MESENTERIC ARTERY (SMA)
○ It forms a more acute angle at its origin (making it *the most susceptible of the major mesenteric vessels to embolic phenomena*), which is generally 1 to 3 cm distal to the celiac axis.
○ It courses almost parallel to the aorta proximally before curving towards the right lower quadrant and giving off branches that supply blood to the (Fig. 3):
• pancreaticoduodenal arcade ⇨ inferior pancreaticoduodenal artery;
• entire small bowel ⇨ jejunal and ileal branches, that form arcades; from the terminal arcade straight vessels enter the intestinal wall;
• right and proximal half of the transverse colon ⇨ middle colic, right colic and ileocolic arteries.

Fig. 5

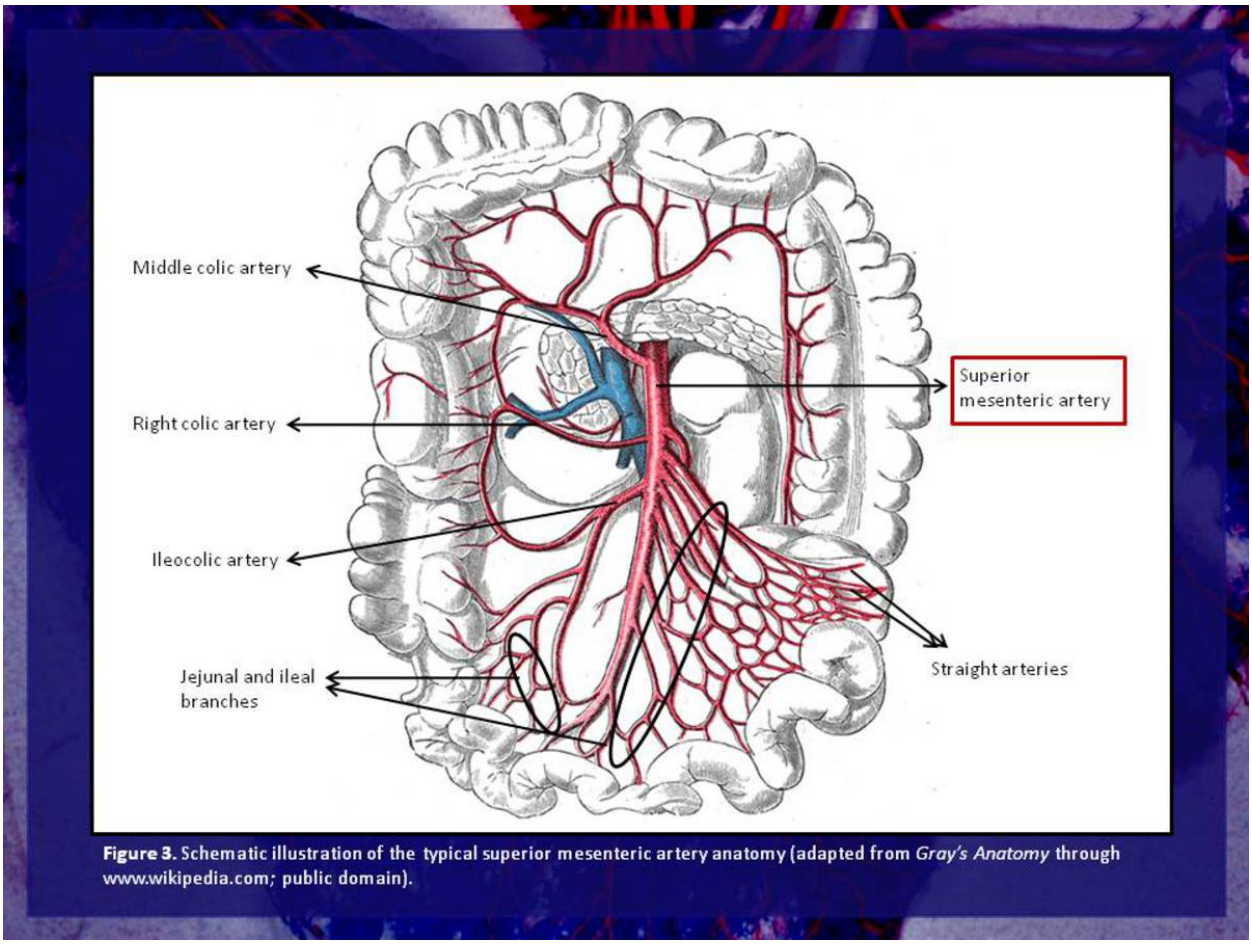

Figure 3. Schematic illustration of the typical superior mesenteric artery anatomy (adapted from *Gray's Anatomy* through www.wikipedia.com; public domain).

Fig. 6

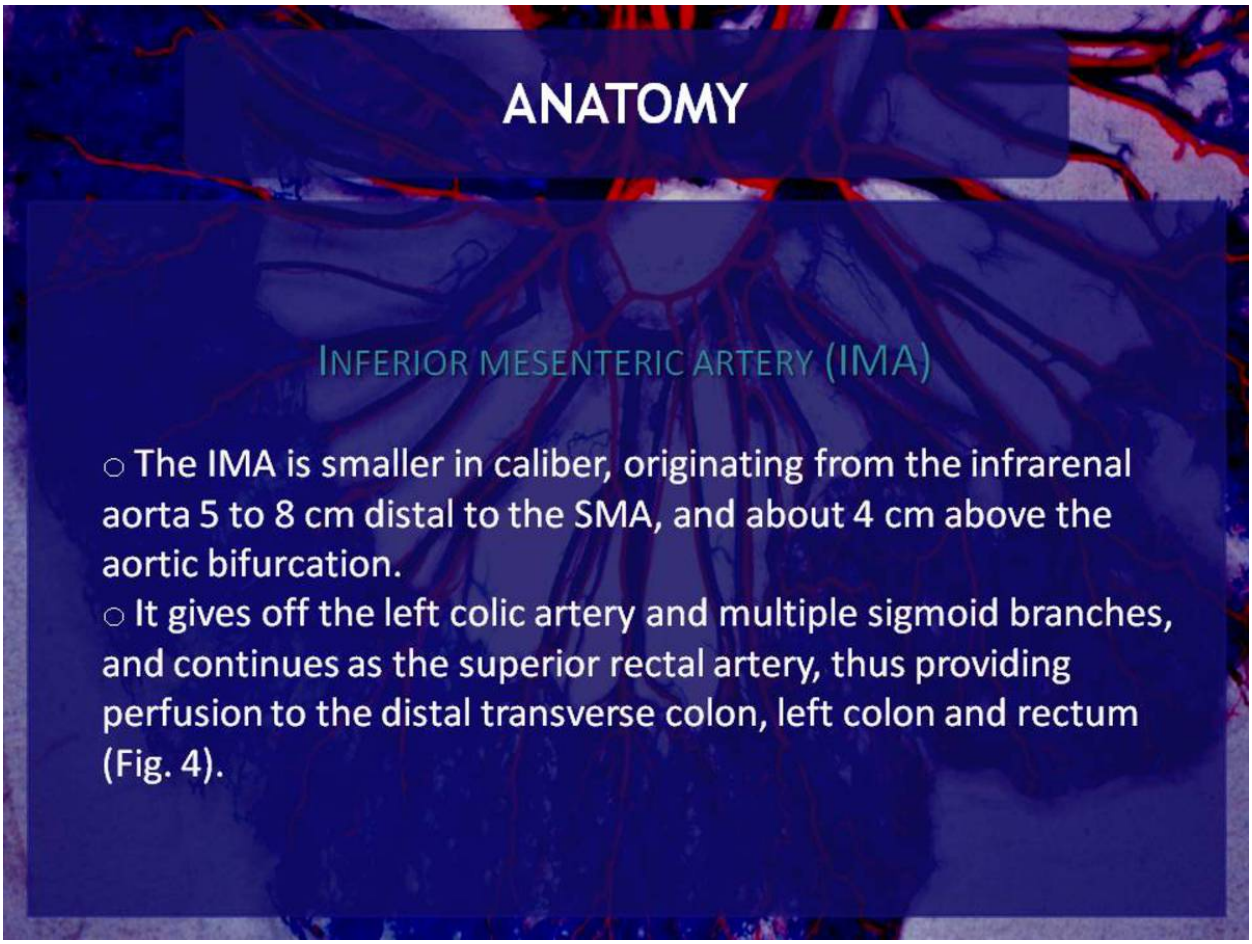
ANATOMY
INFERIOR MESENTERIC ARTERY (IMA)
The IMA is smaller in caliber, originating from the infrarenal aorta 5 to 8 cm distal to the SMA, and about 4 cm above the aortic bifurcation.
It gives off the left colic artery and multiple sigmoid branches, and continues as the superior rectal artery, thus providing perfusion to the distal transverse colon, left colon and rectum (Fig. 4).

Fig. 7

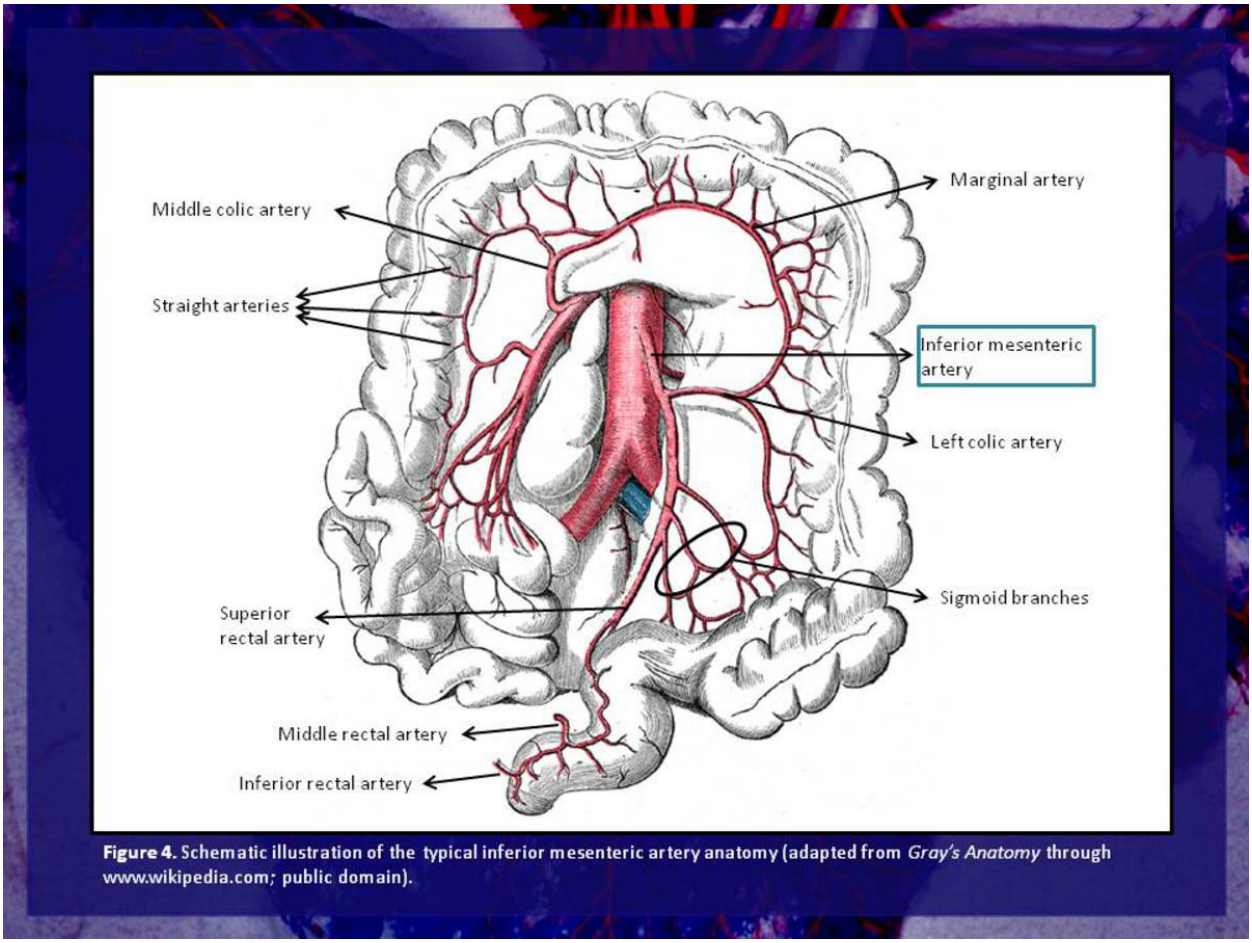

Figure 4. Schematic illustration of the typical inferior mesenteric artery anatomy (adapted from *Gray's Anatomy* through www.wikipedia.com; public domain).

Fig. 8

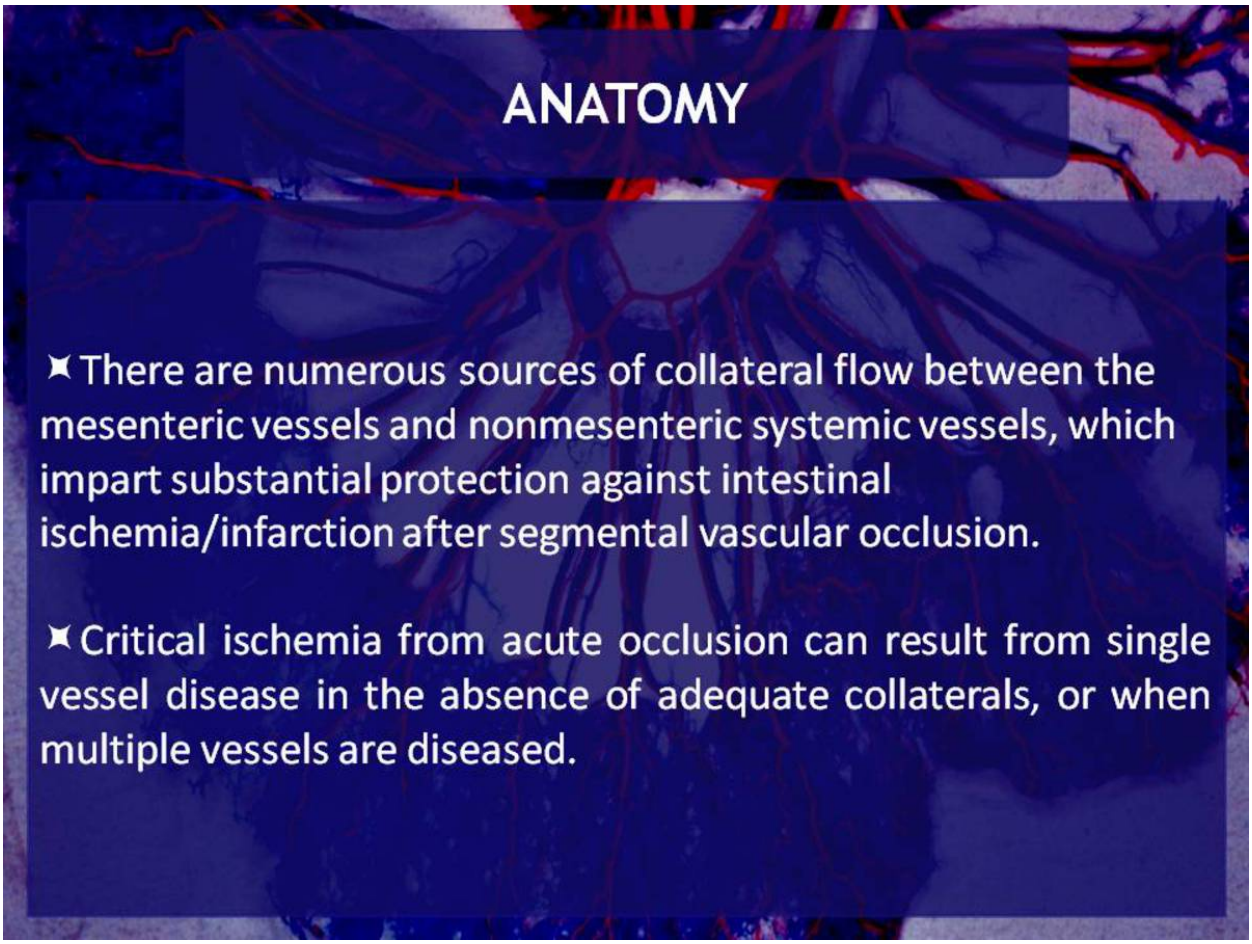
ANATOMY
There are numerous sources of collateral flow between the mesenteric vessels and nonmesenteric systemic vessels, which impart substantial protection against intestinal ischemia/infarction after segmental vascular occlusion.
Critical ischemia from acute occlusion can result from single vessel disease in the absence of adequate collaterals, or when multiple vessels are diseased.

Fig. 9

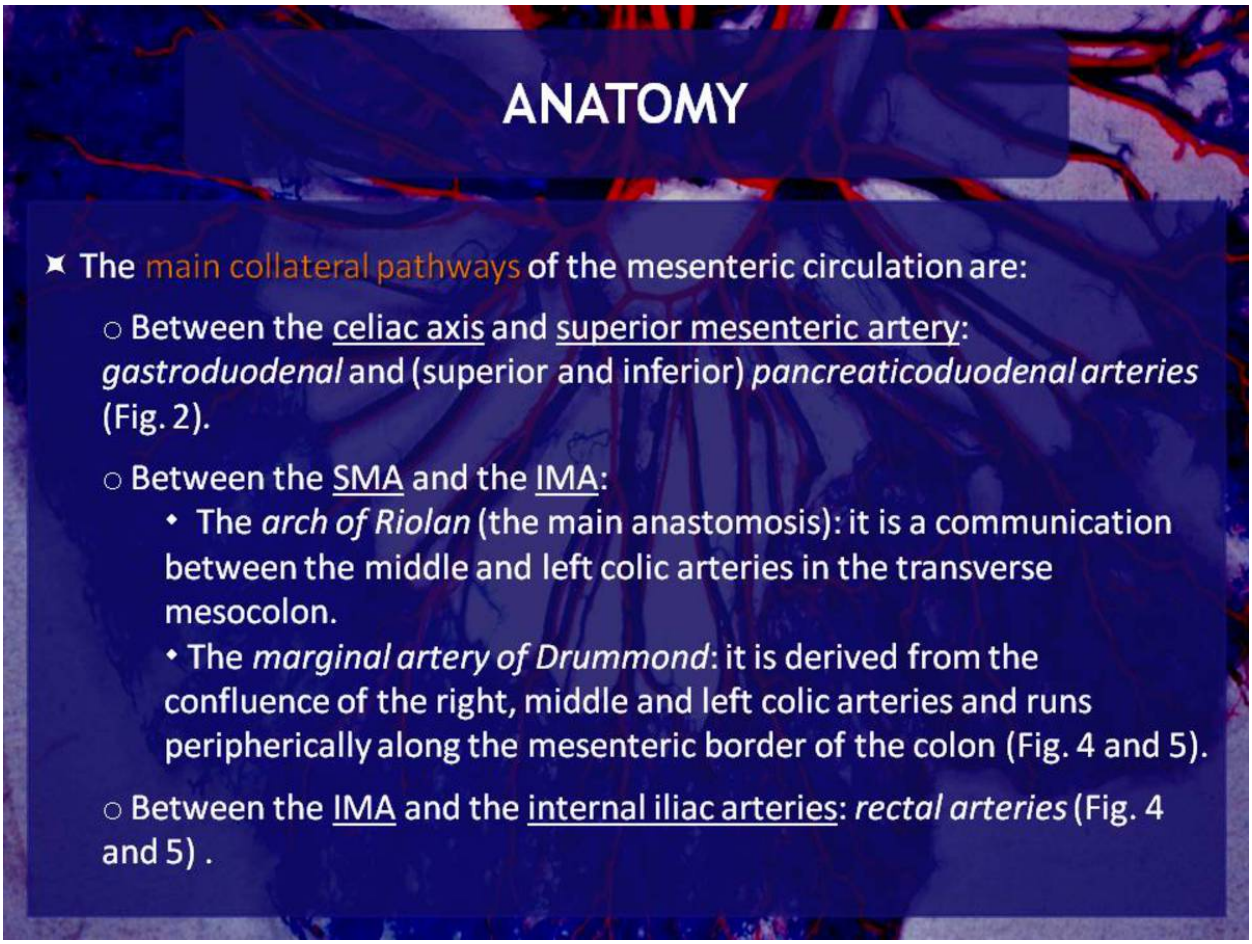
ANATOMY
The main collateral pathways of the mesenteric circulation are:
Between the celiac axis and superior mesenteric artery: gastroduodenal and (superior and inferior) pancreaticoduodenal arteries (Fig. 2).
Between the SMA and the IMA:
The arch of Riolan (the main anastomosis): it is a communication between the middle and left colic arteries in the transverse mesocolon.
The marginal artery of Drummond: it is derived from the confluence of the right, middle and left colic arteries and runs peripherically along the mesenteric border of the colon (Fig. 4 and 5).
Between the IMA and the internal iliac arteries: rectal arteries (Fig. 4 and 5) .

Fig. 10

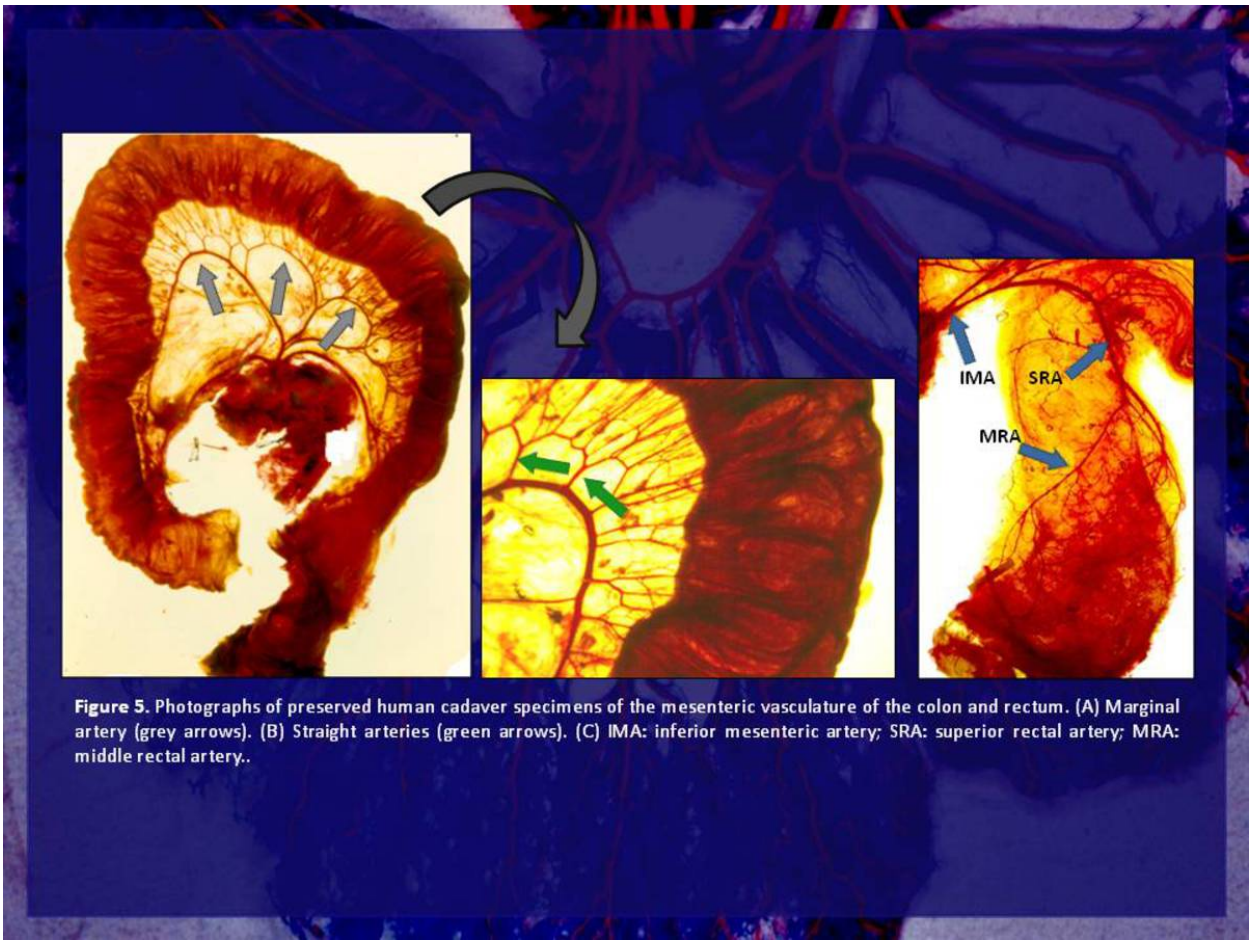

Figure 5. Photographs of preserved human cadaver specimens of the mesenteric vasculature of the colon and rectum. (A) Marginal artery (grey arrows). (B) Straight arteries (green arrows). (C) IMA: inferior mesenteric artery; SRA: superior rectal artery; MRA: middle rectal artery..

Fig. 11

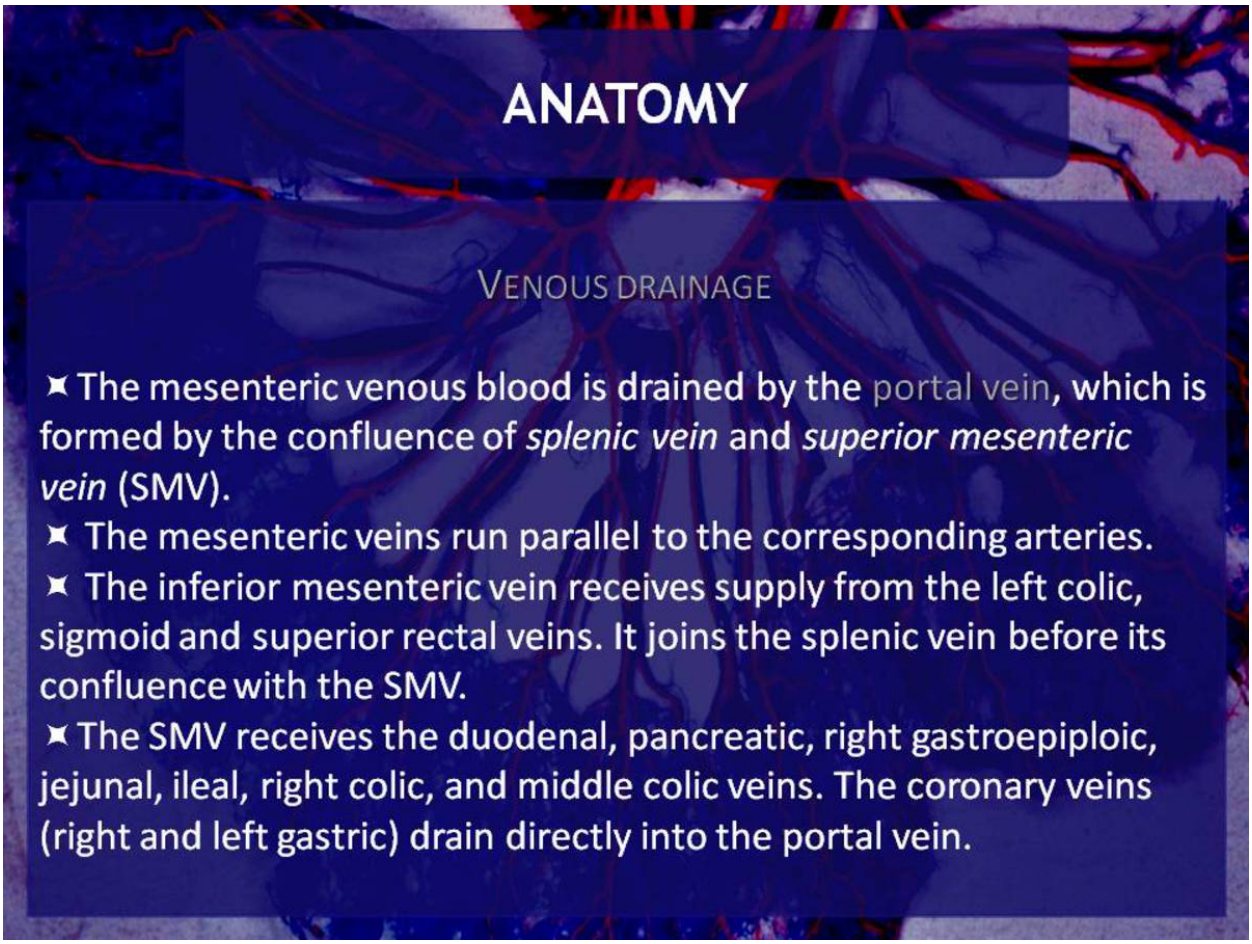
ANATOMY
VENOUS DRAINAGE
The mesenteric venous blood is drained by the portal vein, which is formed by the confluence of splenic vein and superior mesenteric vein (SMV).
The mesenteric veins run parallel to the corresponding arteries.
The inferior mesenteric vein receives supply from the left colic, sigmoid and superior rectal veins. It joins the splenic vein before its confluence with the SMV.
The SMV receives the duodenal, pancreatic, right gastroepiploic, jejunal, ileal, right colic, and middle colic veins. The coronary veins (right and left gastric) drain directly into the portal vein.

Fig. 12

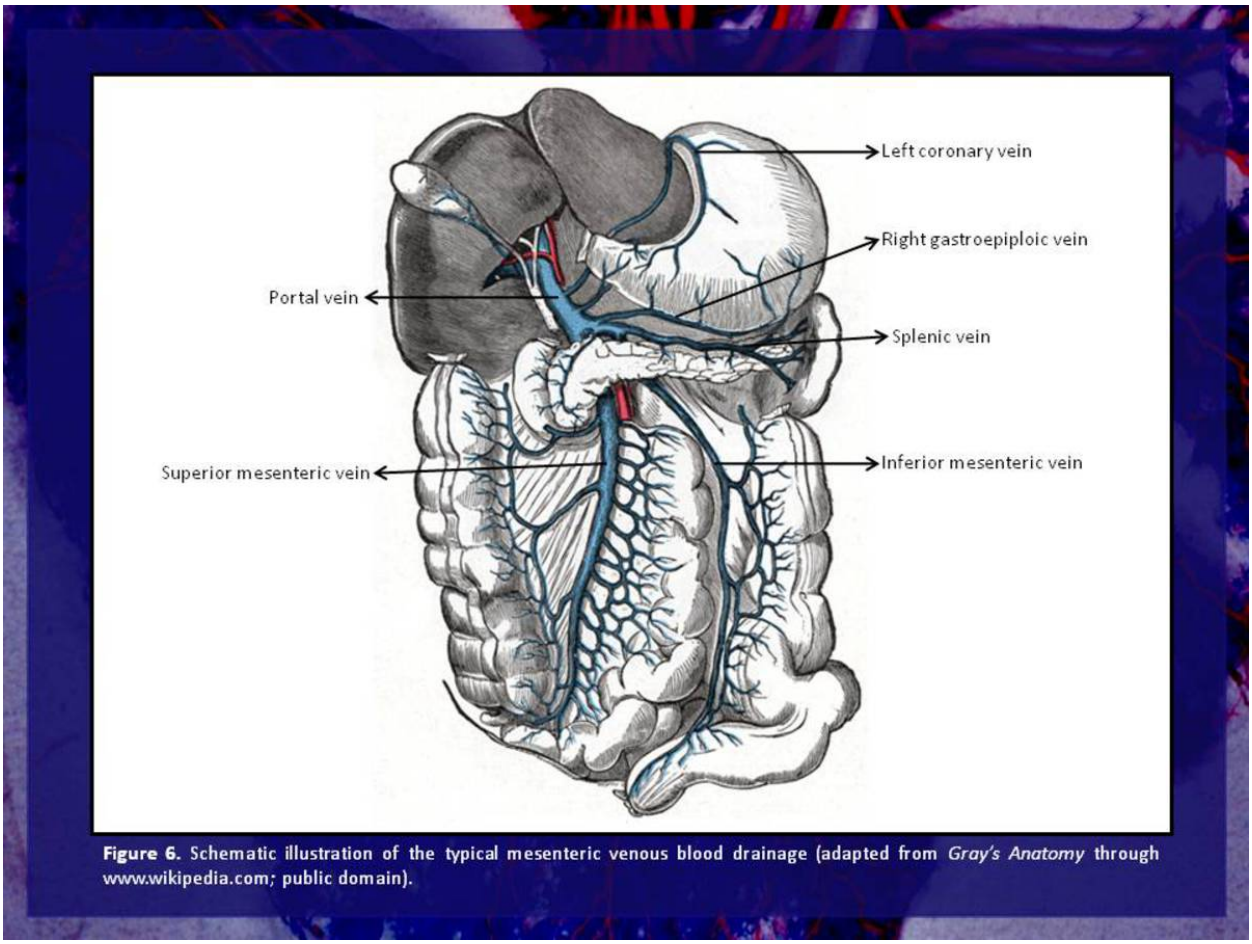

Figure 6. Schematic illustration of the typical mesenteric venous blood drainage (adapted from *Gray's Anatomy* through www.wikipedia.com; public domain).

Fig. 13

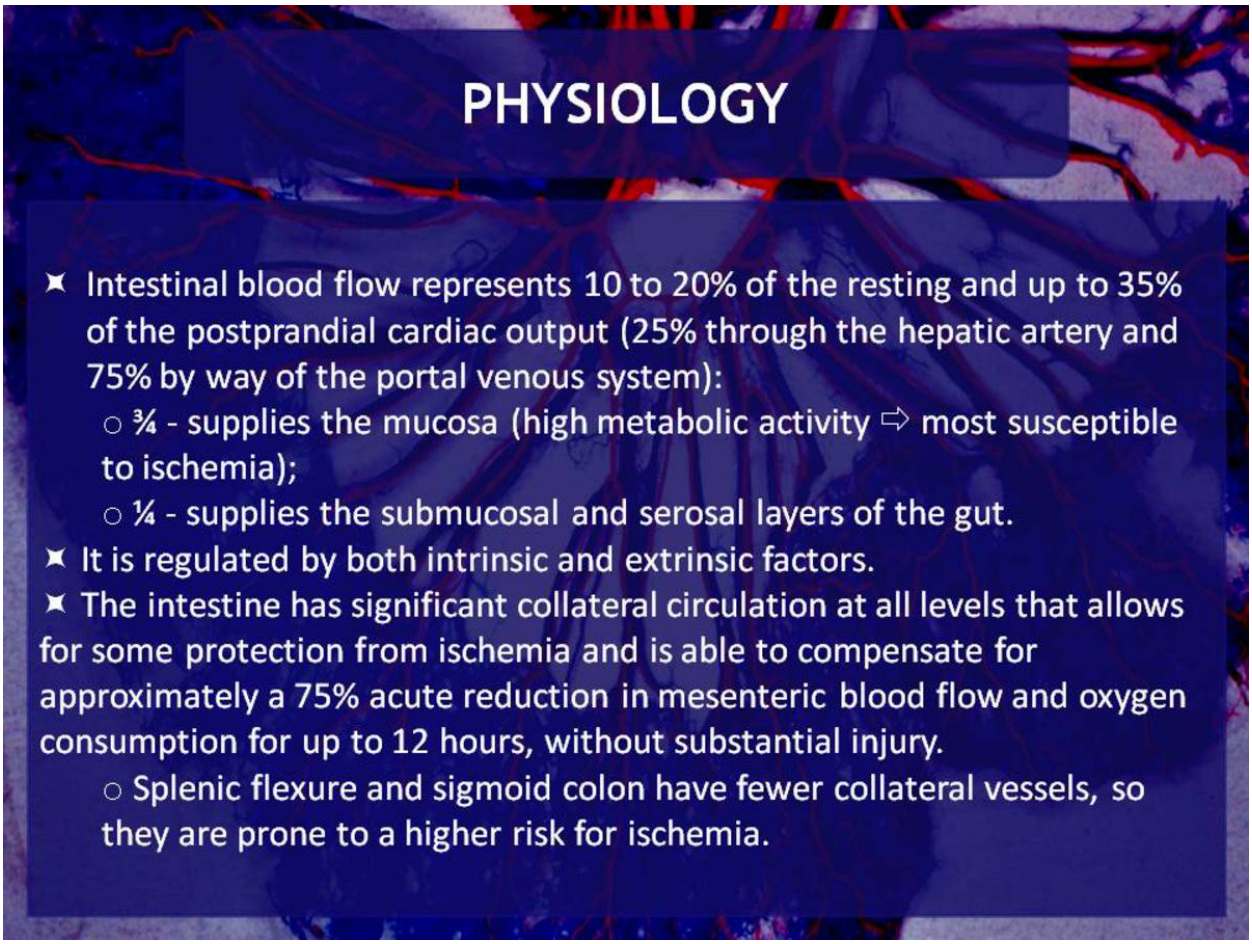
PHYSIOLOGY
Intestinal blood flow represents 10 to 20% of the resting and up to 35% of the postprandial cardiac output (25% through the hepatic artery and 75% by way of the portal venous system):
¾ - supplies the mucosa (high metabolic activity ⇨ most susceptible to ischemia);
¼ - supplies the submucosal and serosal layers of the gut.
It is regulated by both intrinsic and extrinsic factors.
The intestine has significant collateral circulation at all levels that allows for some protection from ischemia and is able to compensate for approximately a 75% acute reduction in mesenteric blood flow and oxygen consumption for up to 12 hours, without substantial injury.
Splenic flexure and sigmoid colon have fewer collateral vessels, so they are prone to a higher risk for ischemia.

Fig. 14

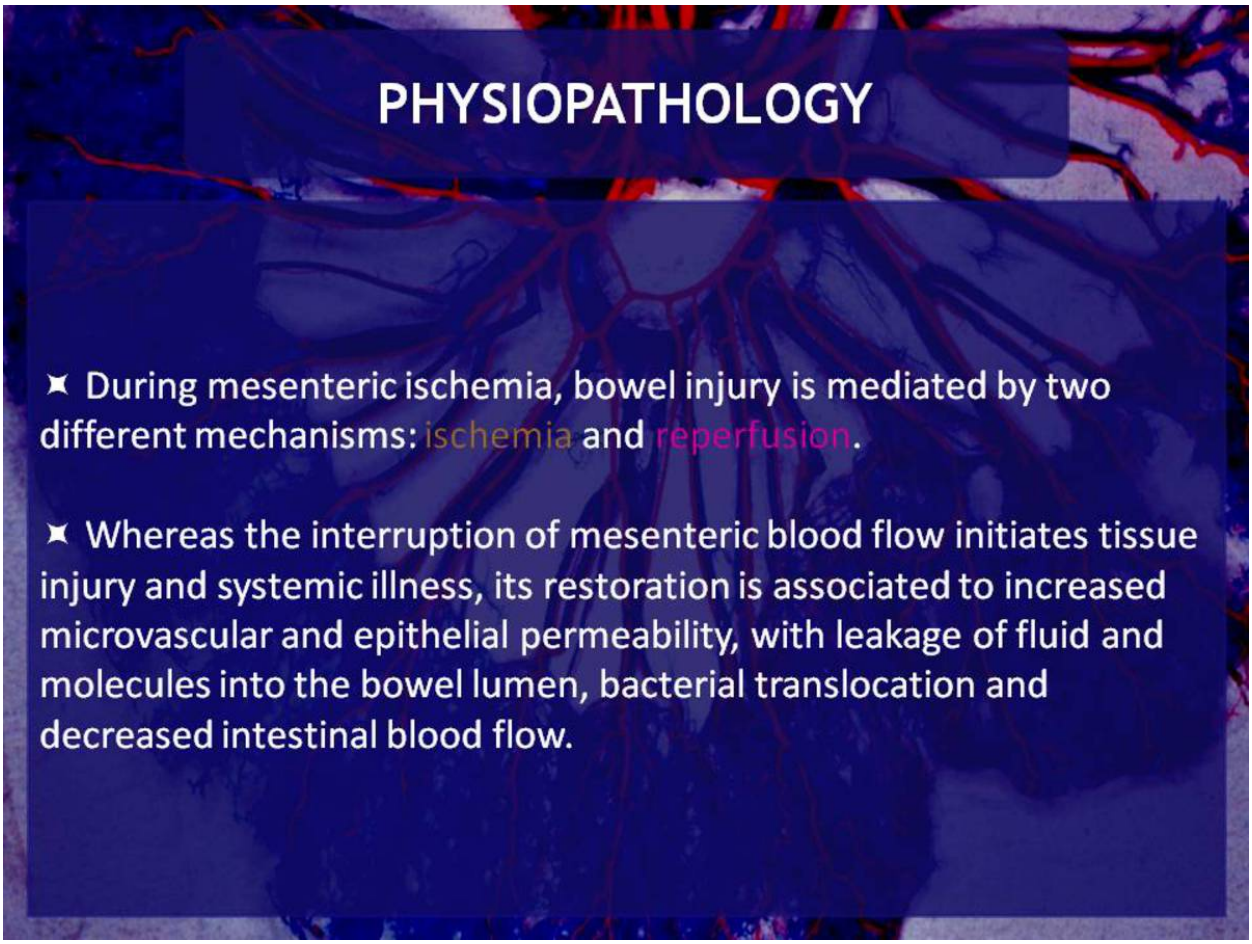
PHYSIOPATHOLOGY
During mesenteric ischemia, bowel injury is mediated by two different mechanisms: ischemia and reperfusion.
Whereas the interruption of mesenteric blood flow initiates tissue injury and systemic illness, its restoration is associated to increased microvascular and epithelial permeability, with leakage of fluid and molecules into the bowel lumen, bacterial translocation and decreased intestinal blood flow.

Fig. 15

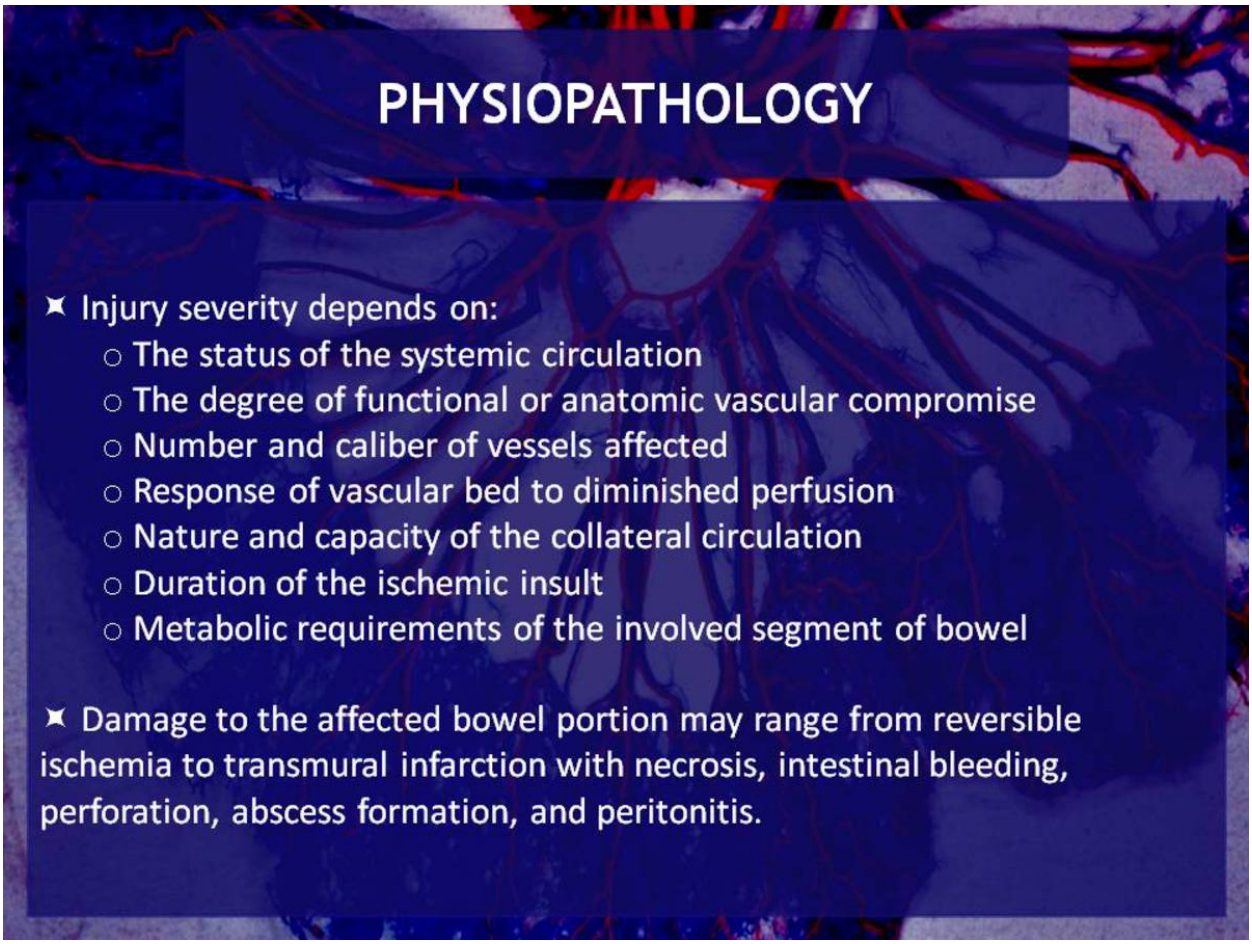
PHYSIOPATHOLOGY
Injury severity depends on:
The status of the systemic circulation
The degree of functional or anatomic vascular compromise
Number and caliber of vessels affected
Response of vascular bed to diminished perfusion
Nature and capacity of the collateral circulation
Duration of the ischemic insult
Metabolic requirements of the involved segment of bowel
Damage to the affected bowel portion may range from reversible ischemia to transmural infarction with necrosis, intestinal bleeding, perforation, abscess formation, and peritonitis.

Fig. 16

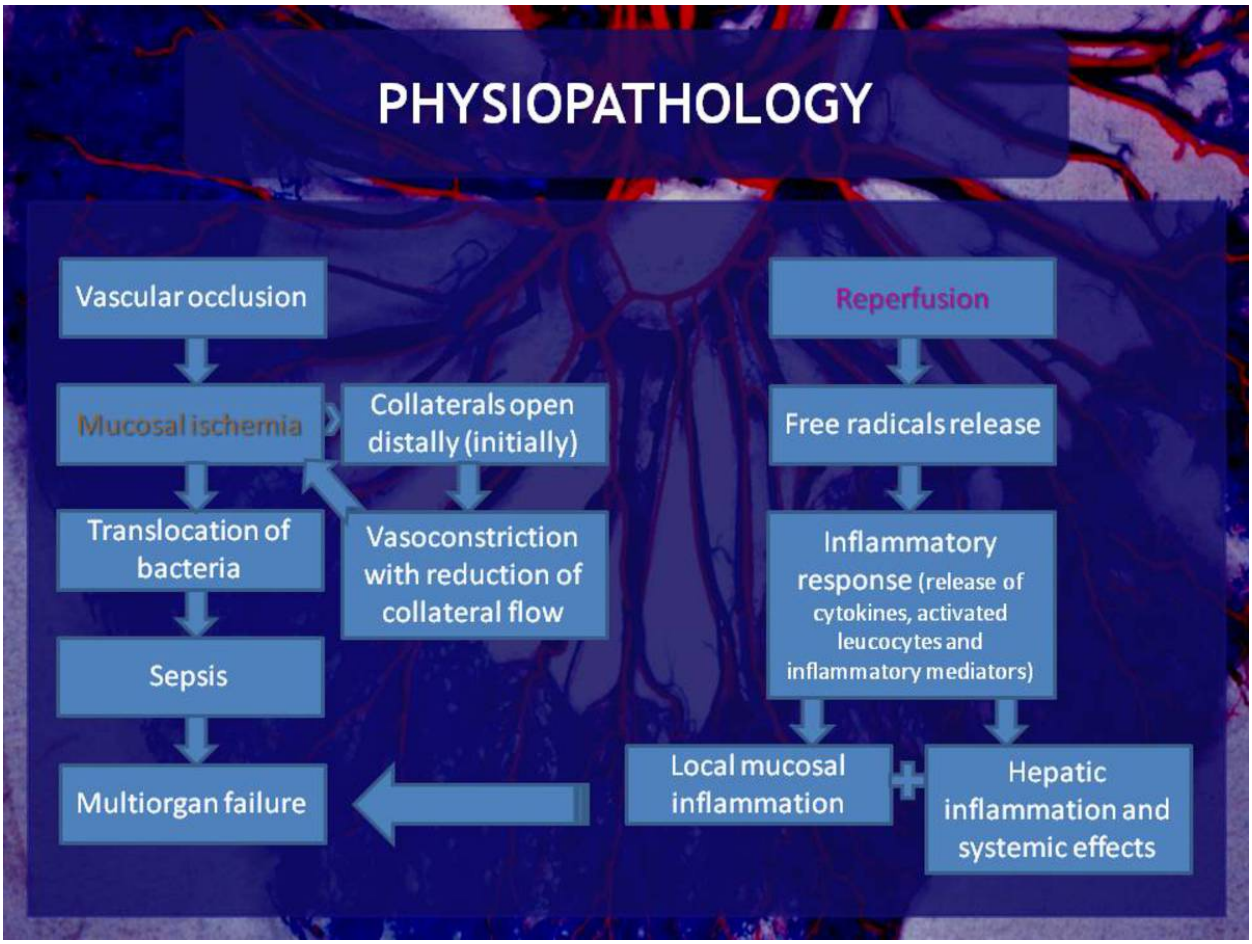
PHYSIOPATHOLOGY
Vascular occlusion
Mucosal ischemia
Collaterals open distally (initially)
Translocation of bacteria
Vasoconstriction with reduction of collateral flow
Sepsis
Multiorgan failure
Reperfusion
Free radicals release
Inflammatory response (release of cytokines, activated leucocytes and inflammatory mediators)
Local mucosal inflammation
Hepatic inflammation and systemic effects

Fig. 17

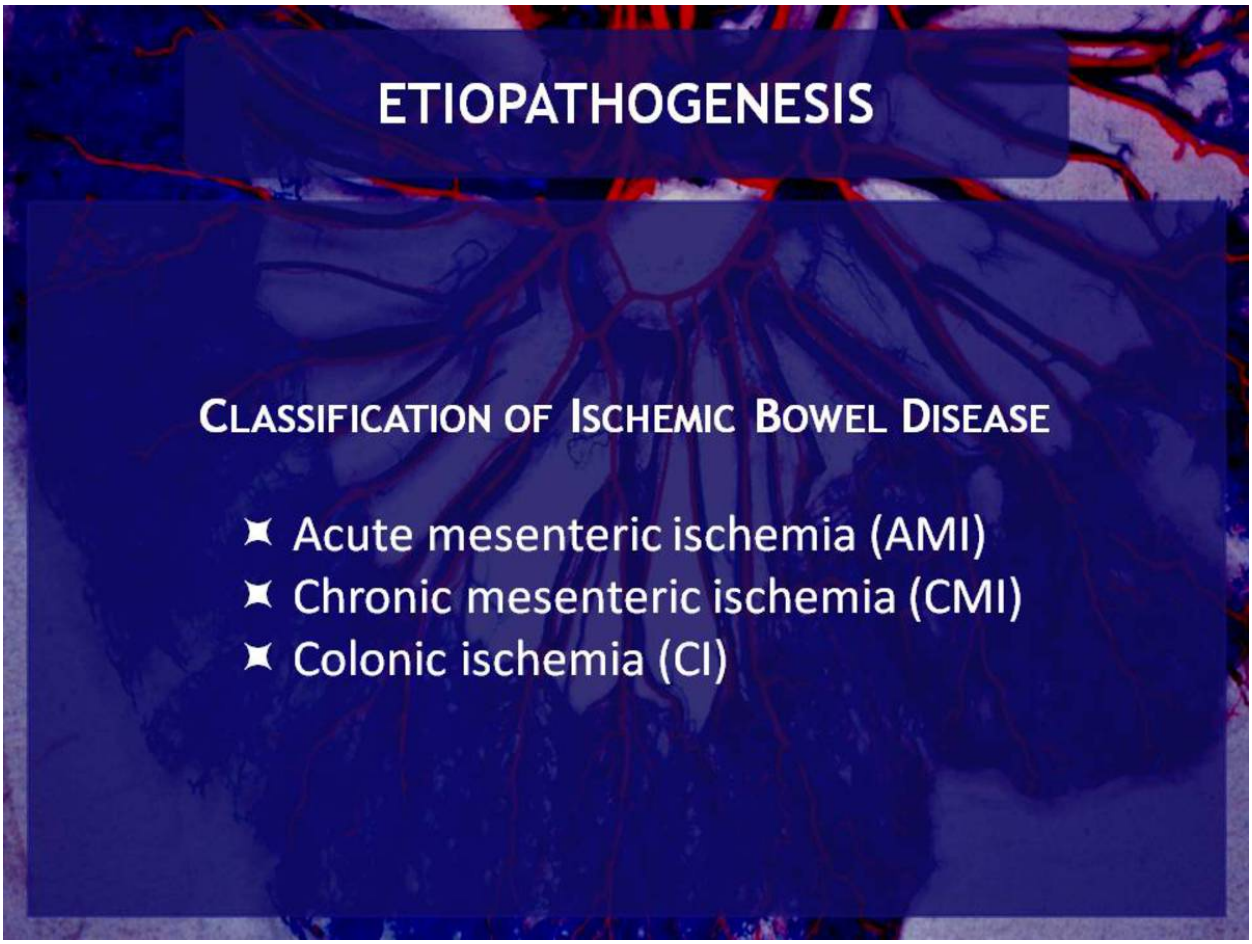
ETIOPATHOGENESIS
CLASSIFICATION OF ISCHEMIC BOWEL DISEASE
Acute mesenteric ischemia (AMI)
Chronic mesenteric ischemia (CMI)
Colonic ischemia (CI)

Fig. 18

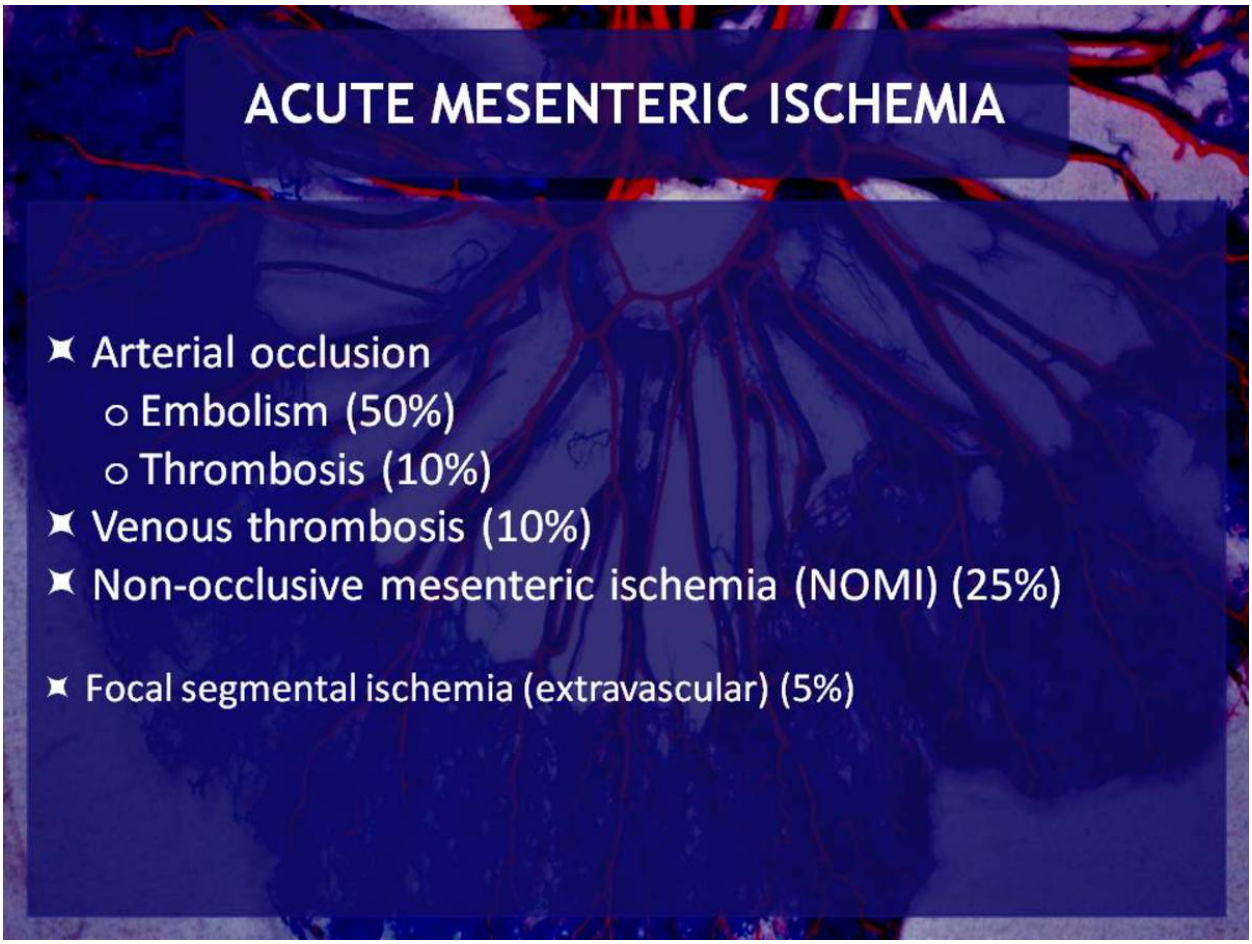
ACUTE MESENTERIC ISCHEMIA
Arterial occlusion
Embolism (50%)
Thrombosis (10%)
Venous thrombosis (10%)
Non-occlusive mesenteric ischemia (NOMI) (25%)
Focal segmental ischemia (extravascular) (5%)

Fig. 19

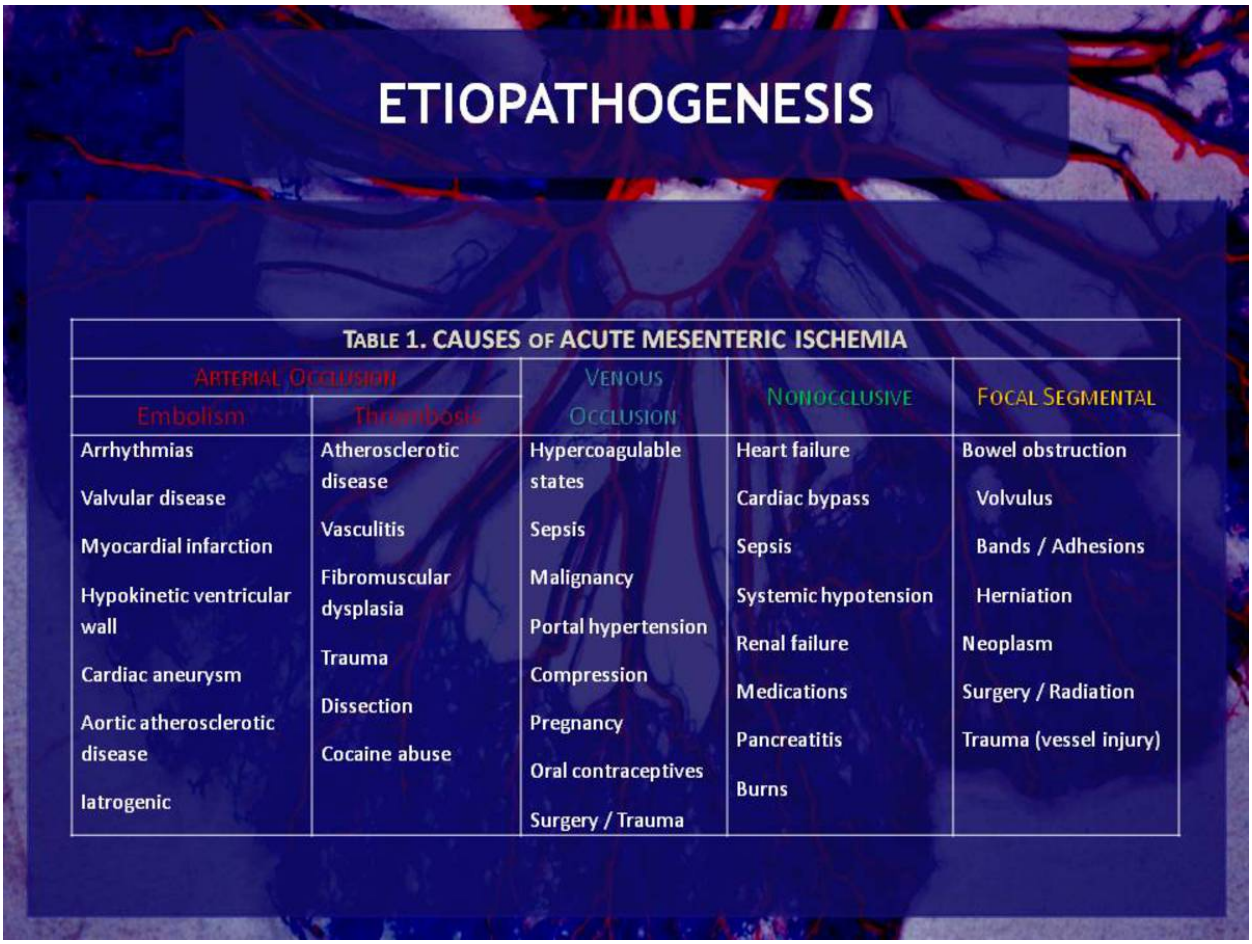
ETIOPATHOGENESIS
TABLE 1. CAUSES OF ACUTE MESENTERIC ISCHEMIA
ARTERIAL OCCLUSION
Embolism
Thrombosis
VENOUS OCCLUSION
NONOCCLUSIVE
FOCAL SEGMENTAL
Arrhythmias
Valvular disease
Myocardial infarction
Hypokinetic ventricular wall
Cardiac aneurysm
Aortic atherosclerotic disease
Iatrogenic
Atherosclerotic disease
Vasculitis
Fibromuscular dysplasia
Trauma
Dissection
Cocaine abuse
Hypercoagulable states
Sepsis
Malignancy
Portal hypertension
Compression
Pregnancy
Oral contraceptives
Surgery / Trauma
Heart failure
Cardiac bypass
Sepsis
Systemic hypotension
Renal failure
Medications
Pancreatitis
Burns
Bowel obstruction
Volvulus
Bands / Adhesions
Herniation
Neoplasm
Surgery / Radiation
Trauma (vessel injury)

Fig. 20

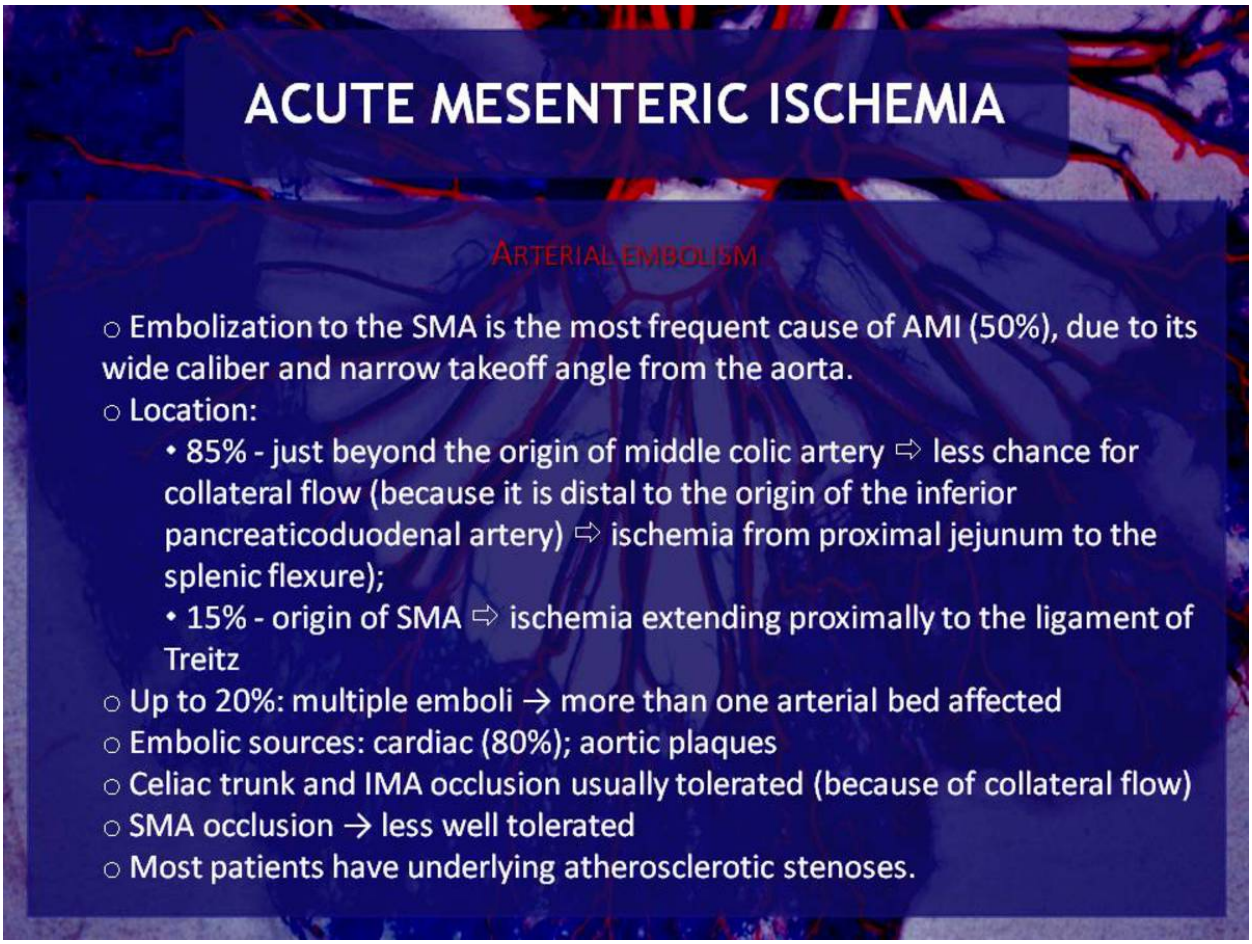
ACUTE MESENTERIC ISCHEMIA
ARTERIAL EMBOLISM
○ Embolization to the SMA is the most frequent cause of AMI (50%), due to its wide caliber and narrow takeoff angle from the aorta.
○ Location:
• 85% - just beyond the origin of middle colic artery ⇨ less chance for collateral flow (because it is distal to the origin of the inferior pancreaticoduodenal artery) ⇨ ischemia from proximal jejunum to the splenic flexure);
• 15% - origin of SMA ⇨ ischemia extending proximally to the ligament of Treitz
○ Up to 20%: multiple emboli → more than one arterial bed affected
○ Embolic sources: cardiac (80%); aortic plaques
○ Celiac trunk and IMA occlusion usually tolerated (because of collateral flow)
○ SMA occlusion → less well tolerated
○ Most patients have underlying atherosclerotic stenoses.

Fig. 21

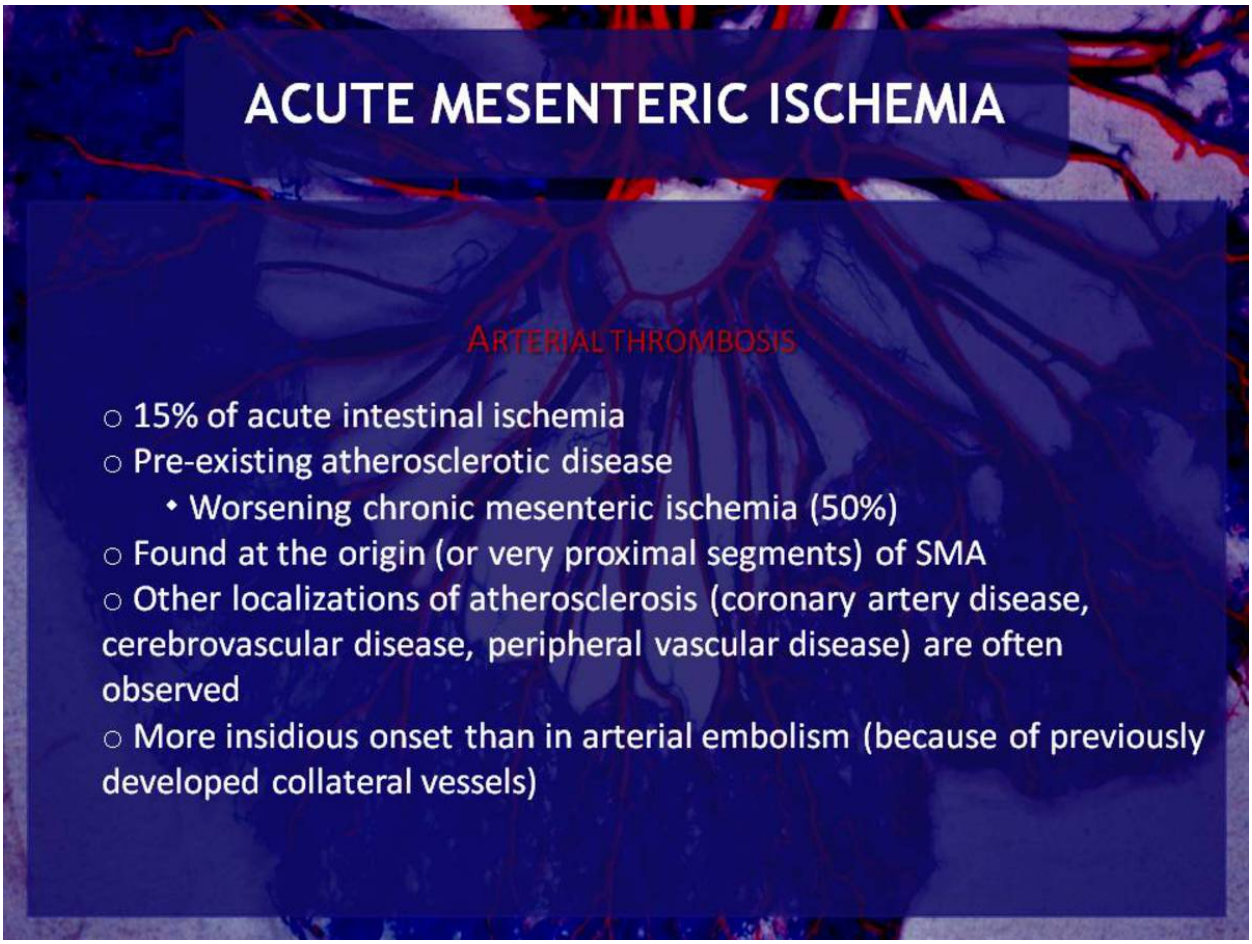
ACUTE MESENTERIC ISCHEMIA
ARTERIAL THROMBOSIS
○ 15% of acute intestinal ischemia
○ Pre-existing atherosclerotic disease
• Worsening chronic mesenteric ischemia (50%)
○ Found at the origin (or very proximal segments) of SMA
○ Other localizations of atherosclerosis (coronary artery disease, cerebrovascular disease, peripheral vascular disease) are often observed
○ More insidious onset than in arterial embolism (because of previously developed collateral vessels)

Fig. 22

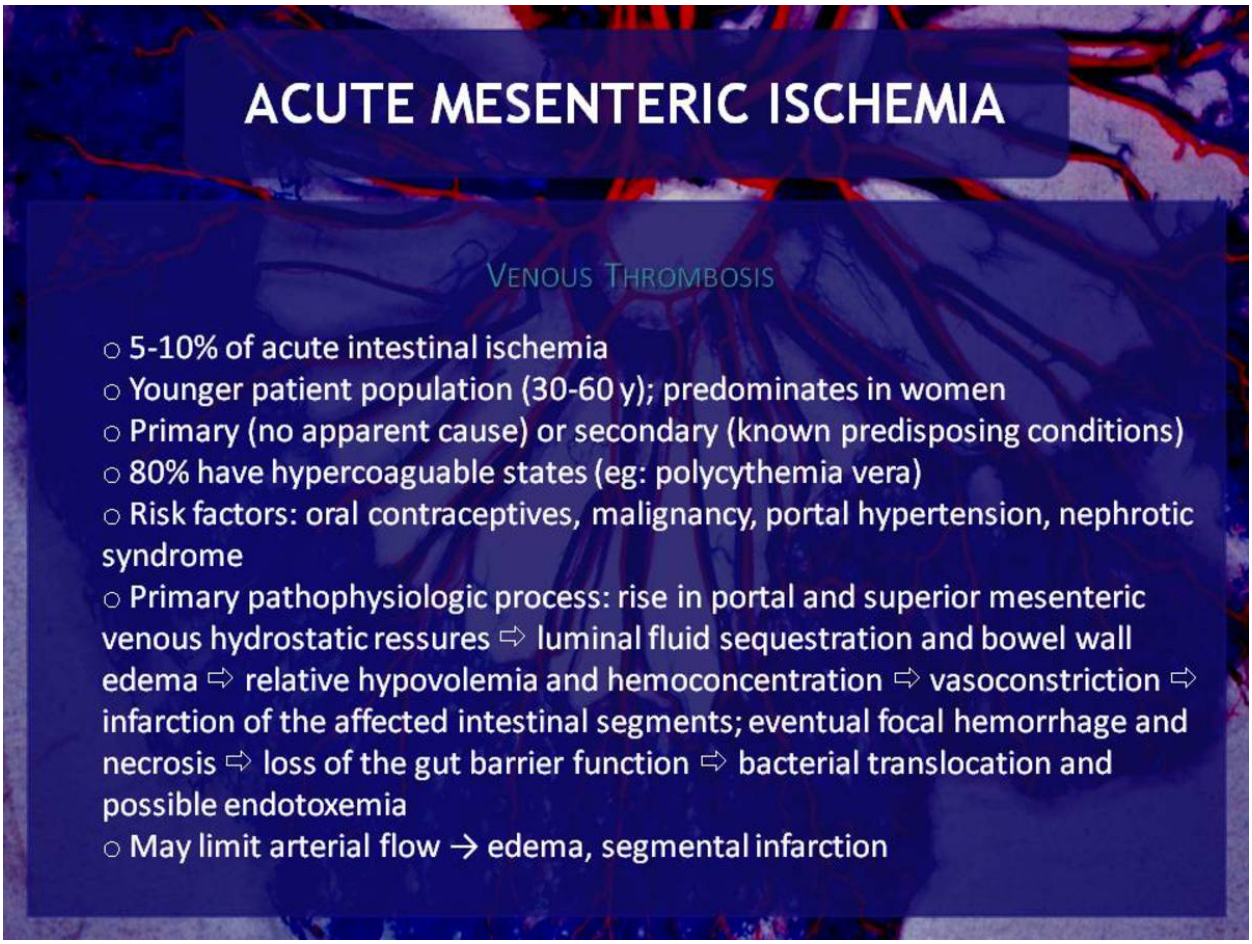
ACUTE MESENTERIC ISCHEMIA
VENOUS THROMBOSIS
○ 5-10% of acute intestinal ischemia
○ Younger patient population (30-60 y); predominates in women
○ Primary (no apparent cause) or secondary (known predisposing conditions)
○ 80% have hypercoaguable states (eg: polycythemia vera)
○ Risk factors: oral contraceptives, malignancy, portal hypertension, nephrotic syndrome
○ Primary pathophysiologic process: rise in portal and superior mesenteric venous hydrostatic ressures ⇨ luminal fluid sequestration and bowel wall edema ⇨ relative hypovolemia and hemoconcentration ⇨ vasoconstriction ⇨ infarction of the affected intestinal segments; eventual focal hemorrhage and necrosis ⇨ loss of the gut barrier function ⇨ bacterial translocation and possible endotoxemia
○ May limit arterial flow → edema, segmental infarction

Fig. 23

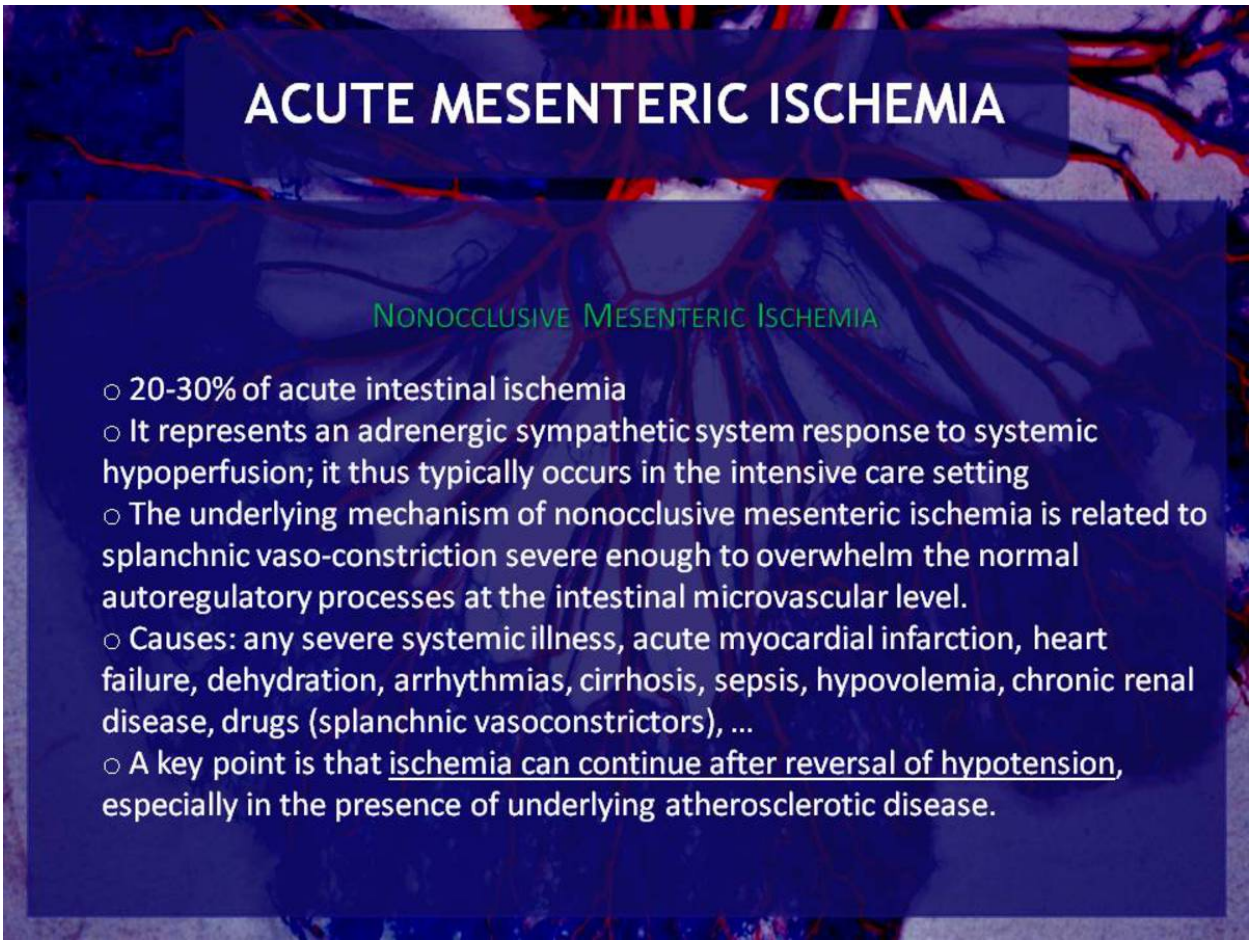
ACUTE MESENTERIC ISCHEMIA
NONOCCLUSIVE MESENTERIC ISCHEMIA
○ 20-30% of acute intestinal ischemia
○ It represents an adrenergic sympathetic system response to systemic hypoperfusion; it thus typically occurs in the intensive care setting
○ The underlying mechanism of nonocclusive mesenteric ischemia is related to splanchnic vaso-constriction severe enough to overwhelm the normal autoregulatory processes at the intestinal microvascular level.
○ Causes: any severe systemic illness, acute myocardial infarction, heart failure, dehydration, arrhythmias, cirrhosis, sepsis, hypovolemia, chronic renal disease, drugs (splanchnic vasoconstrictors), ...
○ A key point is that ischemia can continue after reversal of hypotension, especially in the presence of underlying atherosclerotic disease.

Fig. 24

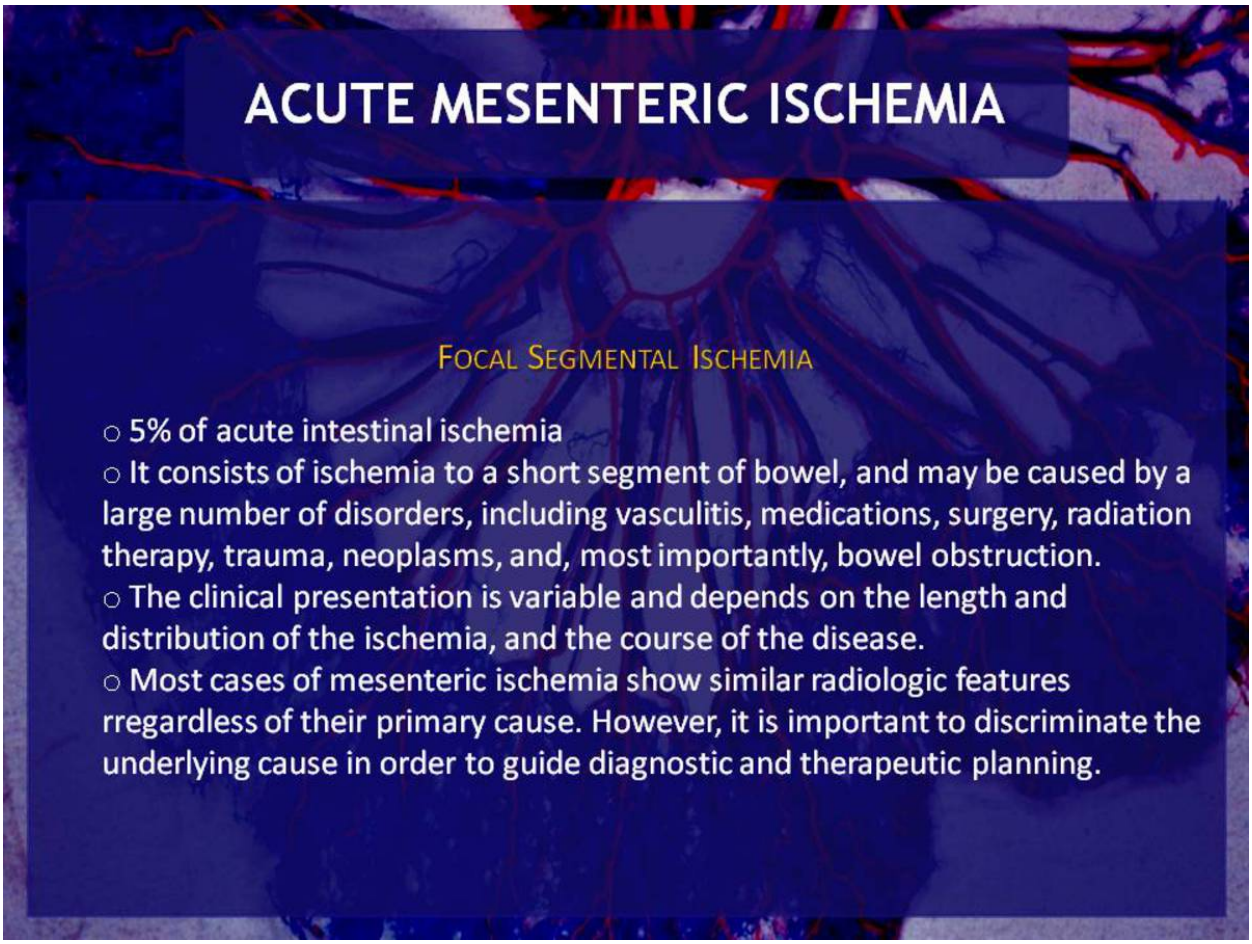
ACUTE MESENTERIC ISCHEMIA
FOCAL SEGMENTAL ISCHEMIA
○ 5% of acute intestinal ischemia
○ It consists of ischemia to a short segment of bowel, and may be caused by a large number of disorders, including vasculitis, medications, surgery, radiation therapy, trauma, neoplasms, and, most importantly, bowel obstruction.
○ The clinical presentation is variable and depends on the length and distribution of the ischemia, and the course of the disease.
○ Most cases of mesenteric ischemia show similar radiologic features rregardless of their primary cause. However, it is important to discriminate the underlying cause in order to guide diagnostic and therapeutic planning.

Fig. 25

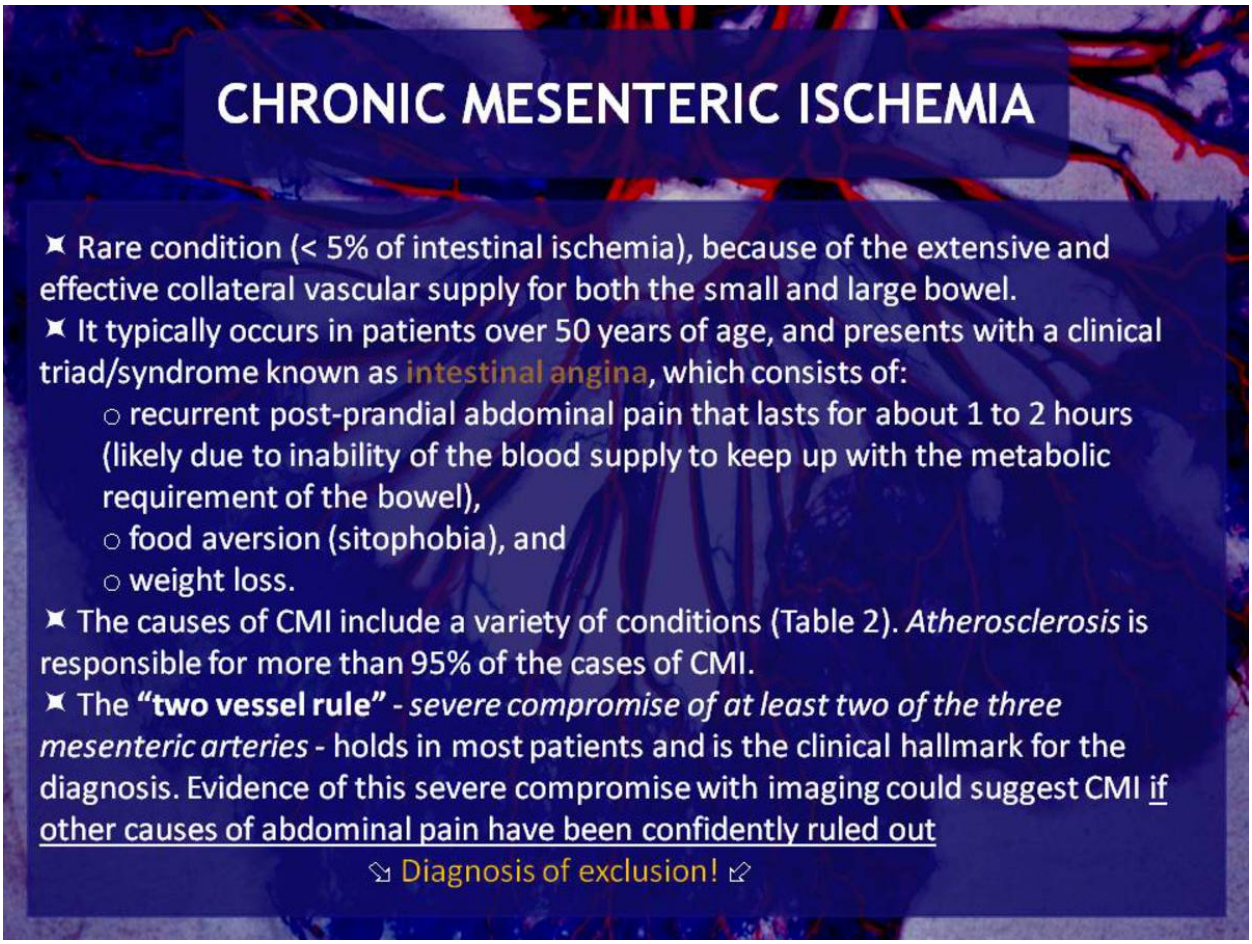
CHRONIC MESENTERIC ISCHEMIA
Rare condition (< 5% of intestinal ischemia), because of the extensive and effective collateral vascular supply for both the small and large bowel.
It typically occurs in patients over 50 years of age, and presents with a clinical triad/syndrome known as intestinal angina, which consists of:
recurrent post-prandial abdominal pain that lasts for about 1 to 2 hours (likely due to inability of the blood supply to keep up with the metabolic requirement of the bowel),
food aversion (sitophobia), and
weight loss.
The causes of CMI include a variety of conditions (Table 2). Atherosclerosis is responsible for more than 95% of the cases of CMI.
The "two vessel rule" - severe compromise of at least two of the three mesenteric arteries - holds in most patients and is the clinical hallmark for the diagnosis. Evidence of this severe compromise with imaging could suggest CMI if other causes of abdominal pain have been confidently ruled out
Diagnosis of exclusion!

Fig. 26

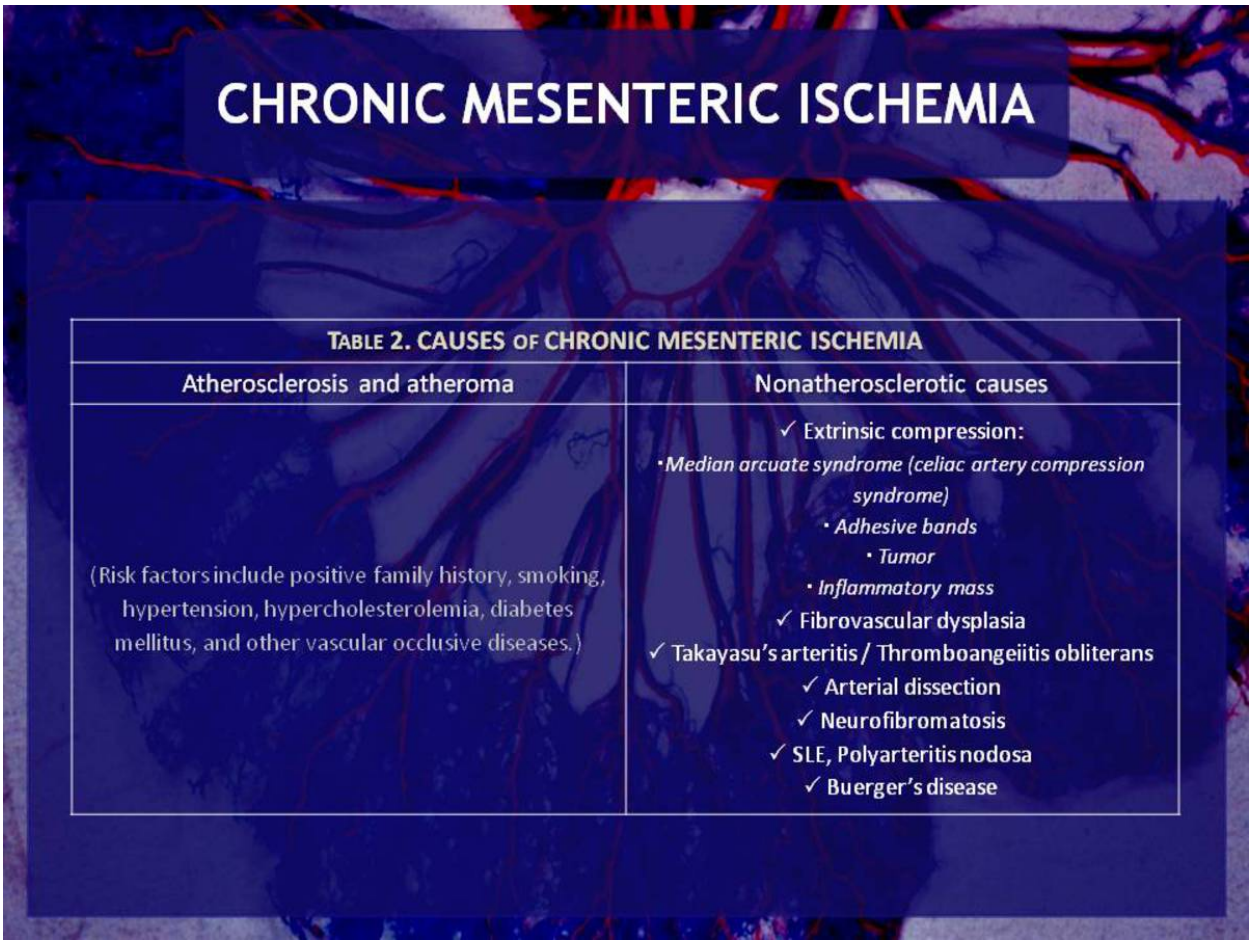
CHRONIC MESENTERIC ISCHEMIA
TABLE 2. CAUSES OF CHRONIC MESENTERIC ISCHEMIA
Atherosclerosis and atheroma
Nonatherosclerotic causes
(Risk factors include positive family history, smoking, hypertension, hypercholesterolemia, diabetes mellitus, and other vascular occlusive diseases.)
✓ Extrinsic compression:
• Median arcuate syndrome (celiac artery compression syndrome)
• Adhesive bands
• Tumor
• Inflammatory mass
✓ Fibrovascular dysplasia
✓ Takayasu's arteritis / Thromboangeiitis obliterans
✓ Arterial dissection
✓ Neurofibromatosis
✓ SLE, Polyarteritis nodosa
✓ Buerger's disease

Fig. 27

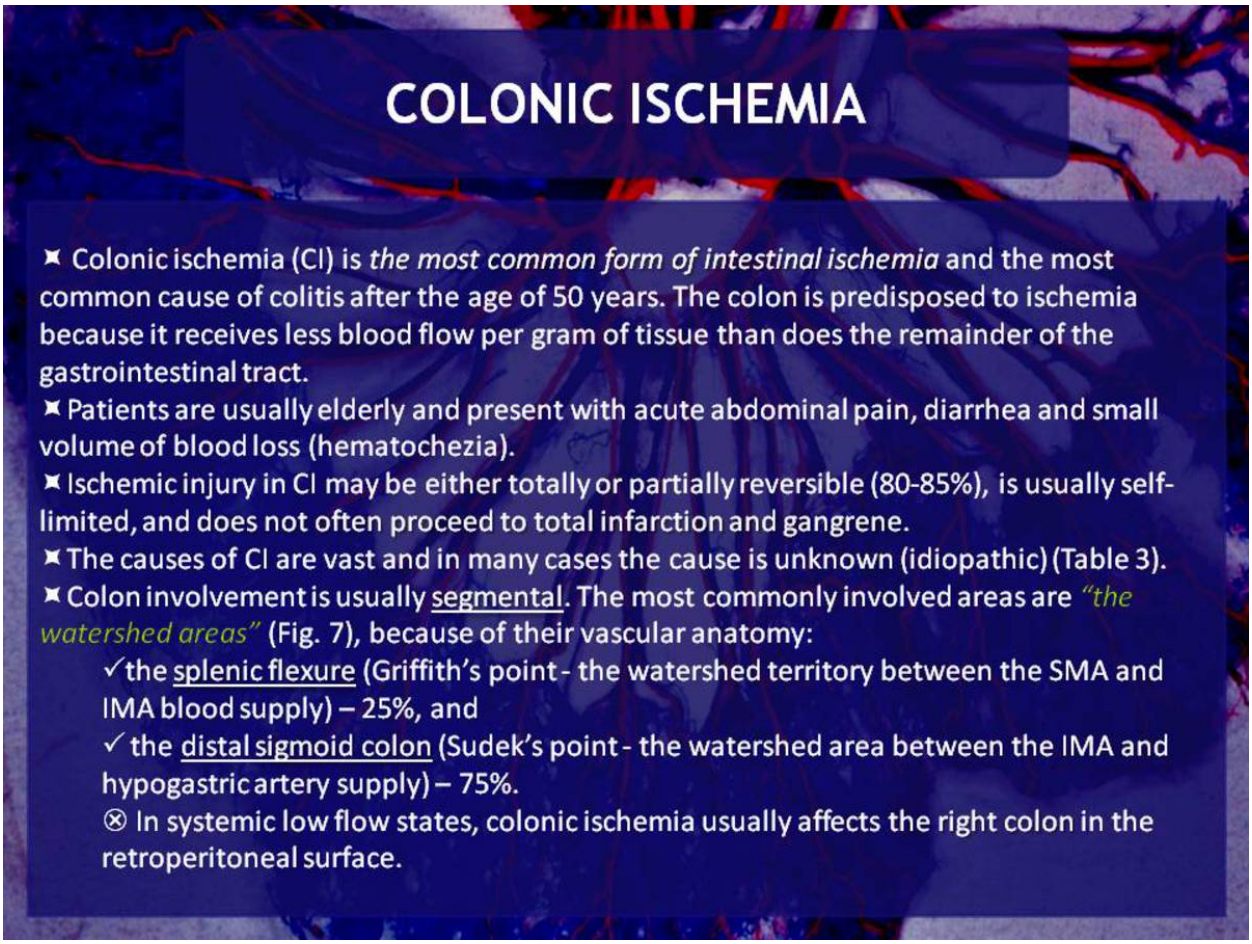
COLONIC ISCHEMIA
Colonic ischemia (CI) is the most common form of intestinal ischemia and the most common cause of colitis after the age of 50 years. The colon is predisposed to ischemia because it receives less blood flow per gram of tissue than does the remainder of the gastrointestinal tract.
Patients are usually elderly and present with acute abdominal pain, diarrhea and small volume of blood loss (hematochezia).
Ischemic injury in CI may be either totally or partially reversible (80-85%), is usually self-limited, and does not often proceed to total infarction and gangrene.
The causes of CI are vast and in many cases the cause is unknown (idiopathic) (Table 3).
Colon involvement is usually segmental. The most commonly involved areas are "the watershed areas" (Fig. 7), because of their vascular anatomy:
✓the splenic flexure (Griffith's point - the watershed territory between the SMA and IMA blood supply) – 25%, and
✓ the distal sigmoid colon (Sudek's point - the watershed area between the IMA and hypogastric artery supply) – 75%.
⊗ In systemic low flow states, colonic ischemia usually affects the right colon in the retroperitoneal surface.

Fig. 28

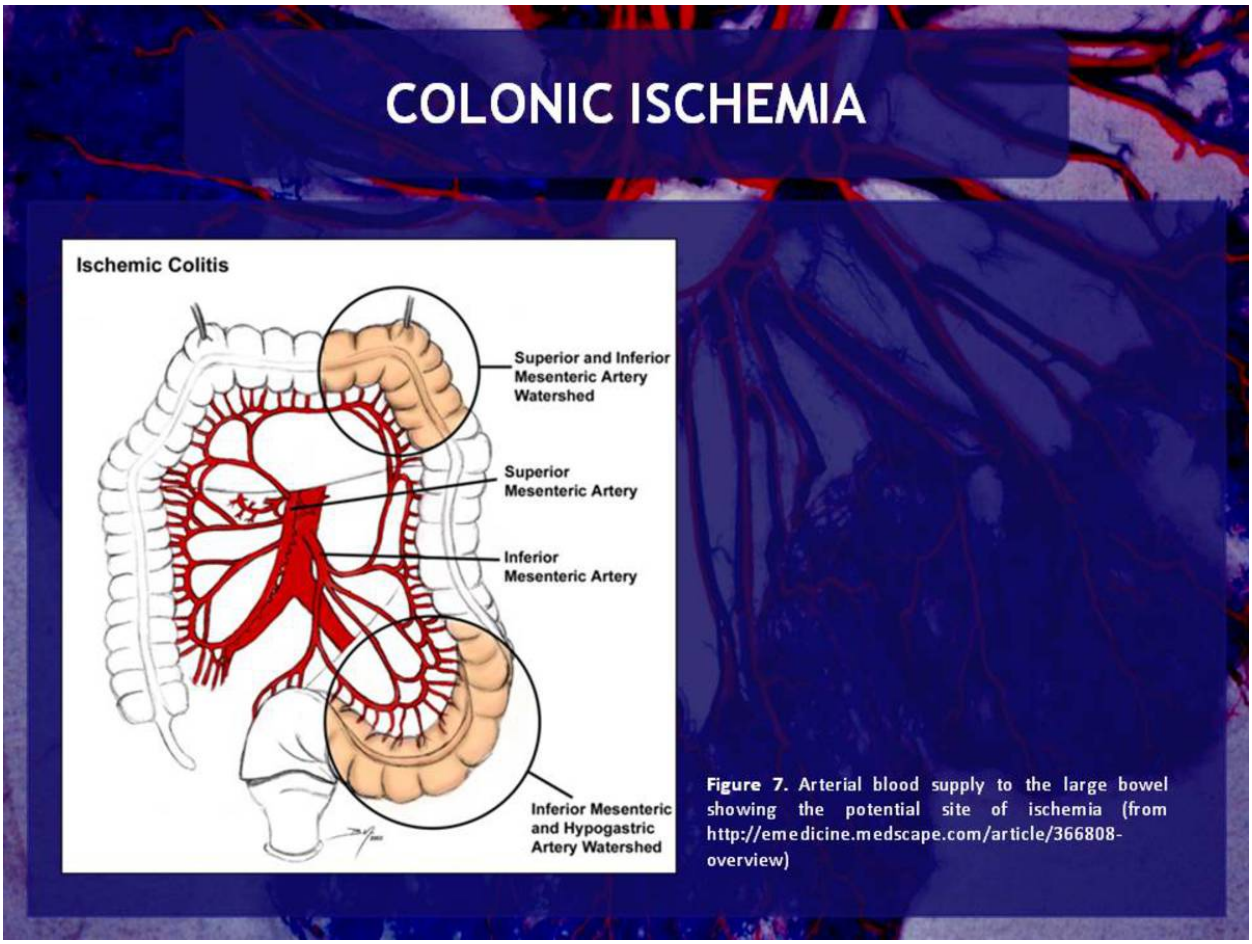
COLONIC ISCHEMIA
Ischemic Colitis
Superior and Inferior Mesenteric Artery Watershed
Superior Mesenteric Artery
Inferior Mesenteric Artery
Inferior Mesenteric and Hypogastric Artery Watershed
Figure 7. Arterial blood supply to the large bowel showing the potential site of ischemia (from http://emedicine.medscape.com/article/366808-overview)

Fig. 29

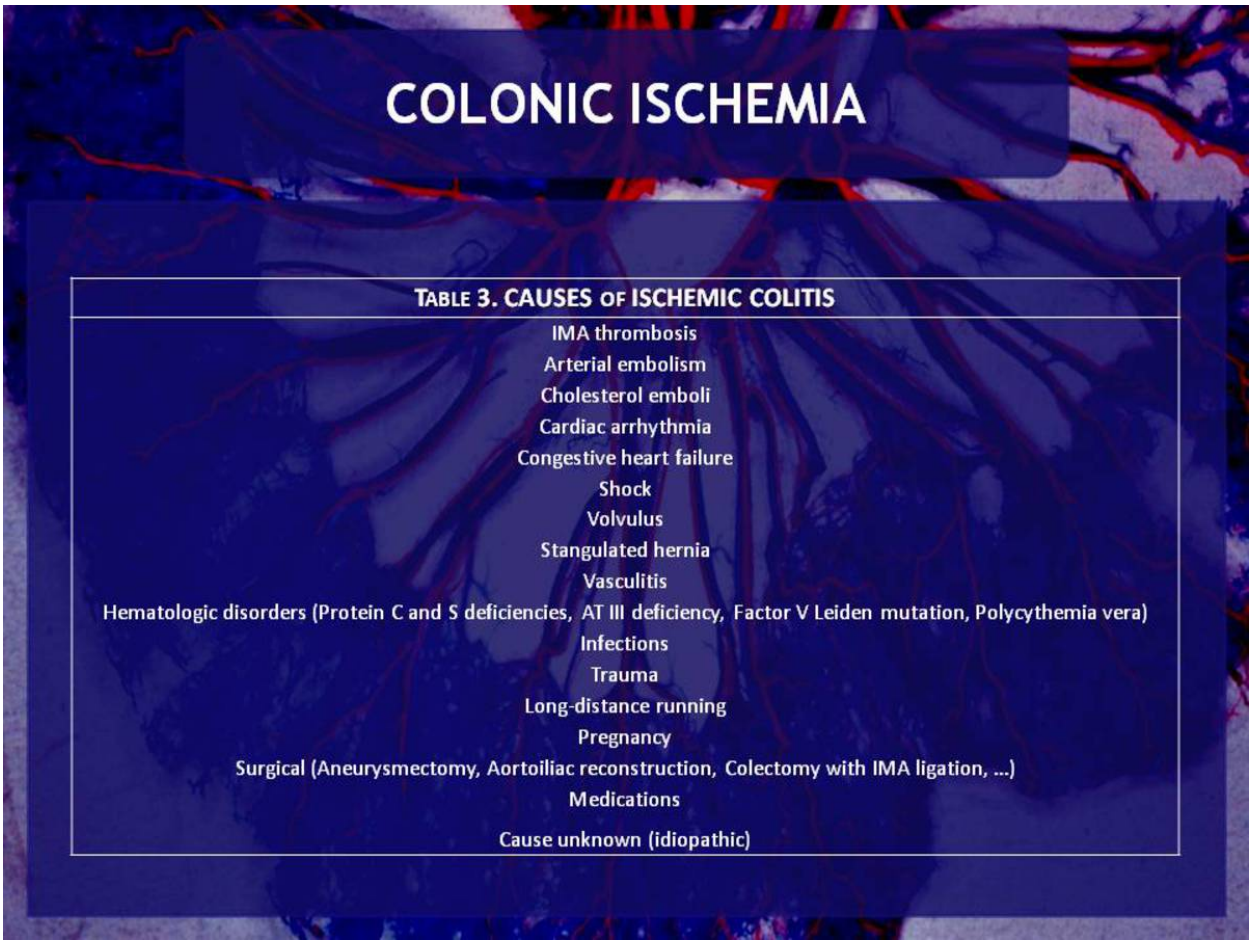
COLONIC ISCHEMIA
TABLE 3. CAUSES OF ISCHEMIC COLITIS
IMA thrombosis
Arterial embolism
Cholesterol emboli
Cardiac arrhythmia
Congestive heart failure
Shock
Volvulus
Stangulated hernia
Vasculitis
Hematologic disorders (Protein C and S deficiencies, AT III deficiency, Factor V Leiden mutation, Polycythemia vera)
Infections
Trauma
Long-distance running
Pregnancy
Surgical (Aneurysmectomy, Aortoiliac reconstruction, Colectomy with IMA ligation, ...)
Medications
Cause unknown (idiopathic)

Fig. 30

Imaging findings OR Procedure details

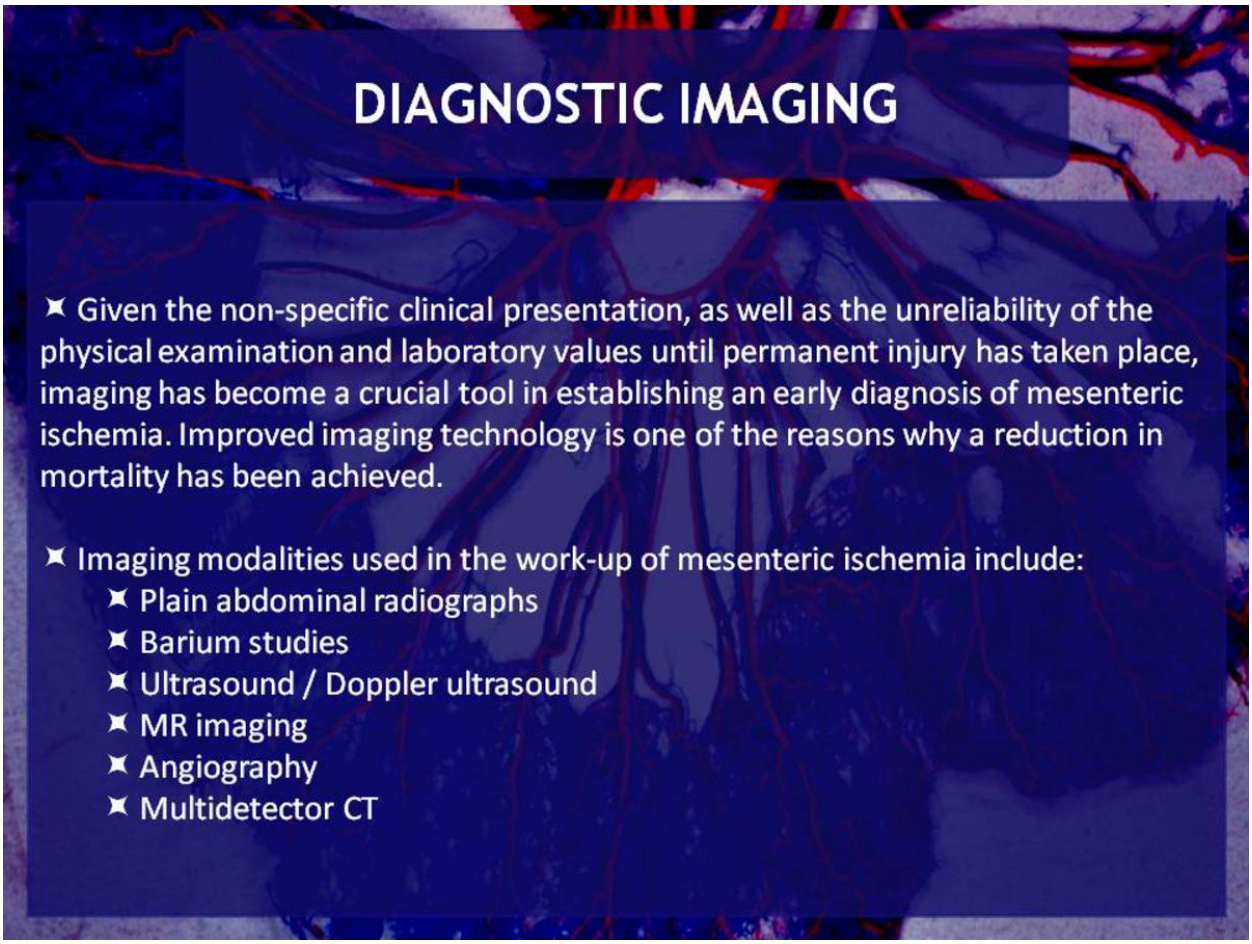

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

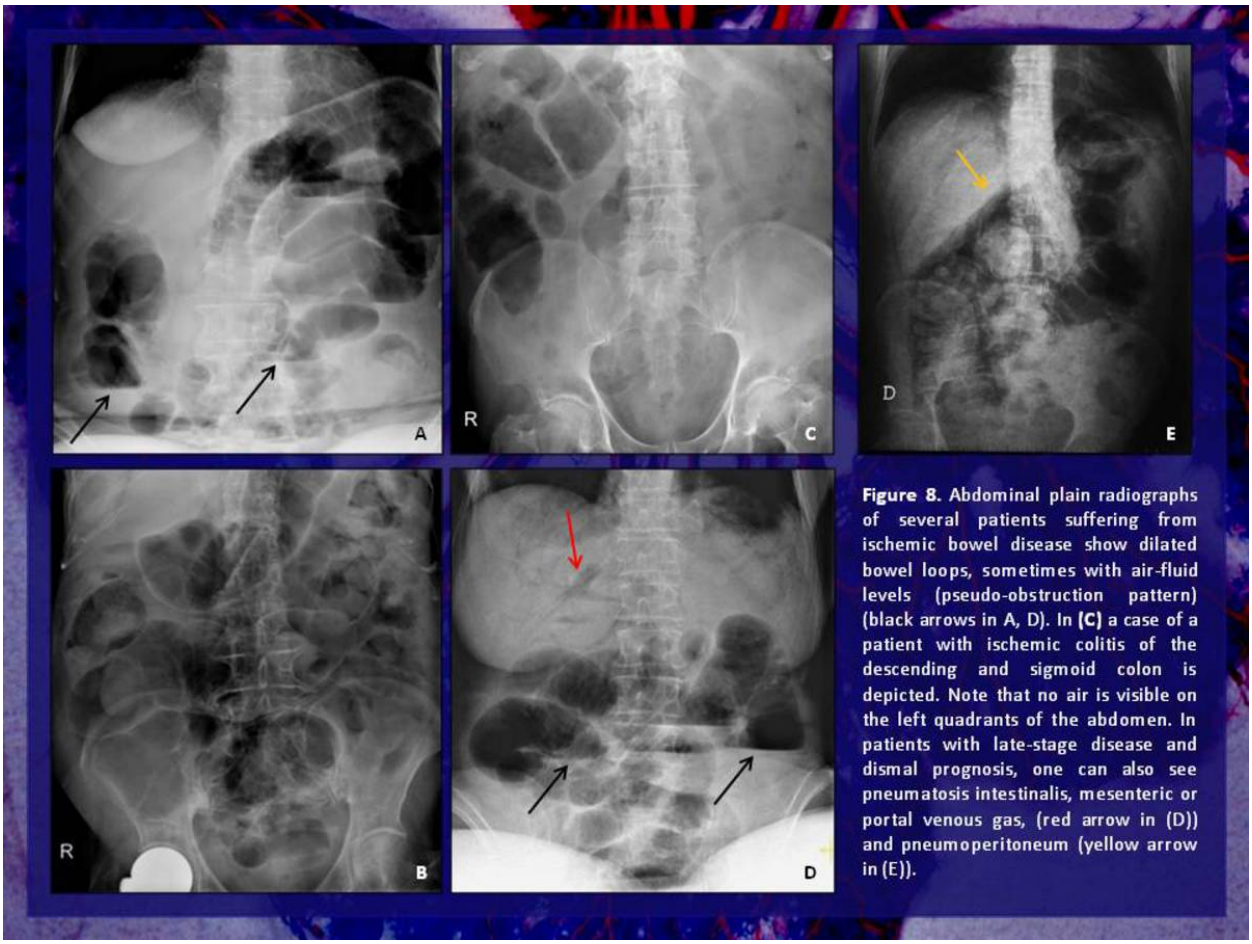

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

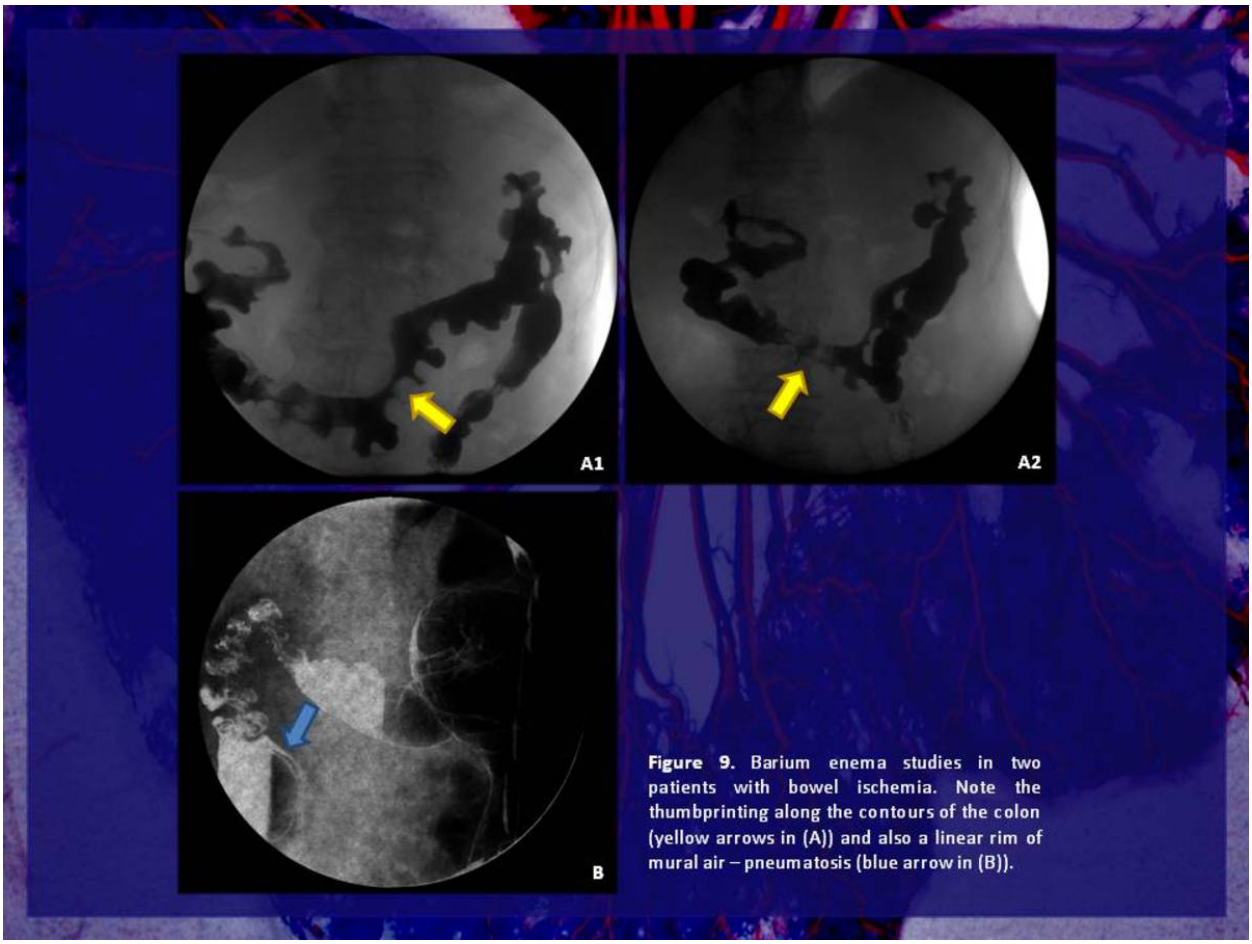

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

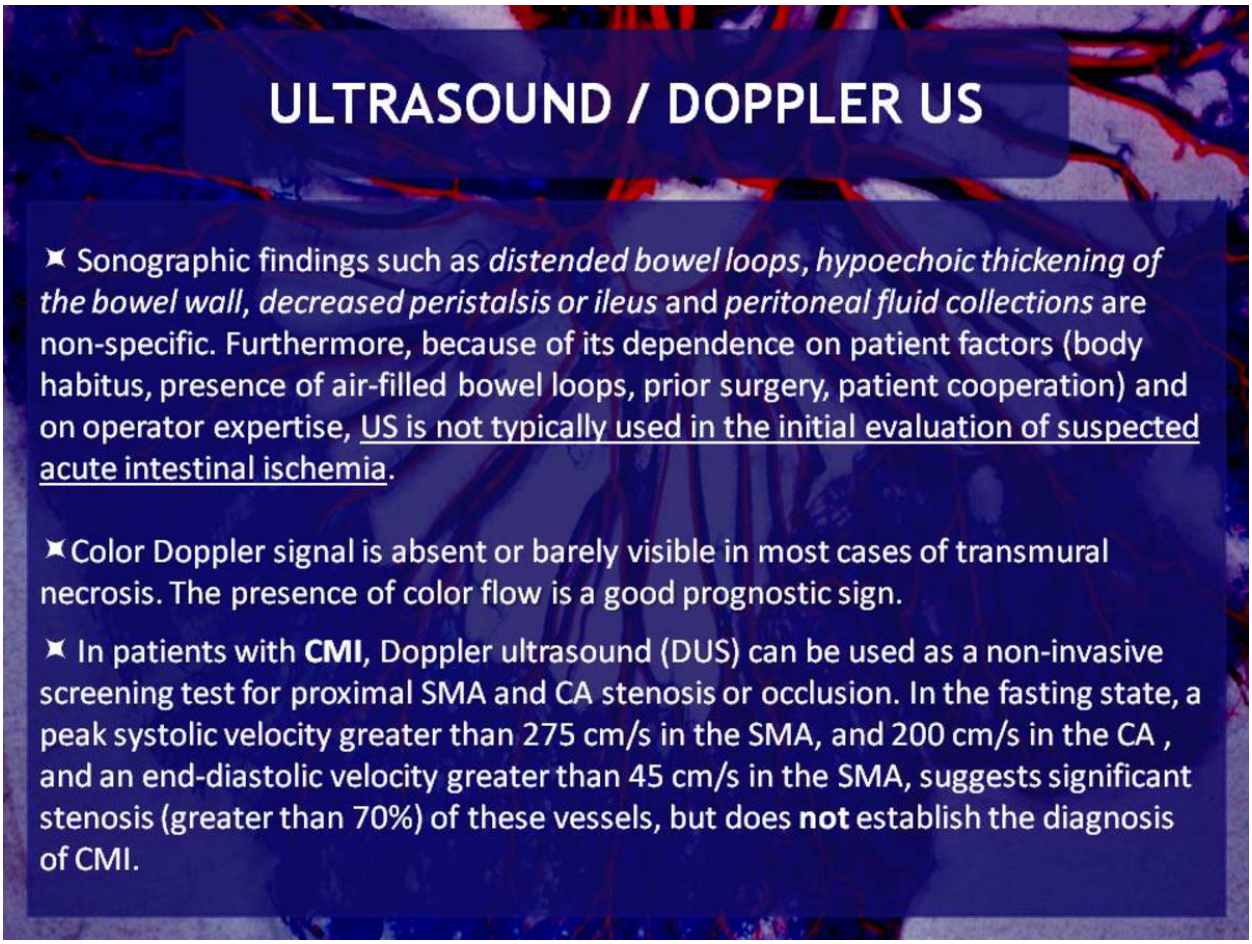

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

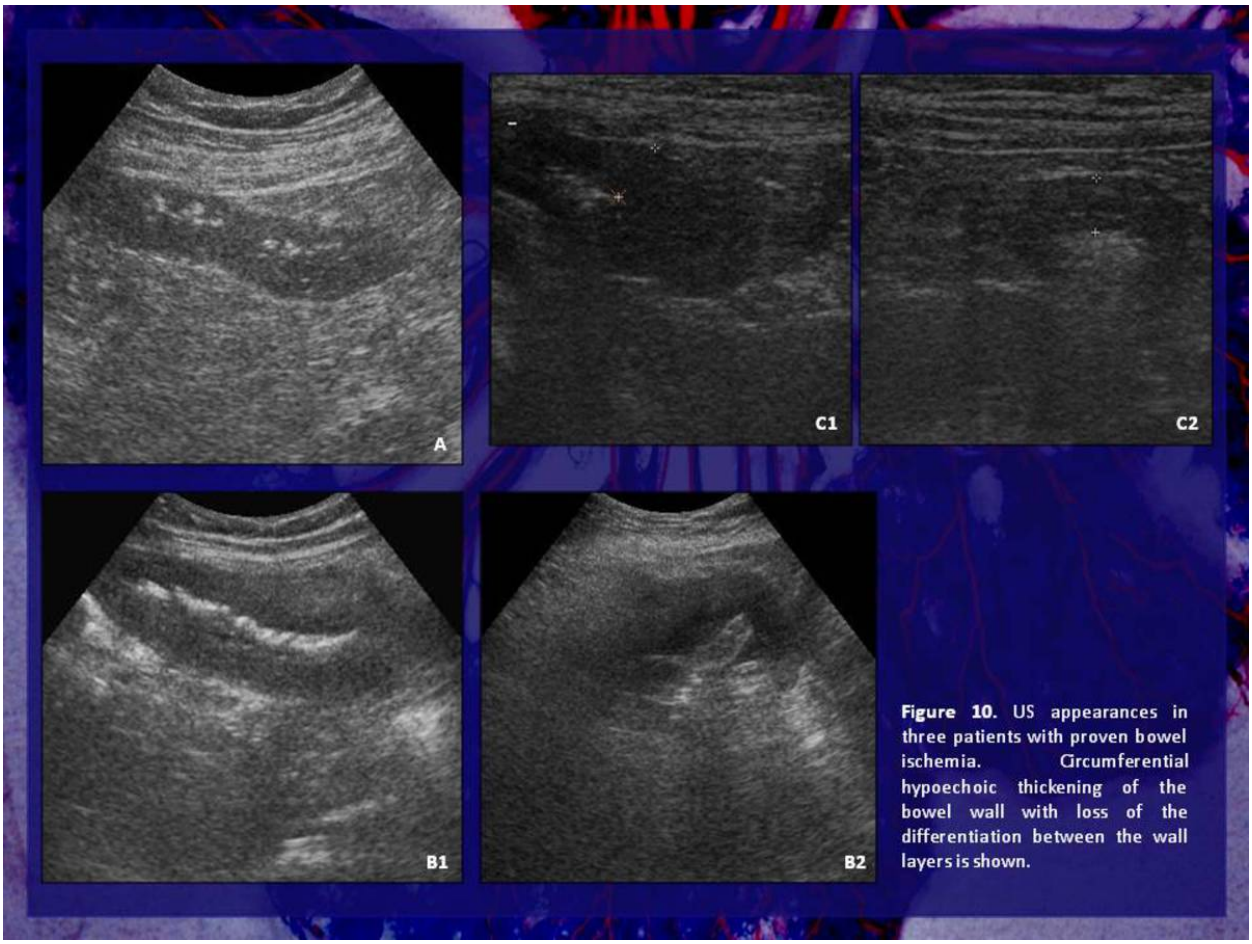

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

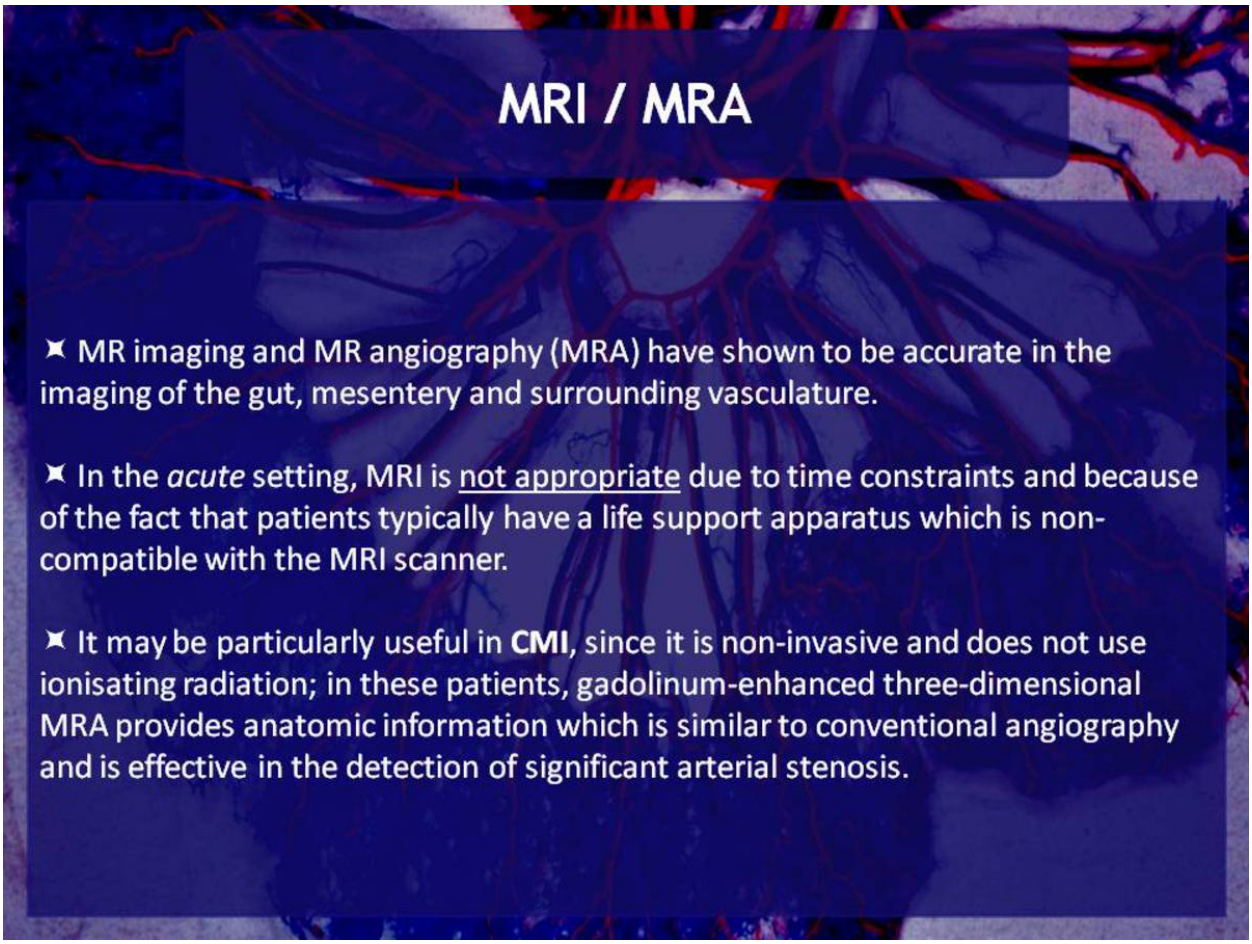

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

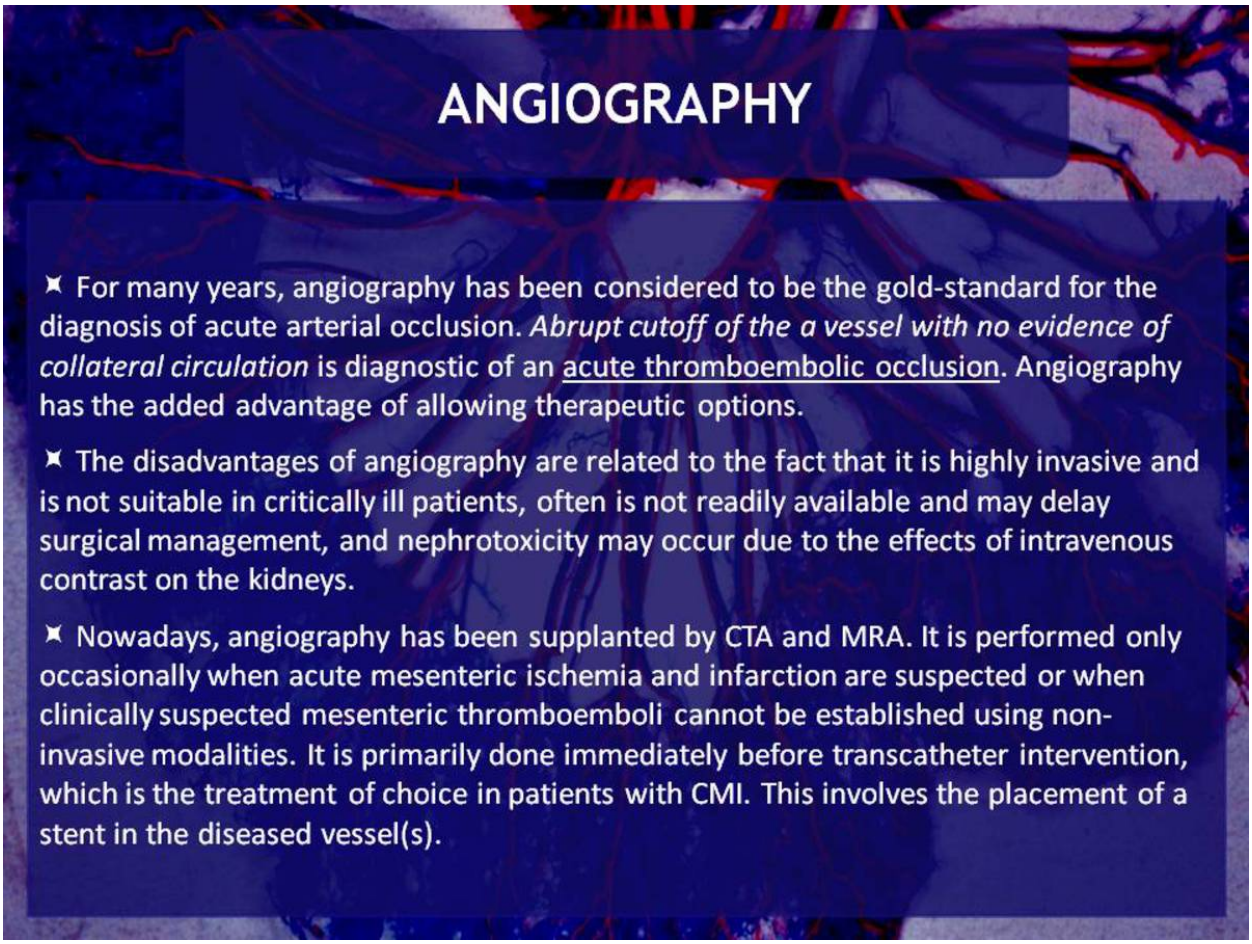

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

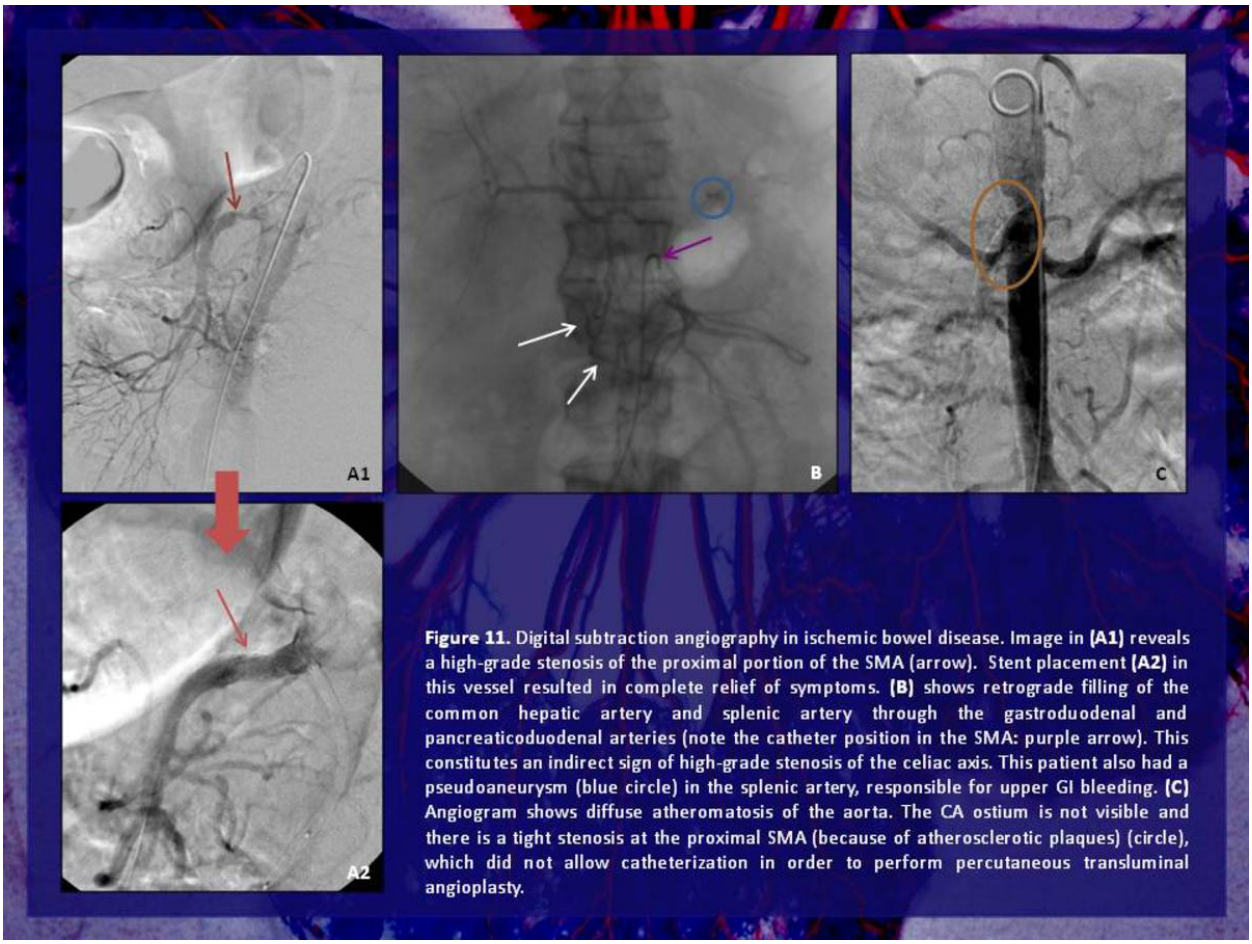

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

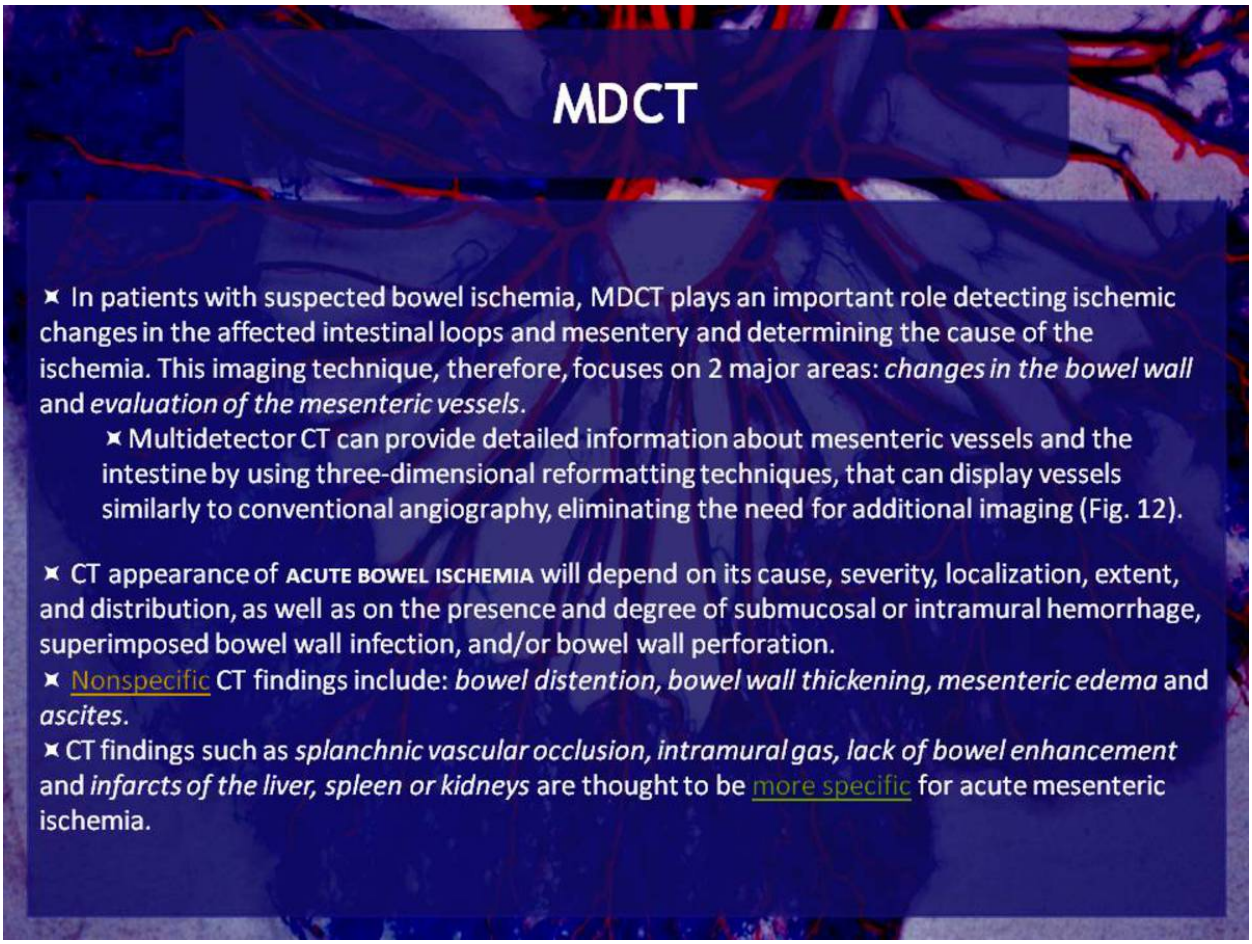

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

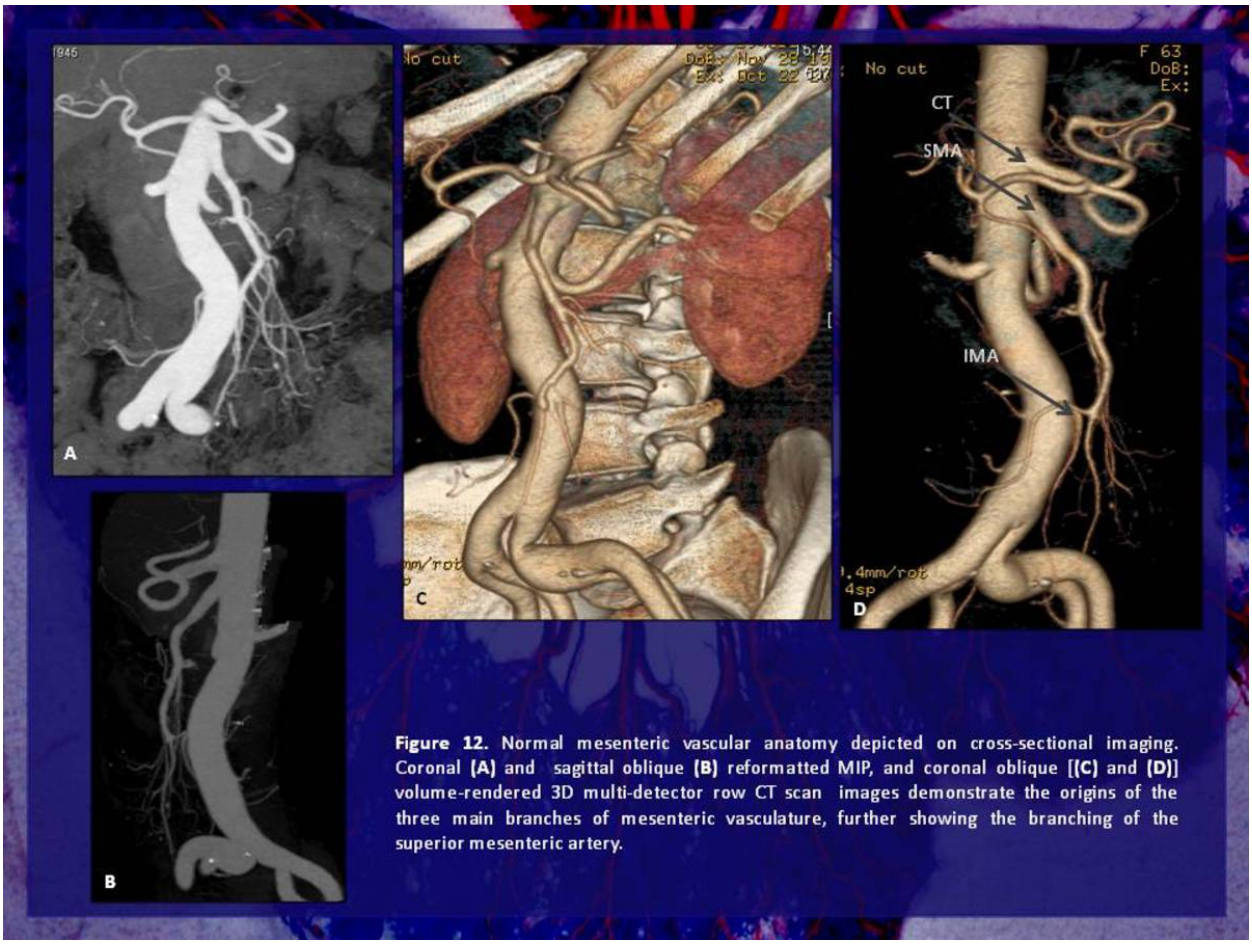

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

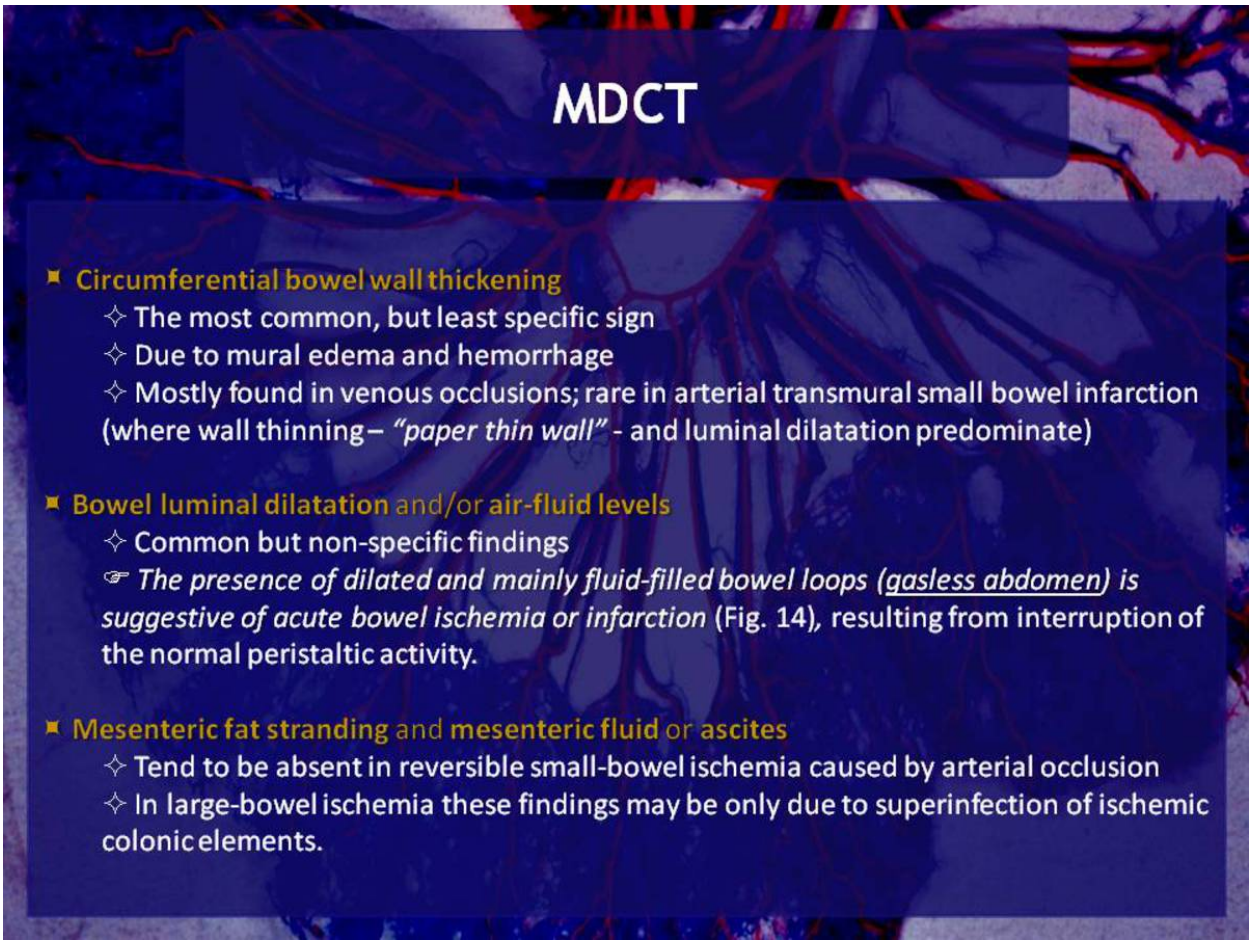

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

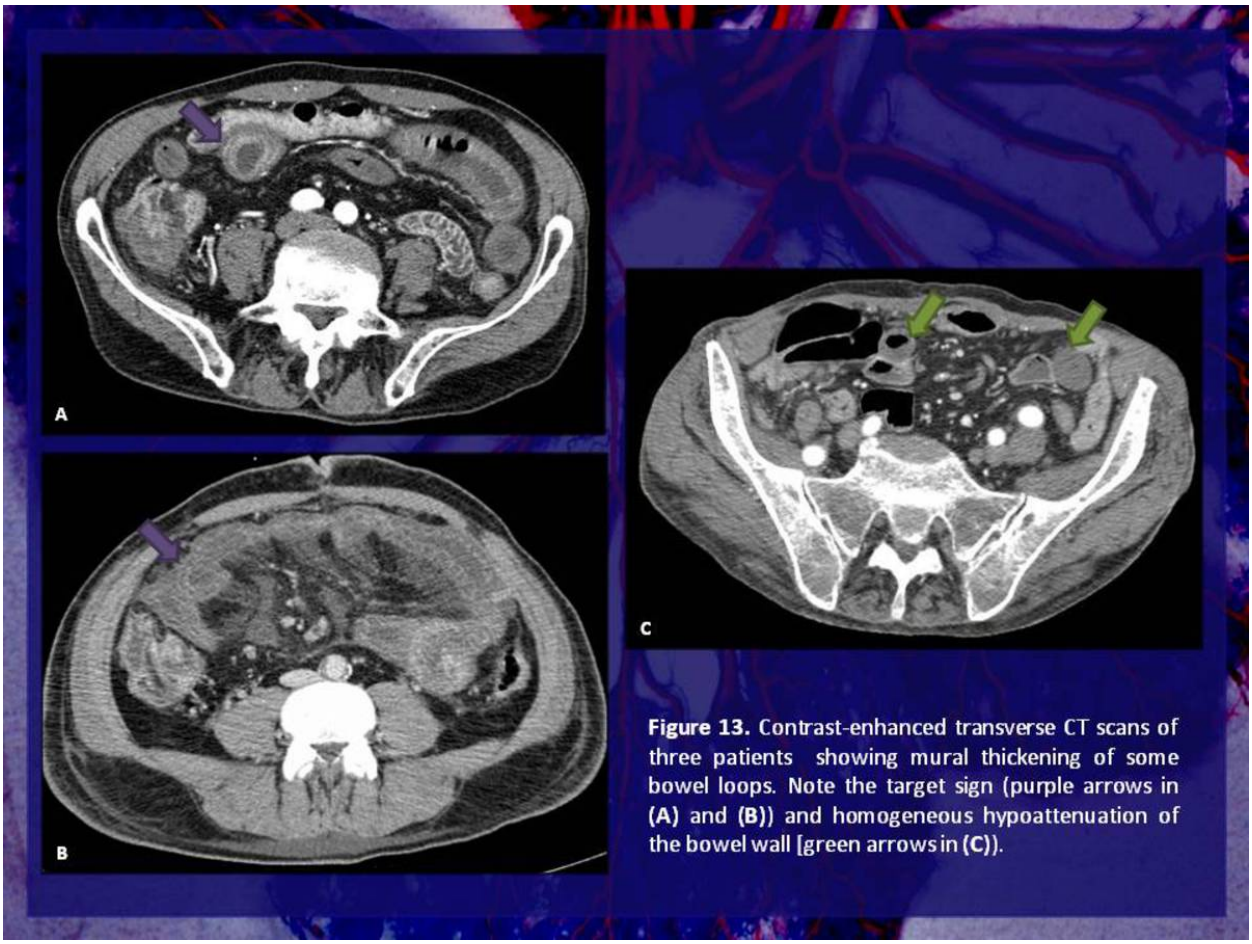

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

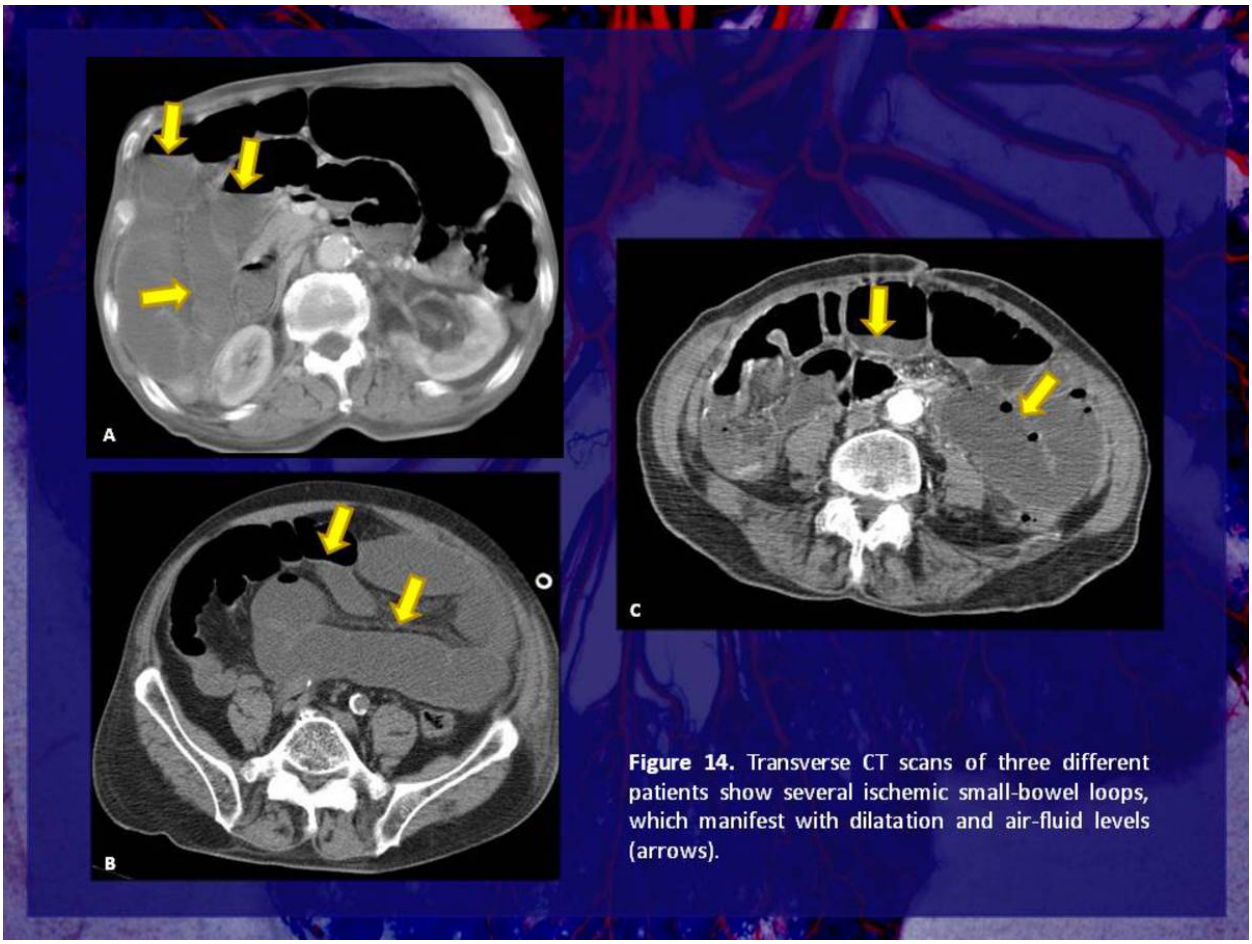

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

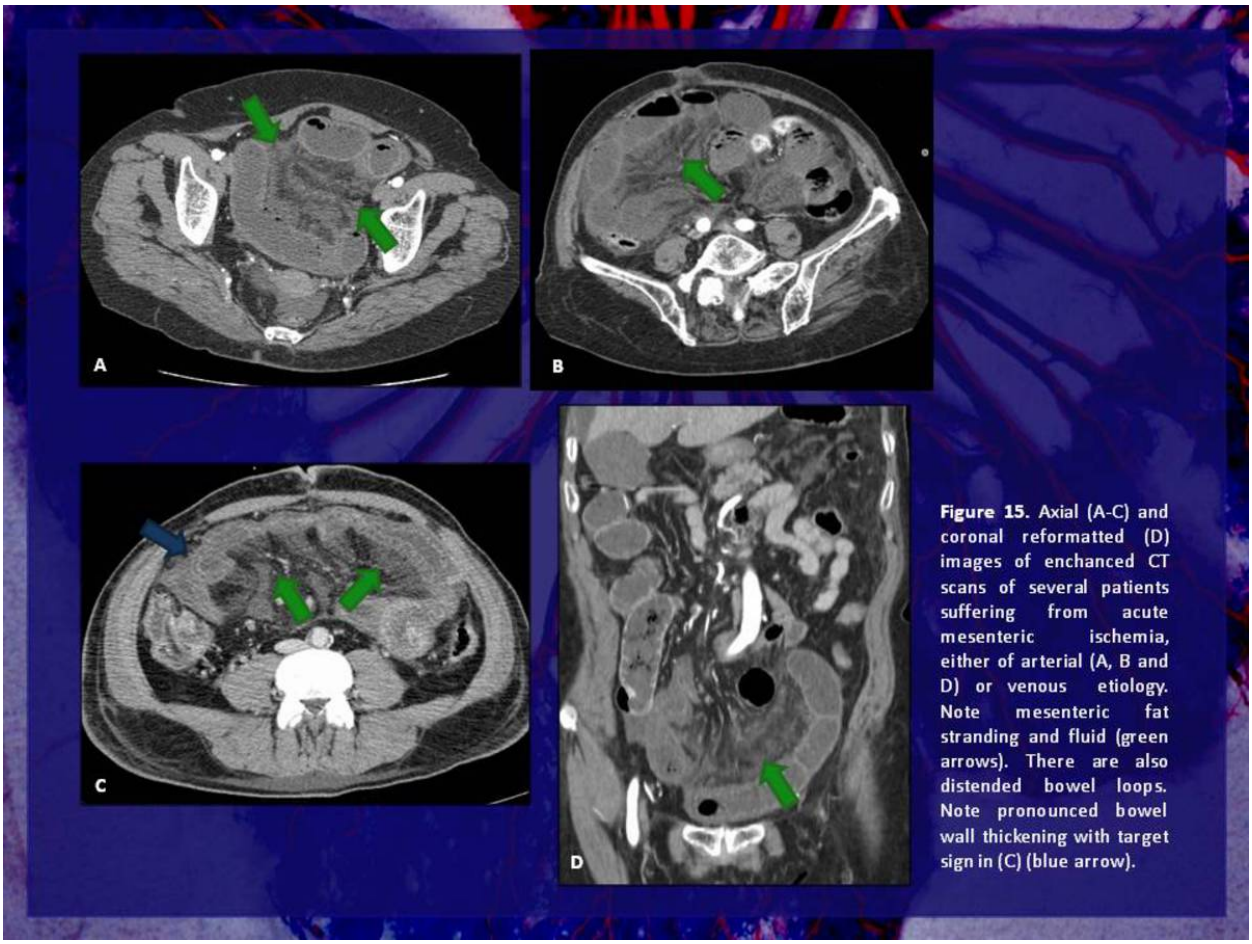

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

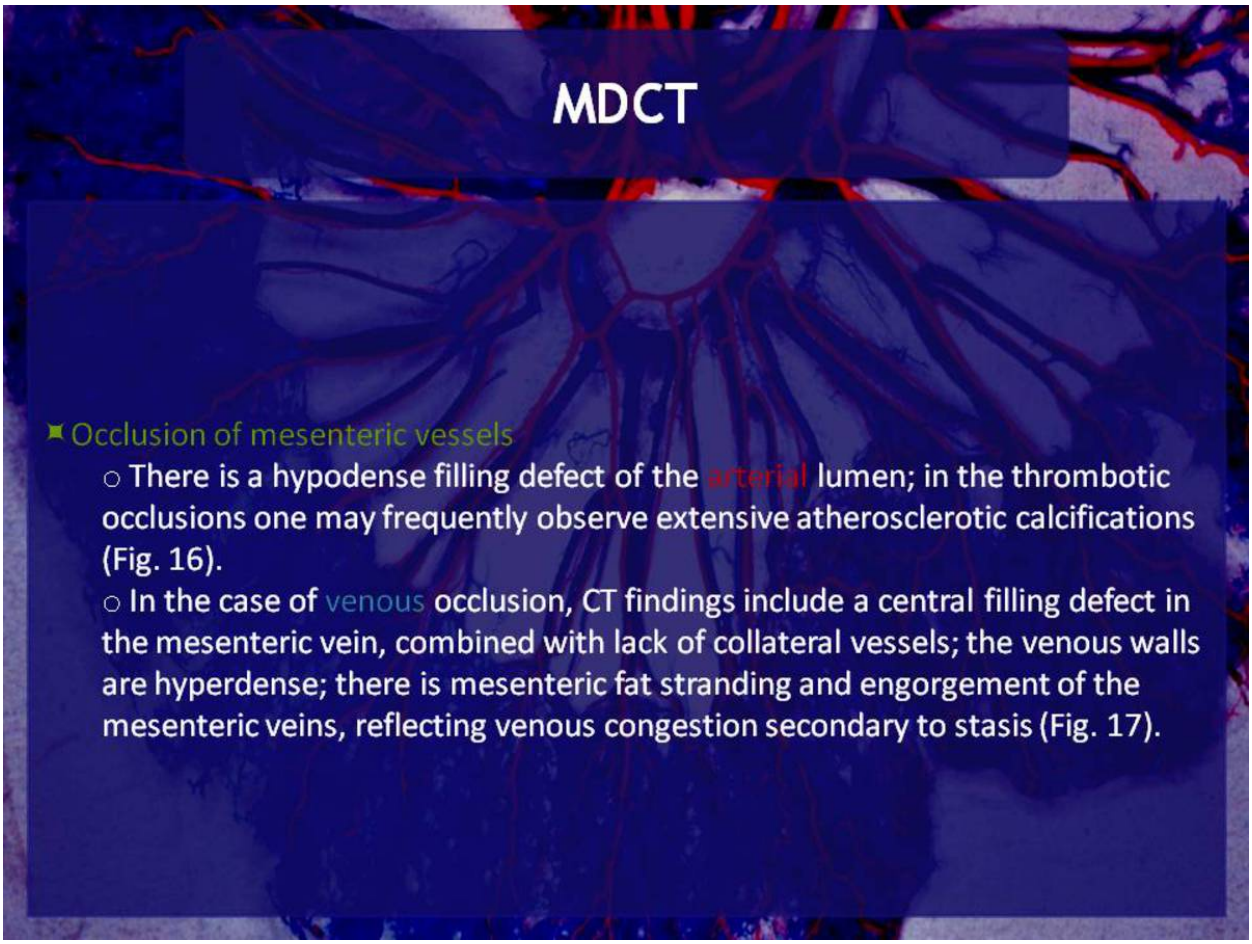

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

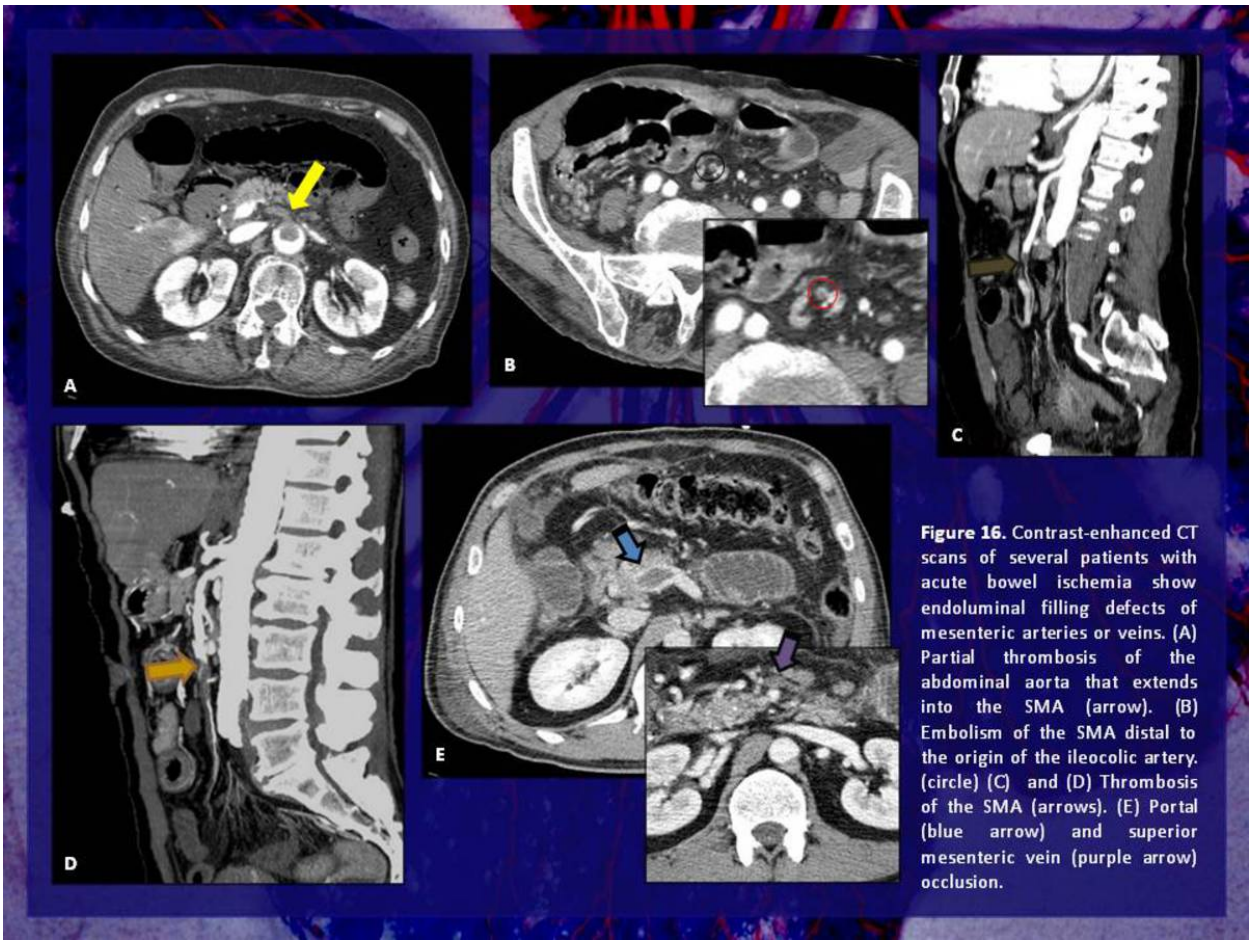

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

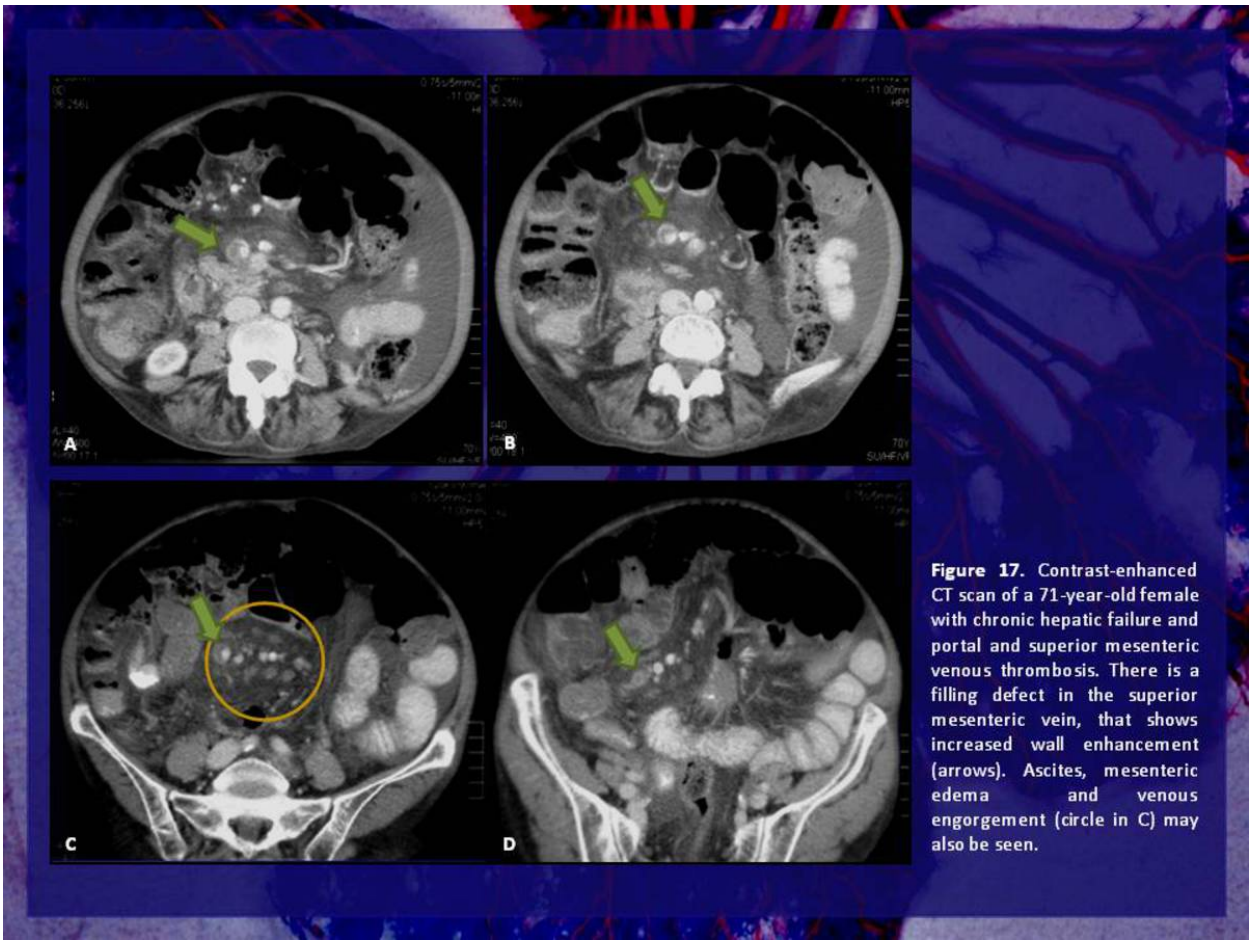

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

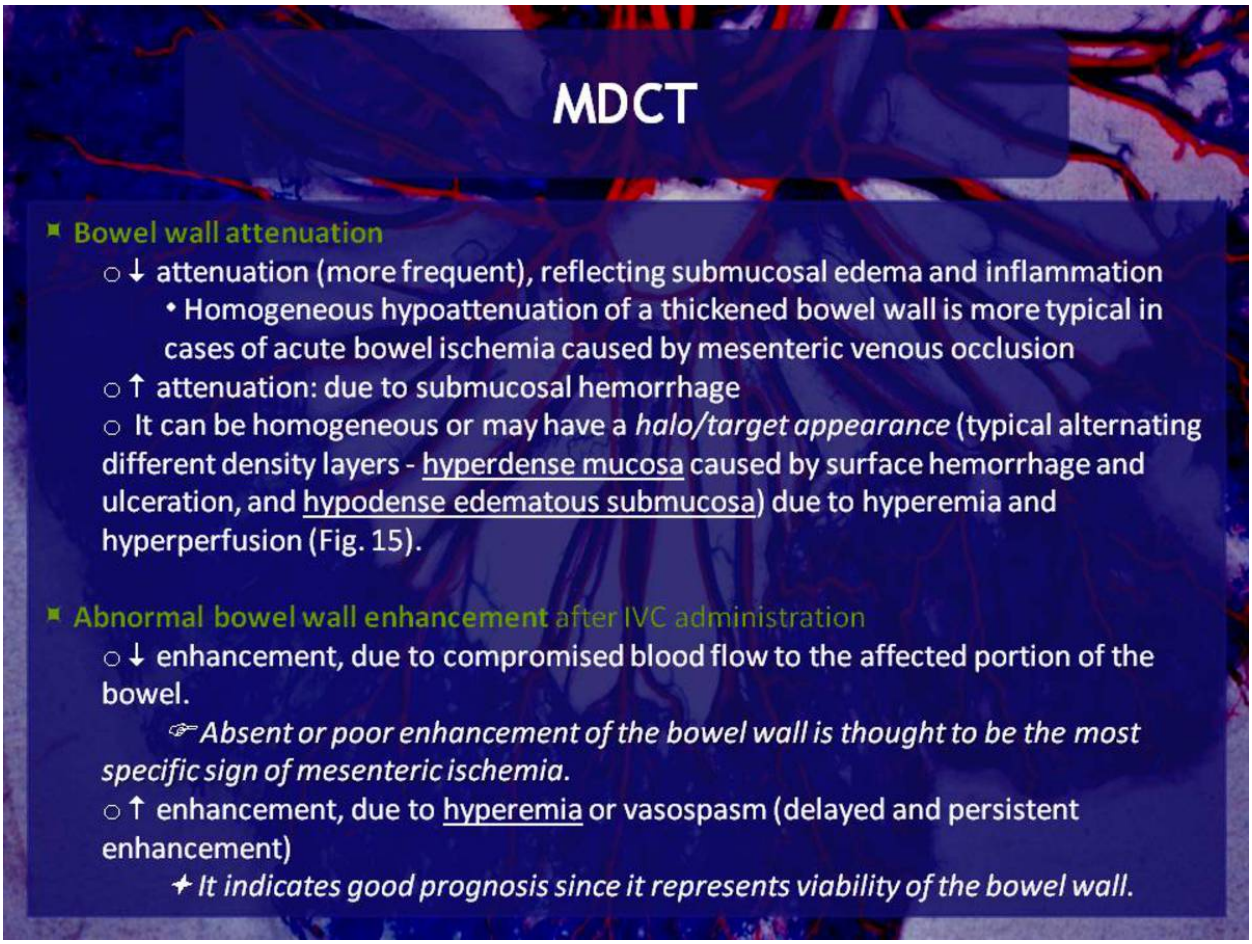

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

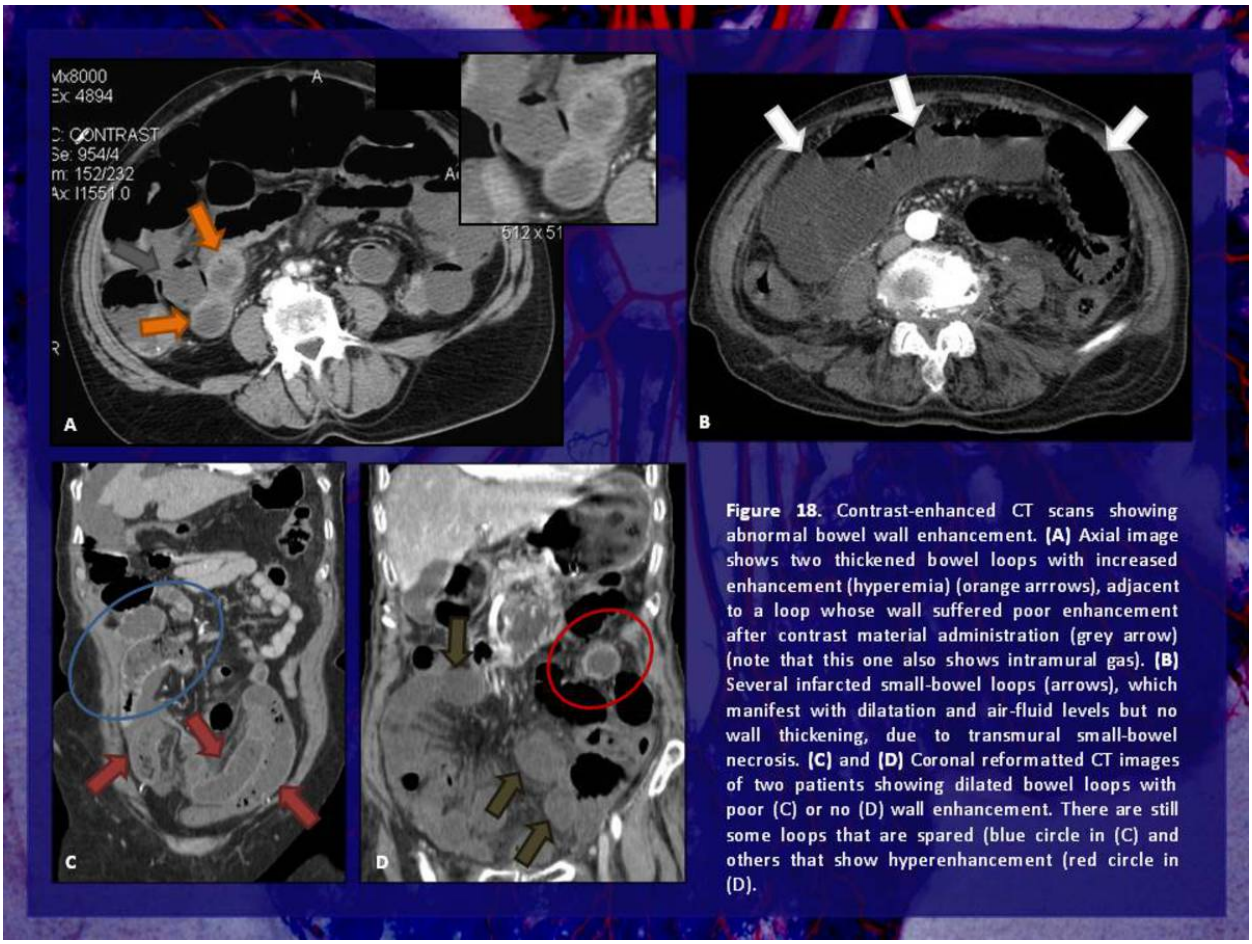

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

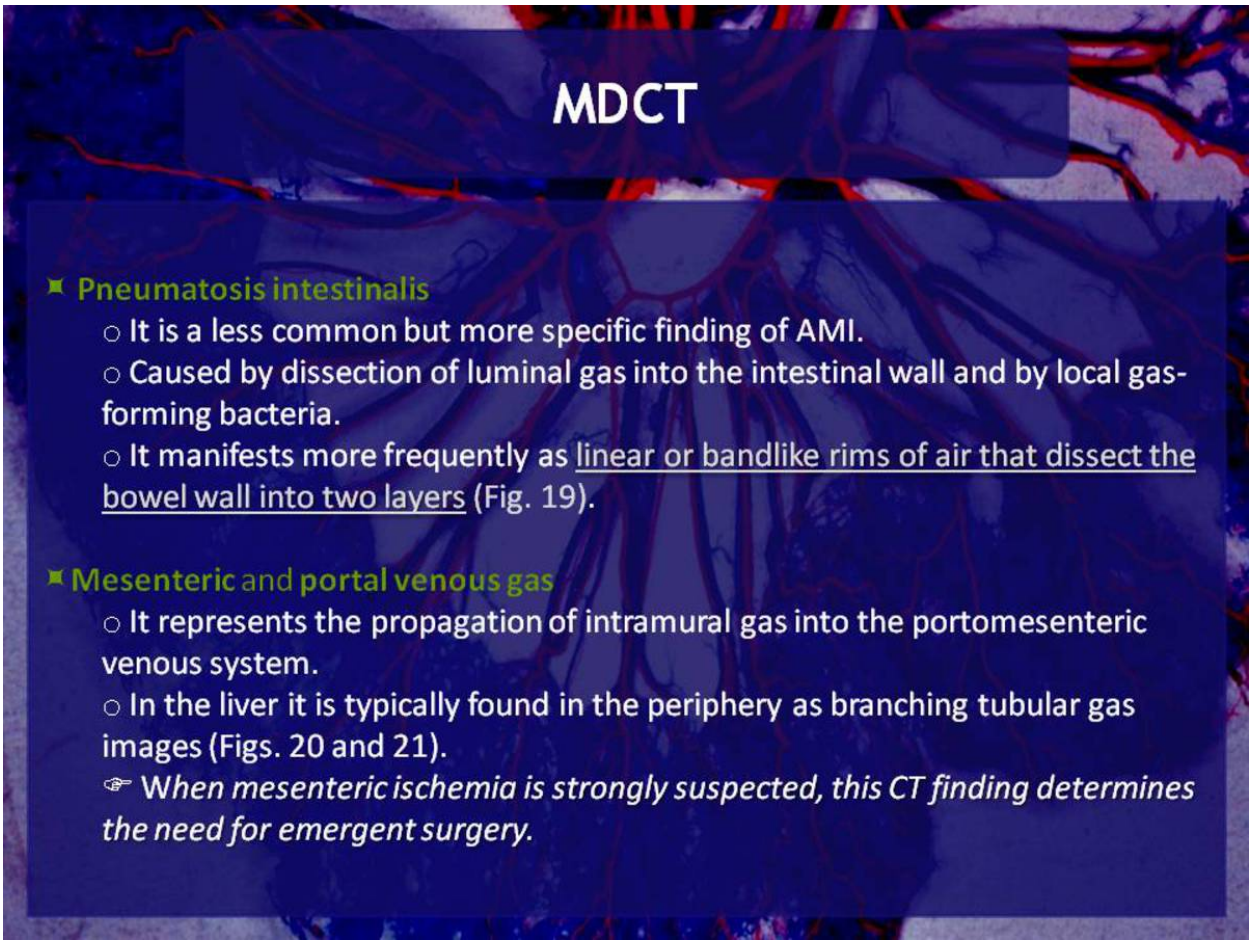

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

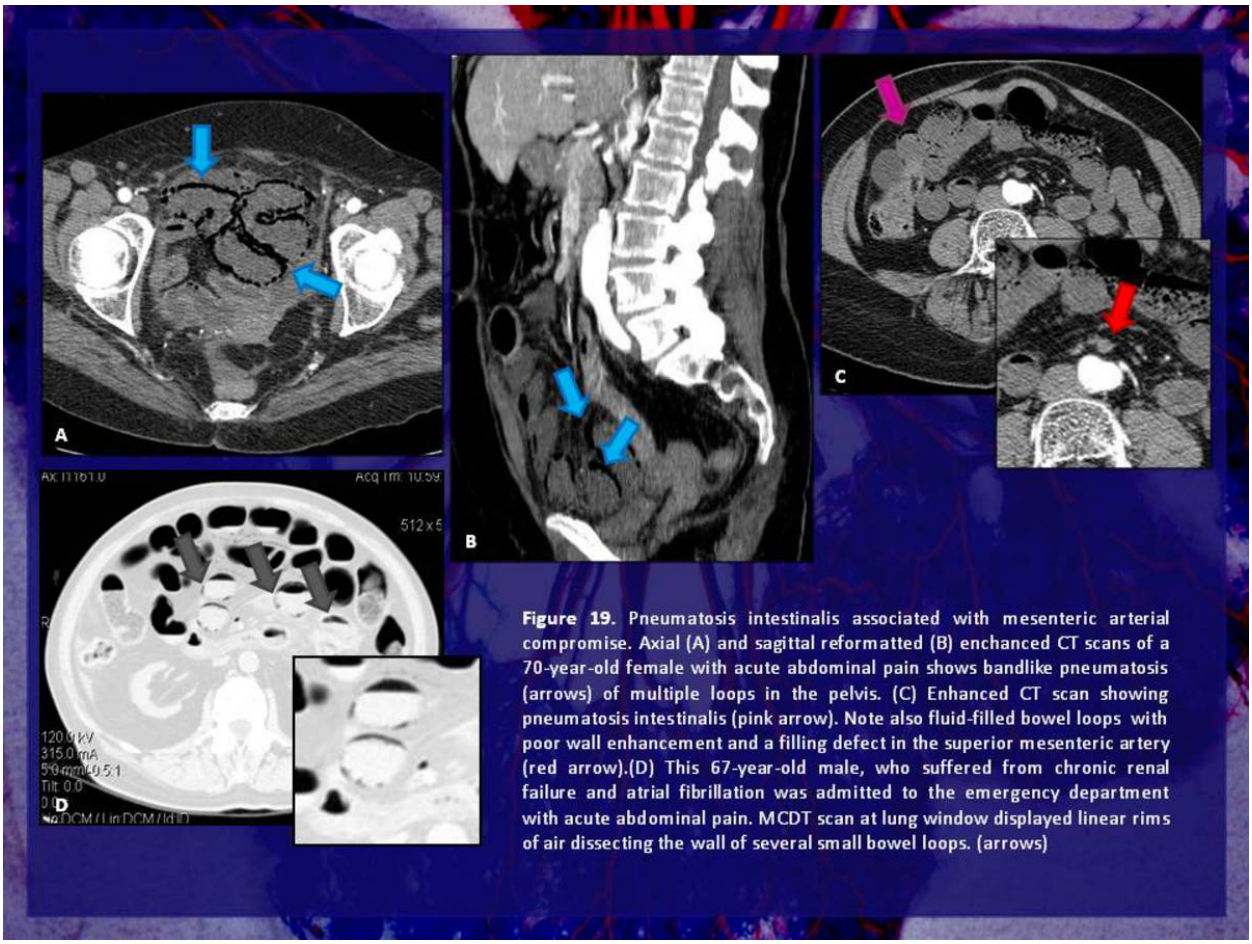

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

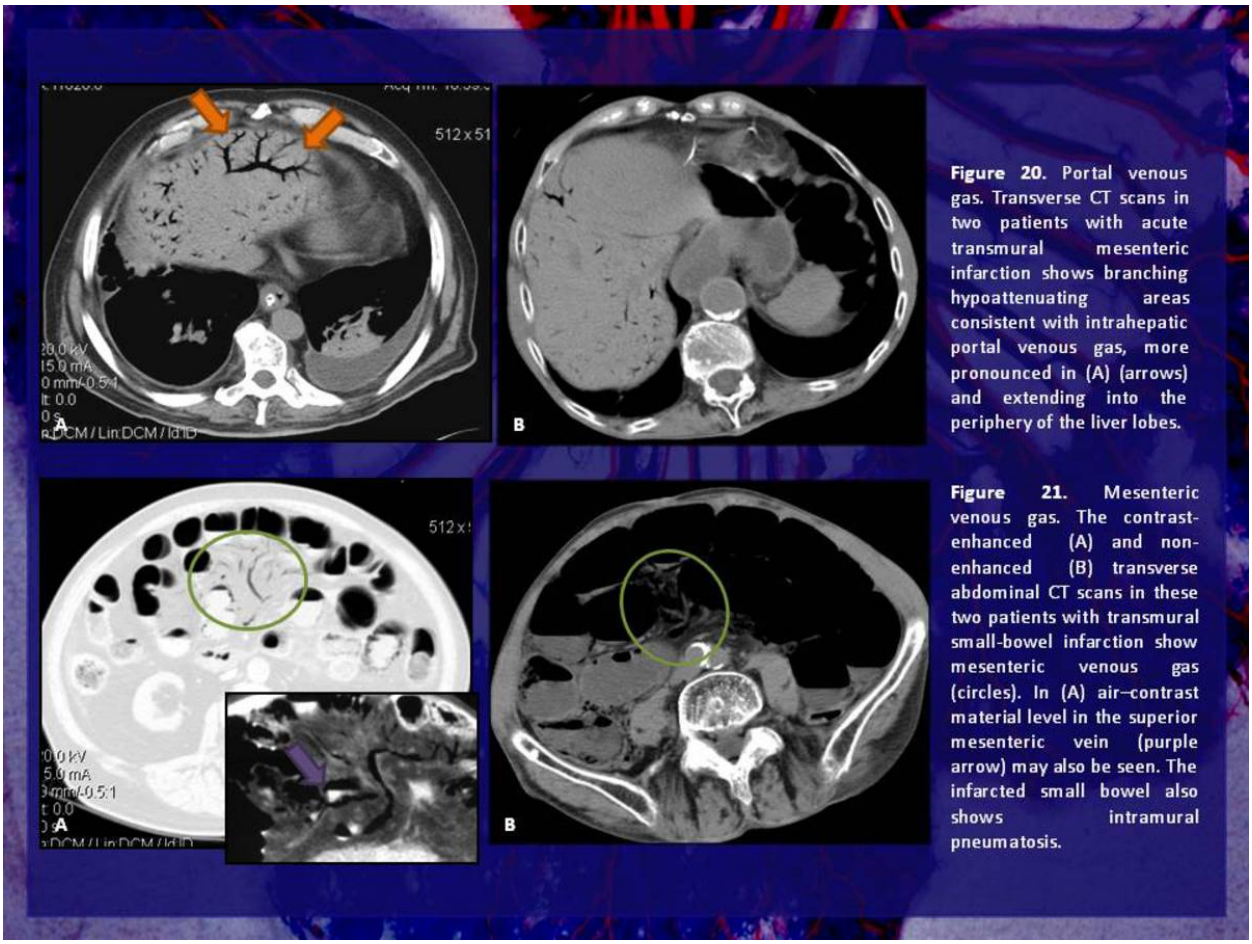

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

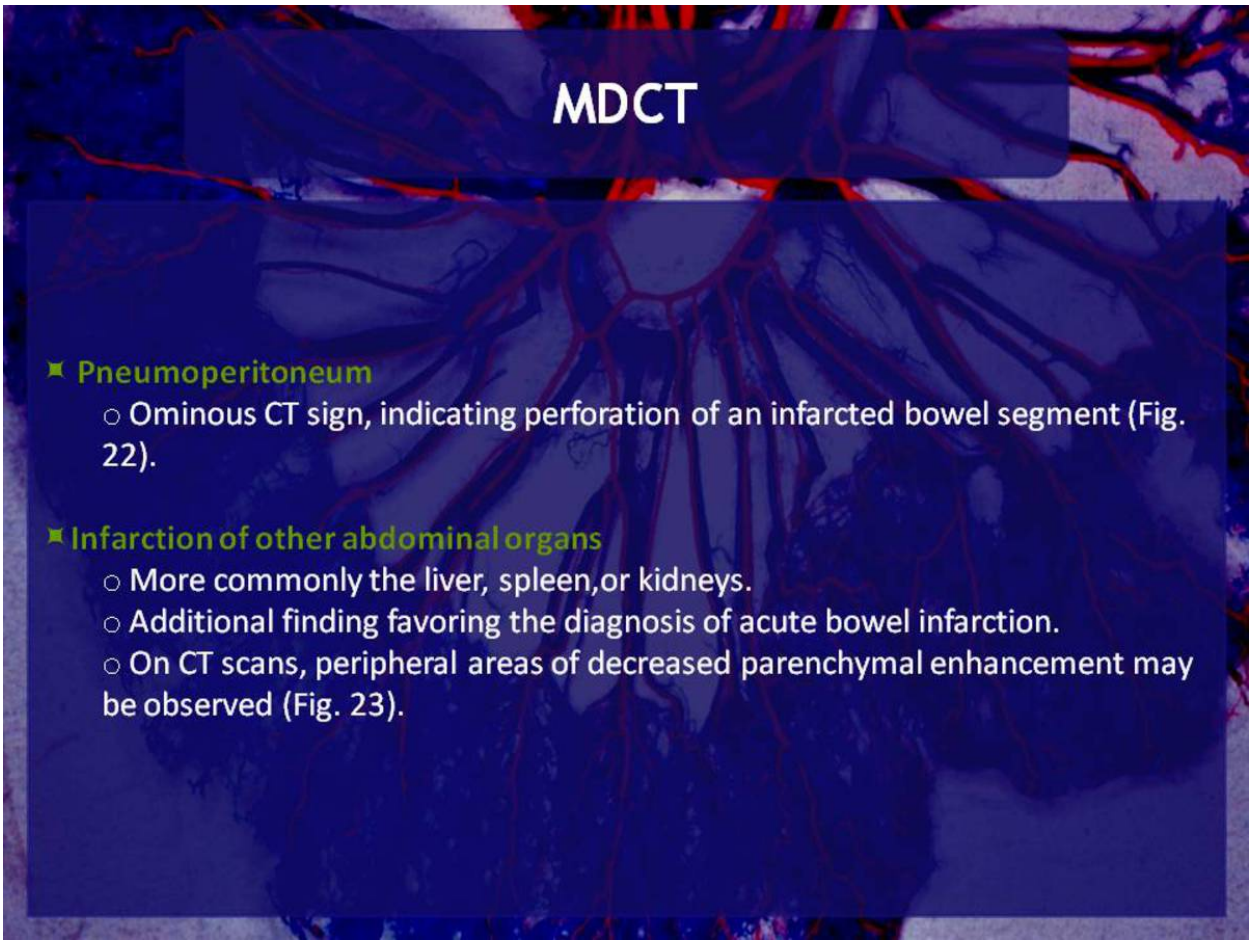

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

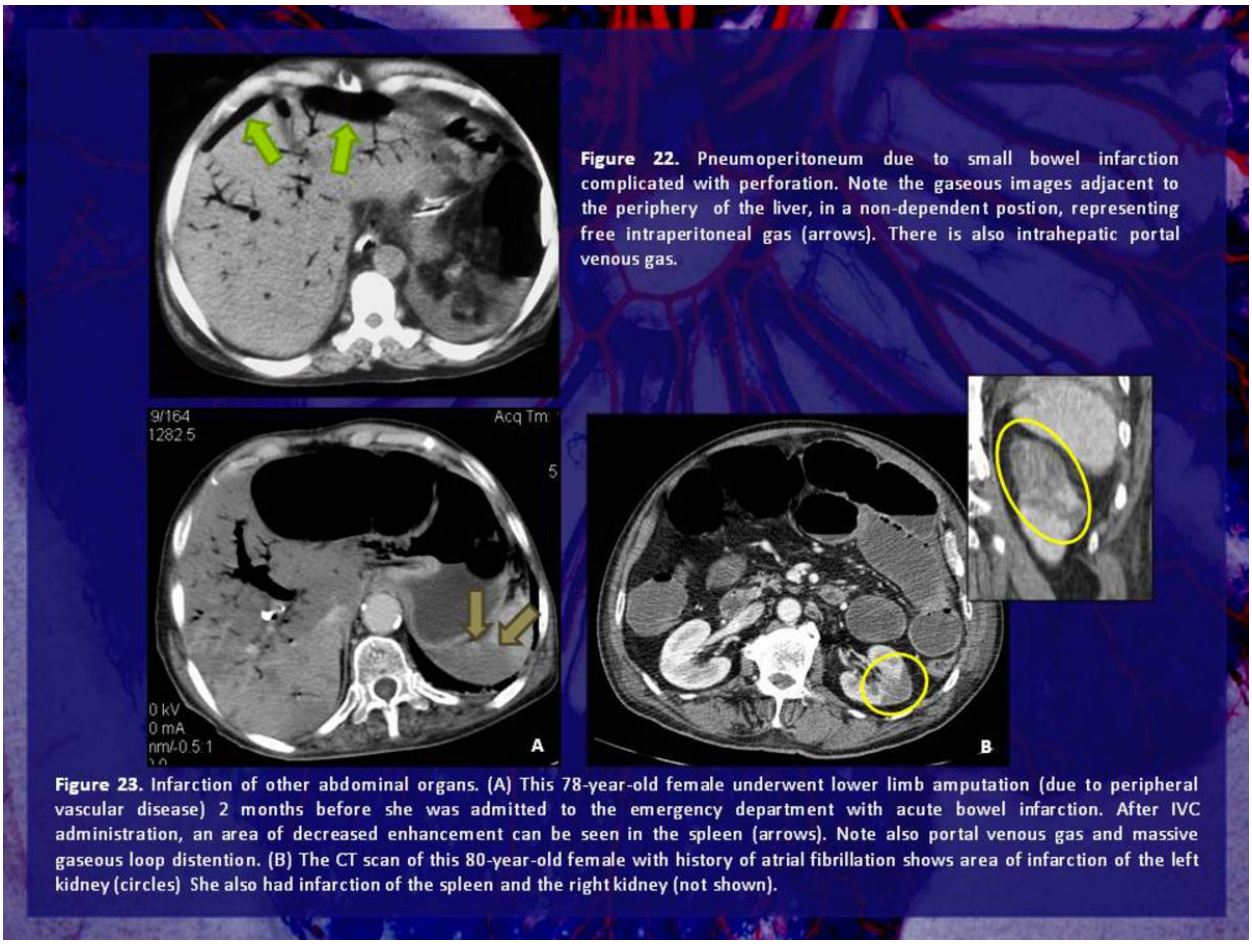

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

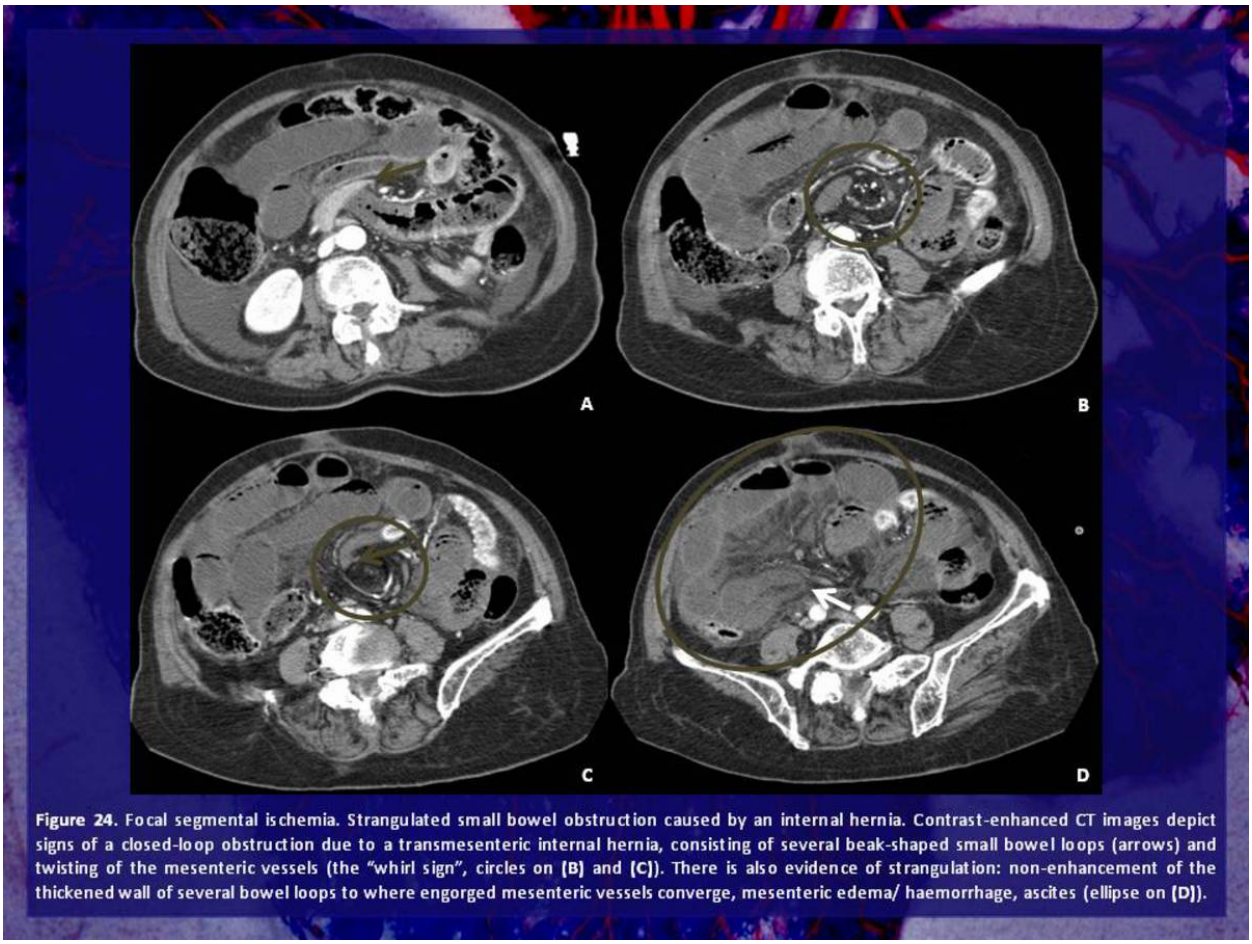

Figure 24. Focal segmental ischemia. Strangulated small bowel obstruction caused by an internal hernia. Contrast-enhanced CT images depict signs of a closed-loop obstruction due to a transmesenteric internal hernia, consisting of several beak-shaped small bowel loops (arrows) and twisting of the mesenteric vessels (the "whirl sign", circles on **(B)** and **(C)**). There is also evidence of strangulation: non-enhancement of the thickened wall of several bowel loops to where engorged mesenteric vessels converge, mesenteric edema/ haemorrhage, ascites (ellipse on **(D)**).

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

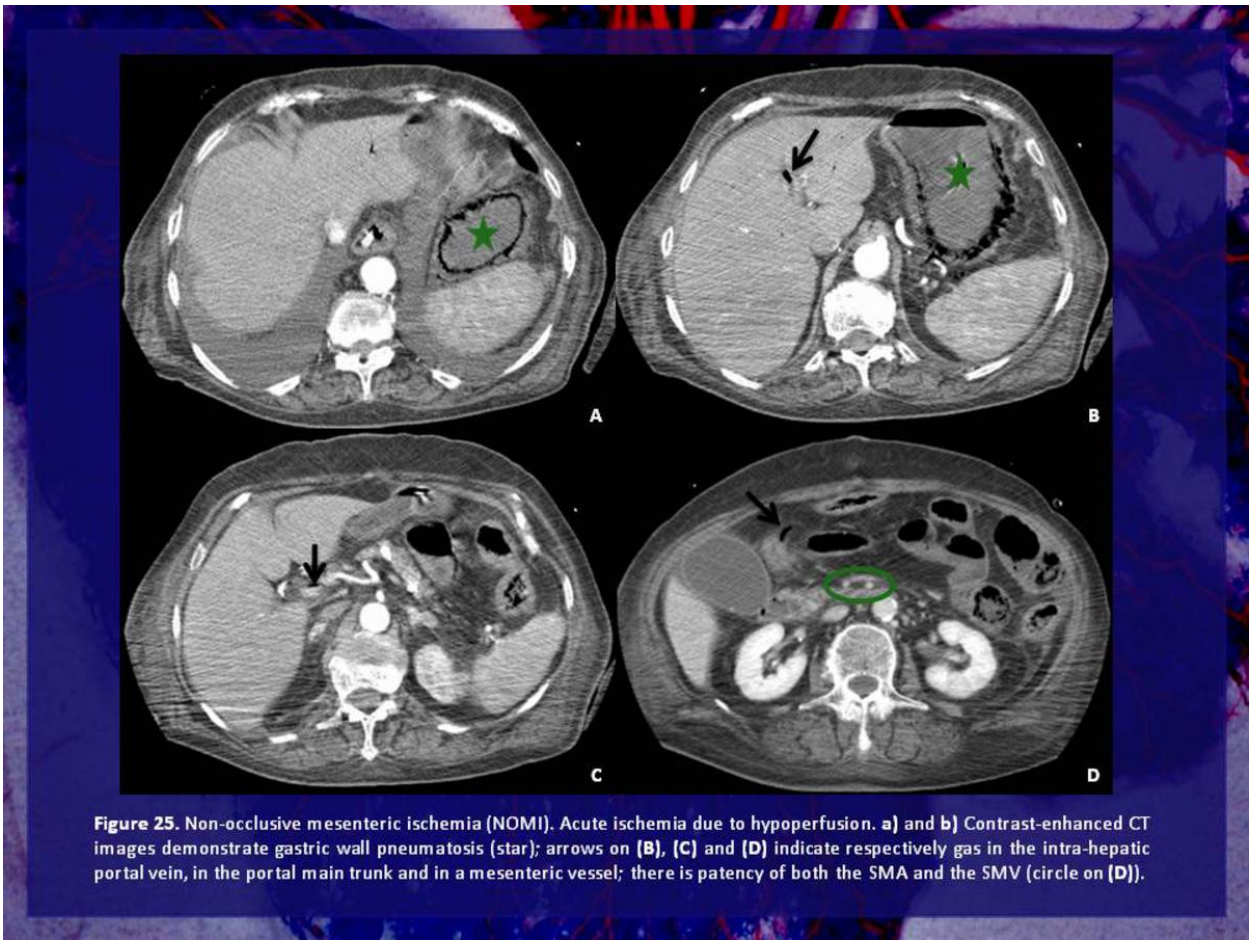

Figure 25. Non-occlusive mesenteric ischemia (NOMI). Acute ischemia due to hypoperfusion. **a)** and **b)** Contrast-enhanced CT images demonstrate gastric wall pneumatosis (star); arrows on **(B)**, **(C)** and **(D)** indicate respectively gas in the intra-hepatic portal vein, in the portal main trunk and in a mesenteric vessel; there is patency of both the SMA and the SMV (circle on **(D)**).

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

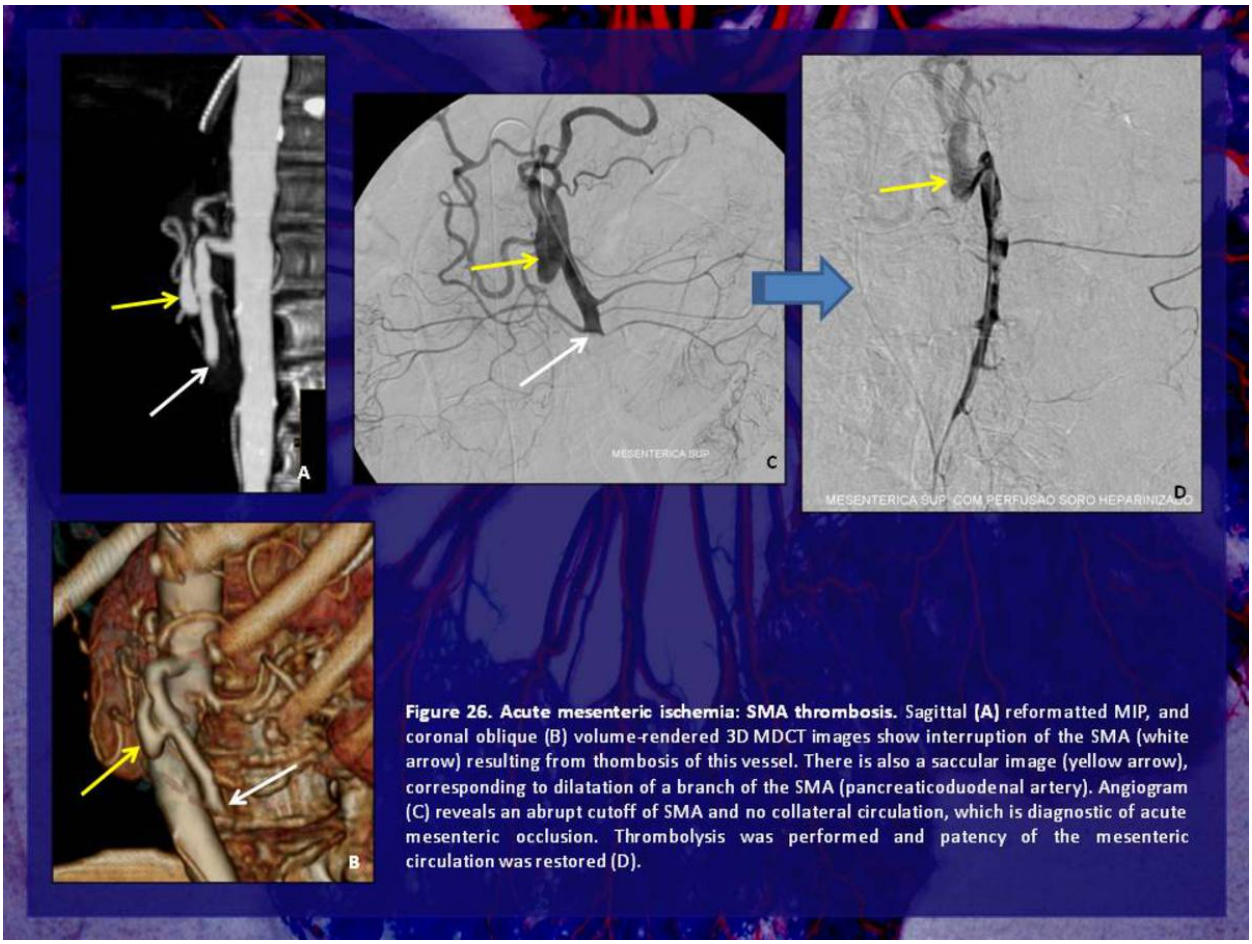

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

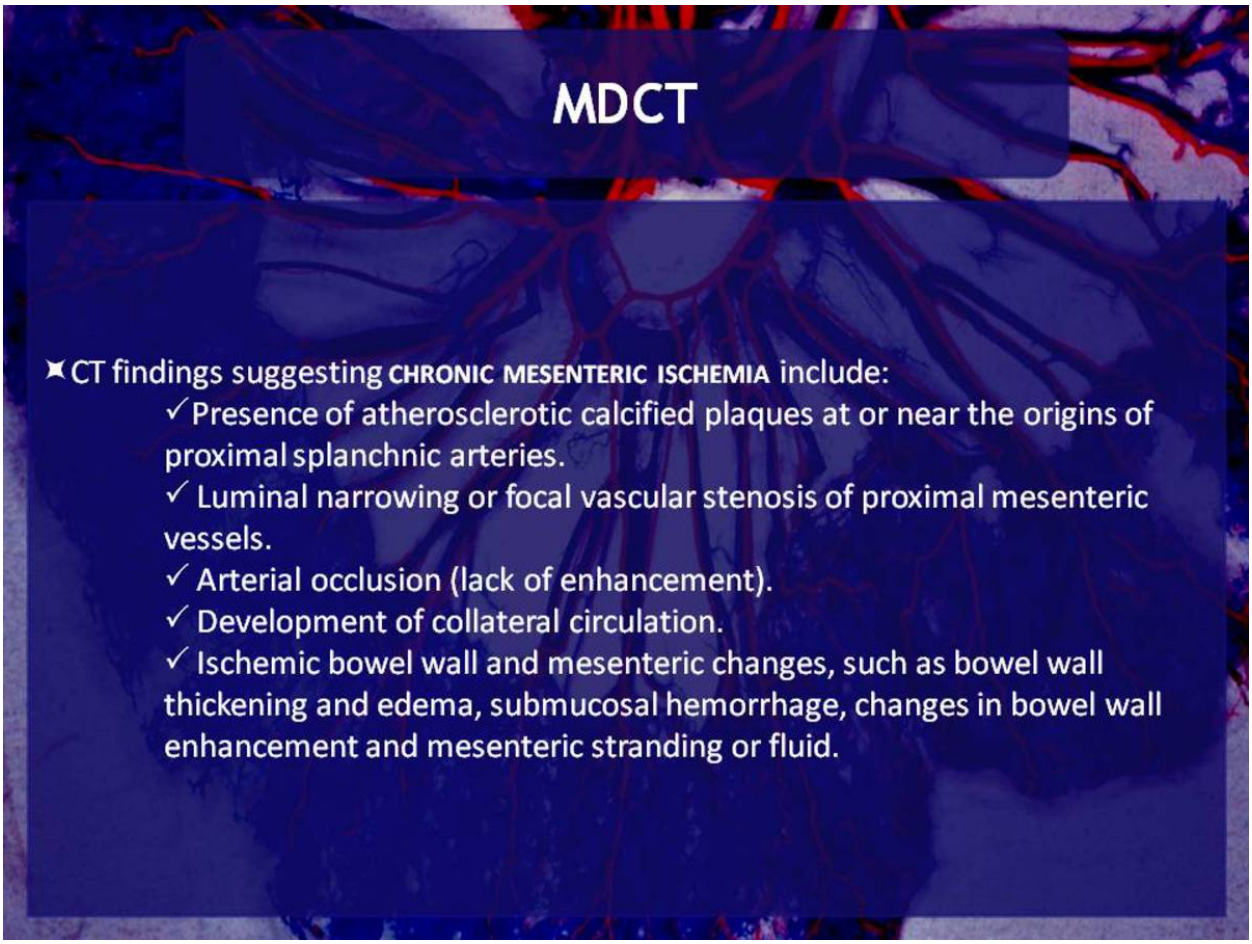

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

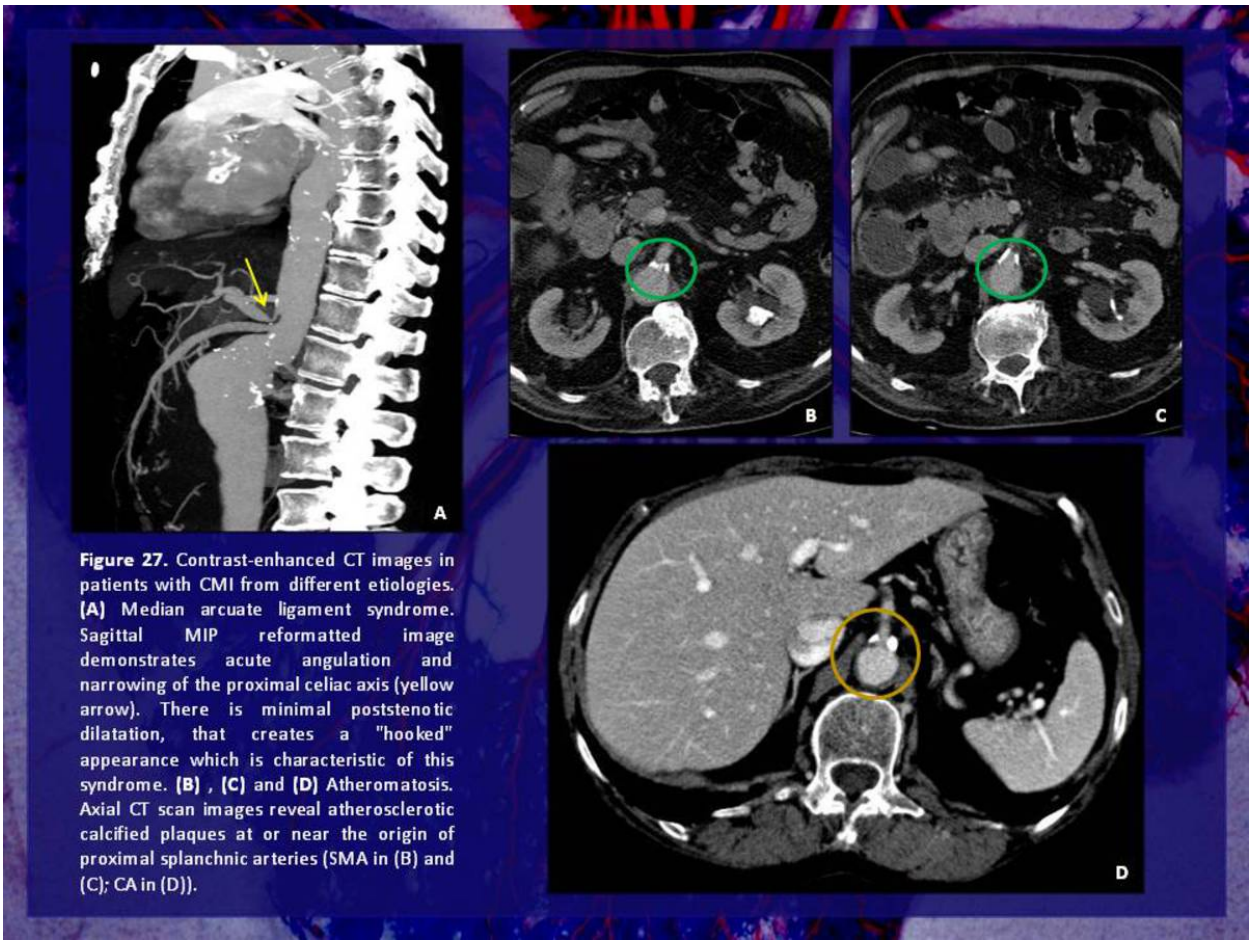

Figure 27. Contrast-enhanced CT images in patients with CMI from different etiologies. **(A)** Median arcuate ligament syndrome. Sagittal MIP reformatted image demonstrates acute angulation and narrowing of the proximal celiac axis (yellow arrow). There is minimal poststenotic dilatation, that creates a "hooked" appearance which is characteristic of this syndrome. **(B)** , **(C)** and **(D)** Atheromatosis. Axial CT scan images reveal atherosclerotic calcified plaques at or near the origin of proximal splanchnic arteries (SMA in (B) and (C); CA in (D)).

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

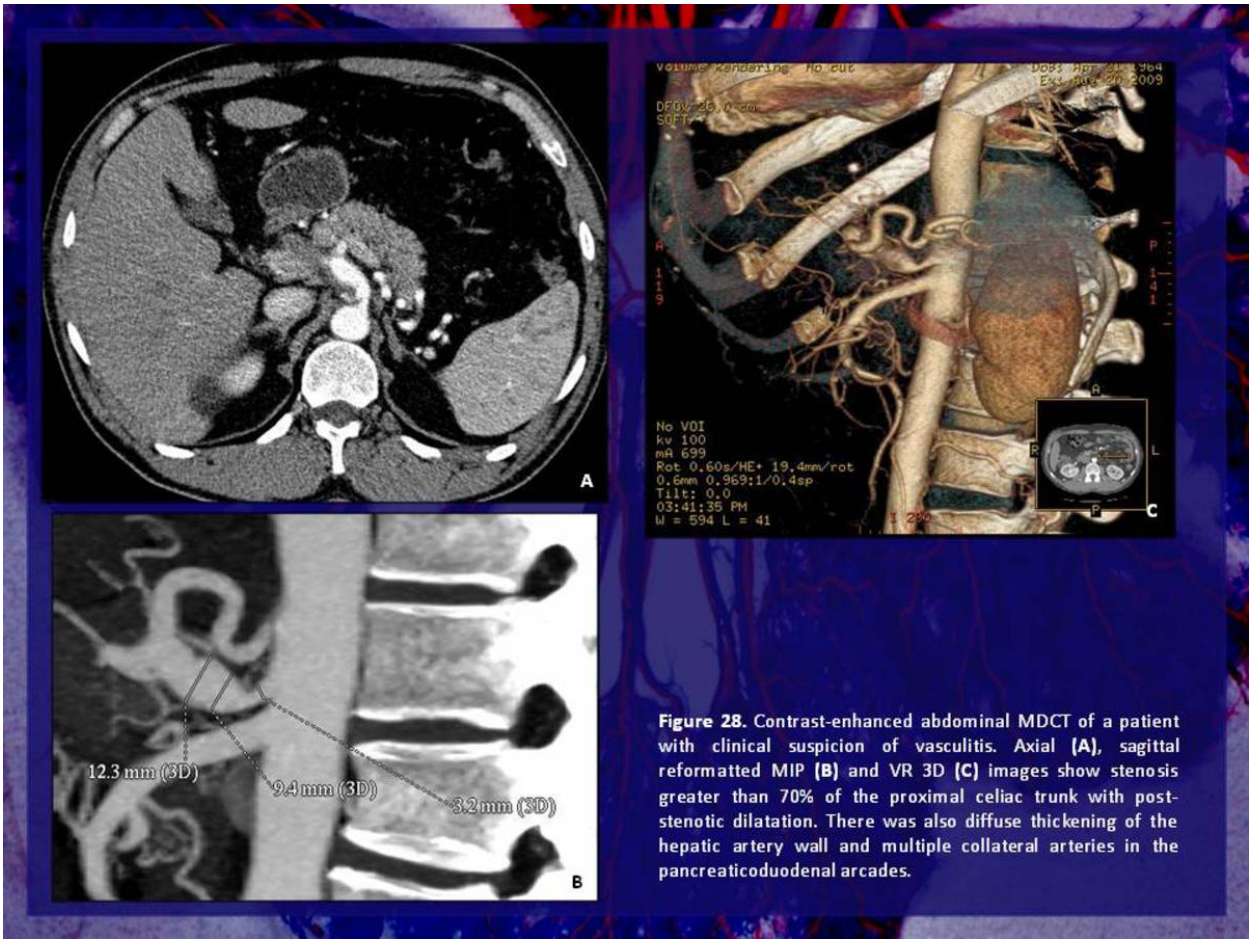

Fig.

References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

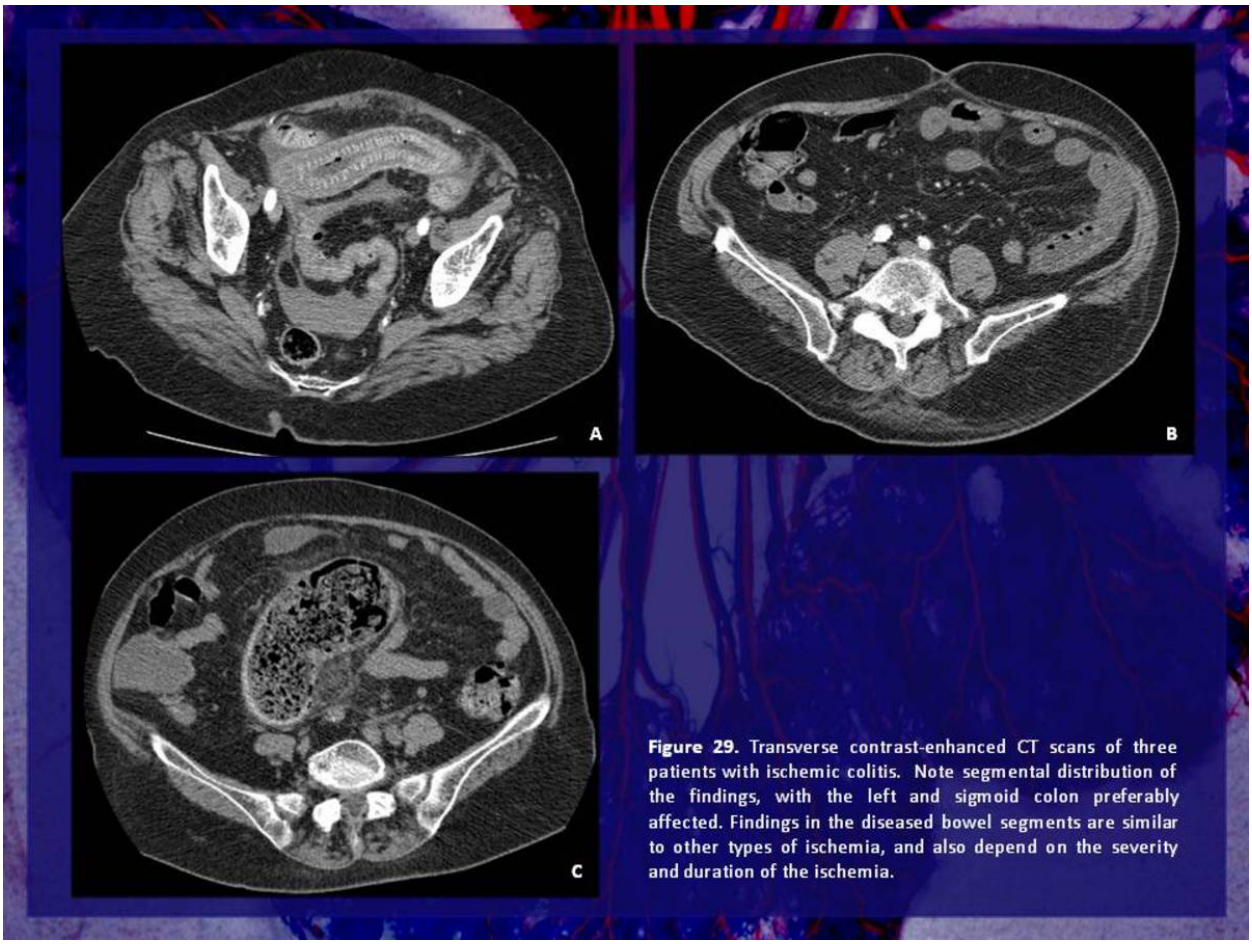

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

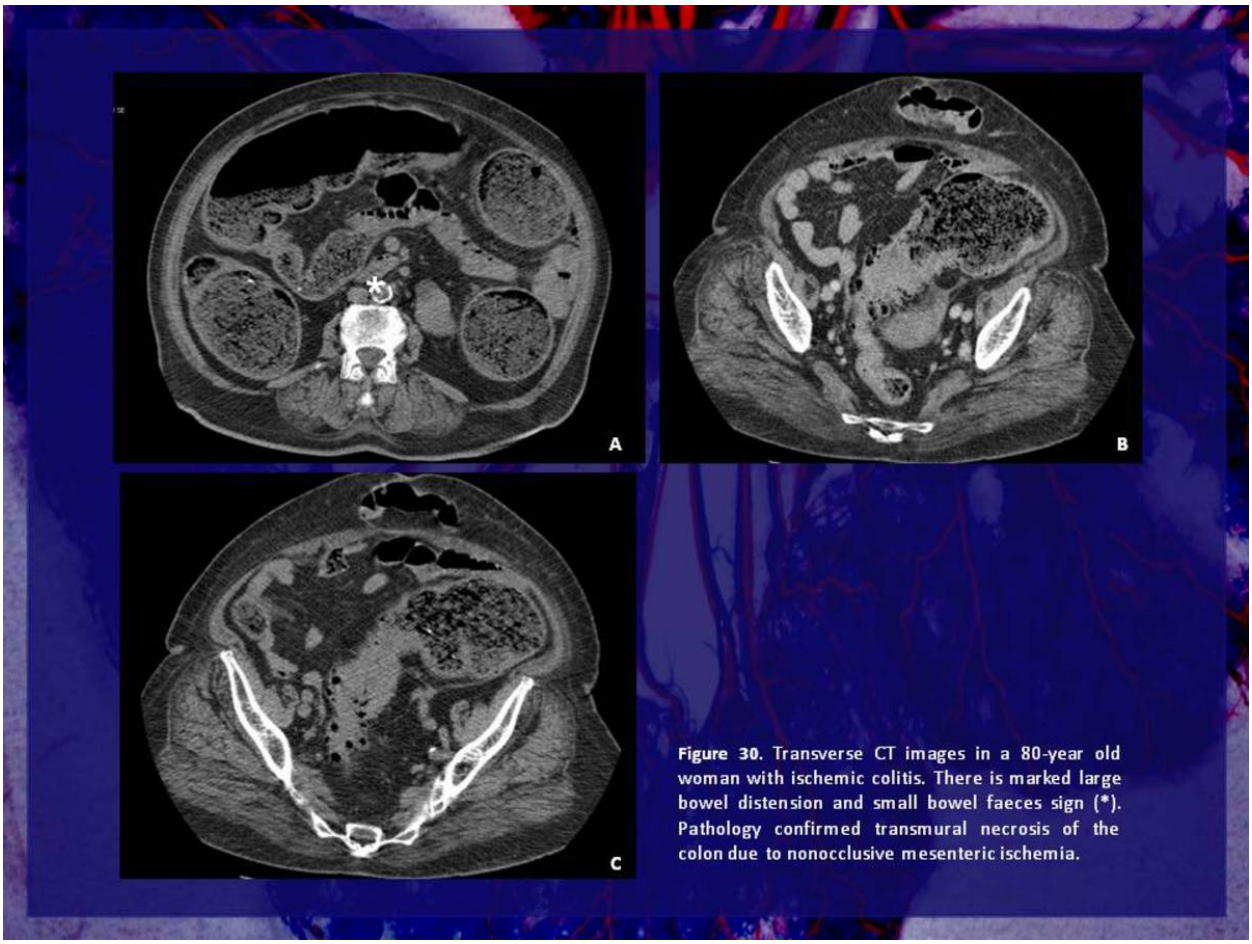

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

Images for this section:

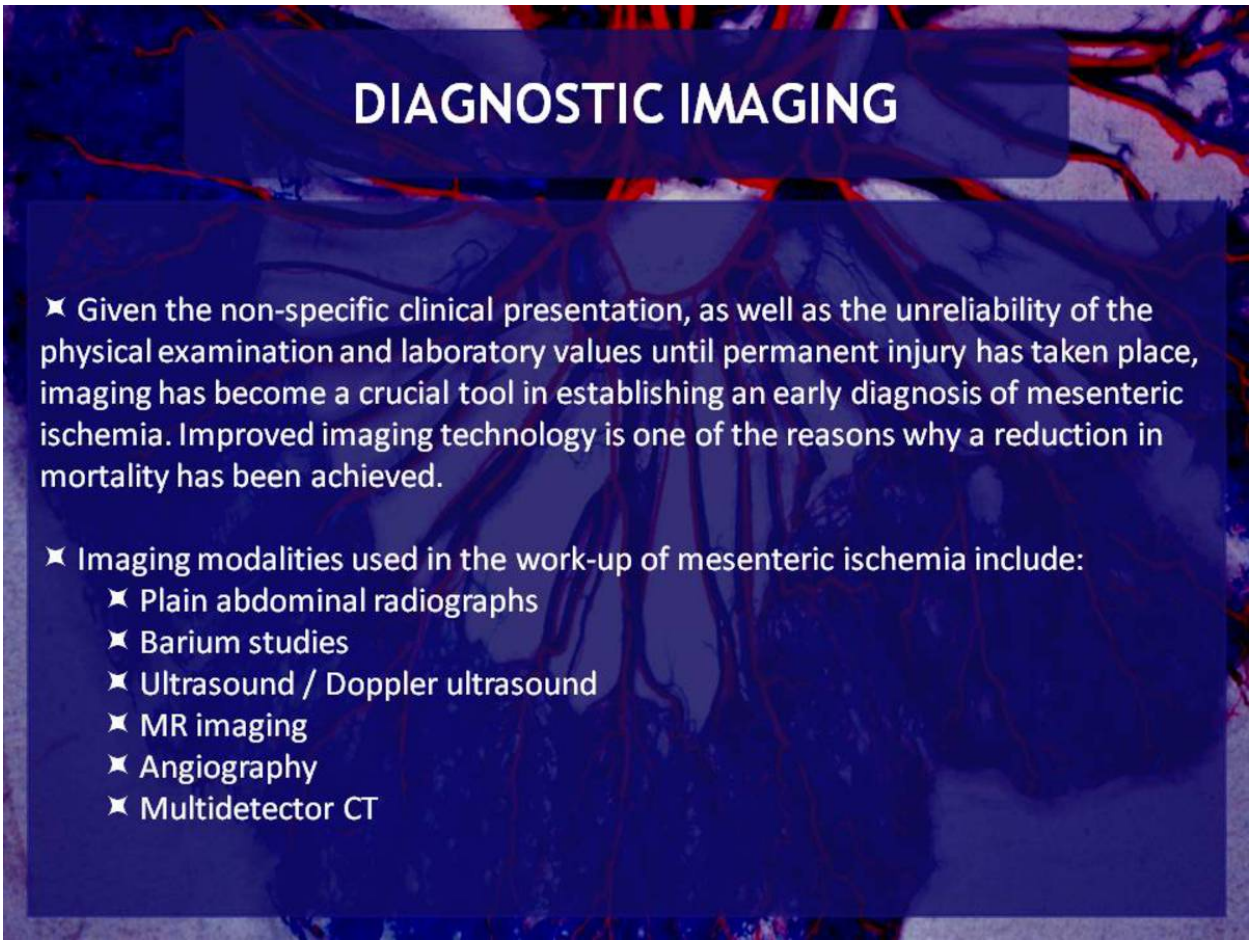
DIAGNOSTIC IMAGING
Given the non-specific clinical presentation, as well as the unreliability of the physical examination and laboratory values until permanent injury has taken place, imaging has become a crucial tool in establishing an early diagnosis of mesenteric ischemia. Improved imaging technology is one of the reasons why a reduction in mortality has been achieved.
Imaging modalities used in the work-up of mesenteric ischemia include:
Plain abdominal radiographs
Barium studies
Ultrasound / Doppler ultrasound
MR imaging
Angiography
Multidetector CT

Fig. 1


PLAIN ABDOMINAL FILMS
May be normal.
Nonspecific findings:
Gasless abdomen
Small bowel pseudo-obstruction pattern (paralytic ileus)
More specific (but far less common) findings (usually indicate late-stage disease):
Thumbprinting: multiple, round, smooth soft-tissue densities projecting into the intestinal lumen (due to mucosal and submucosal edema and hemorrhage)
Separation of bowel loops caused by mesenteric thickening
Pneumatosis intestinalis: intramural gas
Mesenteric or portal venous gas
In most cases, plain radiographs give little clue to the specific diagnosis, hence their little use in the diagnostic evaluation of mesenteric ischemia.
The main utility of the plain film is to exclude other causes of acute abdomen such as perforation and obstruction.

Fig. 2

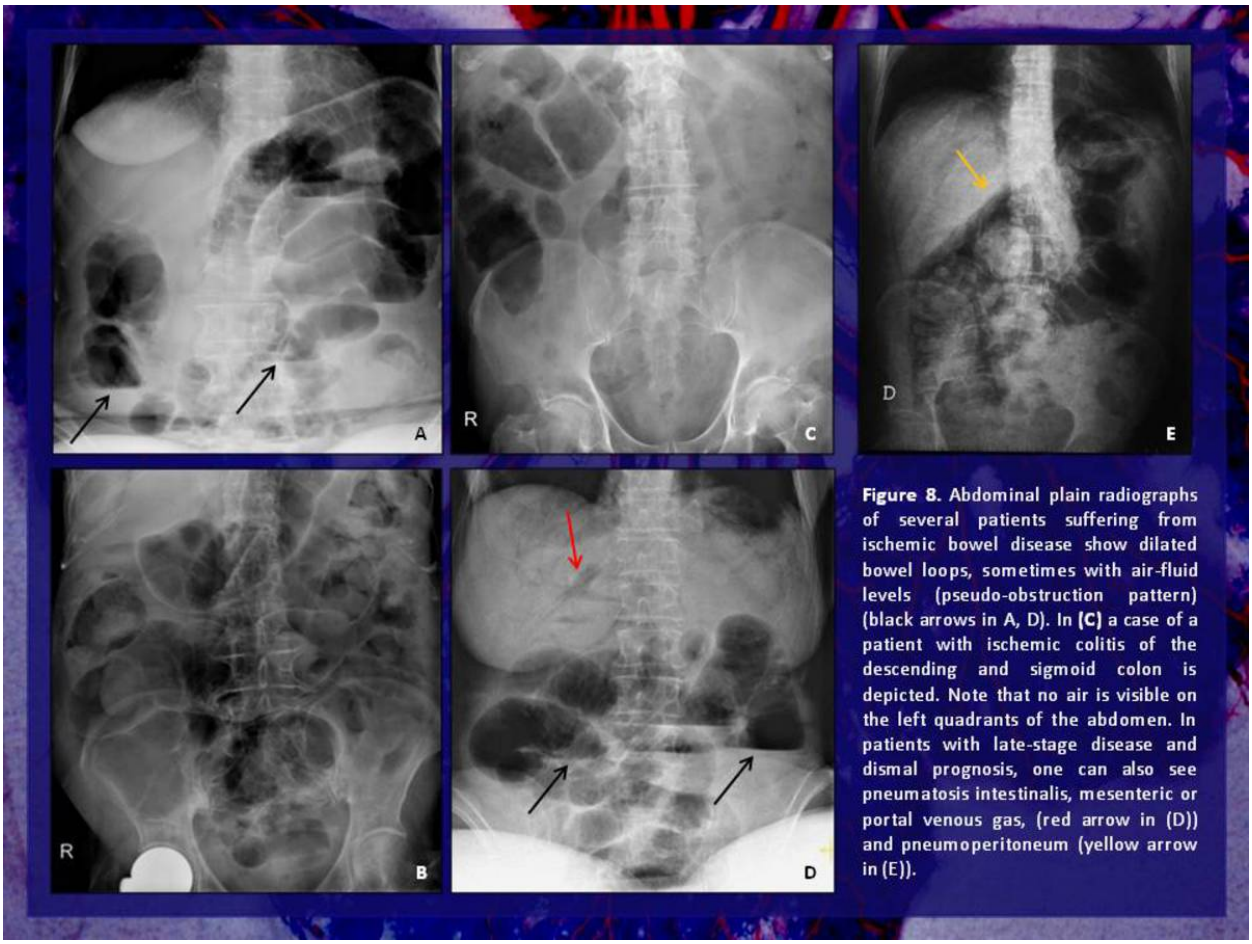

Figure 8. Abdominal plain radiographs of several patients suffering from ischemic bowel disease show dilated bowel loops, sometimes with air-fluid levels (pseudo-obstruction pattern) (black arrows in A, D). In **(C)** a case of a patient with ischemic colitis of the descending and sigmoid colon is depicted. Note that no air is visible on the left quadrants of the abdomen. In patients with late-stage disease and dismal prognosis, one can also see pneumatosis intestinalis, mesenteric or portal venous gas, (red arrow in (D)) and pneumoperitoneum (yellow arrow in (E)).

Fig. 3


BARIUM STUDIES
Similarly to plain abdominal films, barium studies are non-specific and insensitive in the evaluation of mesenteric ischemia. Furthermore, dense barium interferes with subsequent examinations (MDCT, angiography, colonoscopy). Consequently, it has been nearly completely replaced by other diagnostic imaging modalities, namely MDCT.
Findings include:
bowel dilatation,
thickened folds,
thumbprinting (especially along the mesenteric border of the bowel),
effacement of the mucosal pattern,
ulceration, and
stasis of barium.

Fig. 4

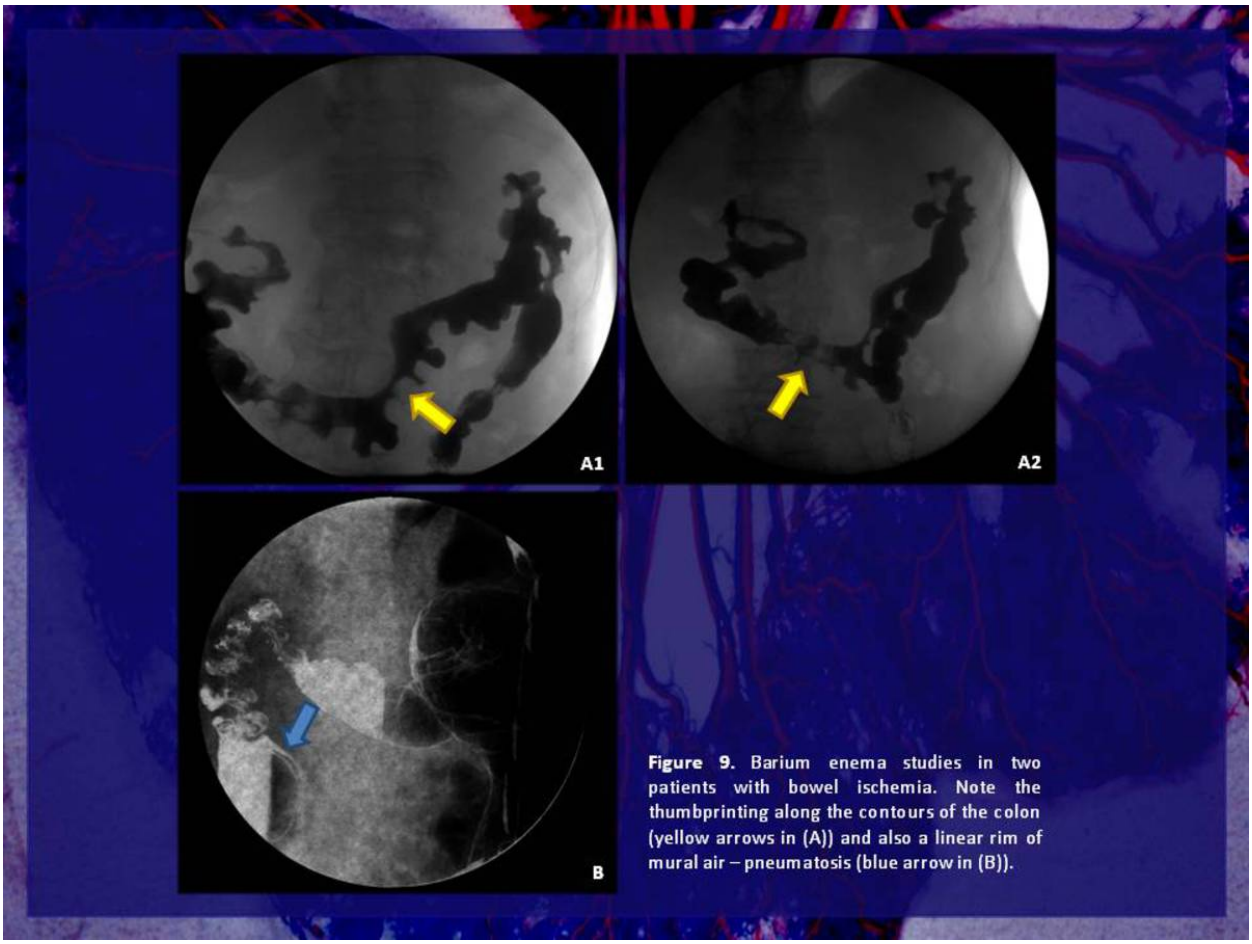
A1
A2
B
Figure 9. Barium enema studies in two patients with bowel ischemia. Note the thumbprinting along the contours of the colon (yellow arrows in (A)) and also a linear rim of mural air – pneumatosis (blue arrow in (B)).

Fig. 5

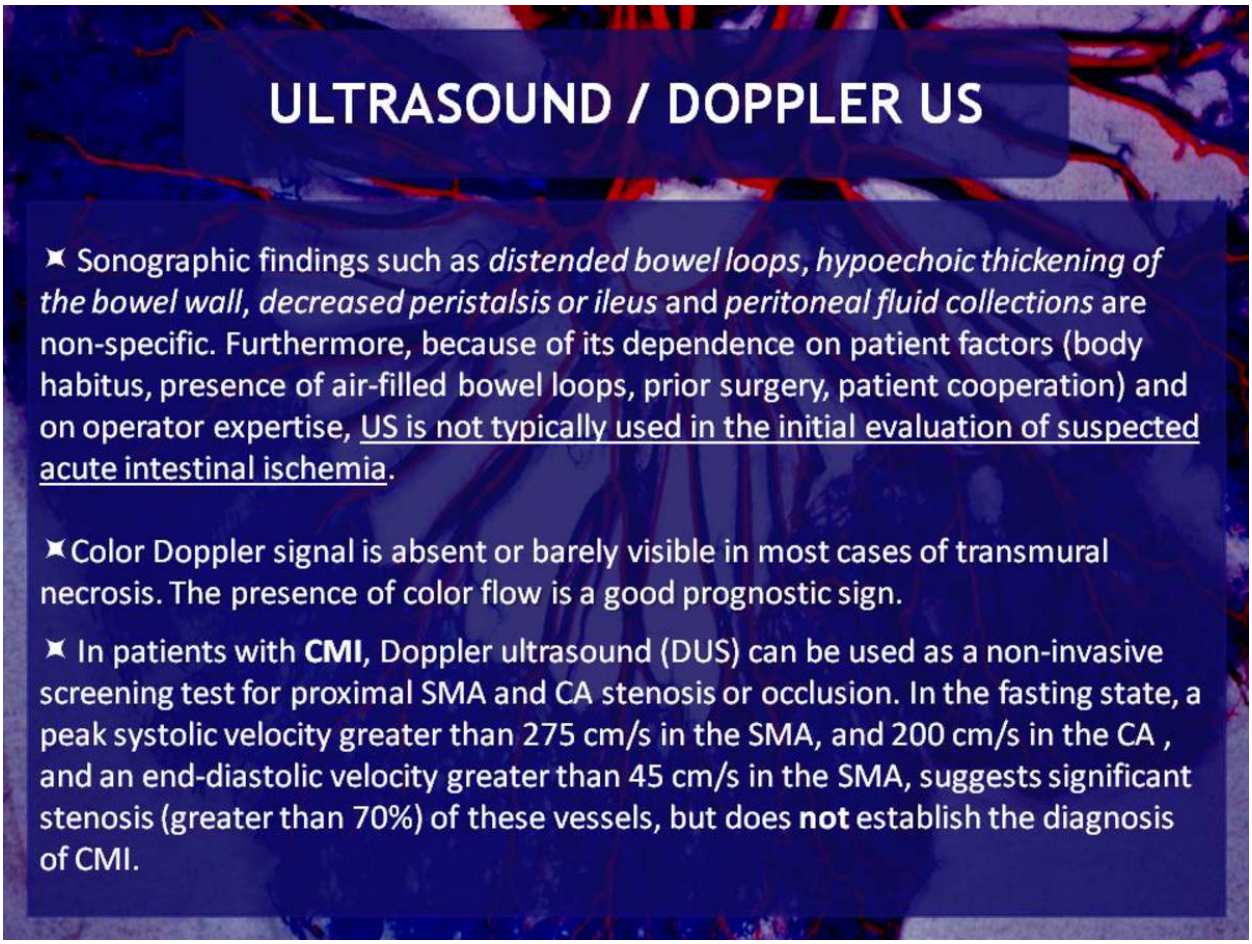
ULTRASOUND / DOPPLER US
Sonographic findings such as distended bowel loops, hypoechoic thickening of the bowel wall, decreased peristalsis or ileus and peritoneal fluid collections are non-specific. Furthermore, because of its dependence on patient factors (body habitus, presence of air-filled bowel loops, prior surgery, patient cooperation) and on operator expertise, US is not typically used in the initial evaluation of suspected acute intestinal ischemia.
Color Doppler signal is absent or barely visible in most cases of transmural necrosis. The presence of color flow is a good prognostic sign.
In patients with CMI, Doppler ultrasound (DUS) can be used as a non-invasive screening test for proximal SMA and CA stenosis or occlusion. In the fasting state, a peak systolic velocity greater than 275 cm/s in the SMA, and 200 cm/s in the CA , and an end-diastolic velocity greater than 45 cm/s in the SMA, suggests significant stenosis (greater than 70%) of these vessels, but does not establish the diagnosis of CMI.

Fig. 6

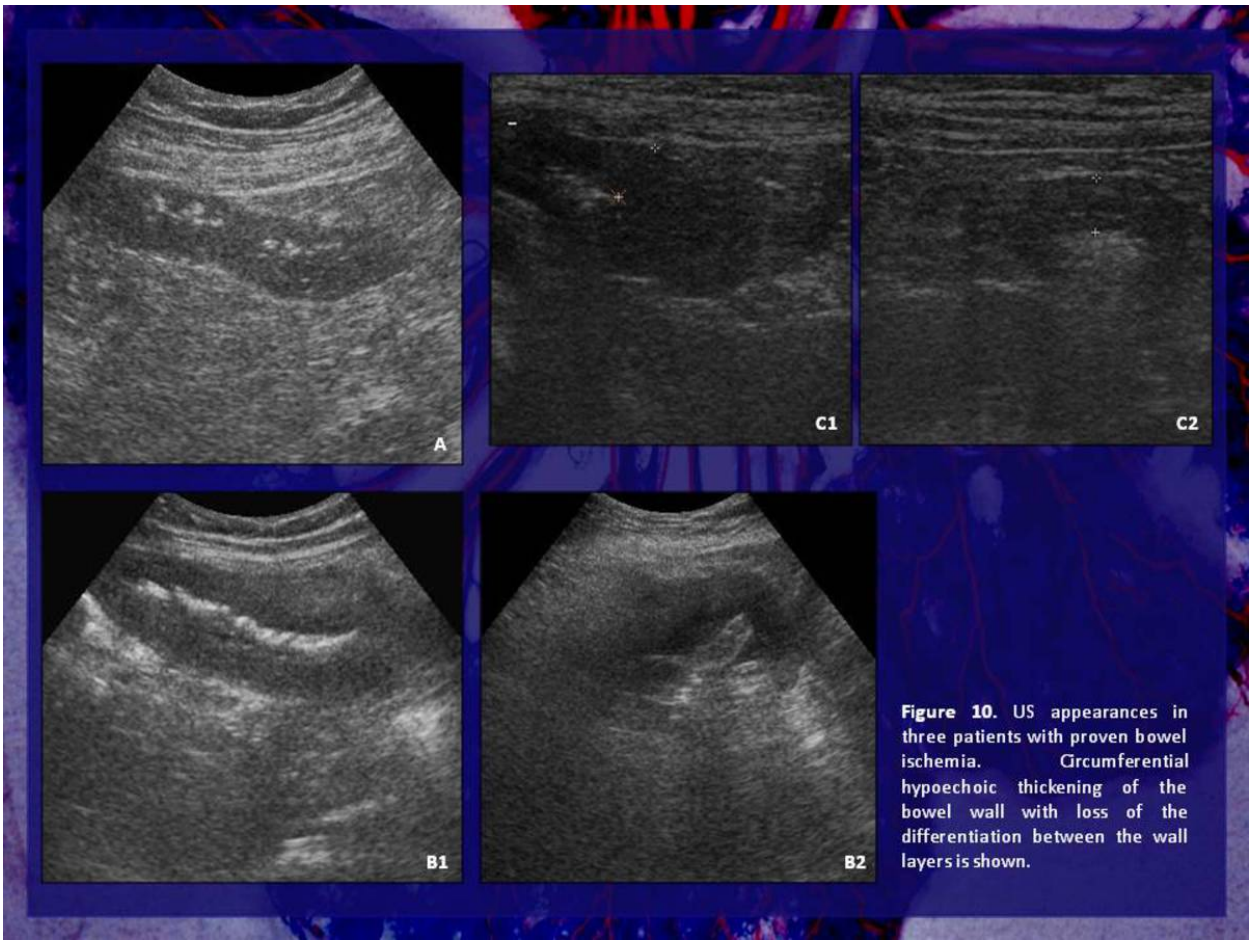
A
C1
C2
B1
B2
Figure 10. US appearances in three patients with proven bowel ischemia. Circumferential hypoechoic thickening of the bowel wall with loss of the differentiation between the wall layers is shown.

Fig. 7

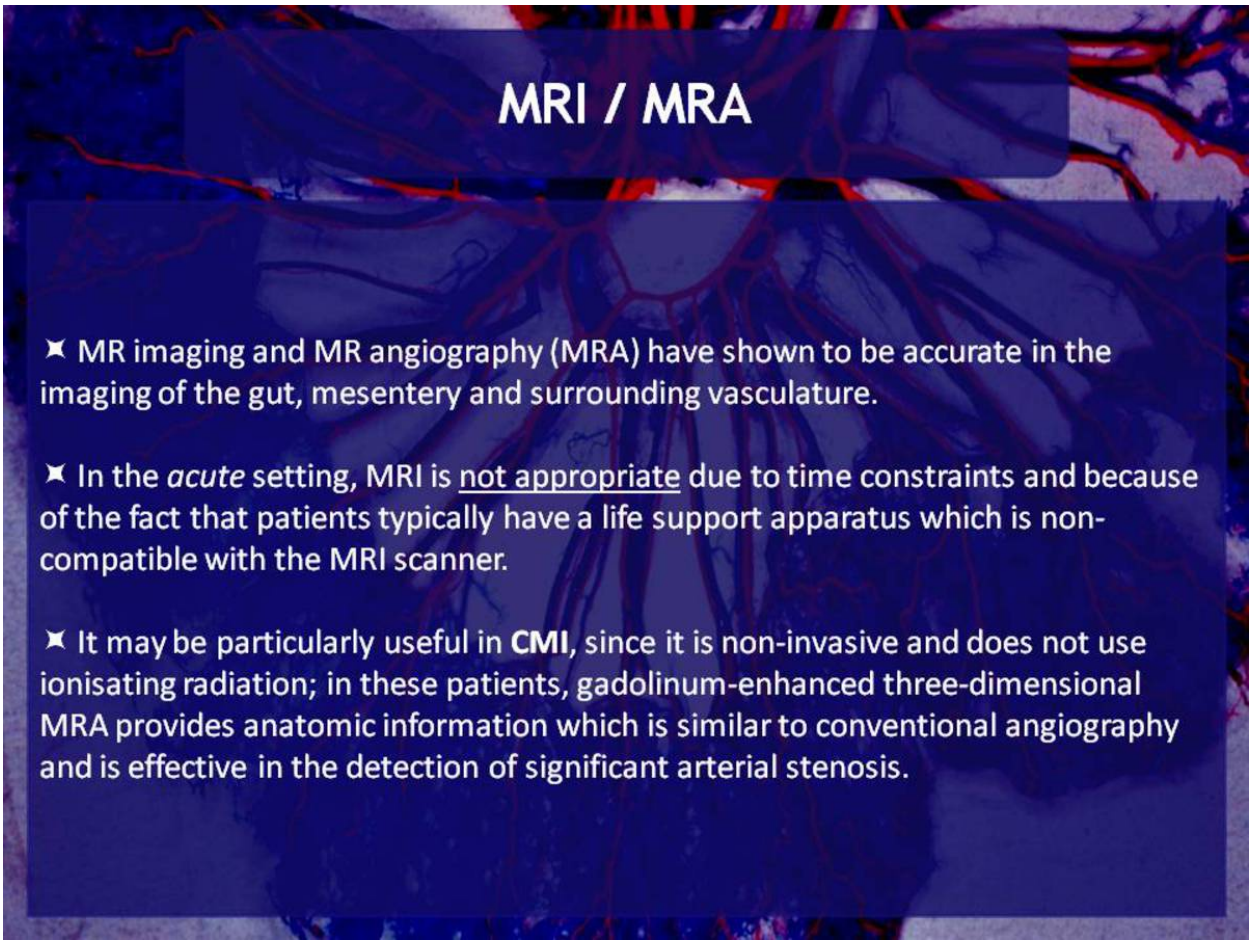
MRI / MRA
MR imaging and MR angiography (MRA) have shown to be accurate in the imaging of the gut, mesentery and surrounding vasculature.
In the *acute* setting, MRI is not appropriate due to time constraints and because of the fact that patients typically have a life support apparatus which is non-compatible with the MRI scanner.
It may be particularly useful in **CMI**, since it is non-invasive and does not use ionisating radiation; in these patients, gadolinum-enhanced three-dimensional MRA provides anatomic information which is similar to conventional angiography and is effective in the detection of significant arterial stenosis.

Fig. 8

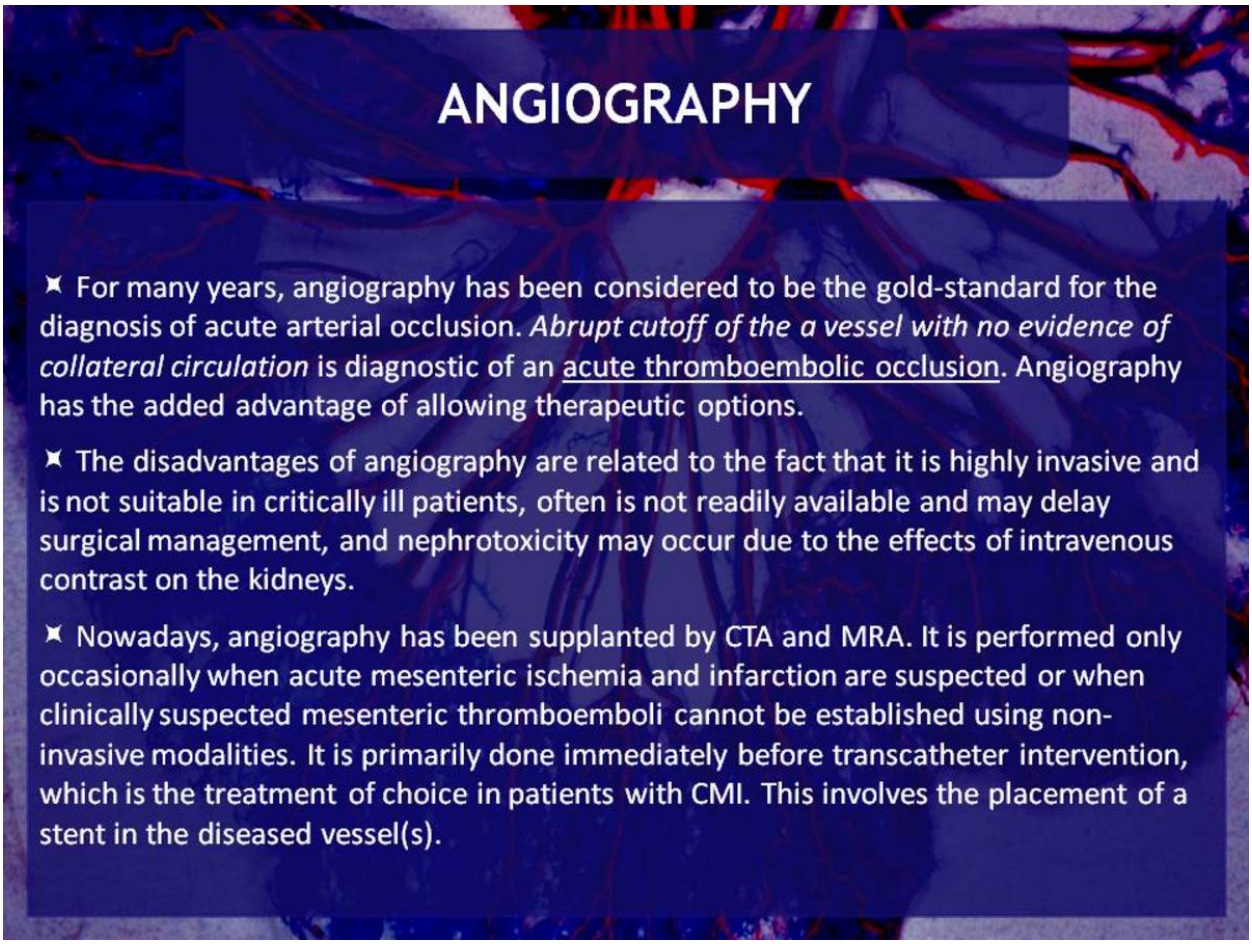
ANGIOGRAPHY
For many years, angiography has been considered to be the gold-standard for the diagnosis of acute arterial occlusion. *Abrupt cutoff of the a vessel with no evidence of collateral circulation* is diagnostic of an acute thromboembolic occlusion. Angiography has the added advantage of allowing therapeutic options.
The disadvantages of angiography are related to the fact that it is highly invasive and is not suitable in critically ill patients, often is not readily available and may delay surgical management, and nephrotoxicity may occur due to the effects of intravenous contrast on the kidneys.
Nowadays, angiography has been supplanted by CTA and MRA. It is performed only occasionally when acute mesenteric ischemia and infarction are suspected or when clinically suspected mesenteric thromboemboli cannot be established using non-invasive modalities. It is primarily done immediately before transcatheter intervention, which is the treatment of choice in patients with CMI. This involves the placement of a stent in the diseased vessel(s).

Fig. 9

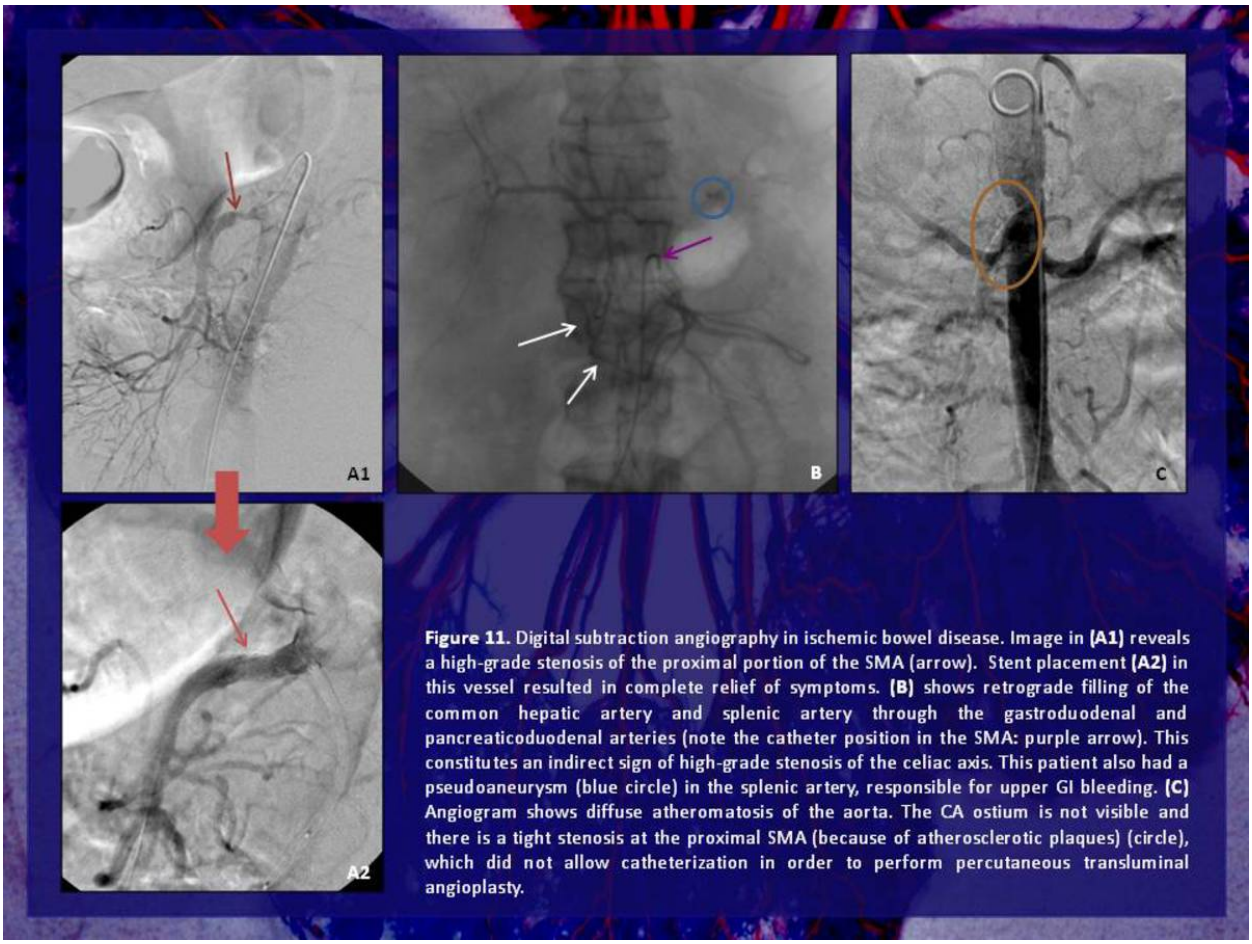
A1
B
C
A2
Figure 11. Digital subtraction angiography in ischemic bowel disease. Image in (A1) reveals a high-grade stenosis of the proximal portion of the SMA (arrow). Stent placement (A2) in this vessel resulted in complete relief of symptoms. (B) shows retrograde filling of the common hepatic artery and splenic artery through the gastroduodenal and pancreaticoduodenal arteries (note the catheter position in the SMA: purple arrow). This constitutes an indirect sign of high-grade stenosis of the celiac axis. This patient also had a pseudoaneurysm (blue circle) in the splenic artery, responsible for upper GI bleeding. (C) Angiogram shows diffuse atheromatosis of the aorta. The CA ostium is not visible and there is a tight stenosis at the proximal SMA (because of atherosclerotic plaques) (circle), which did not allow catheterization in order to perform percutaneous transluminal angioplasty.

Fig. 10

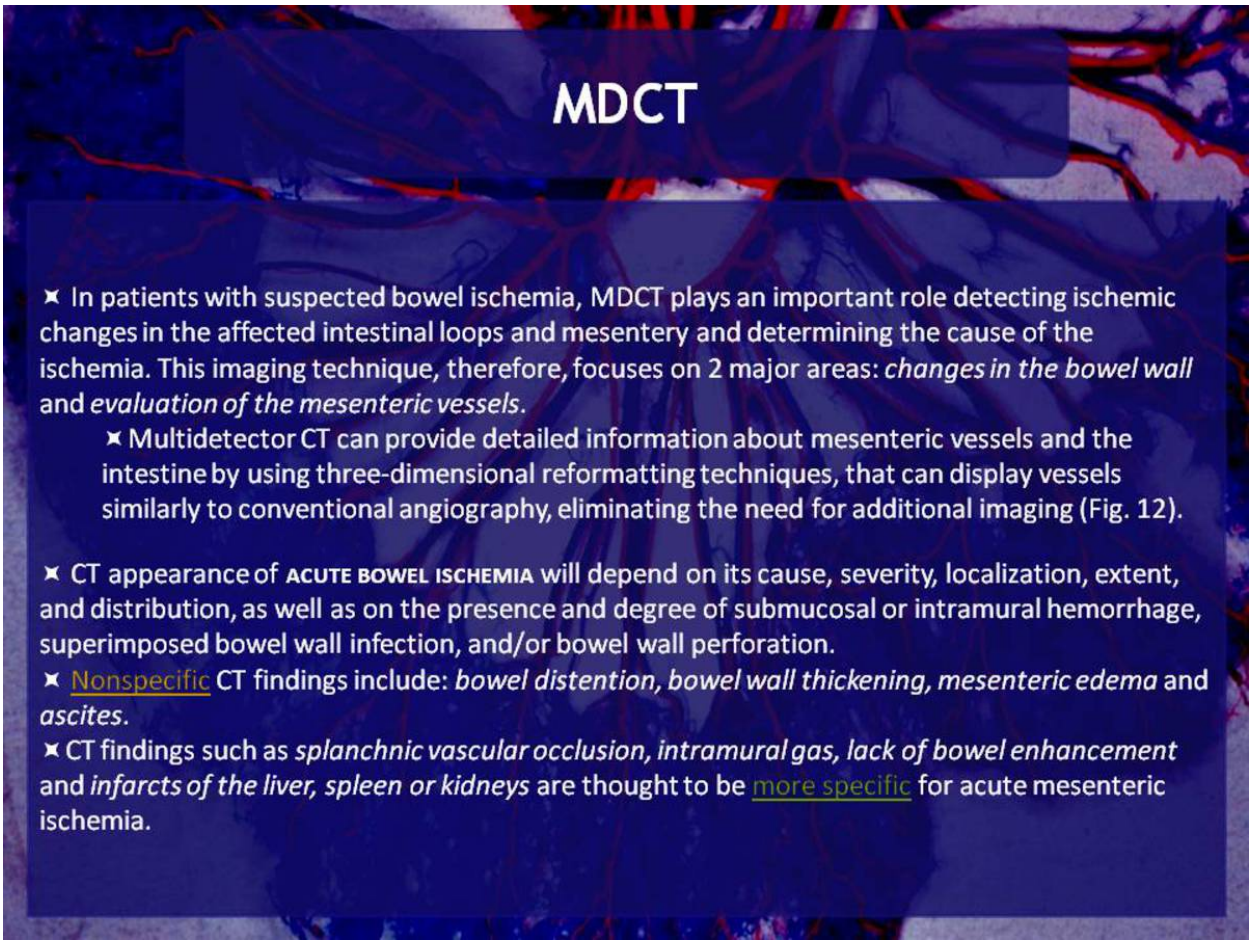
MDCT
In patients with suspected bowel ischemia, MDCT plays an important role detecting ischemic changes in the affected intestinal loops and mesentery and determining the cause of the ischemia. This imaging technique, therefore, focuses on 2 major areas: changes in the bowel wall and evaluation of the mesenteric vessels.
Multidetector CT can provide detailed information about mesenteric vessels and the intestine by using three-dimensional reformatting techniques, that can display vessels similarly to conventional angiography, eliminating the need for additional imaging (Fig. 12).
CT appearance of ACUTE BOWEL ISCHEMIA will depend on its cause, severity, localization, extent, and distribution, as well as on the presence and degree of submucosal or intramural hemorrhage, superimposed bowel wall infection, and/or bowel wall perforation.
Nonspecific CT findings include: bowel distention, bowel wall thickening, mesenteric edema and ascites.
CT findings such as splanchnic vascular occlusion, intramural gas, lack of bowel enhancement and infarcts of the liver, spleen or kidneys are thought to be more specific for acute mesenteric ischemia.

Fig. 11

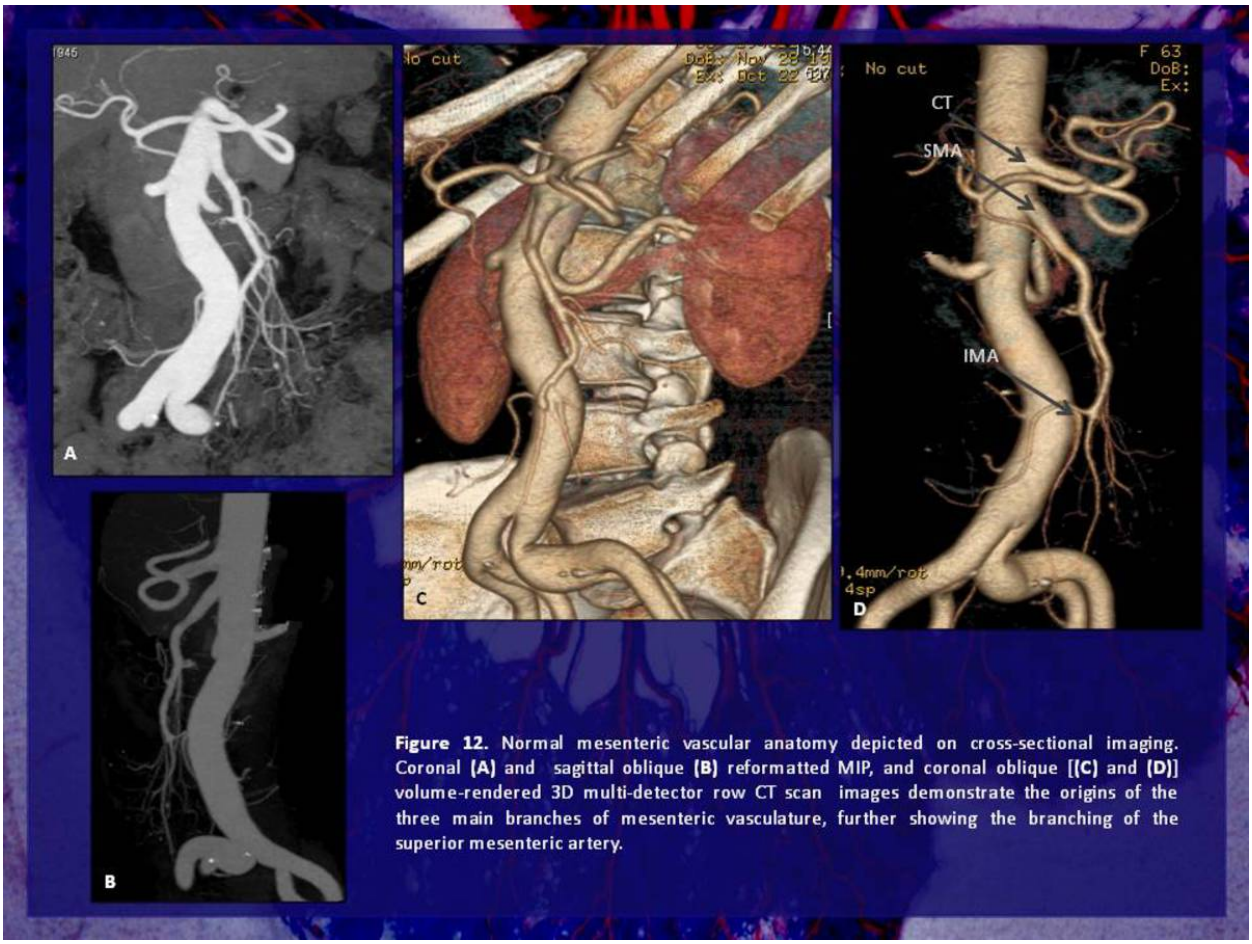

Figure 12. Normal mesenteric vascular anatomy depicted on cross-sectional imaging. Coronal **(A)** and sagittal oblique **(B)** reformatted MIP, and coronal oblique **[(C)** and **(D)]** volume-rendered 3D multi-detector row CT scan images demonstrate the origins of the three main branches of mesenteric vasculature, further showing the branching of the superior mesenteric artery.

Fig. 12

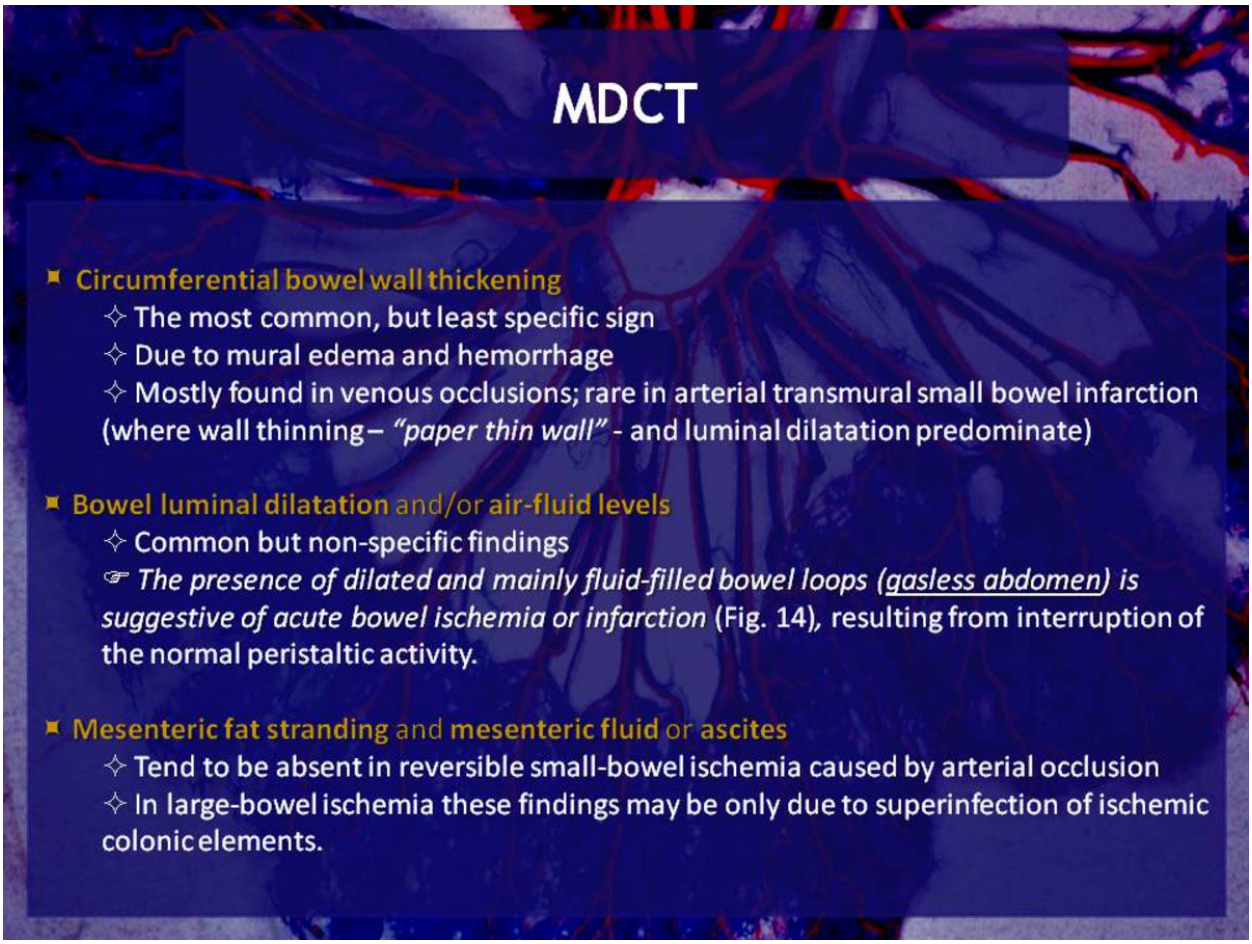
MDCT
Circumferential bowel wall thickening
The most common, but least specific sign
Due to mural edema and hemorrhage
Mostly found in venous occlusions; rare in arterial transmural small bowel infarction (where wall thinning – "paper thin wall" - and luminal dilatation predominate)
Bowel luminal dilatation and/or air-fluid levels
Common but non-specific findings
The presence of dilated and mainly fluid-filled bowel loops (gasless abdomen) is suggestive of acute bowel ischemia or infarction (Fig. 14), resulting from interruption of the normal peristaltic activity.
Mesenteric fat stranding and mesenteric fluid or ascites
Tend to be absent in reversible small-bowel ischemia caused by arterial occlusion
In large-bowel ischemia these findings may be only due to superinfection of ischemic colonic elements.

Fig. 13

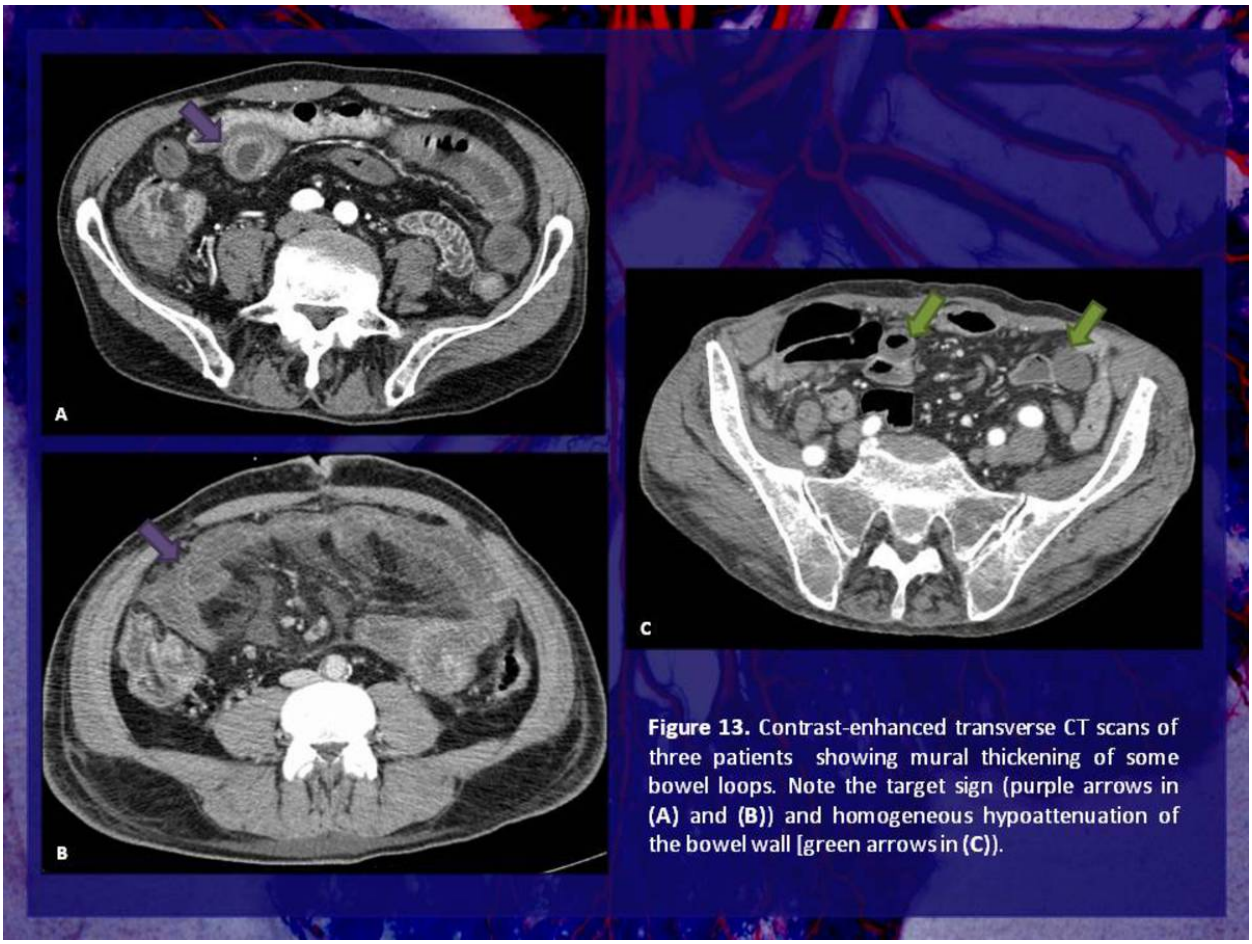
A
B
C
Figure 13. Contrast-enhanced transverse CT scans of three patients showing mural thickening of some bowel loops. Note the target sign (purple arrows in (A) and (B)) and homogeneous hypoattenuation of the bowel wall [green arrows in (C)).

Fig. 14

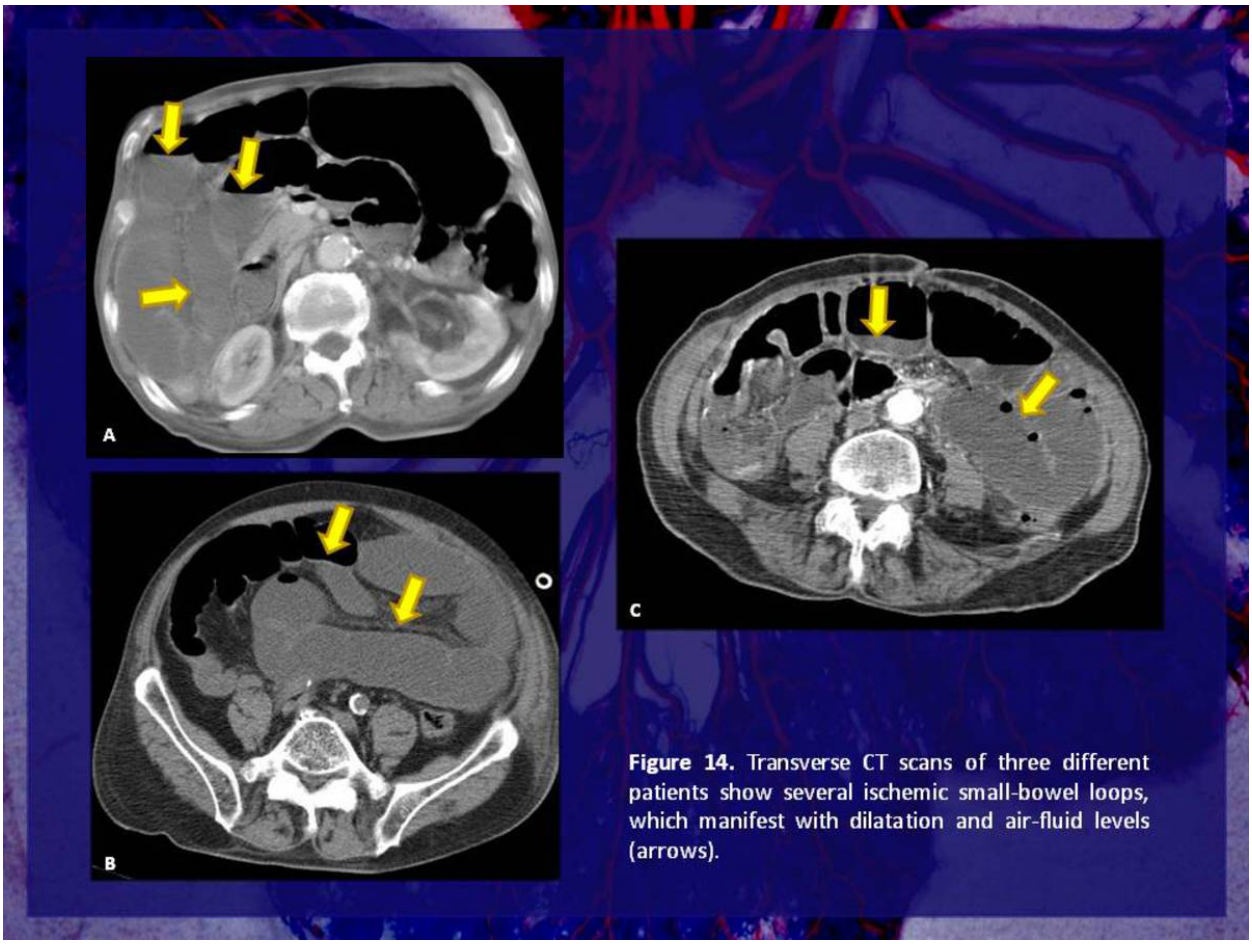
A
B
C
Figure 14. Transverse CT scans of three different patients show several ischemic small-bowel loops, which manifest with dilatation and air-fluid levels (arrows).

Fig. 15

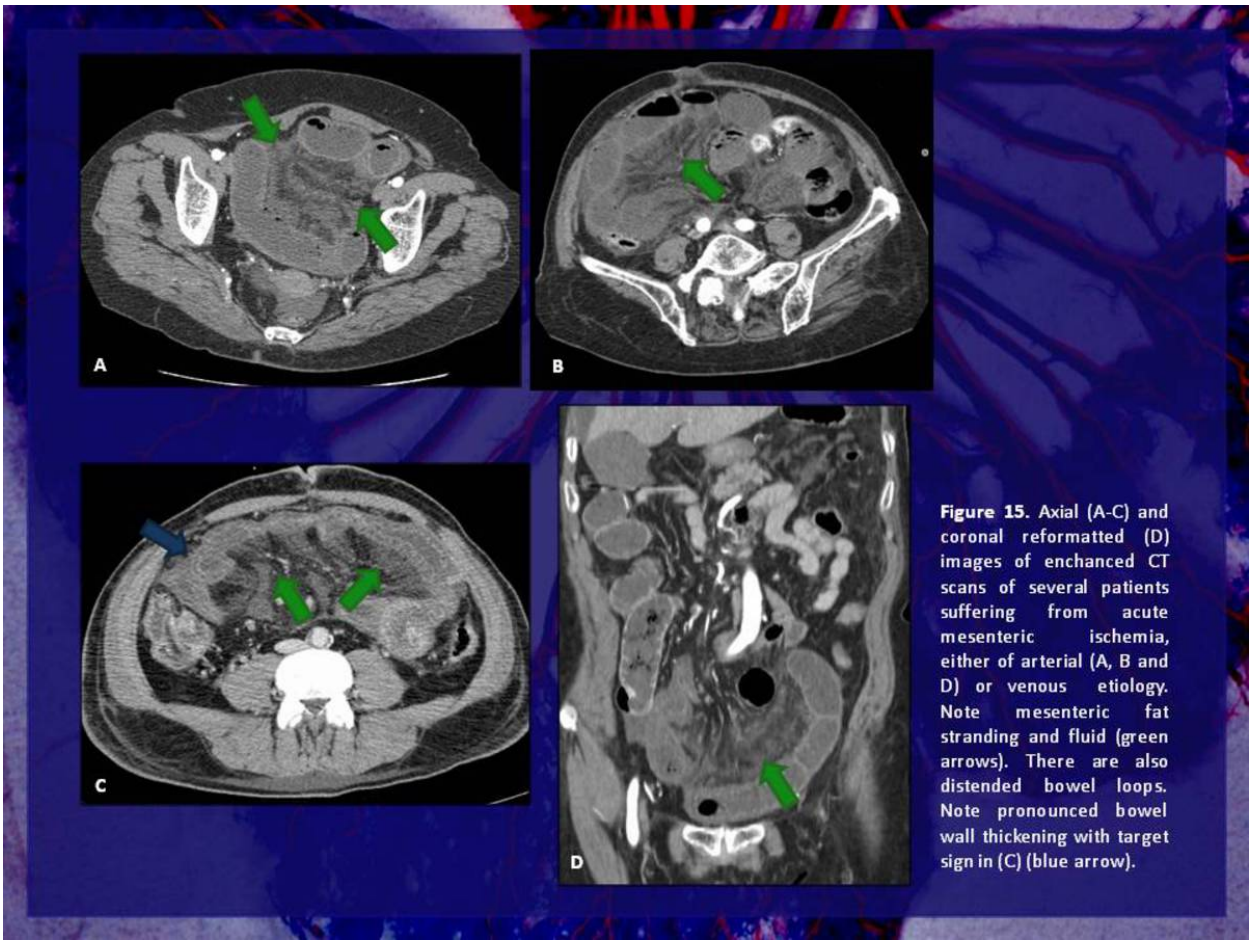
A
B
C
D
Figure 15. Axial (A-C) and coronal reformatted (D) images of enchanced CT scans of several patients suffering from acute mesenteric ischemia, either of arterial (A, B and D) or venous etiology. Note mesenteric fat stranding and fluid (green arrows). There are also distended bowel loops. Note pronounced bowel wall thickening with target sign in (C) (blue arrow).

Fig. 16

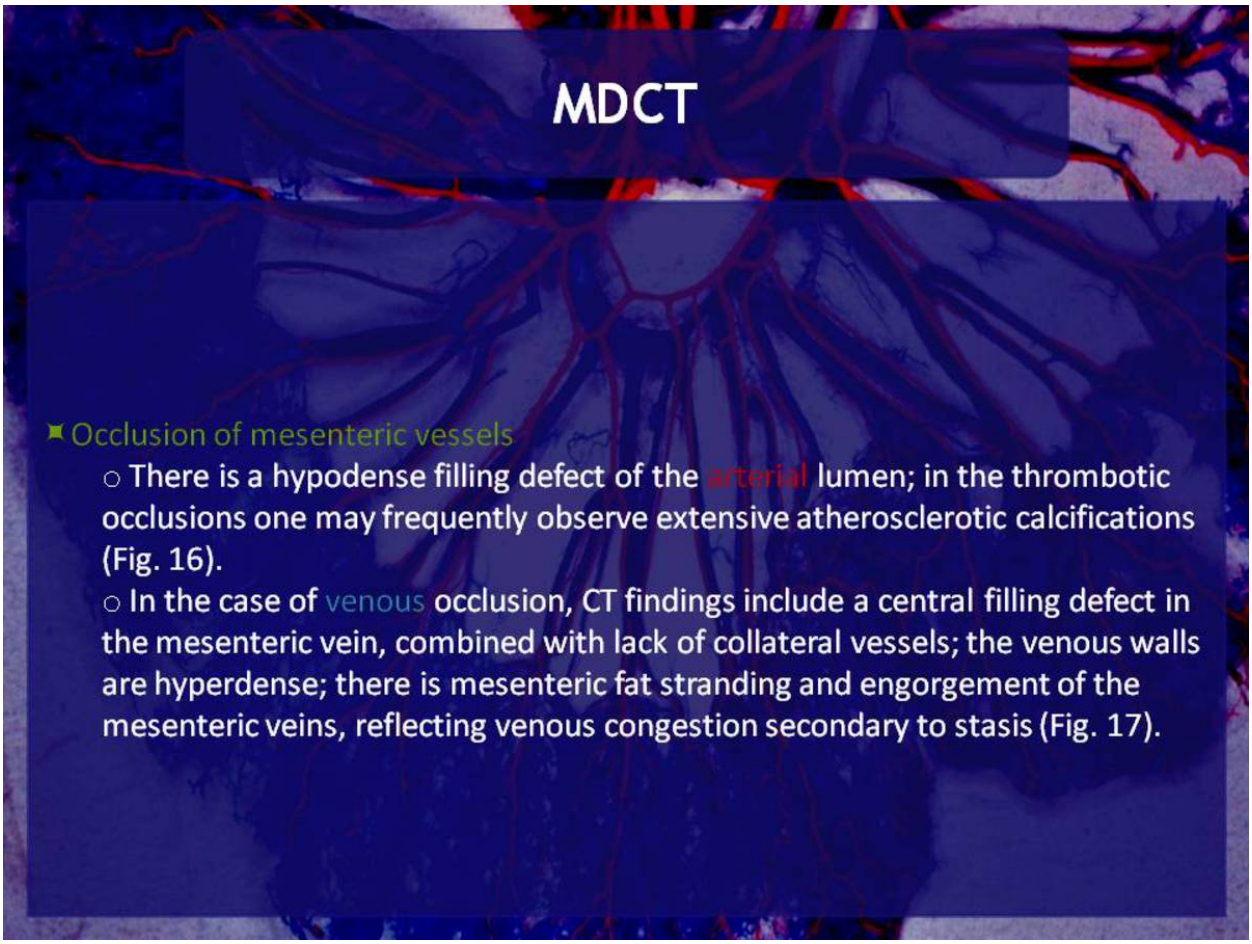
MDCT
Occlusion of mesenteric vessels
There is a hypodense filling defect of the arterial lumen; in the thrombotic occlusions one may frequently observe extensive atherosclerotic calcifications (Fig. 16).
In the case of venous occlusion, CT findings include a central filling defect in the mesenteric vein, combined with lack of collateral vessels; the venous walls are hyperdense; there is mesenteric fat stranding and engorgement of the mesenteric veins, reflecting venous congestion secondary to stasis (Fig. 17).

Fig. 17

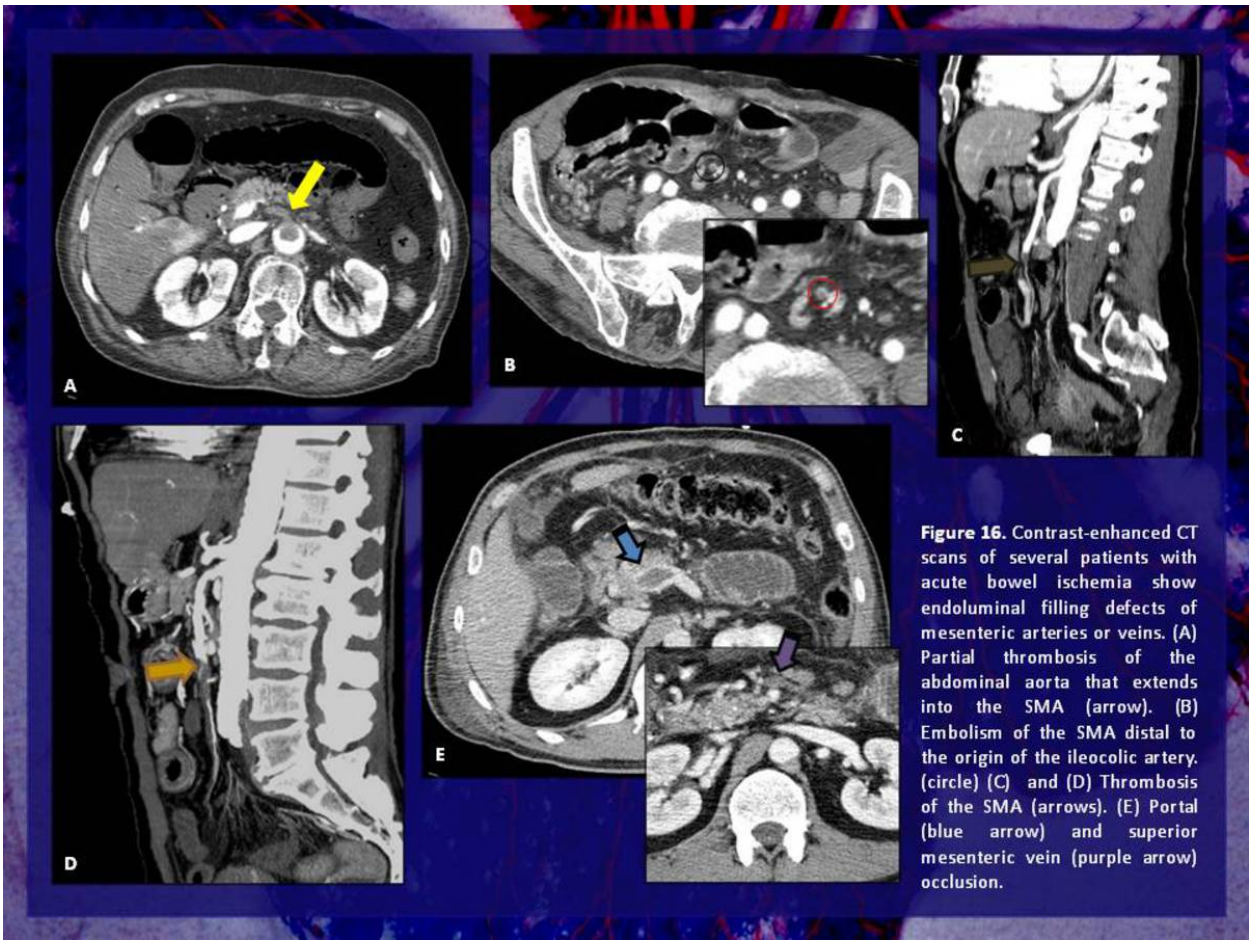
A
B
C
D
E
Figure 16. Contrast-enhanced CT scans of several patients with acute bowel ischemia show endoluminal filling defects of mesenteric arteries or veins. (A) Partial thrombosis of the abdominal aorta that extends into the SMA (arrow). (B) Embolism of the SMA distal to the origin of the ileocolic artery. (circle) (C) and (D) Thrombosis of the SMA (arrows). (E) Portal (blue arrow) and superior mesenteric vein (purple arrow) occlusion.

Fig. 18

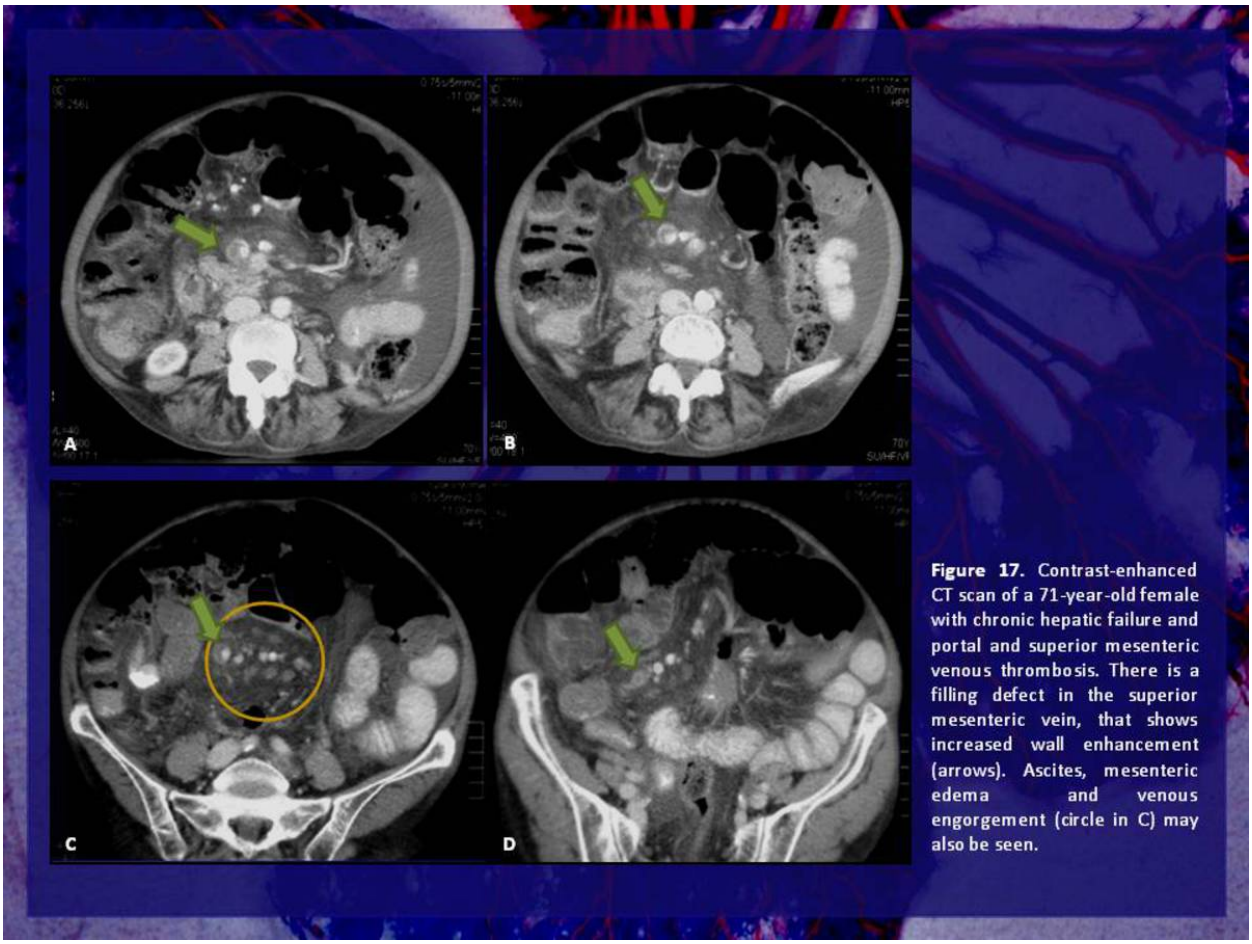
A
B
C
D
Figure 17. Contrast-enhanced CT scan of a 71-year-old female with chronic hepatic failure and portal and superior mesenteric venous thrombosis. There is a filling defect in the superior mesenteric vein, that shows increased wall enhancement (arrows). Ascites, mesenteric edema and venous engorgement (circle in C) may also be seen.

Fig. 19

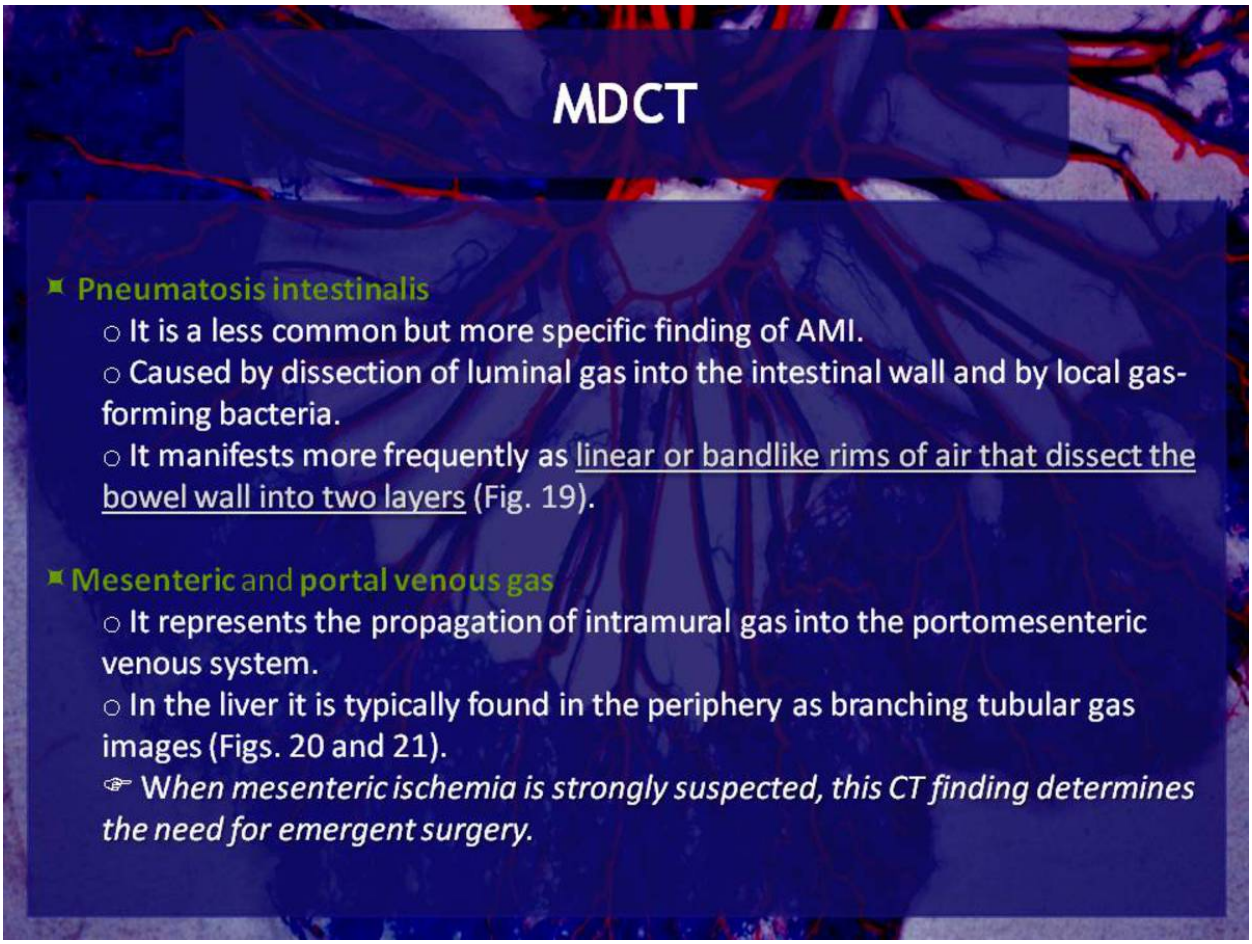
MDCT
Pneumatosis intestinalis
It is a less common but more specific finding of AMI.
Caused by dissection of luminal gas into the intestinal wall and by local gas-forming bacteria.
It manifests more frequently as linear or bandlike rims of air that dissect the bowel wall into two layers (Fig. 19).
Mesenteric and portal venous gas
It represents the propagation of intramural gas into the portomesenteric venous system.
In the liver it is typically found in the periphery as branching tubular gas images (Figs. 20 and 21).
When mesenteric ischemia is strongly suspected, this CT finding determines the need for emergent surgery.

Fig. 20

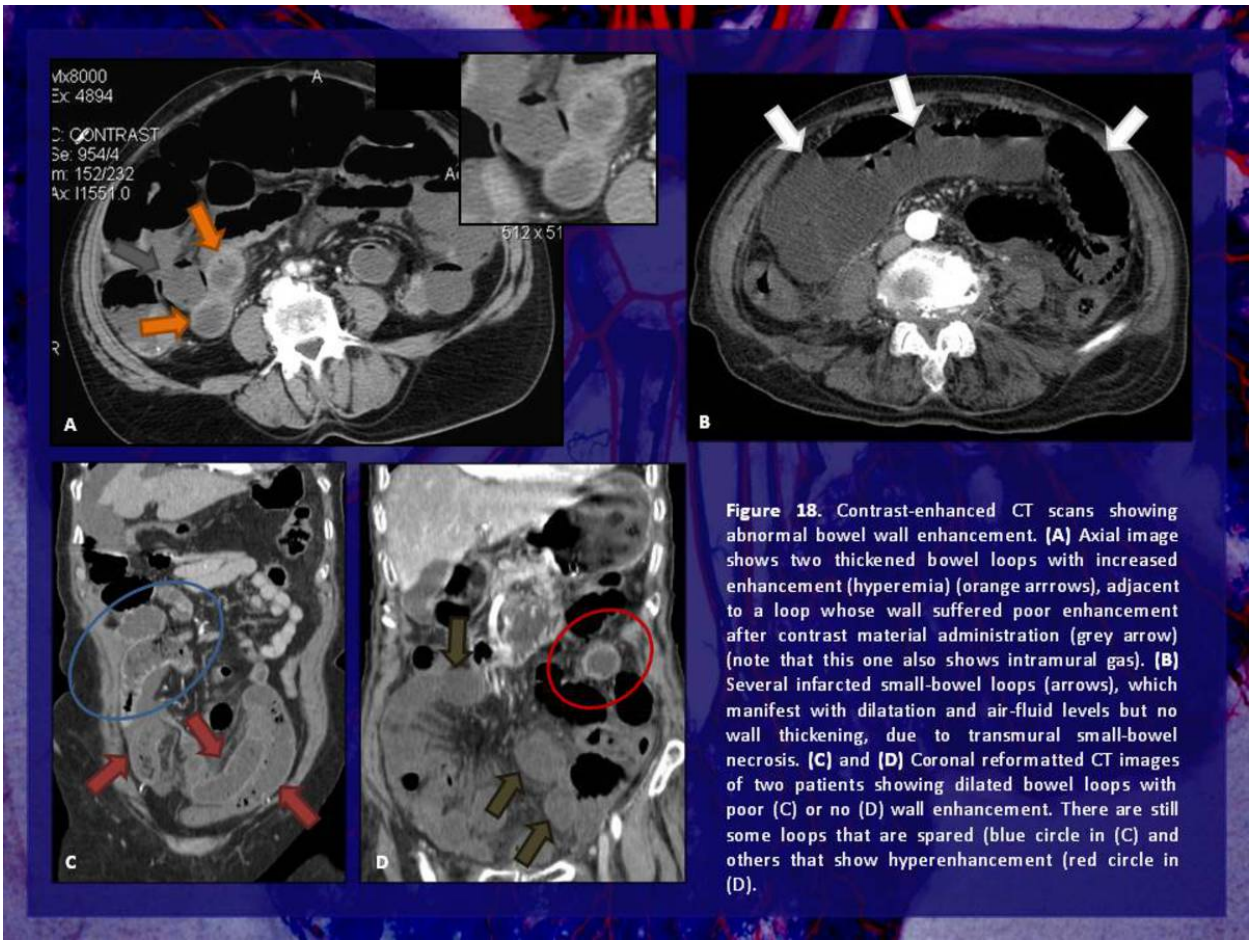
A
B
C
D
512 x 51
Figure 18. Contrast-enhanced CT scans showing abnormal bowel wall enhancement. (A) Axial image shows two thickened bowel loops with increased enhancement (hyperemia) (orange arrrows), adjacent to a loop whose wall suffered poor enhancement after contrast material administration (grey arrow) (note that this one also shows intramural gas). (B) Several infarcted small-bowel loops (arrows), which manifest with dilatation and air-fluid levels but no wall thickening, due to transmural small-bowel necrosis. (C) and (D) Coronal reformatted CT images of two patients showing dilated bowel loops with poor (C) or no (D) wall enhancement. There are still some loops that are spared (blue circle in (C) and others that show hyperenhancement (red circle in (D).

Fig. 21

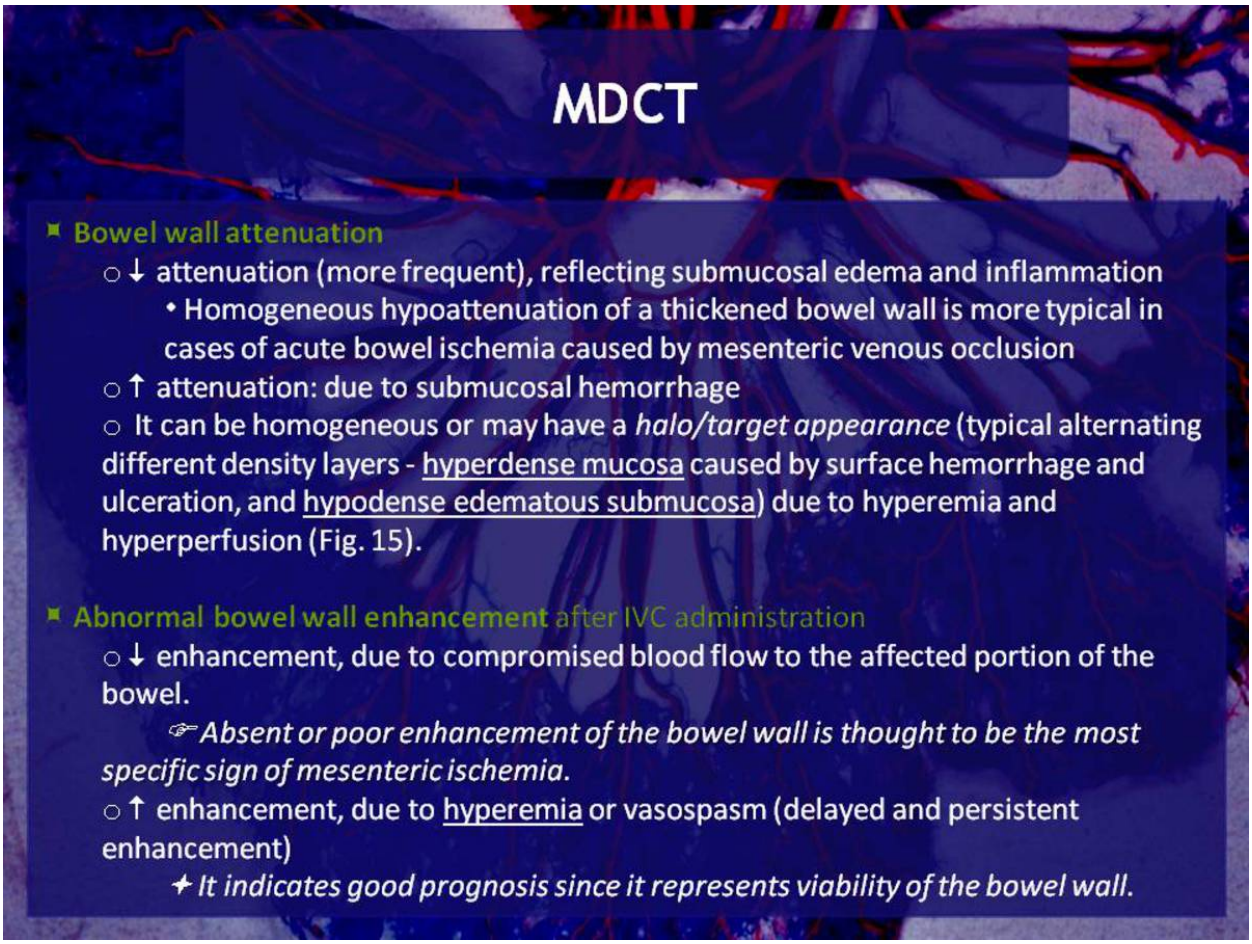
MDCT
Bowel wall attenuation
↓ attenuation (more frequent), reflecting submucosal edema and inflammation
• Homogeneous hypoattenuation of a thickened bowel wall is more typical in cases of acute bowel ischemia caused by mesenteric venous occlusion
↑ attenuation: due to submucosal hemorrhage
It can be homogeneous or may have a halo/target appearance (typical alternating different density layers - hyperdense mucosa caused by surface hemorrhage and ulceration, and hypodense edematous submucosa) due to hyperemia and hyperperfusion (Fig. 15).
Abnormal bowel wall enhancement after IVC administration
↓ enhancement, due to compromised blood flow to the affected portion of the bowel.
Absent or poor enhancement of the bowel wall is thought to be the most specific sign of mesenteric ischemia.
↑ enhancement, due to hyperemia or vasospasm (delayed and persistent enhancement)
It indicates good prognosis since it represents viability of the bowel wall.

Fig. 22

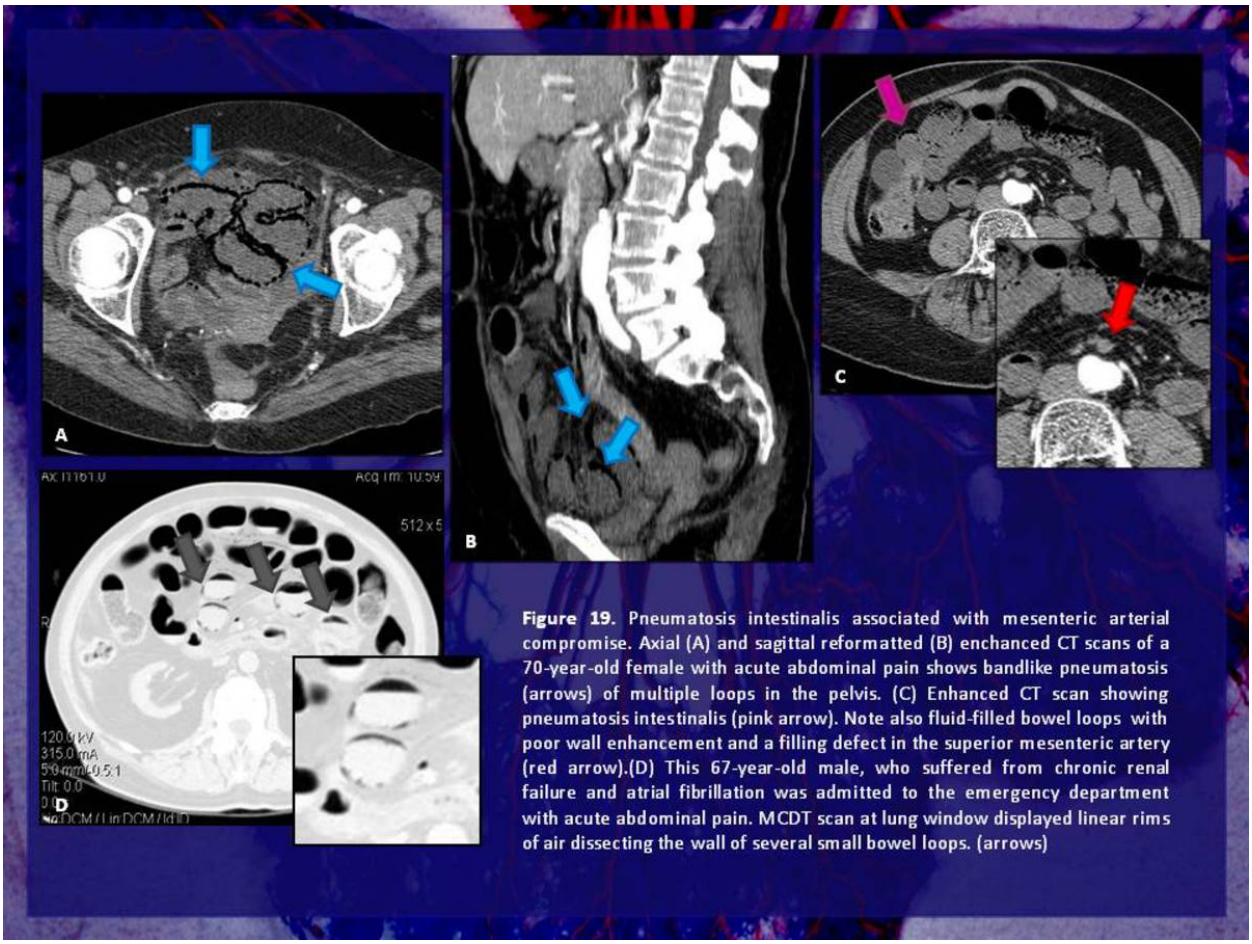
A
B
C
D
Figure 19. Pneumatosis intestinalis associated with mesenteric arterial compromise. Axial (A) and sagittal reformatted (B) enchanced CT scans of a 70-year-old female with acute abdominal pain shows bandlike pneumatosis (arrows) of multiple loops in the pelvis. (C) Enhanced CT scan showing pneumatosis intestinalis (pink arrow). Note also fluid-filled bowel loops with poor wall enhancement and a filling defect in the superior mesenteric artery (red arrow).(D) This 67-year-old male, who suffered from chronic renal failure and atrial fibrillation was admitted to the emergency department with acute abdominal pain. MCDT scan at lung window displayed linear rims of air dissecting the wall of several small bowel loops. (arrows)

Fig. 23

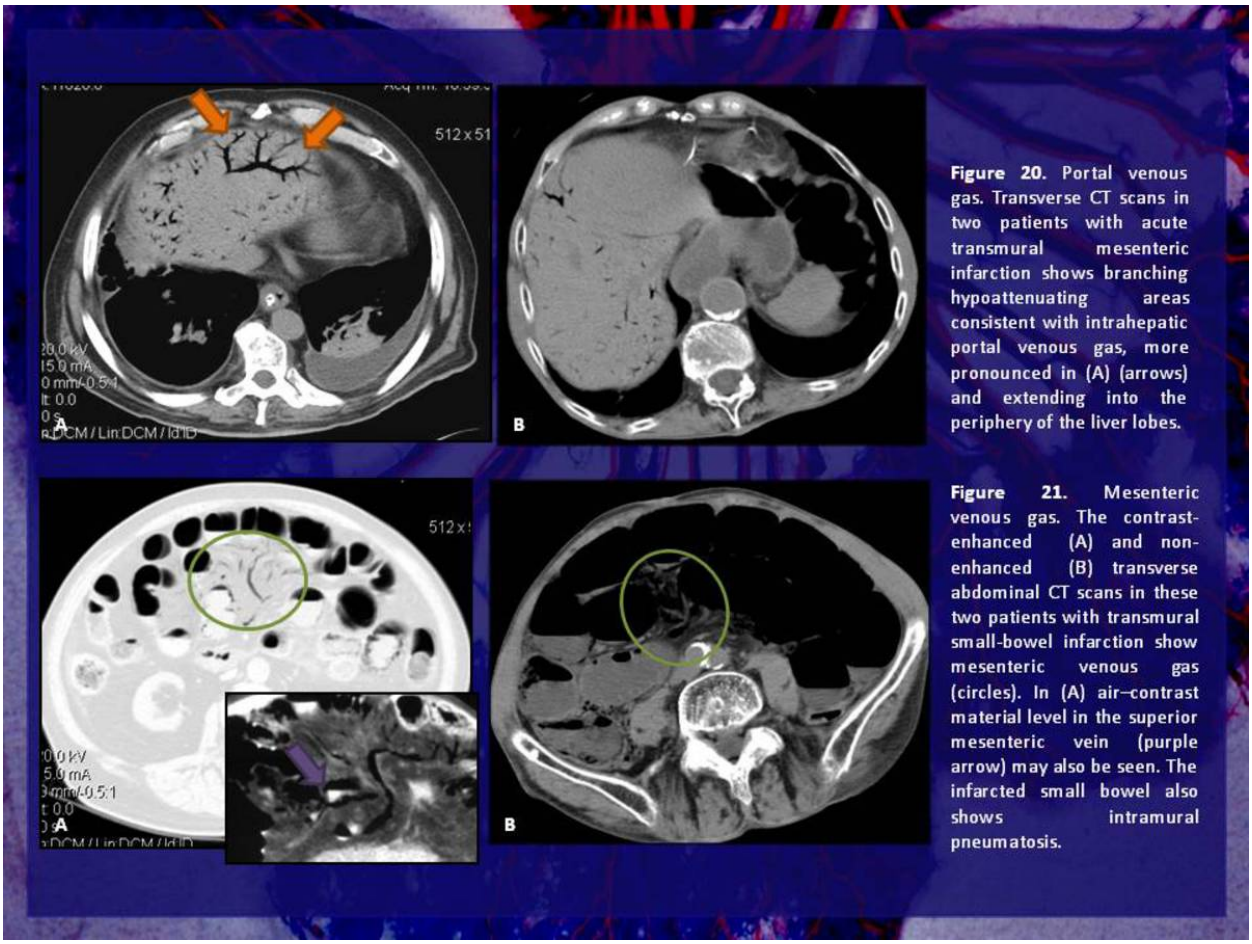
512x51
A
B
Figure 20. Portal venous gas. Transverse CT scans in two patients with acute transmural mesenteric infarction shows branching hypoattenuating areas consistent with intrahepatic portal venous gas, more pronounced in (A) (arrows) and extending into the periphery of the liver lobes.
A
B
Figure 21. Mesenteric venous gas. The contrast-enhanced (A) and non-enhanced (B) transverse abdominal CT scans in these two patients with transmural small-bowel infarction show mesenteric venous gas (circles). In (A) air–contrast material level in the superior mesenteric vein (purple arrow) may also be seen. The infarcted small bowel also shows intramural pneumatosis.

Fig. 24

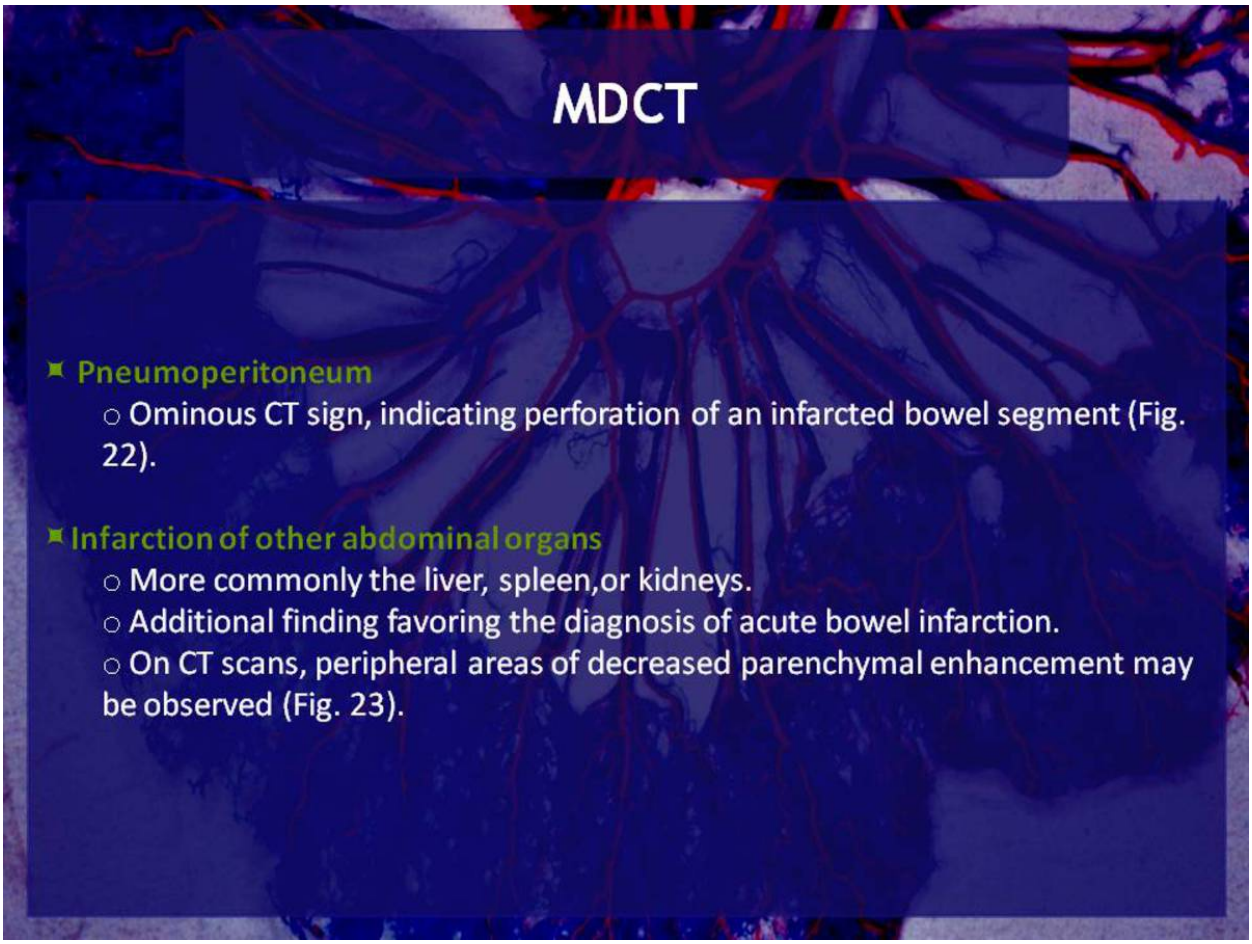
MDCT
Pneumoperitoneum
Ominous CT sign, indicating perforation of an infarcted bowel segment (Fig. 22).
Infarction of other abdominal organs
More commonly the liver, spleen,or kidneys.
Additional finding favoring the diagnosis of acute bowel infarction.
On CT scans, peripheral areas of decreased parenchymal enhancement may be observed (Fig. 23).

Fig. 25

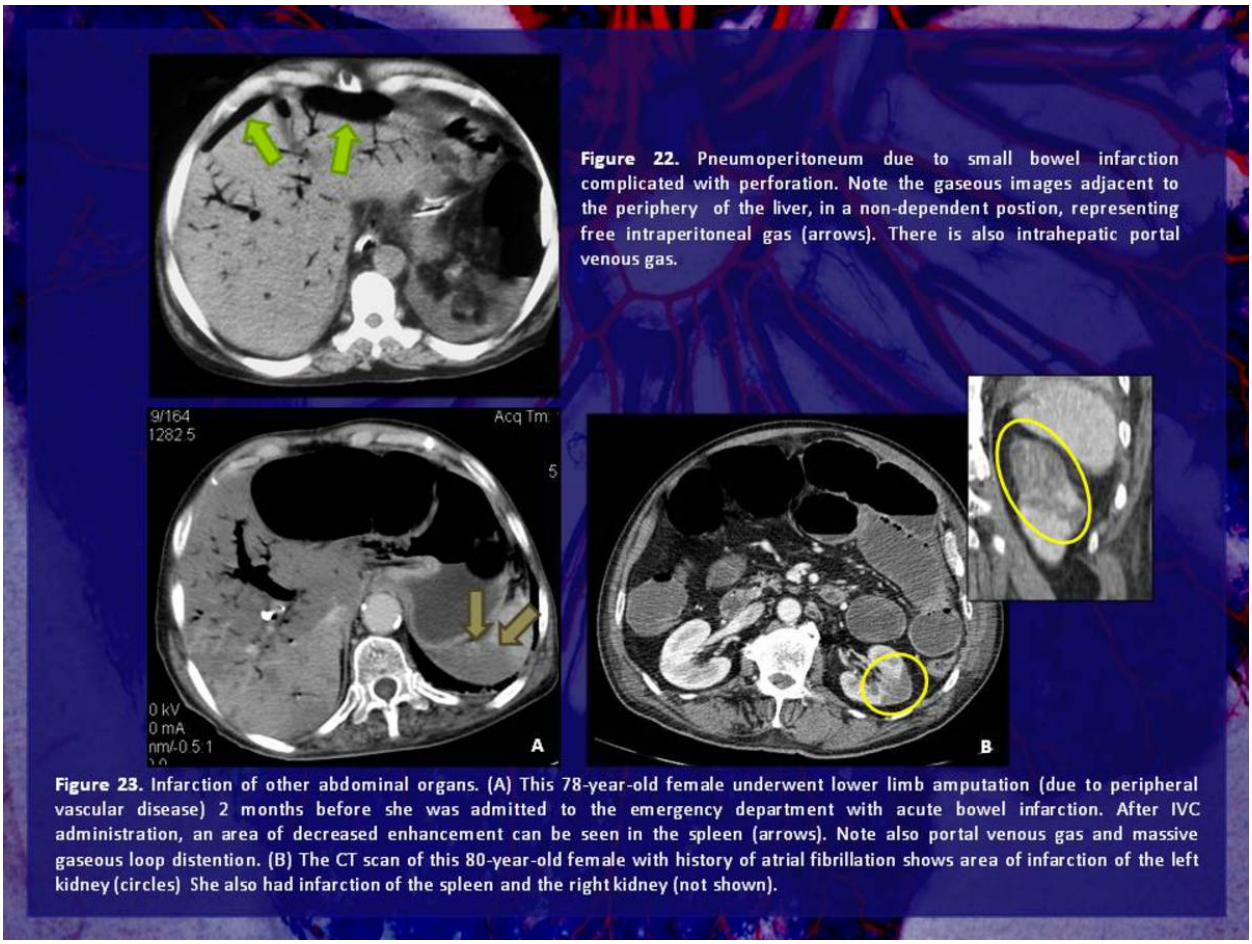
Figure 22. Pneumoperitoneum due to small bowel infarction complicated with perforation. Note the gaseous images adjacent to the periphery of the liver, in a non-dependent postion, representing free intraperitoneal gas (arrows). There is also intrahepatic portal venous gas.
9/164
1282.5
Acq Tm
0 kV
0 mA
nm/-0.5 1
A
B
Figure 23. Infarction of other abdominal organs. (A) This 78-year-old female underwent lower limb amputation (due to peripheral vascular disease) 2 months before she was admitted to the emergency department with acute bowel infarction. After IVC administration, an area of decreased enhancement can be seen in the spleen (arrows). Note also portal venous gas and massive gaseous loop distention. (B) The CT scan of this 80-year-old female with history of atrial fibrillation shows area of infarction of the left kidney (circles) She also had infarction of the spleen and the right kidney (not shown).

Fig. 26

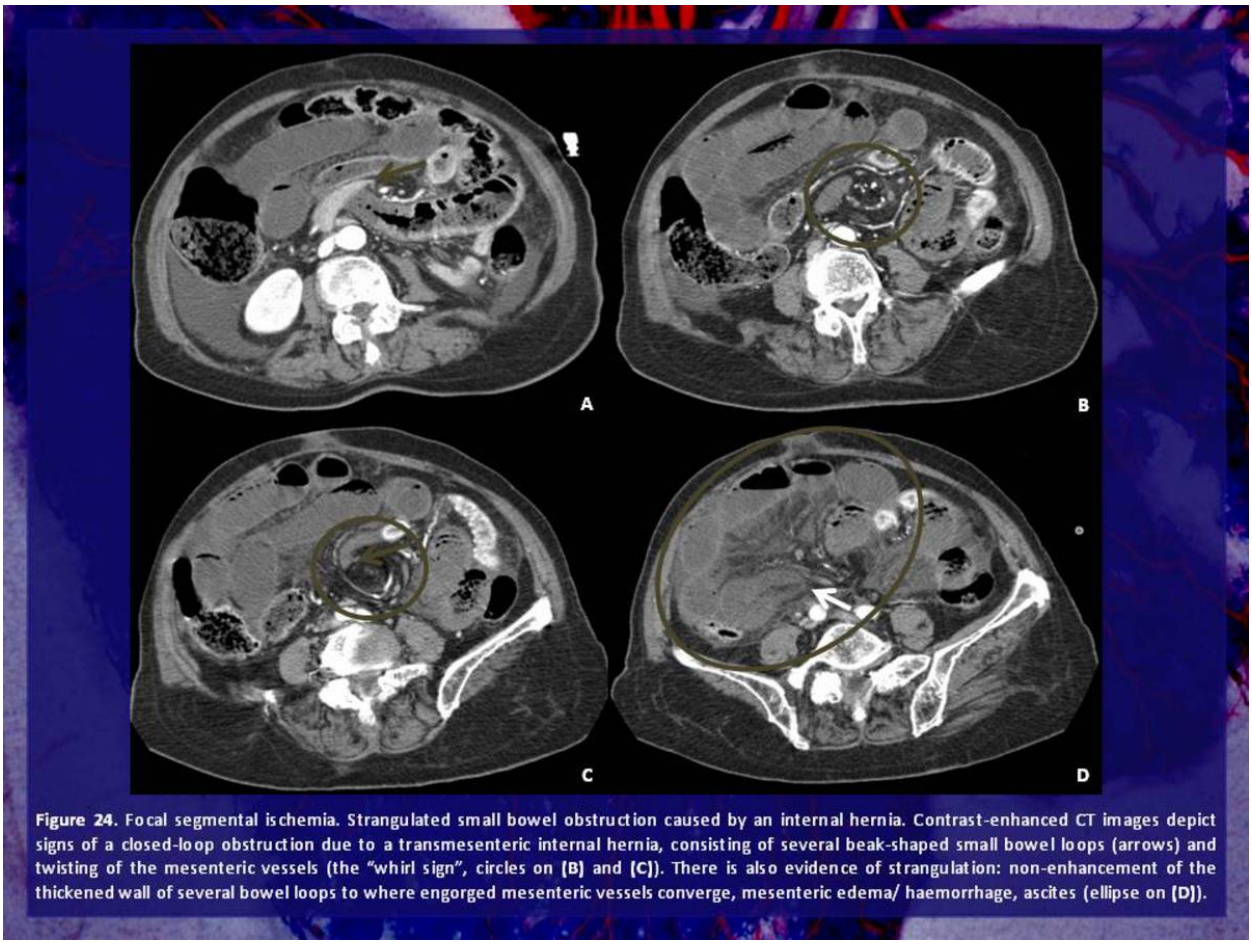

Figure 24. Focal segmental ischemia. Strangulated small bowel obstruction caused by an internal hernia. Contrast-enhanced CT images depict signs of a closed-loop obstruction due to a transmesenteric internal hernia, consisting of several beak-shaped small bowel loops (arrows) and twisting of the mesenteric vessels (the "whirl sign", circles on **(B)** and **(C)**). There is also evidence of strangulation: non-enhancement of the thickened wall of several bowel loops to where engorged mesenteric vessels converge, mesenteric edema/ haemorrhage, ascites (ellipse on **(D)**).

Fig. 27

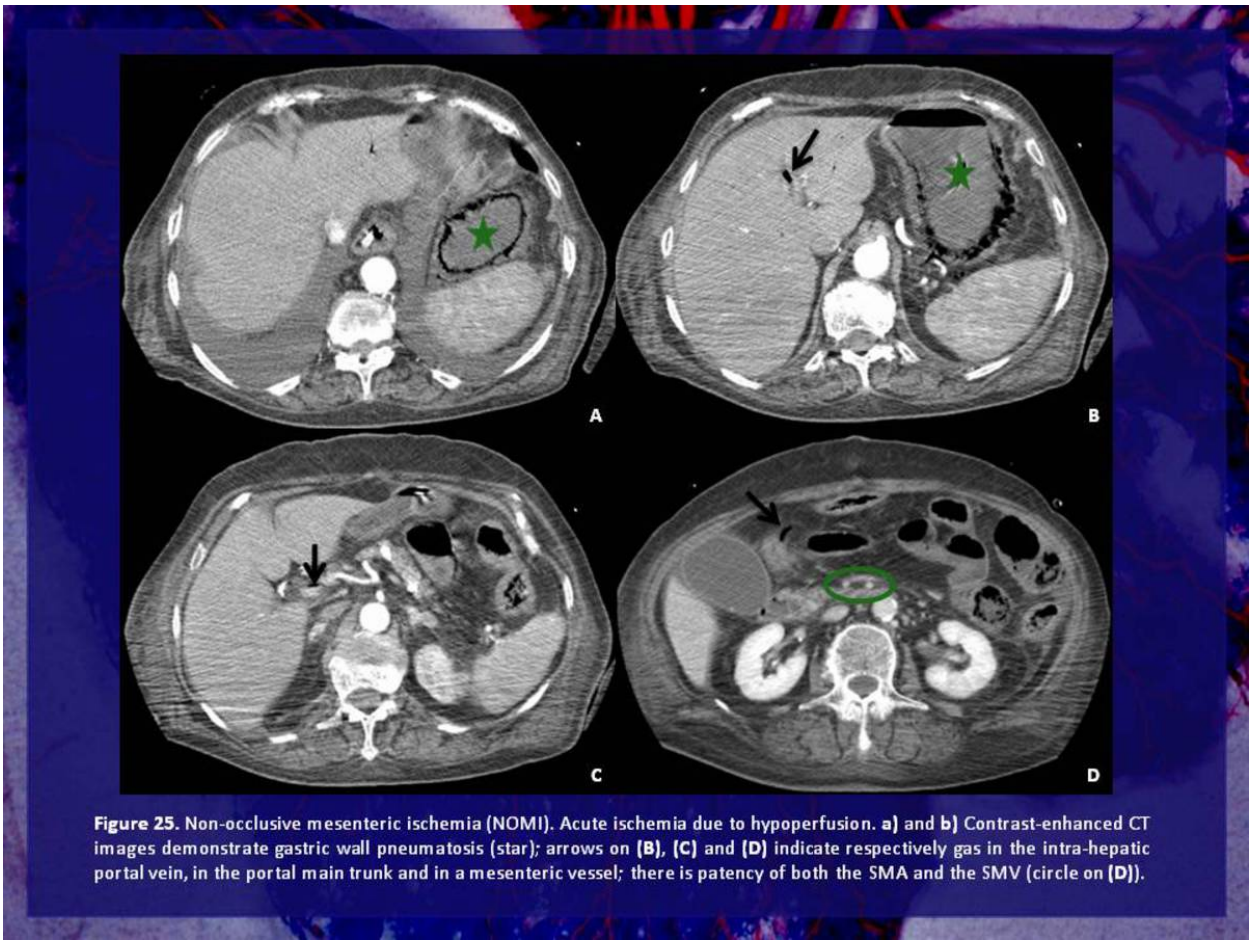

Figure 25. Non-occlusive mesenteric ischemia (NOMI). Acute ischemia due to hypoperfusion. **a)** and **b)** Contrast-enhanced CT images demonstrate gastric wall pneumatosis (star); arrows on **(B)**, **(C)** and **(D)** indicate respectively gas in the intra-hepatic portal vein, in the portal main trunk and in a mesenteric vessel; there is patency of both the SMA and the SMV (circle on **(D)**).

Fig. 28

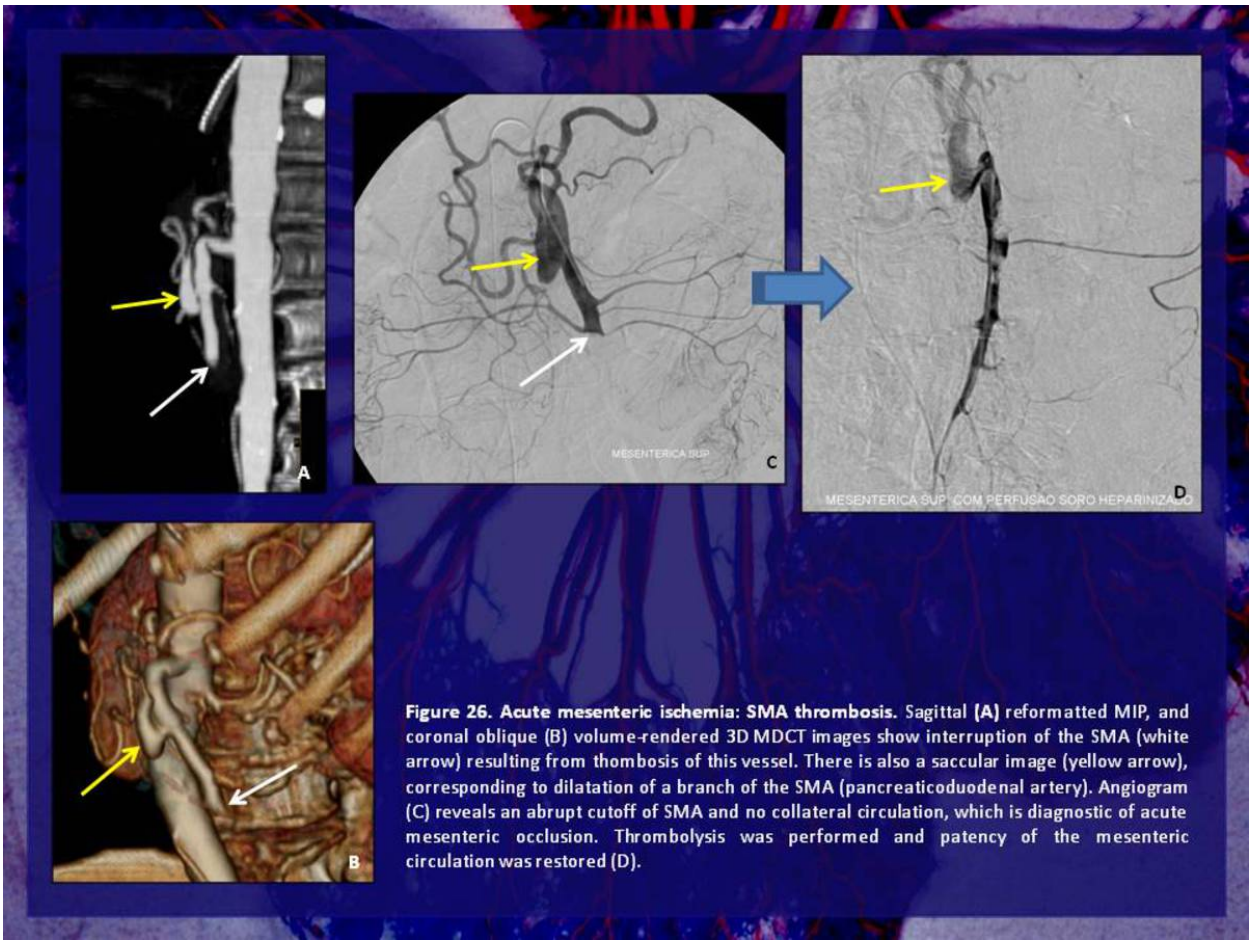

Figure 26. Acute mesenteric ischemia: SMA thrombosis. Sagittal **(A)** reformatted MIP, and coronal oblique (B) volume-rendered 3D MDCT images show interruption of the SMA (white arrow) resulting from thombosis of this vessel. There is also a saccular image (yellow arrow), corresponding to dilatation of a branch of the SMA (pancreaticoduodenal artery). Angiogram (C) reveals an abrupt cutoff of SMA and no collateral circulation, which is diagnostic of acute mesenteric occlusion. Thrombolysis was performed and patency of the mesenteric circulation was restored (D).

Fig. 29

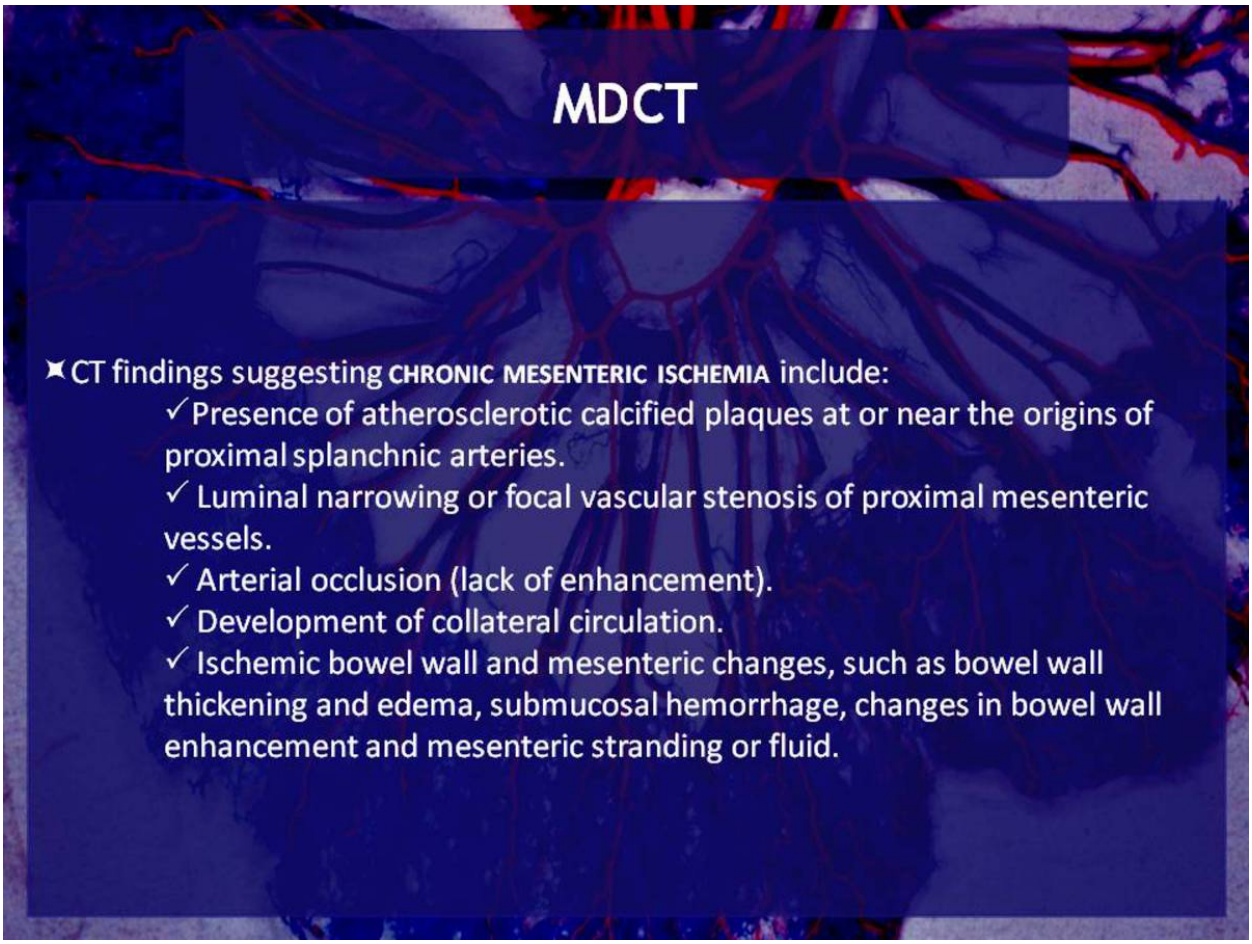
MDCT
CT findings suggesting CHRONIC MESENTERIC ISCHEMIA include:
✓Presence of atherosclerotic calcified plaques at or near the origins of proximal splanchnic arteries.
✓ Luminal narrowing or focal vascular stenosis of proximal mesenteric vessels.
✓ Arterial occlusion (lack of enhancement).
✓ Development of collateral circulation.
✓ Ischemic bowel wall and mesenteric changes, such as bowel wall thickening and edema, submucosal hemorrhage, changes in bowel wall enhancement and mesenteric stranding or fluid.

Fig. 30

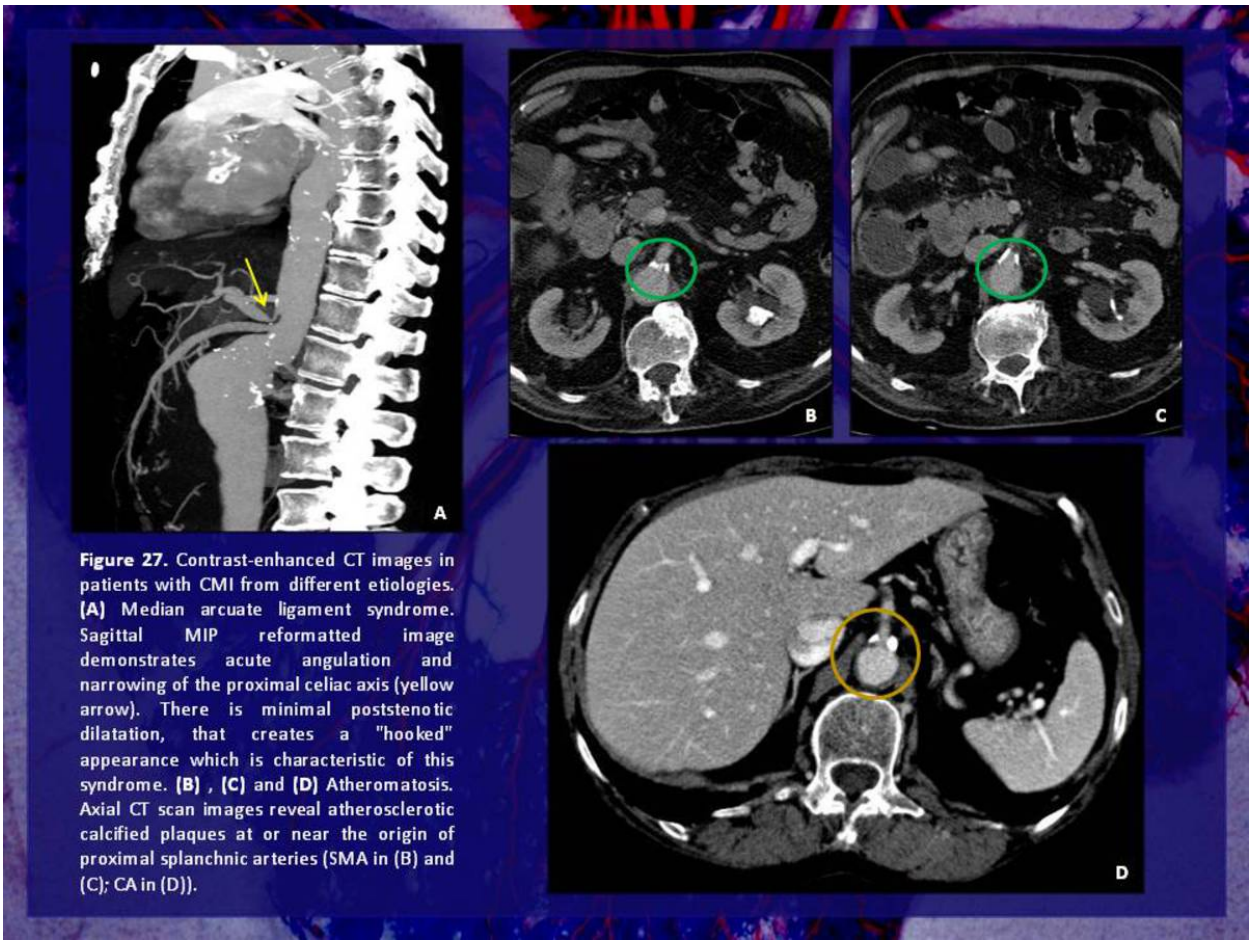

Figure 27. Contrast-enhanced CT images in patients with CMI from different etiologies. **(A)** Median arcuate ligament syndrome. Sagittal MIP reformatted image demonstrates acute angulation and narrowing of the proximal celiac axis (yellow arrow). There is minimal poststenotic dilatation, that creates a "hooked" appearance which is characteristic of this syndrome. **(B)** , **(C)** and **(D)** Atheromatosis. Axial CT scan images reveal atherosclerotic calcified plaques at or near the origin of proximal splanchnic arteries (SMA in (B) and (C); CA in (D)).

Fig. 31

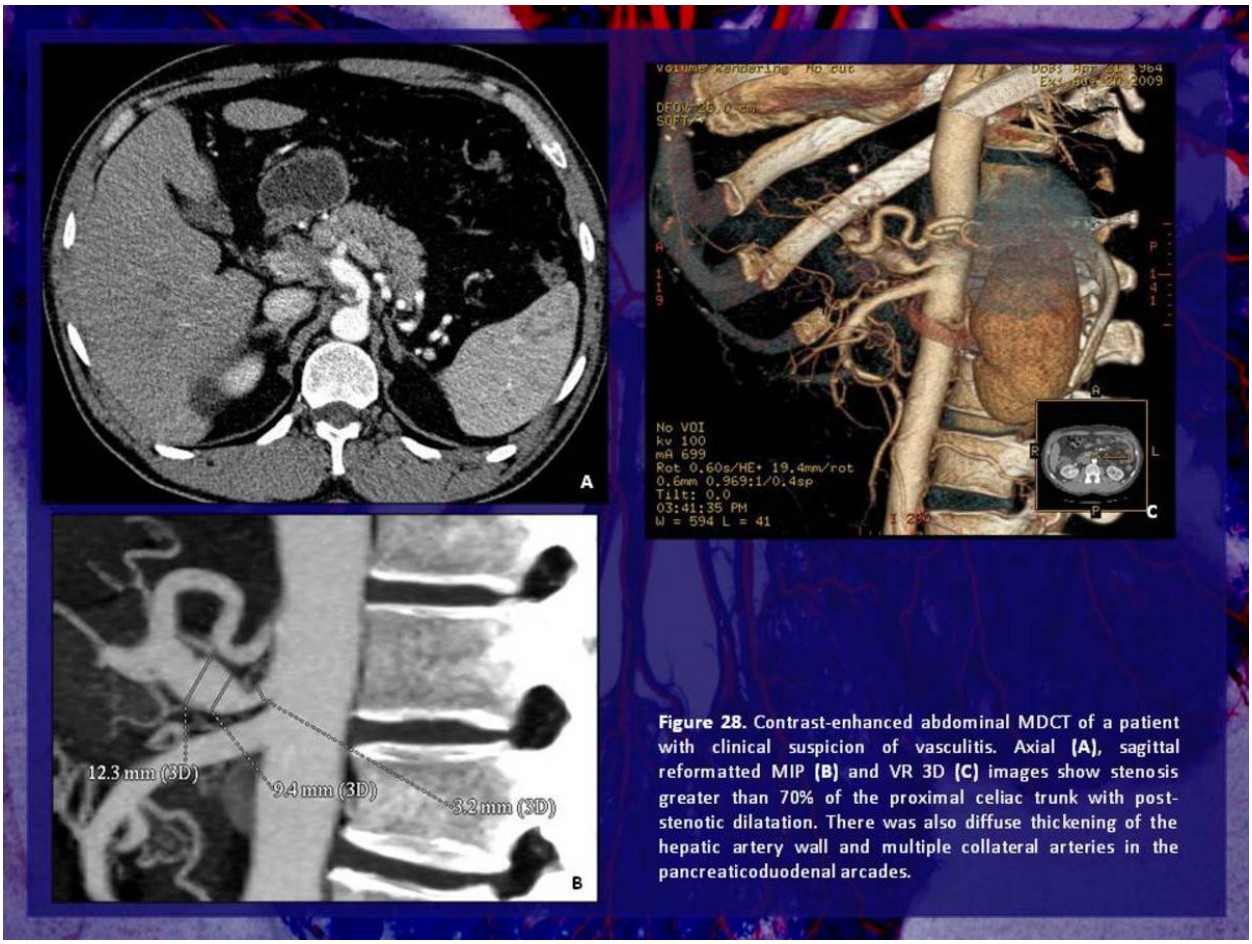
A
No VOI
kv 100
mA 699
Rot 0.60s/HE+ 19.4mm/rot
0.6mm 0.969:1/0.4sp
Tilt: 0.0
03:41:35 PM
W = 594 L = 41
C
12.3 mm (3D)
9.4 mm (3D)
3.2 mm (3D)
B
Figure 28. Contrast-enhanced abdominal MDCT of a patient with clinical suspicion of vasculitis. Axial (A), sagittal reformatted MIP (B) and VR 3D (C) images show stenosis greater than 70% of the proximal celiac trunk with post-stenotic dilatation. There was also diffuse thickening of the hepatic artery wall and multiple collateral arteries in the pancreaticoduodenal arcades.

Fig. 32

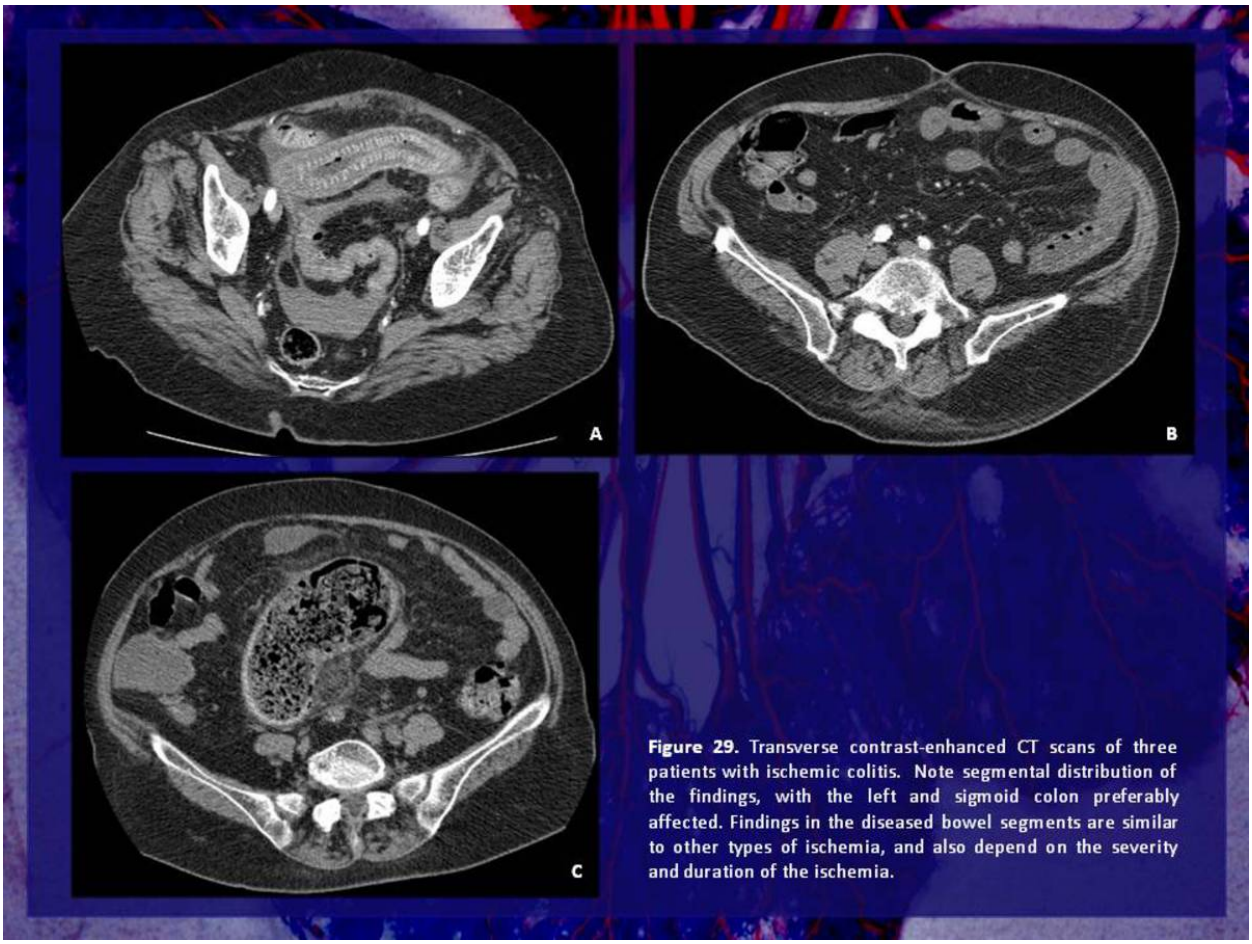
A
B
C
Figure 29. Transverse contrast-enhanced CT scans of three patients with ischemic colitis. Note segmental distribution of the findings, with the left and sigmoid colon preferably affected. Findings in the diseased bowel segments are similar to other types of ischemia, and also depend on the severity and duration of the ischemia.

Fig. 33

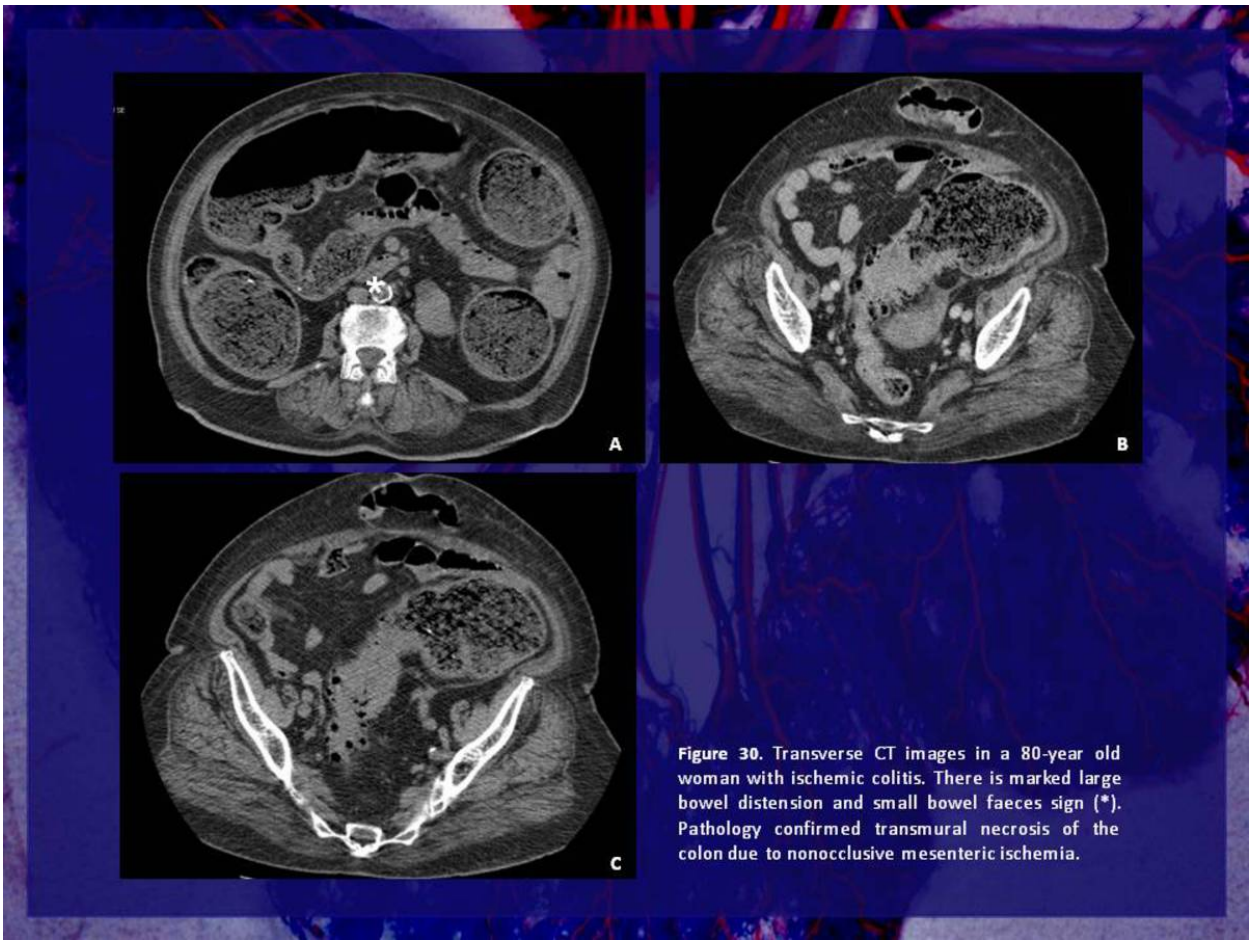
A
B
C
Figure 30. Transverse CT images in a 80-year old woman with ischemic colitis. There is marked large bowel distension and small bowel faeces sign (*). Pathology confirmed transmural necrosis of the colon due to nonocclusive mesenteric ischemia.

Fig. 34

Conclusion

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

Images for this section:


CONCLUSIONS
Despite all the advances that have been achieved on medical imaging, the diagnosis of mesenteric ischemia remains a challenge, since the clinical, laboratory and radiological features are variable and tend to be non-specific. A high level of clinical suspicion is needed, as the outcome crucially depends on an early accurate diagnosis and prompt treatment.
Radiologists should be aware of the spectrum of imaging findings and underlying mechanisms of this potentially fatal condition in order to help avoiding the high morbidity and mortality that can arise from it.

Fig. 1

Personal Information

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

Images for this section:


THIS WORK COMES FROM...
Catarina Ruivo, MD
Maria Antónia Portilha, MD
João Filipe Costa, MD
Luís Curvo Semedo, MD
José Ilharco, MD
António Bernardes, PhD
Filipe Caseiro Alves, PhD
Hospitais da Universidade
de Coimbra
Coimbra
PORTUGAL

Fig. 1

References

Fig.
References: C. Ruivo; Radiology, Hospitais da Universidade de Coimbra, Coimbra, PORTUGAL

Images for this section:


REFERENCES
Chou CK. CT Manifestations of Bowel Ischemia. AJR 2002;178:87–91.
Menon NJ et al. Acute Mesenteric Ischaemia. Acta chir belg 2005;105:344-354.
Cerqueira NF et al. Pathophysiology of mesenteric ischemia/reperfusion: a review. Acta Cirúrgica Brasileira 2005; Vol 20 (4):336-343.
Horton KM et al. Multi-Detector Row CT of Mesenteric Ischemia: Can It Be Done? RadioGraphics 2001;21:1463–1473.
Oldenburg WA et al. Acute Mesenteric Ischemia: A Clinical Review. Arch Intern Med 2004; Vol. 164:1054-1062.
Frauenferder T et al. Nontraumatic Emergent Abdominal Vascular Conditions: Advantages of Multi-Detector Row CT and Three-Dimensional Imaging. RadioGraphics 2004;24:481–496.
Wiesner W et al. CT of Acute Bowel Ischemia. Radiology 2003;226:635–650.
Rha SE et al. CT and MR Imaging Findings of Bowel Ischemia from Various Primary Causes. Radiographics 2000; 20:29-42.
Wiesner W et al. Pneumatosis Intestinalis and Portomesenteric Venous Gas in Intestinal Ischemia: Correlation of CT Findings with Severity of Ischemia and Clinical Outcome. AJR 2001;177:1319–1323.
Rosen A et al. Mesenteric Vein Thrombosis: CT Identification. AJR 143:83-86, July 1984.
Gore RM et al. Helical CT in the Evaluation of the Acute Abdomen. AJR 2000;174:901–913.
Shih MCP, Hagspiel KD. CTA and MRA in Mesenteric Ischemia: Part 1, Role in Diagnosis and Differential Diagnosis. AJR 2007;188:452–461.
Chou CK et al. Clinical Significance of Poor CT Enhancement of the Thickened Small-Bowel Wall in Patients with Acute Abdominal Pain. AJR 2006;186:491–498.
Cognet F et al. Chronic Mesenteric Ischemia: Imaging and Percutaneous Treatment. RadioGraphics 2002;22:863–880
Song SY et al. Collateral pathways in patients with celiac axis stenosis: angiographic-spiral CT correlation. Radiographics. 2002 Jul-Aug;22(4):881-93.

Fig. 1