

SERVIZIO SANITARIO REGIONALE  
EMILIA-ROMAGNA  
UOC Radiologia Interaziendale Ferrara

UNIVERSITÀ  
DEGLI STUDI  
DI FERRARA  
- EX LABORE FRUCTUS -



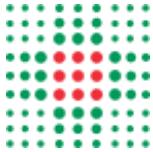
# Patologia ischemica ileo-colica

Massimo Tilli  
Maria Teresa Cannizzaro

AOU S. Anna (Ferrara)



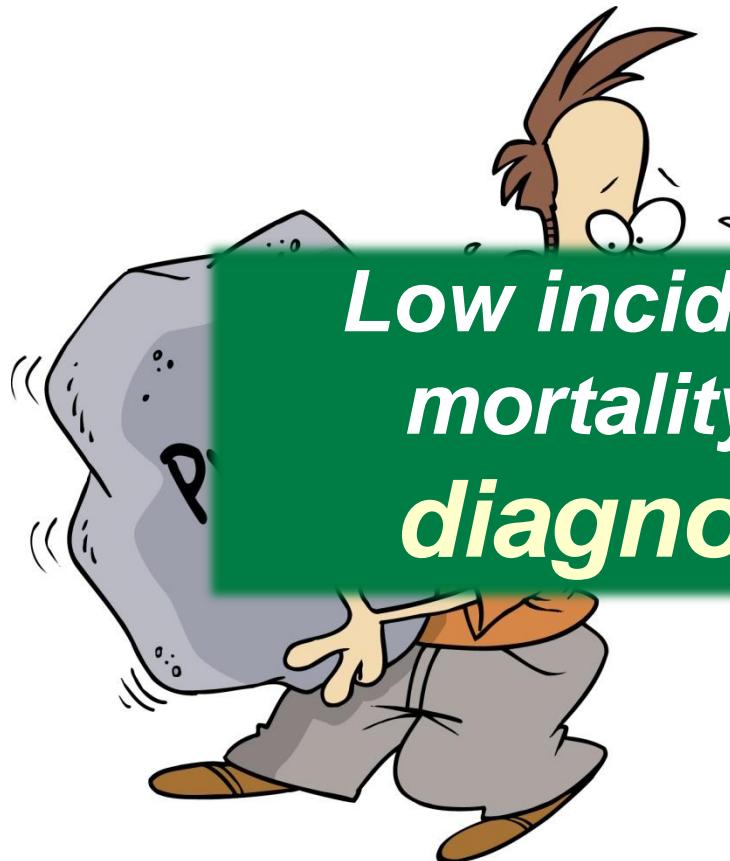




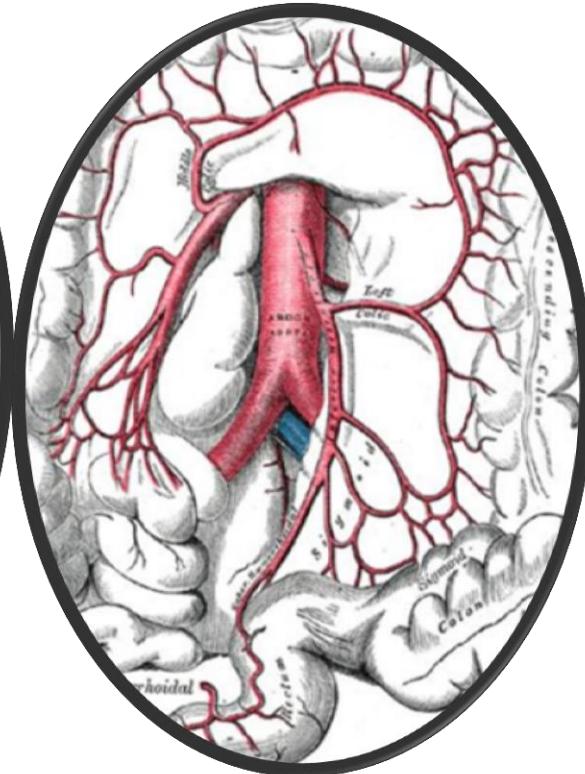
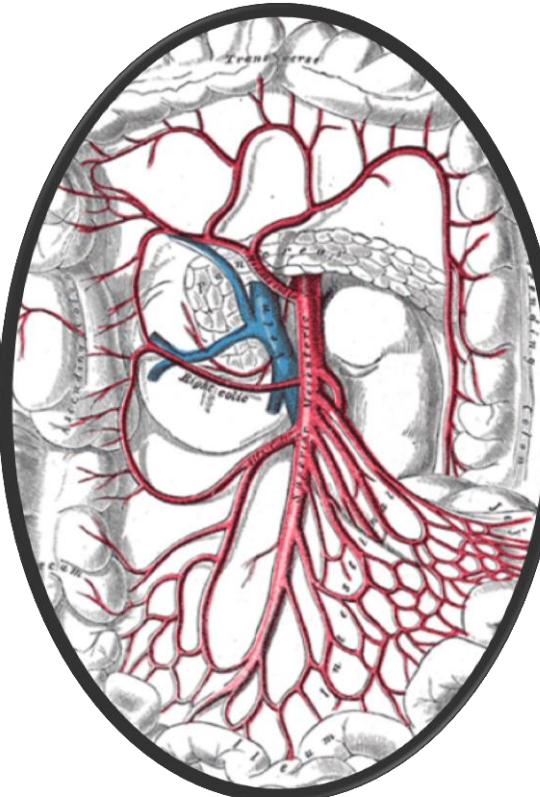
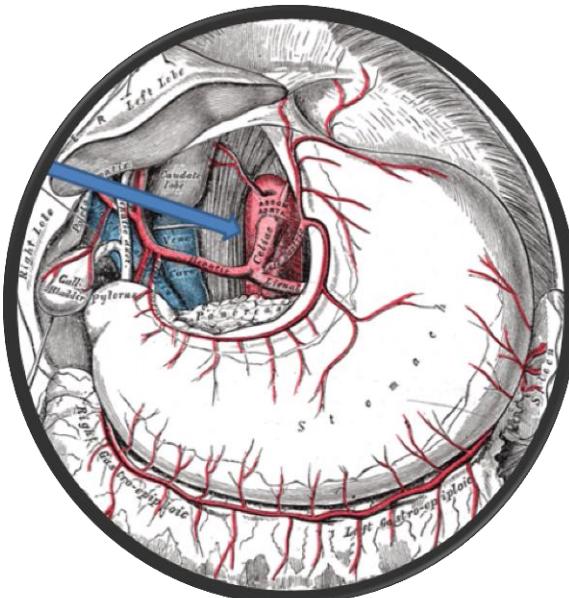
# Problem

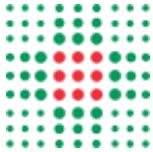
*...in clinical practice is usually recognized too late, after it has led to intestinal gangrene, sepsis and*

*Low incidence but high mortality rate due to diagnostic delay*

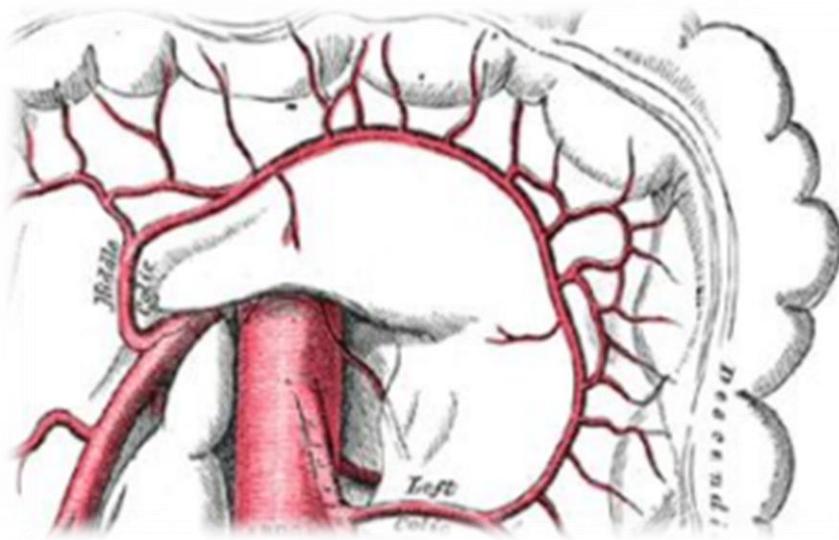


# Blood supply

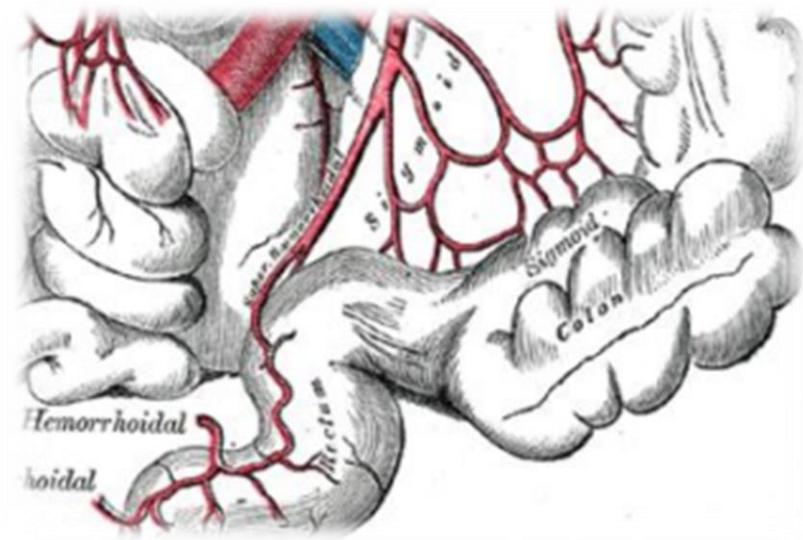




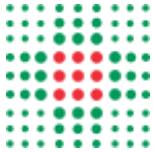
# "Watershed" areas



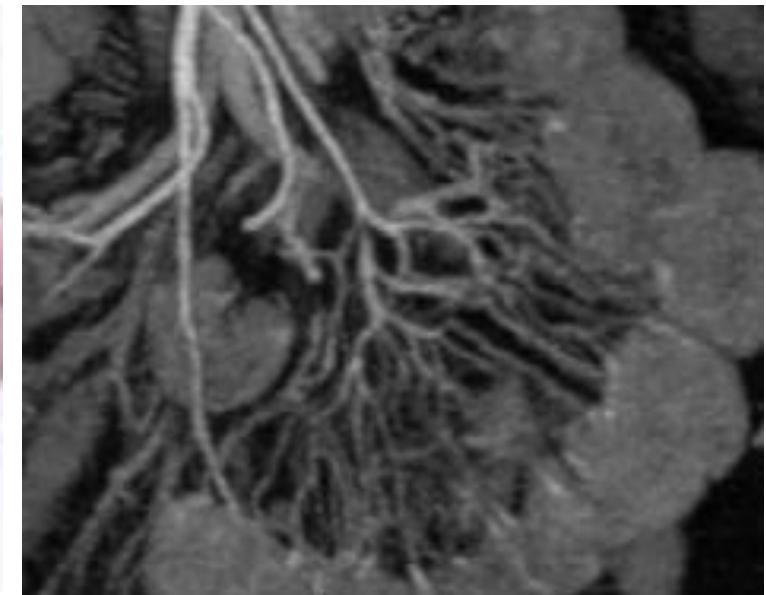
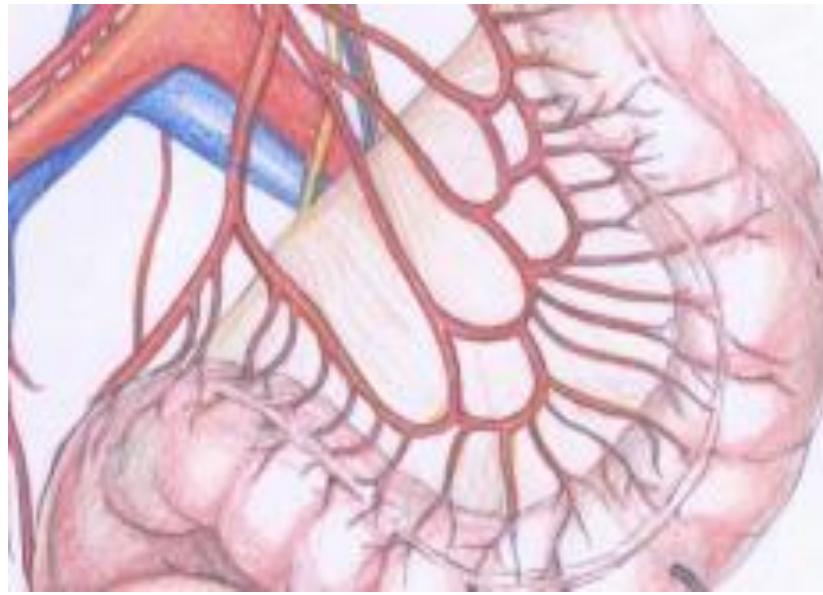
-Between the SMA and IMA



-Between IMA and rectal arteries

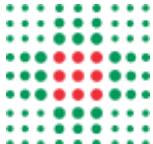


# Autoregulation

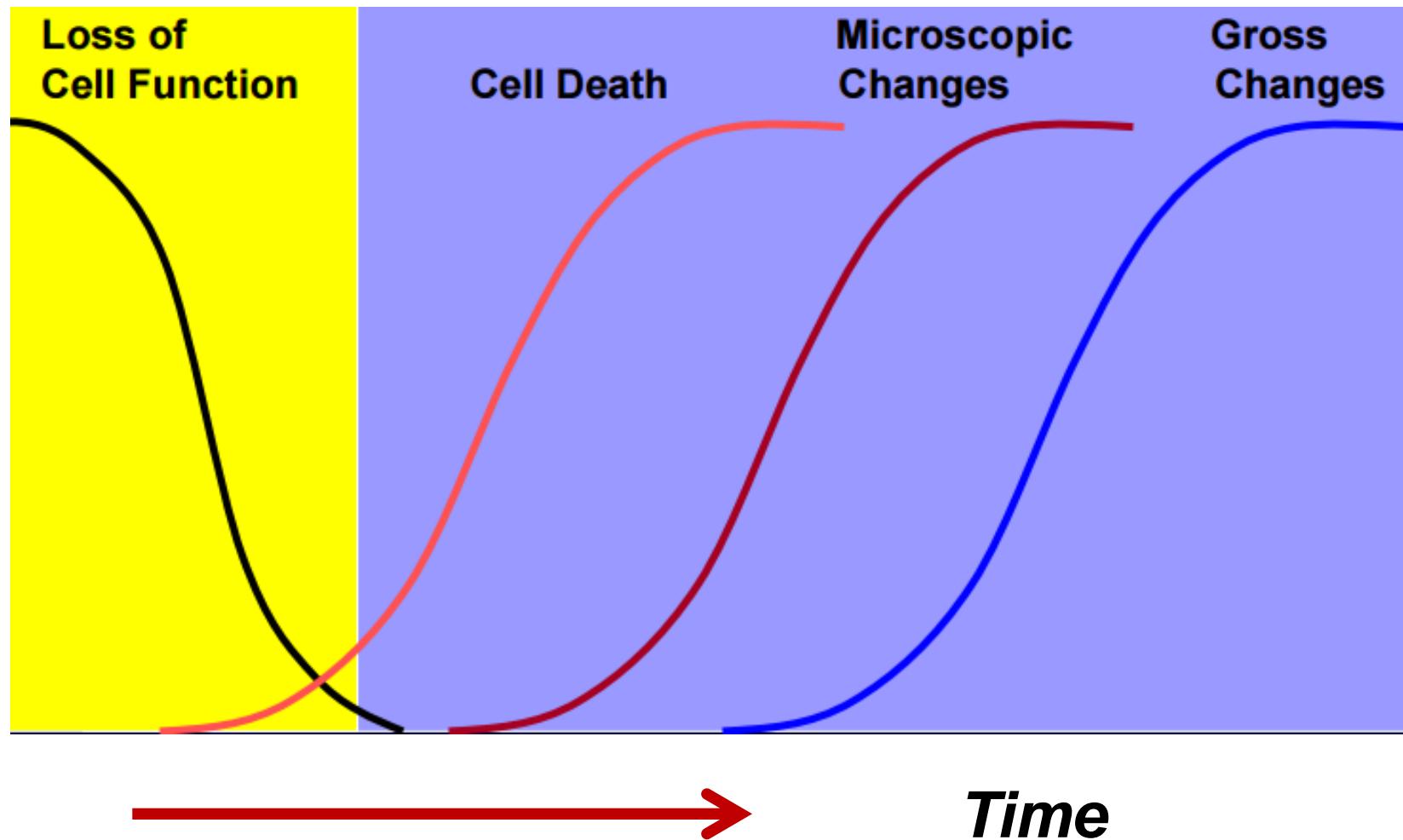


*The intestine may compensate:*

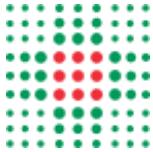
- *increasing oxygen extraction*
- *developing collateral flow pathways (up to 12h)*



# *Extent of injury*



Concept from Robbins Basic Pathology, WB Saunders, 2003.



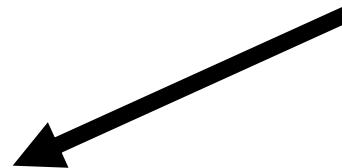
# Response to ischemia

Hypoxic injury phase

Relative resistance of epithelial cells to transient ischemia

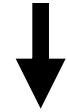
Reperfusion

Restoration of blood flow after a period of ischemia

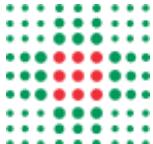


Non-effective

Effective



Reperfusion injury: complex response characterized by release of free oxygen radicals, toxic byproducts of ischemic injury, and neutrophil activation which can lead to Multi-Organ Failure (MOF)



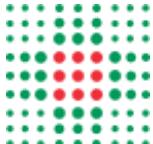
# *Extent of injury*



*Prolonged ischemia generates vasoconstriction in afferent bed and reduces collateral supply*

↓  
***Autoregulation failure***

↓  
***Wall infarction***



# Different Clinical Stages

**Spastic stage**

(1-3 h)

- **Mucosal-limited damage**
- **Abdominal pain, vomiting, diarrhea, initial bowel wall spasm**
- **Emo-concentration**

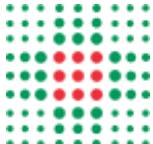
**Paralitic stage**

(3-24 h)

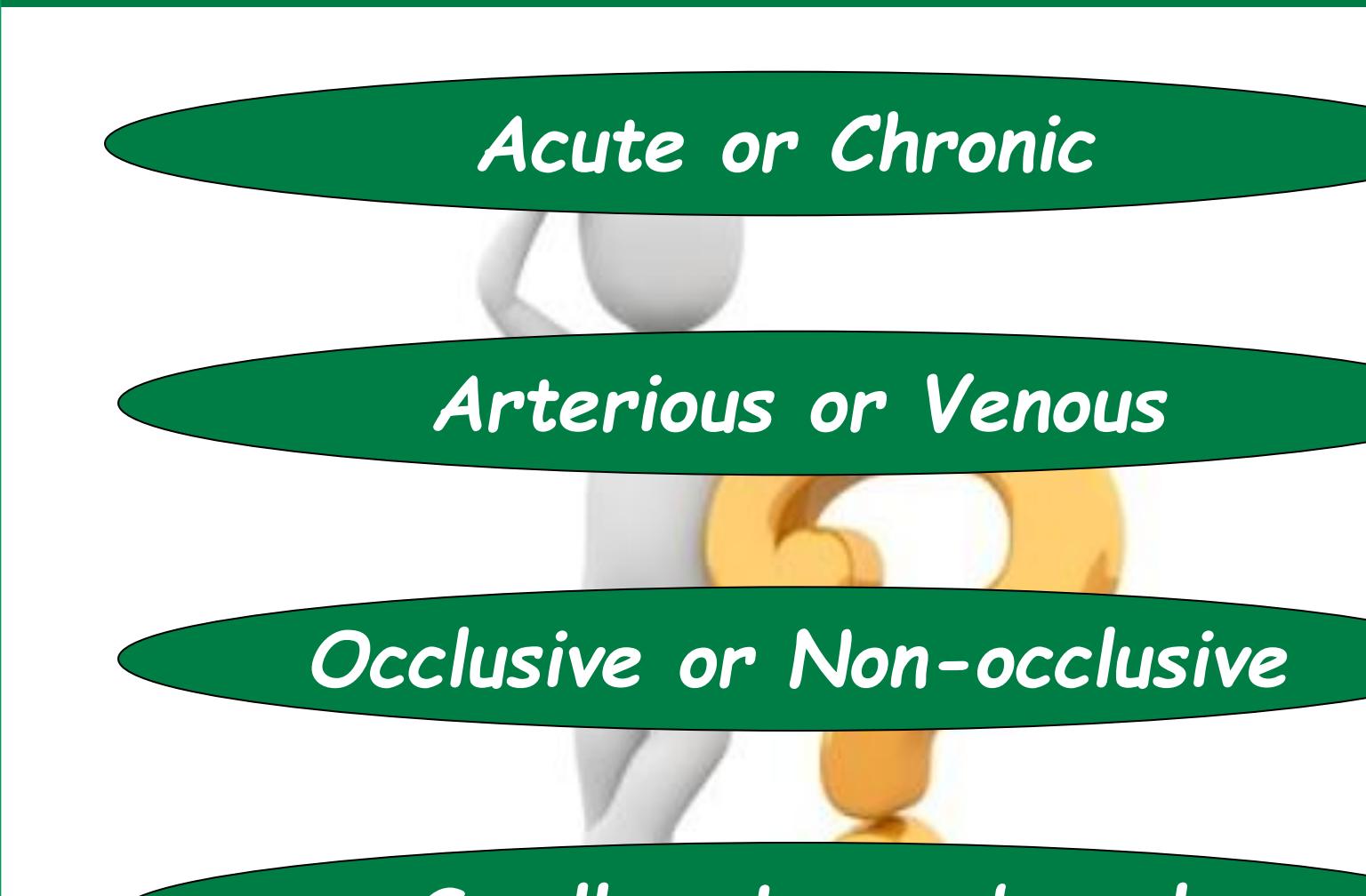
- **Deeper ischemic damage (submucosal and muscular)**
- **Abdominal pain, constipation, no peristalsis**
- **Emoconcentration, elevating neutrophil counts, metabolic acidosis**

**Peritonitic stage**

- **Wall transmural necrosis (infarction)**
- **Peritonitis, shock**



# *Classification*



*Acute or Chronic*

*Arterious or Venous*

*Occlusive or Non-occlusive*

*Small or Large bowel*

# Classification

**Acute  
Mesenteric  
Ischemia**

Occlusive  
(70-80%)

NOMI  
(20-30%)

arterial

venous

embolism

thrombosys

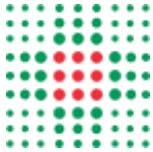
thrombosys

**Ischemic Colitis**

**Mechanical obstruction**  
(strangulation, tumor)

**Chronic abdominal angina**





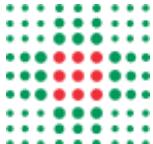
# *Classification*

*Pre-splanchnic*

*Splanchnic*

*Post-splanchnic*



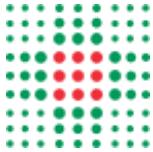


# *Pre-splanchnic*

## *Non Occlusive Mesenteric Ischemia (NOMI)*

- 15-20% of acute mesenteric ischemia
- Secondary vasoconstriction of mesenteric arteries (low-flow states, hypotension, sepsis or heart failure)
- Ischemia is distributed over a wide area of the bowel in a non-consecutive manner





# *Splanchnic*

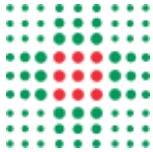
## *Acute mesenteric arterial Embolism (AMAE)*

- 50-55% of acute mesenteric ischemia
- Generally involves the distal aspect of the vessel
- Absence of associated collateral vessels

## *Acute mesenteric arterial Thrombosis (AMAT)*

- 25% of acute mesenteric ischemia
- Associated with chronic atherosclerotic disease
- Well-developed collateral circulation





# *Splanchnic*

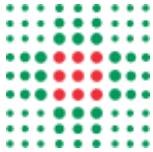
## *Ischemic Colitis (IC)*

- Secondary to acute or chronic decrease of bowel blood supply
- Most common causes are low-flow conditions associated with chronic atherosclerotic disease
- Second most frequent cause of lower GI bleeding

## *Chronic ischemia*

- Atherosclerotic involvement of splanchnic vessels (>2-3)
- Well-developed collateral circulation
- Post-prandial abdominal pain and weight loss





# *Post-splanchnic*

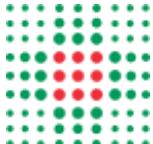
## *Mesenteric Venous Thrombosis (MVT)*

*-15-20% of acute mesenteric ischemia*

*-Common risk factors:*

- Hypercoagulable states*
- Portal hypertension*
- Recent surgery*





# *Radiologic diagnosis*

## **Are we confident..???**



December 2015 Volume 84, Issue 12, Pages 2444–2453

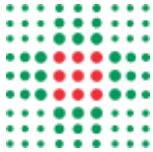
Detecting acute mesenteric ischemia in CT of the acute abdomen is dependent on clinical suspicion: Review of 95 consecutive patients

Tiina T. Lehtimäki<sup>1</sup>✉, Jussi M. Kärkkäinen<sup>1</sup>✉, Petri Saari<sup>1</sup>, Hannu Manninen<sup>1</sup>, Hannu Paajanen<sup>1</sup>, Ritva Vanninen<sup>1</sup>

***AMI is underdiagnosed without clinical suspicion***

***(81% vs 97% in detecting crucial findings of AMI)***





# *Radiologic diagnosis*

Original Article  
Emergency Radiology  
April 2013, Volume 20, Issue 2, pp 139-147

First online: 03 October 2012

Acute bowel ischemia: analysis of diagnostic error by overlooked findings at MDCT angiography

Maria Cristina Firetto, Alessandro A. Lemos  , Aldo Marini, Ettore Contessini Avesani, Pietro R. Biondetti

Original Article  
Journal of Gastrointestinal Surgery  
pp 1-12

First online: 09 November 2015

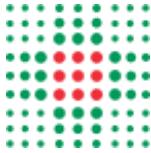
Interpretation of Abdominal CT Findings in Patients Who Develop Acute or Chronic Mesenteric Ischemia

Jussi M. Karkkäinen  , Petri Saari, Hannu-Pekka Kettunen, Tiina T. Lehtimäki, Ritva Vanninen, Hannu Paajanen, Hannu Manninen

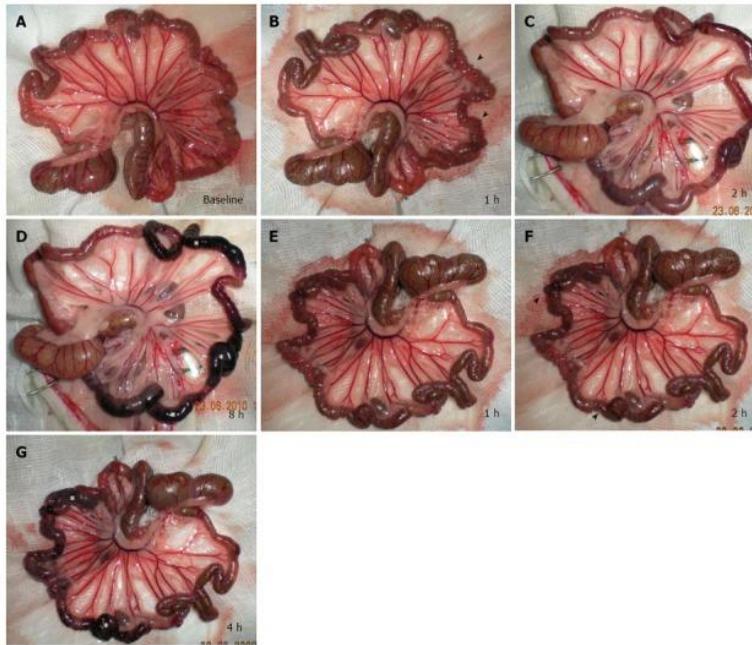
## Problems

- *No CT detection of vessel occlusion*
- *Low specificity of indirect signs*
- *Significant inter-observer variability*





# What have we learned?



J Biol Regul Homeost Agents. 2013 Jul-Sep;27(3):771-9.

## 7T mMR in the assessment of acute arterial mesenteric ischemia in a rat model.

Berritto D<sup>1</sup>, Iacobellis F, Somma F, Corona M, Faqian A, Iacomino A, Feragalli B, Saba L, La Porta M, Grassi R.

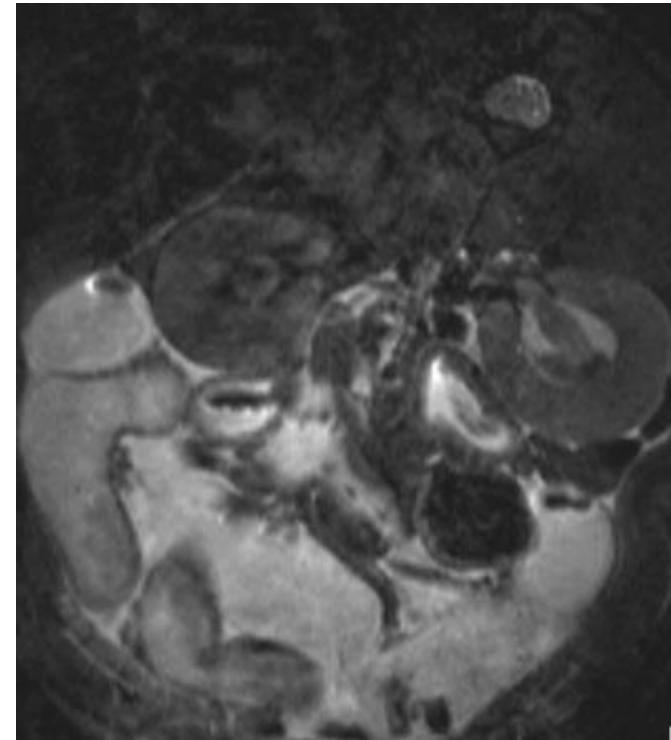
World J Gastroenterol. 2013 Oct 28; 19(40): 6825-6833.

Published online 2013 Oct 28. doi: [10.3748/wjg.v19.i40.6825](https://doi.org/10.3748/wjg.v19.i40.6825)

PMCID: PMC3812481

## Acute arterial mesenteric ischemia and reperfusion: Macroscopic and MRI findings, preliminary report

Luca Saba, Daniela Berritto, Francesca Iacobellis, Mariano Scaglione, Sigismondo Castaldo, Santolo Cozzolino, Maria Antonietta Mazzei, Veronica Di Mizio, and Roberto Grassi



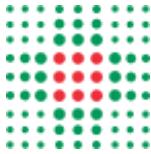
La radiologia medica  
September 2011, Volume 116, Issue 6, pp 829-841

First online: 19 April 2011

Seven-Tesla micro-MRI in early detection of acute arterial ischaemia: evolution of findings in an in vivo rat model

D. Berritto, F. Somma, N. Landi, C. Cavaliere, M. Corona, S. Russo, F. Fulciniti, S. Cappabianca, A. Rotondo and 1 more

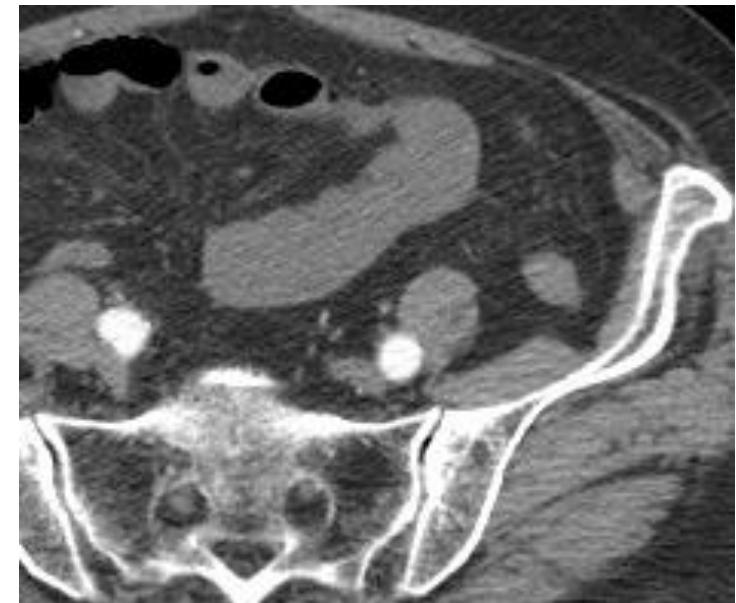
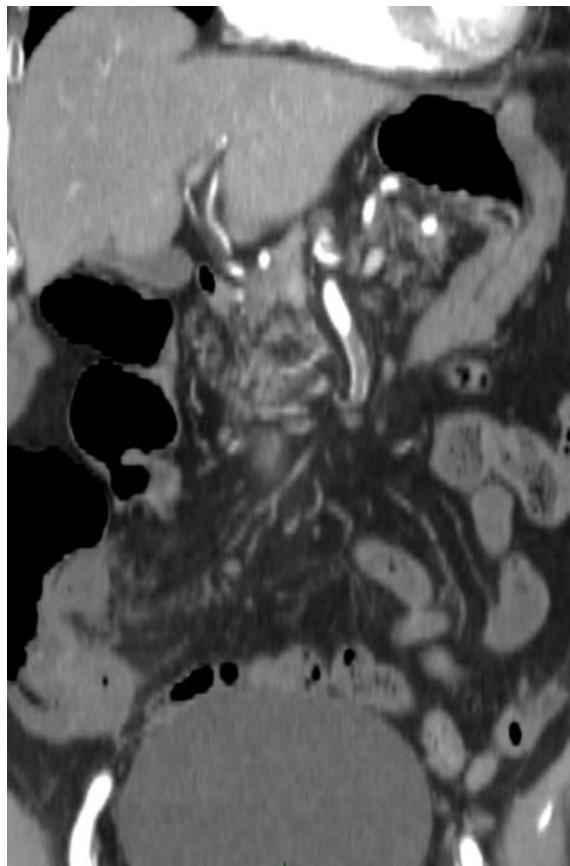


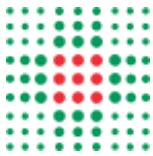


# Mesenteric ischemia

First  
phase

- *Vessels occlusion (emboli or thrombi)*
- *Spastic reflex ileo*
- *Poor wall enhancement*

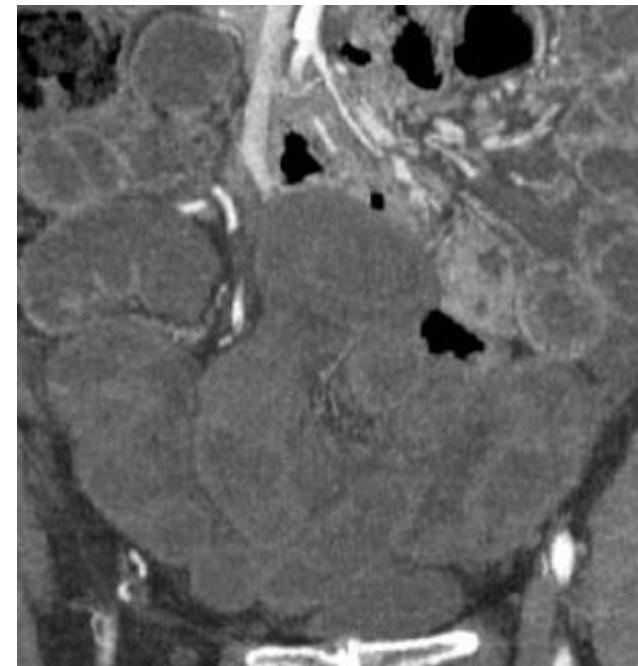
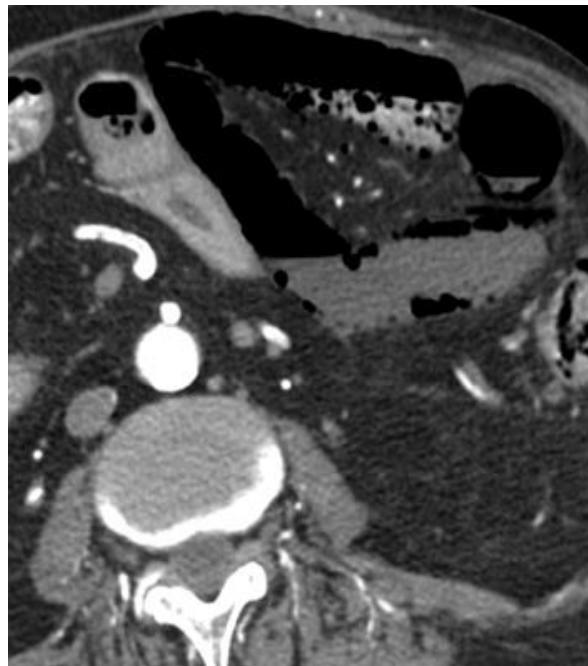


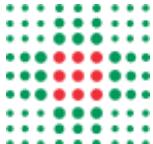


# Mesenteric ischemia



- “*Paper thin*” wall
- *Ipotonic ileo*
- *Gas filled loops*
- *Decrease wall enhancement*
- *Small account of fluid*

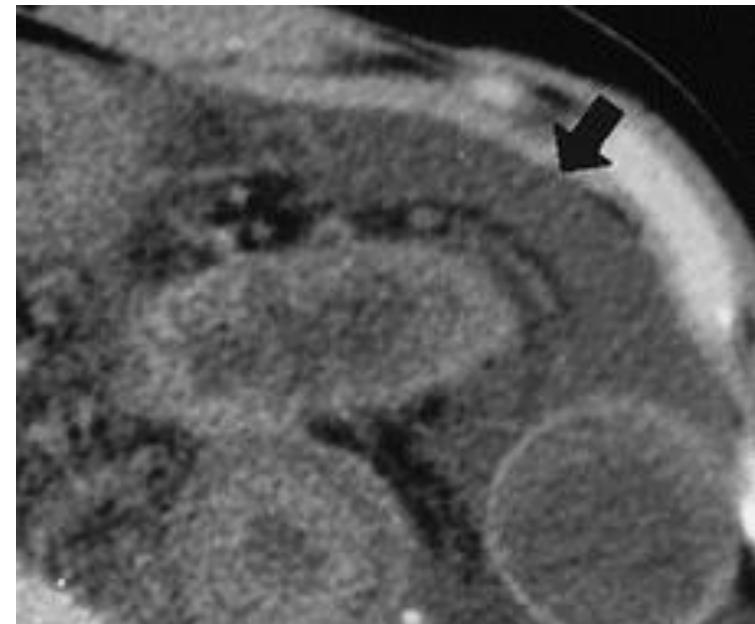
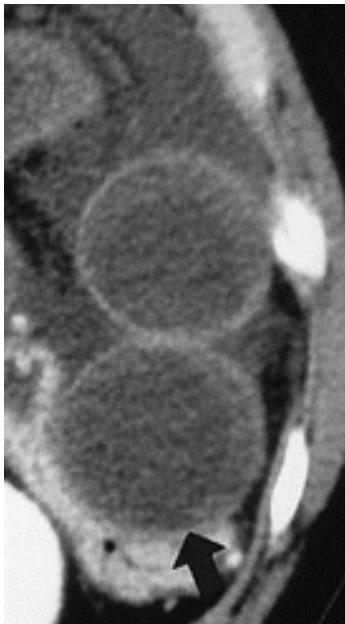


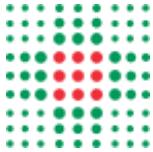


# Mesenteric ischemia

Third  
has

- *Degree of wall enhancement (wall infarct or necrosis or thickening in case of reperfusion)*
- *Paralitic ileo*
- *Ascites*
- *Pneumatosis (?)*





# *Correct Reporting Approach*

***Vessels patency***

***Wall thickness***

***Wall enhancement***

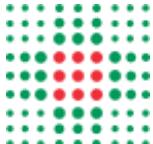
***Luminal dilation***

***Mesentery***

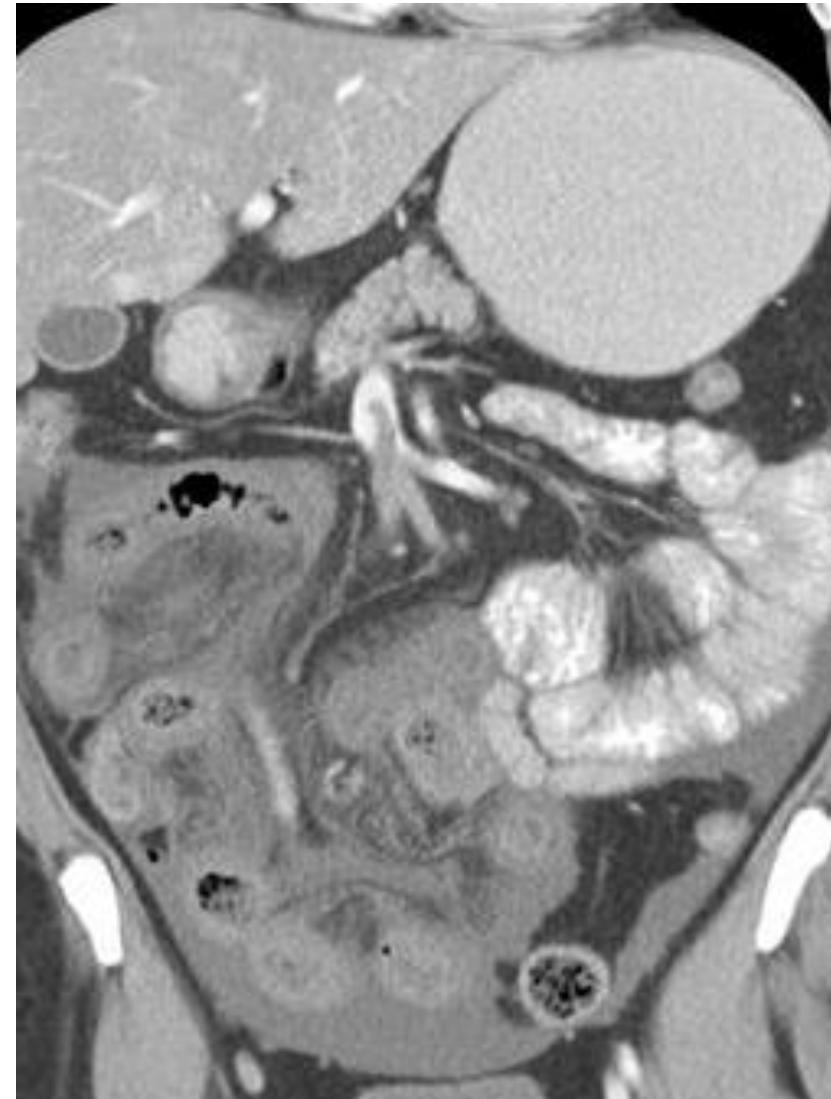
***Ascites***

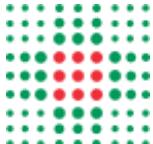
***Pneumatosis***



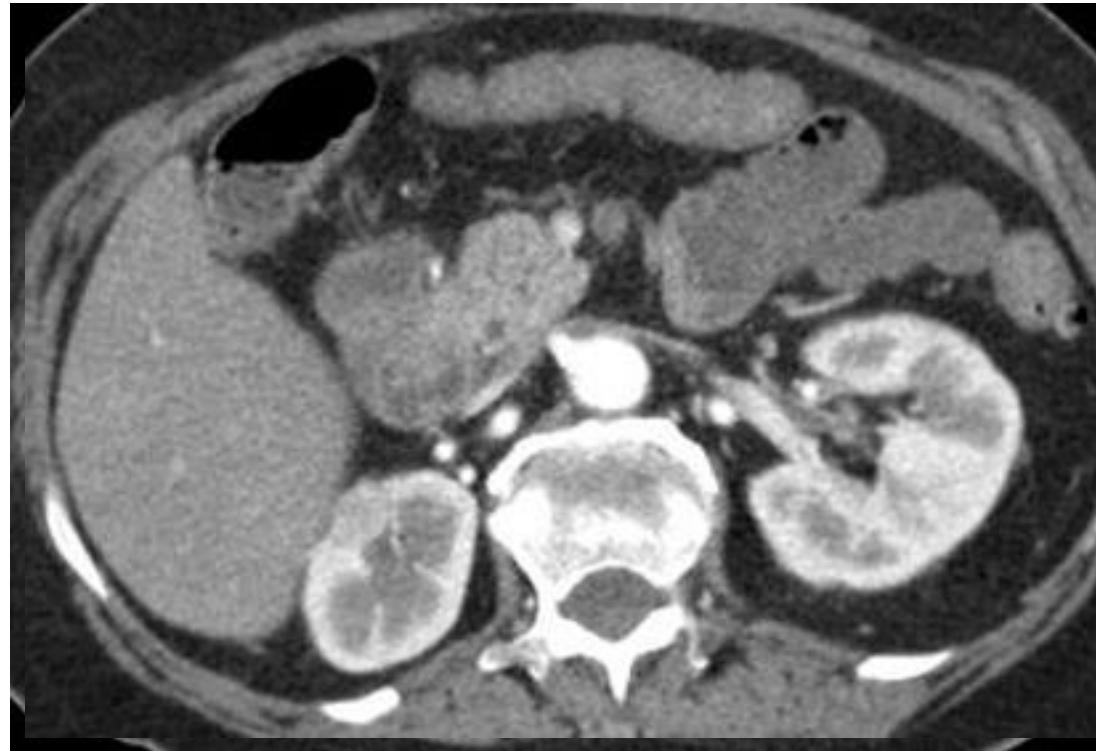


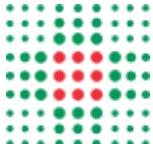
# *Vessel patency*



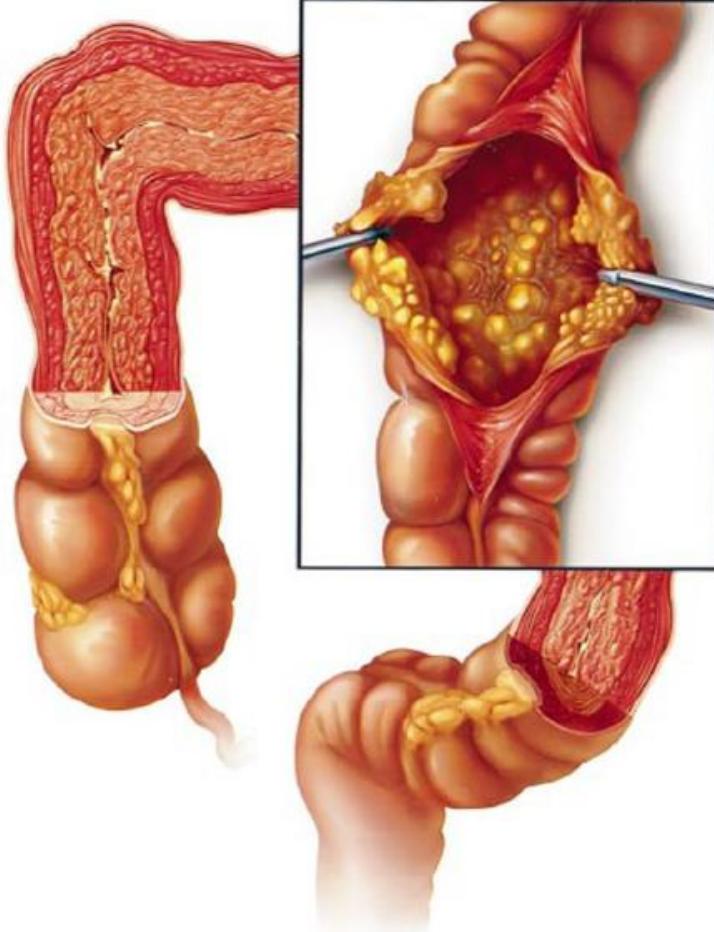


# *Vessel patency*





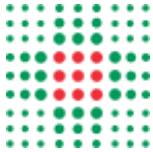
# Bowel wall thickening



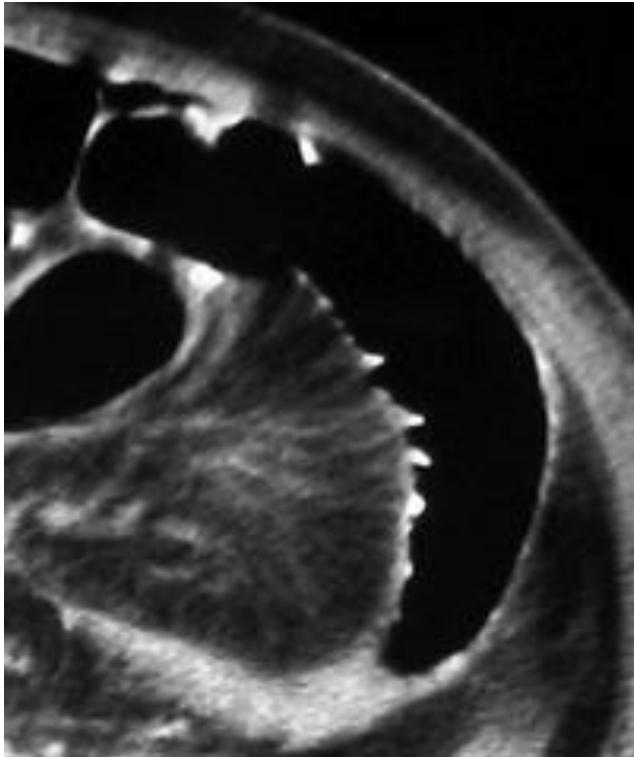
*More common finding*

*Least specific finding  
(depends on the  
degree of distension)*

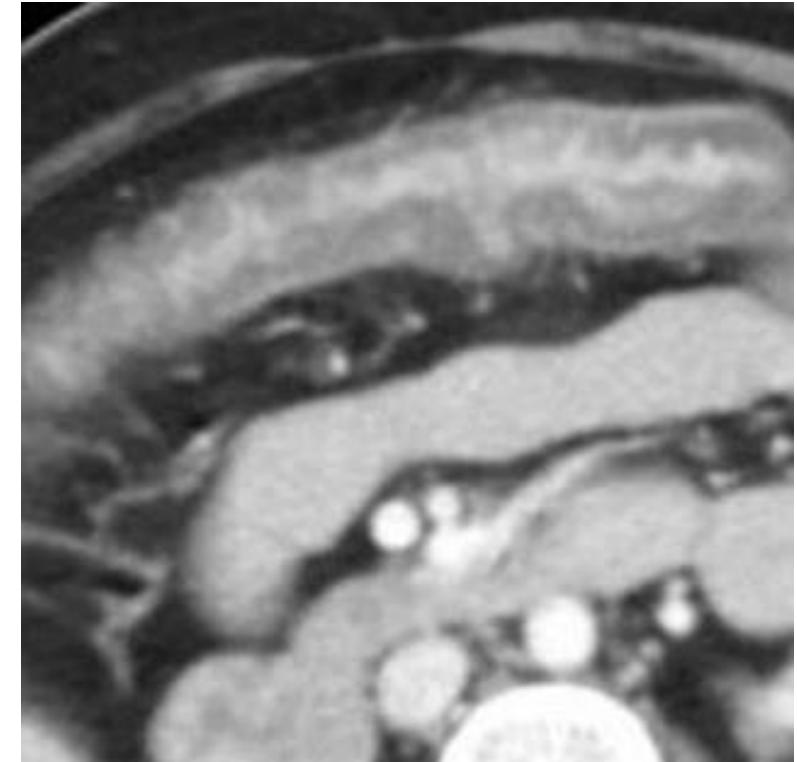
**Cut-off : 3-5 mm**



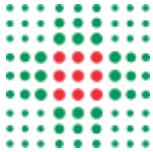
# Wall thickness



***“Paper thin” wall  
(more for arterious occlusion)***

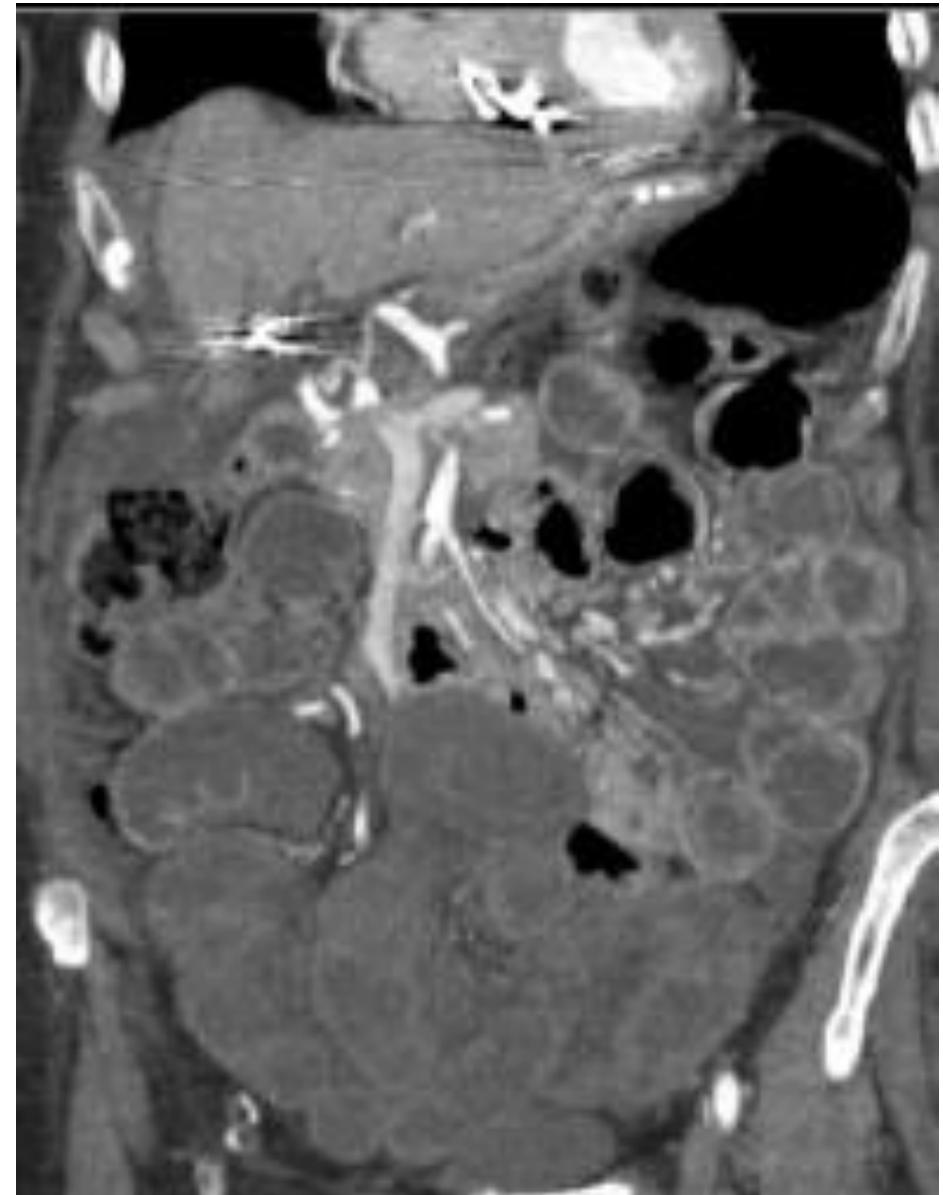


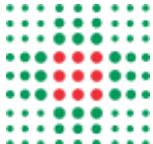
***Wall congestion  
(more for venous thrombosis)***



# *Wall thickness*

*Length of  
involvement*

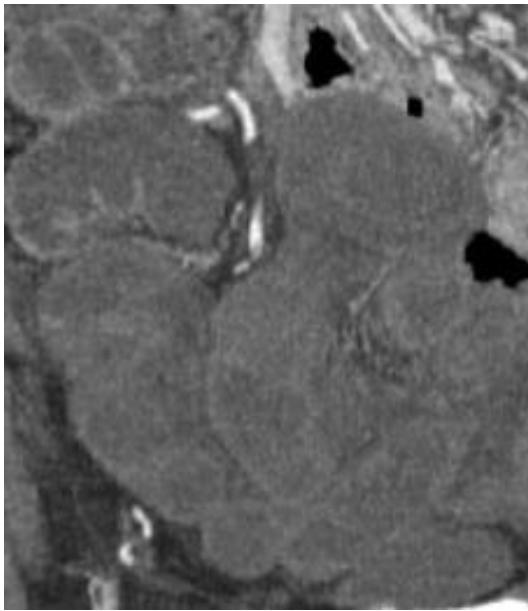




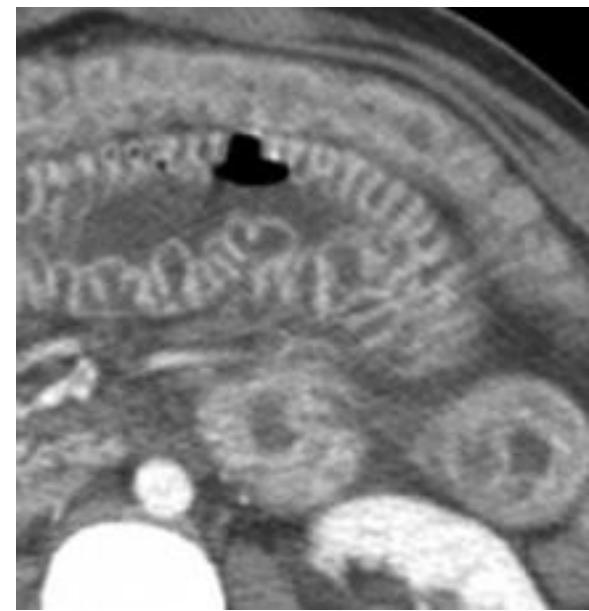
# Wall enhancement



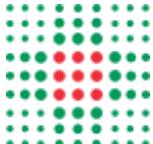
Normal



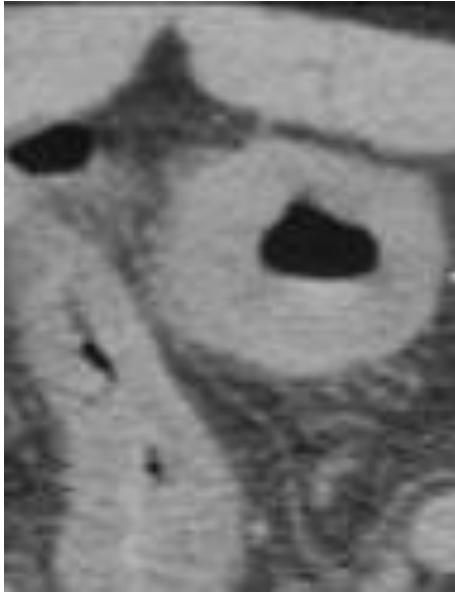
Hypoattenuation  
(acute ischemia)



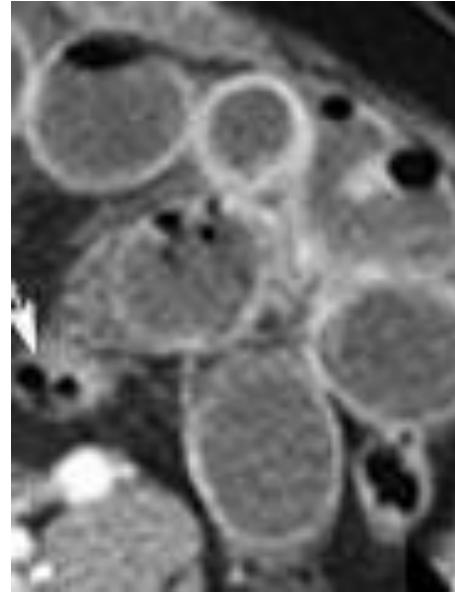
Hyperattenuation  
(shock bowel)



# *Wall enhancement*



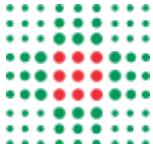
***Poor enhancement***



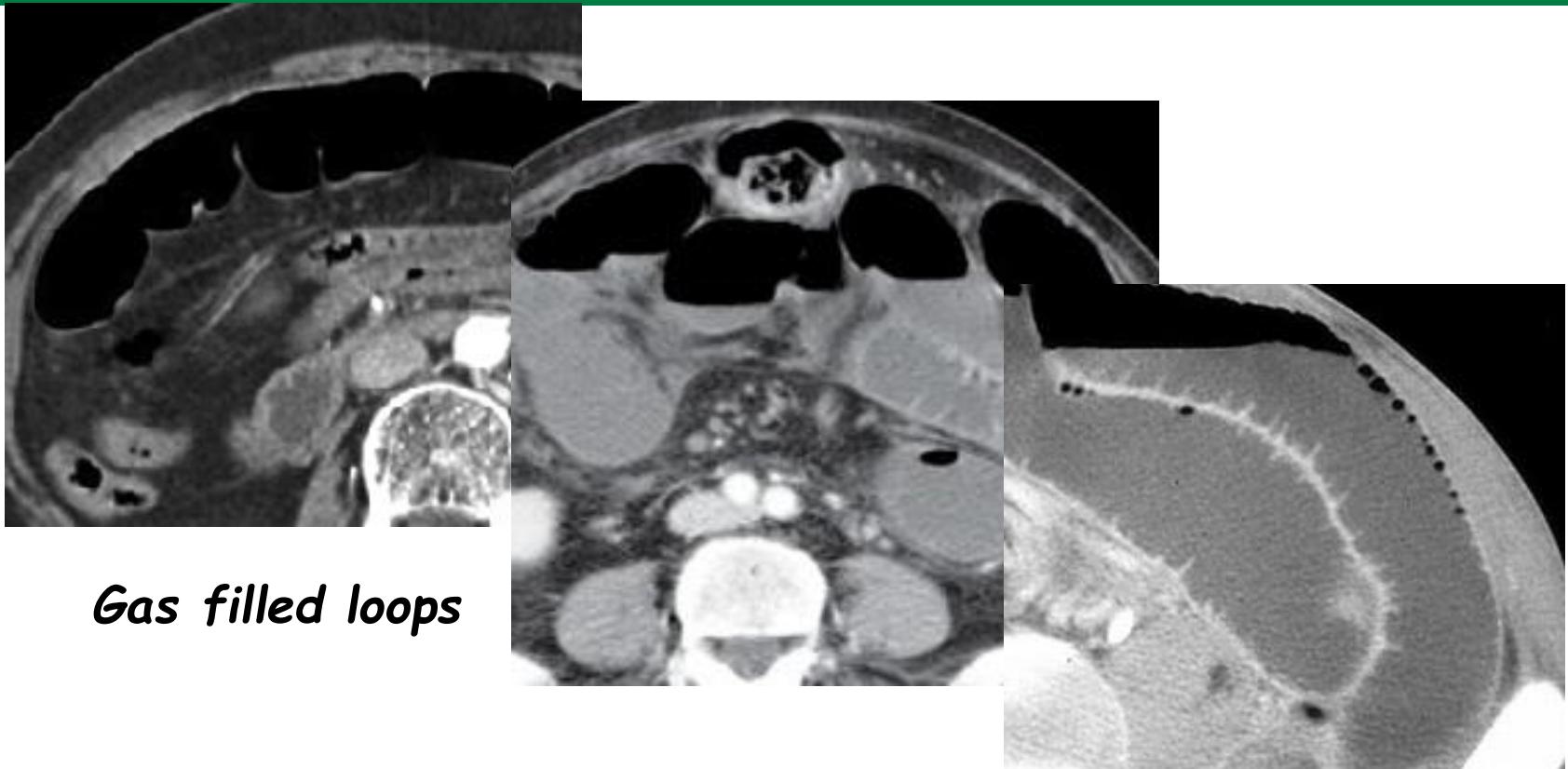
***Mucosal enhancement***



***Sub-mucosal congestion***



# *Luminal dilation*



*Gas filled loops*

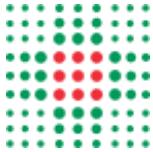
*Air-Fluid levels and progressive  
dilation of loops*

*Spastic*

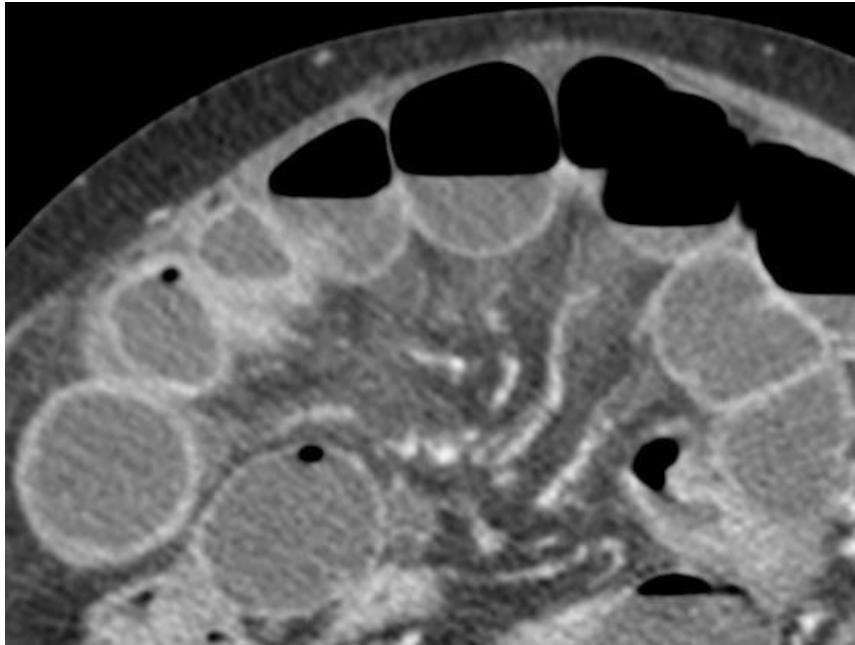


*Paralitic ileo*



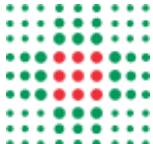


# *Mesenteric congestion*

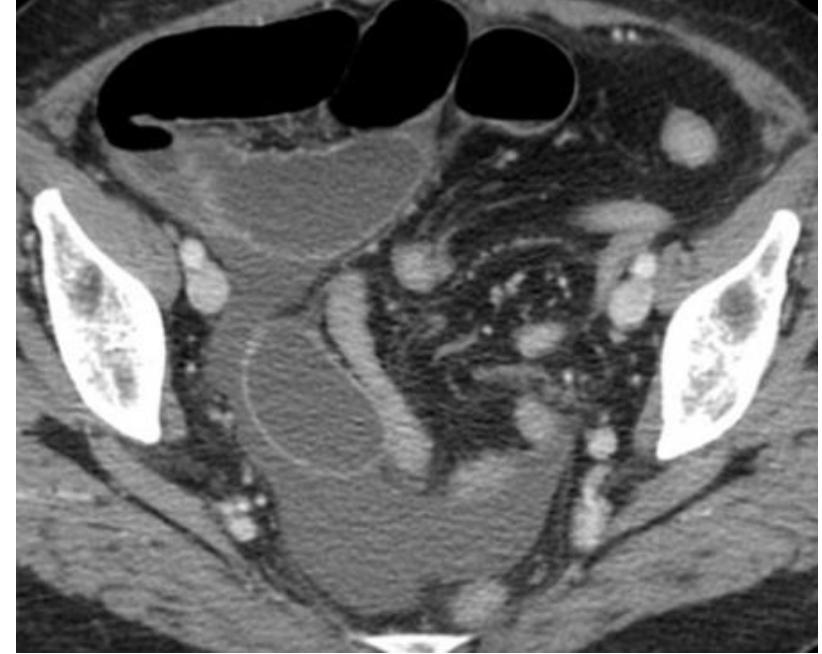


*Edema and venous engorgement  
(more frequent in MVT or in  
case of riperfusion failure)*

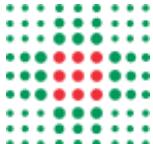




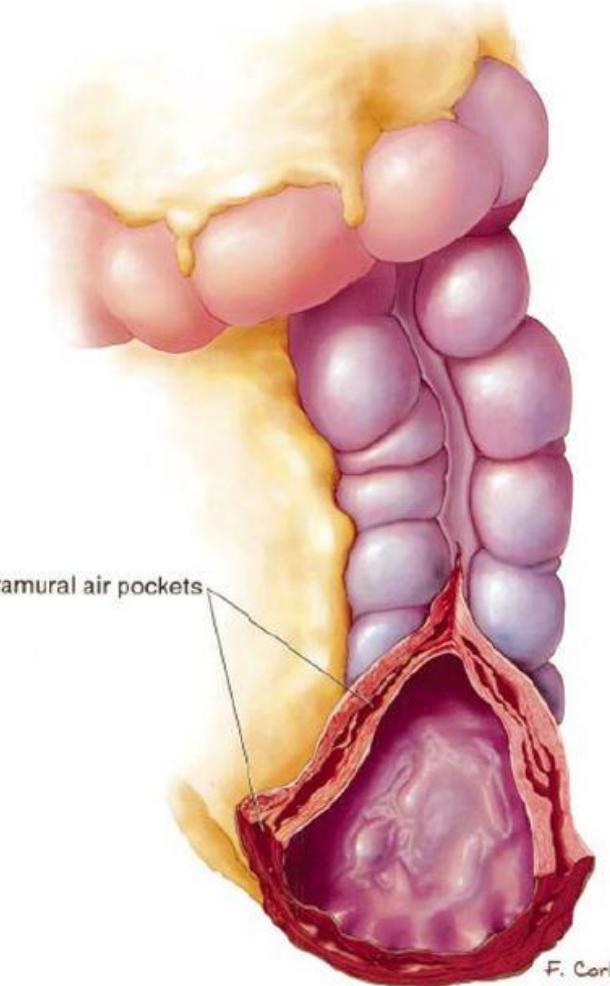
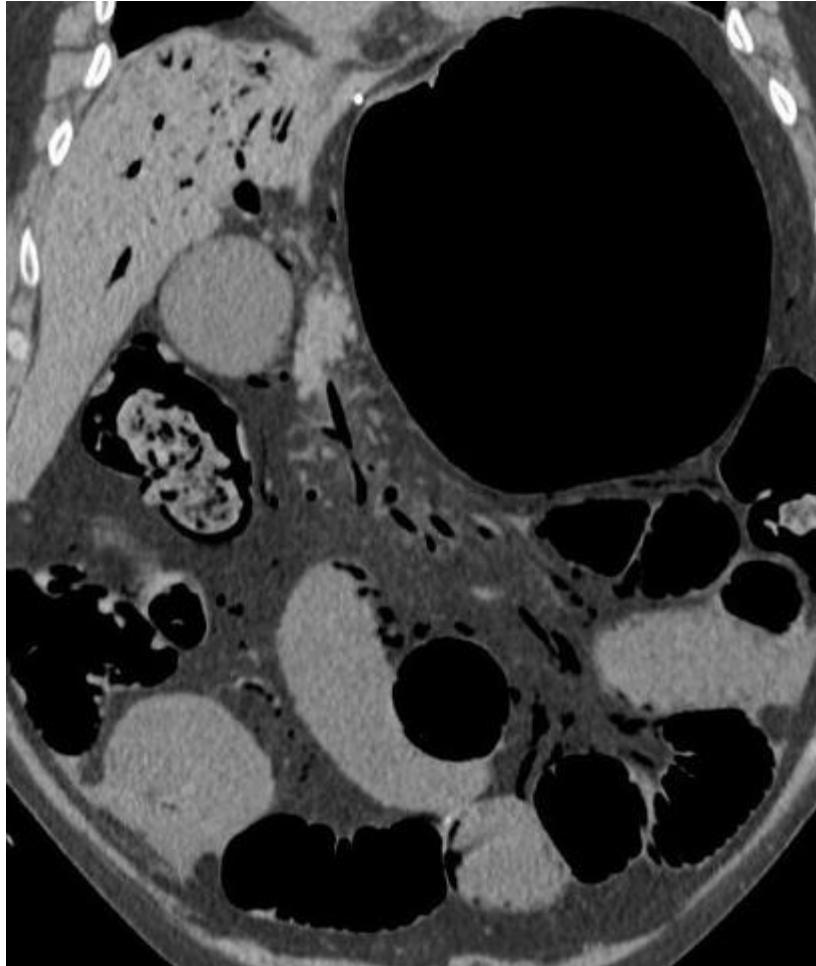
# Ascites

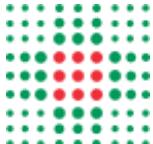


*Index of severity only in case of  
mesenteric arterial occlusion  
(not for MVT and IC)*

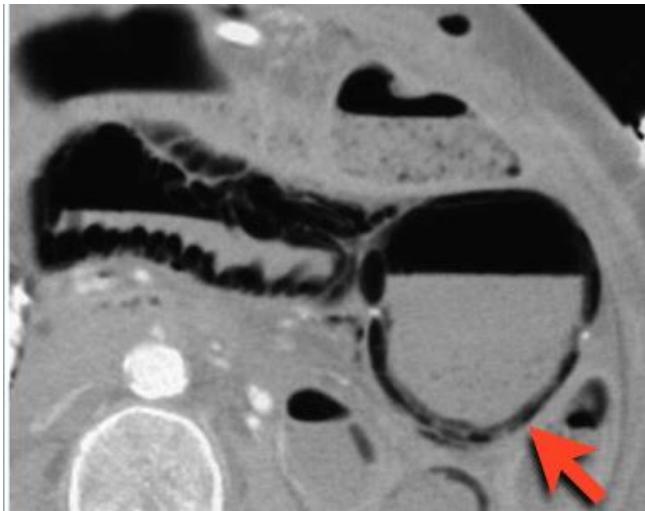


# Pneumatosis





# Pneumatosis

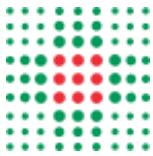


*Secondary to transmural bowel infarction (wall air dissection)*

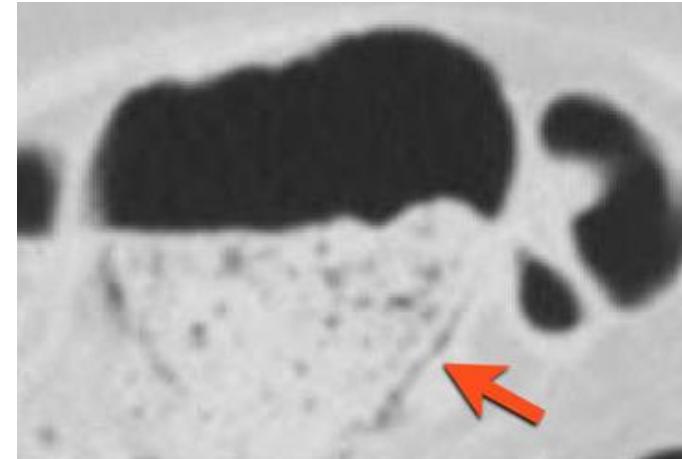
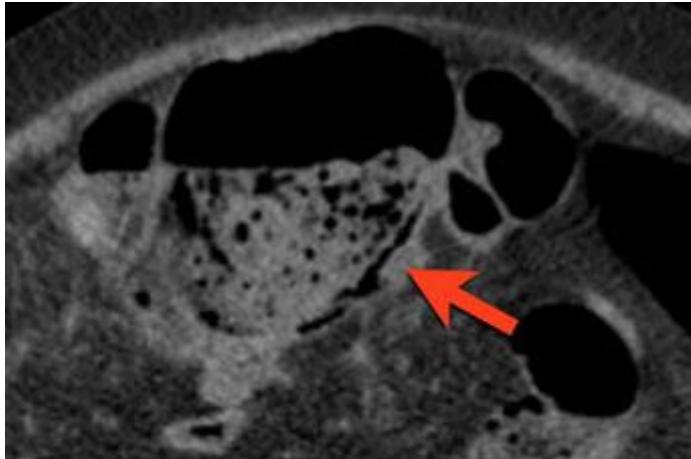
**Association with  
portomesenteric venous gas !!!**



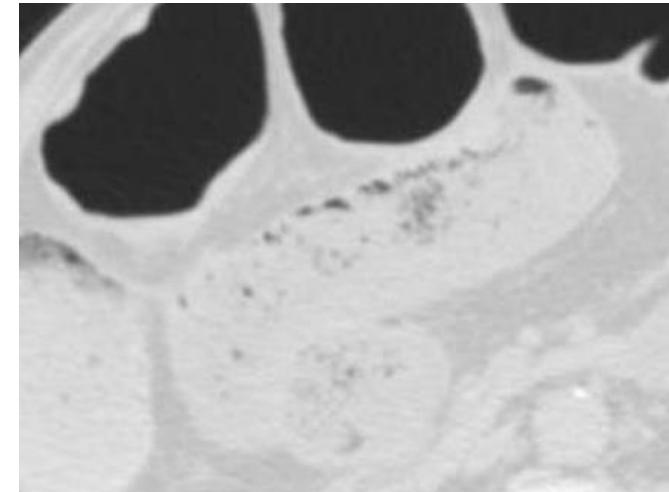
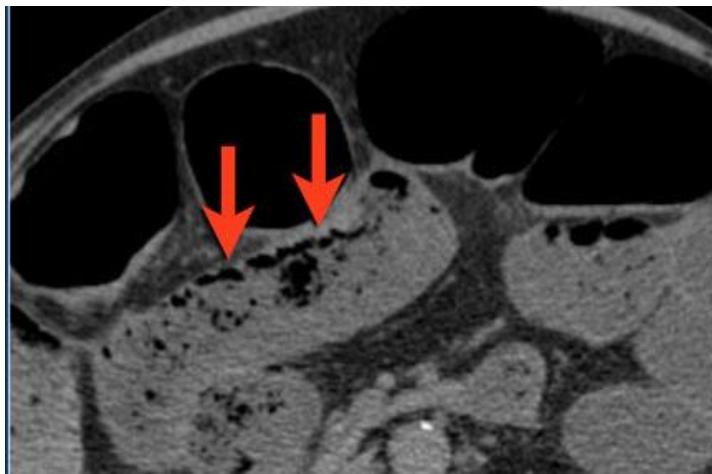
*Pneumatosis Intestinalis in the Adult: Benign to Life-Threatening Causes*  
Lisa M. et al. AJR 2007



# Pseudopneumatosis

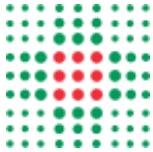


*Gas bubbles are trapped between the fecal debris and the bowel wall*

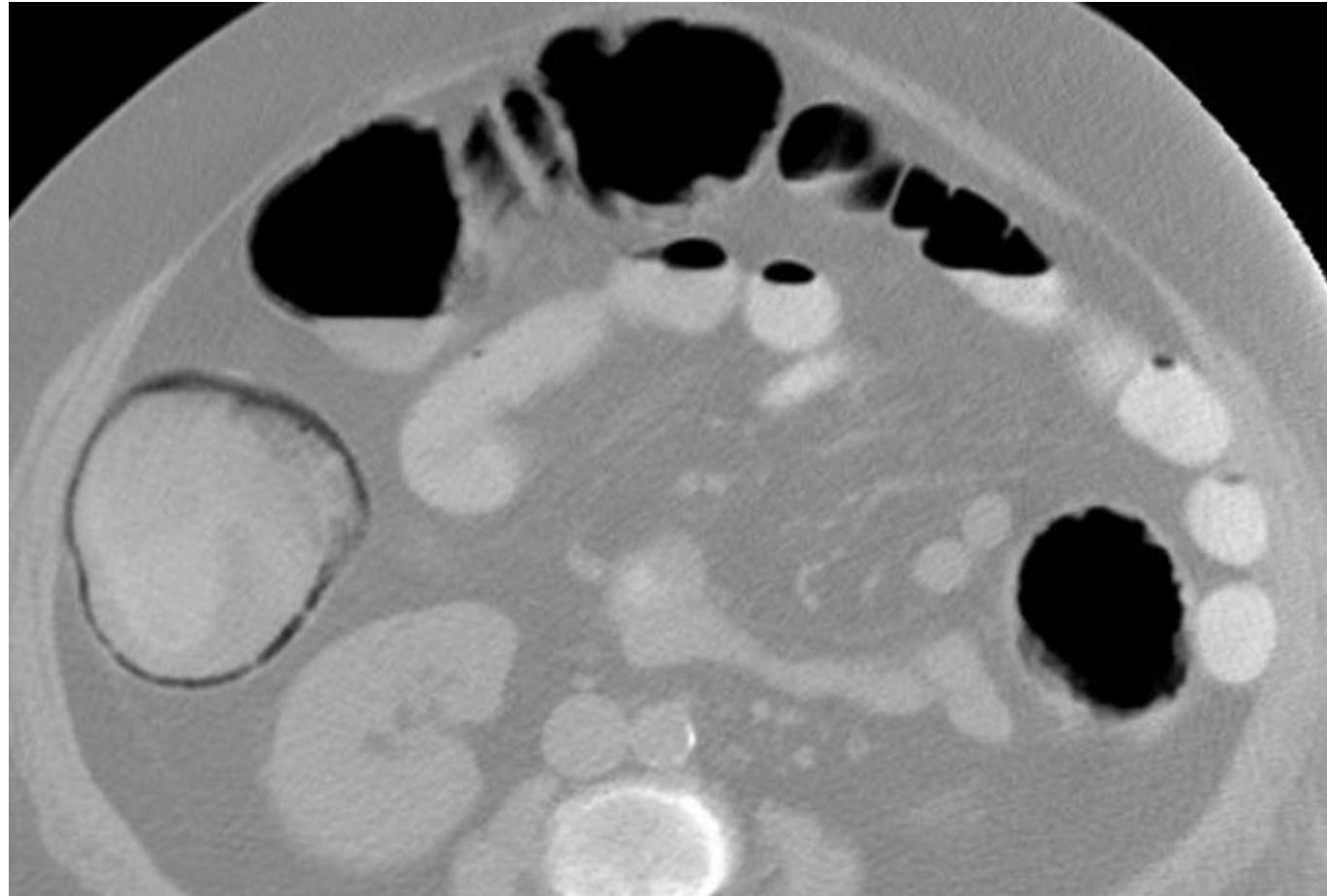


*String of pearls sign: Entrapment of air bubbles between the folds*

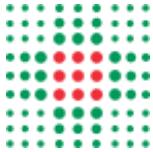




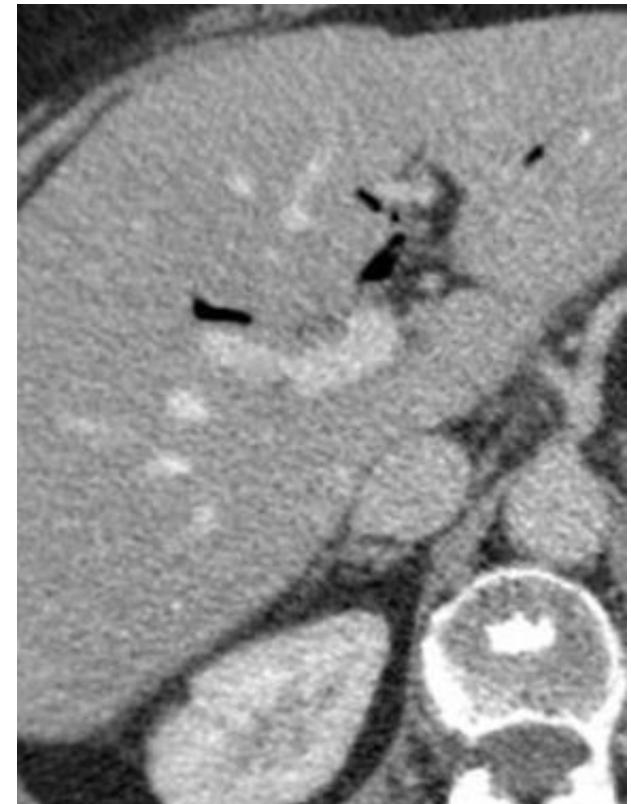
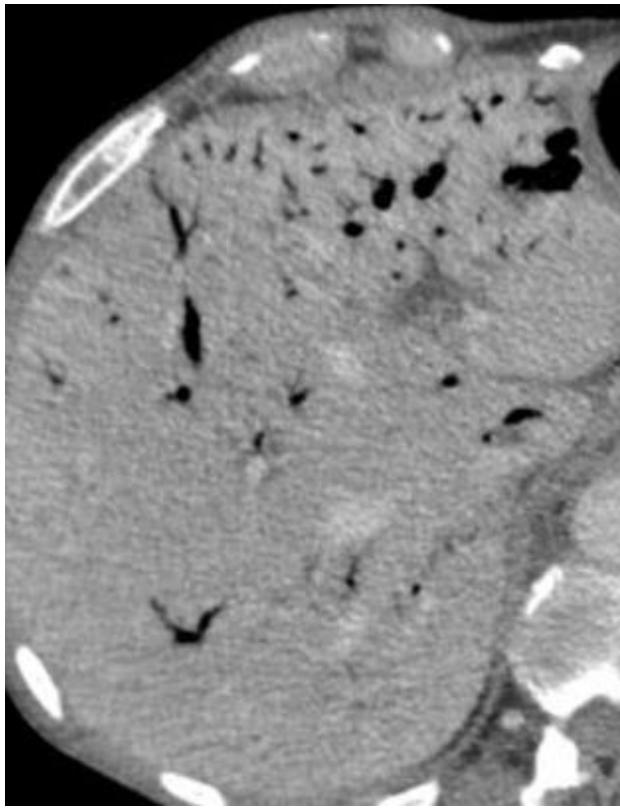
# *Incidental pneumatosis*



*Asymptomatic pneumatosis may be seen in patients with asthma and COPD*

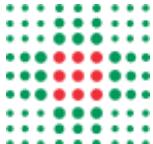


# *Portal venous gas*



*Portal venous gas is located peripherally in the liver  
(2 cm close to external border)*

*Pneumobilia is usually more centrally located*



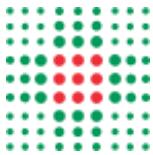
# Case 1

Pz di 84 aa

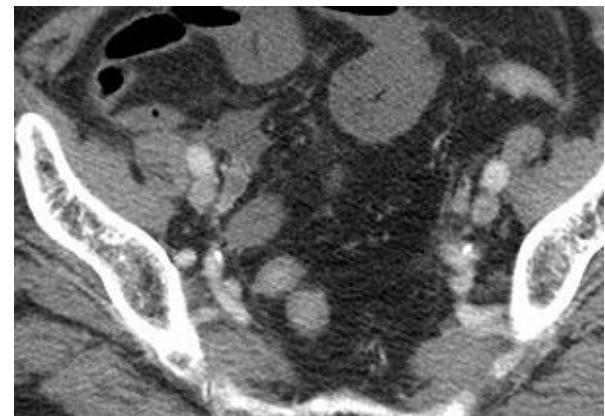
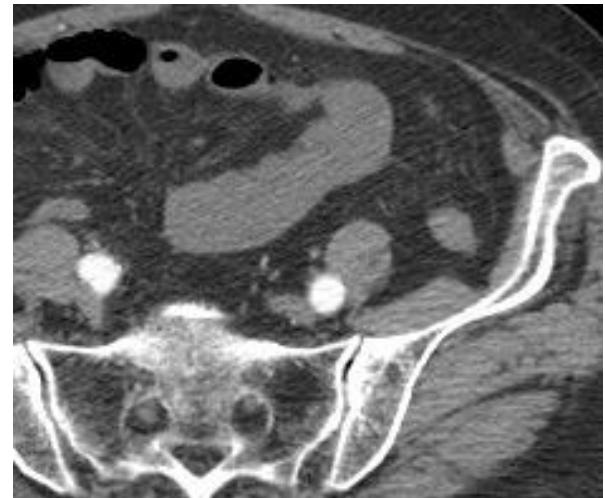
**Algie addominali con diarrea e vomito**

**Leucocitosi (20.96) e aumento PCR, mioglobina e LDH**





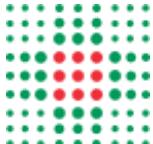
# Case 1



## Anatomia Patologica:

**Anse ileali (135 cm) con necrosi ed infarcimento ematico esteso all'adipe periviscerale parietale; ectasia e congestione vascolare**

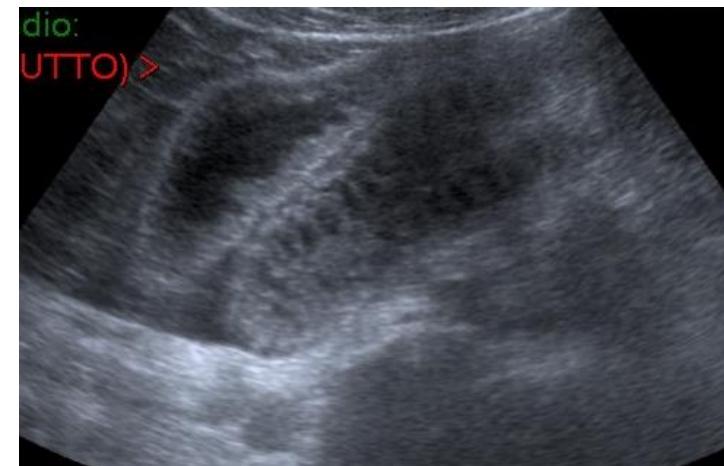
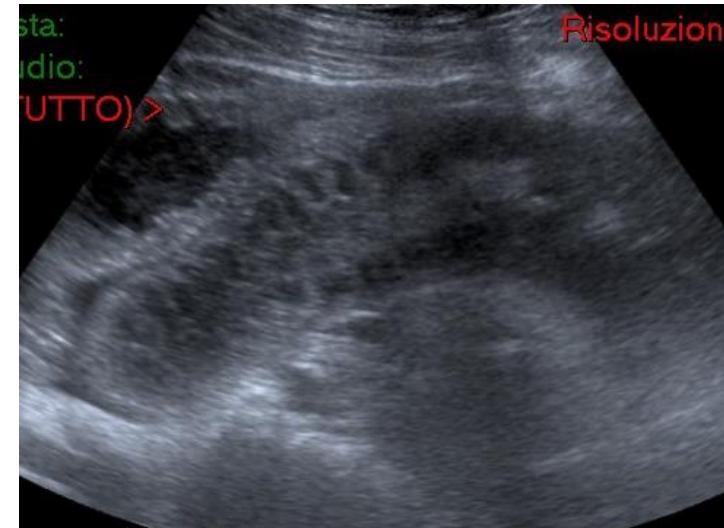


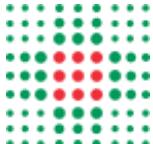


# Case 2

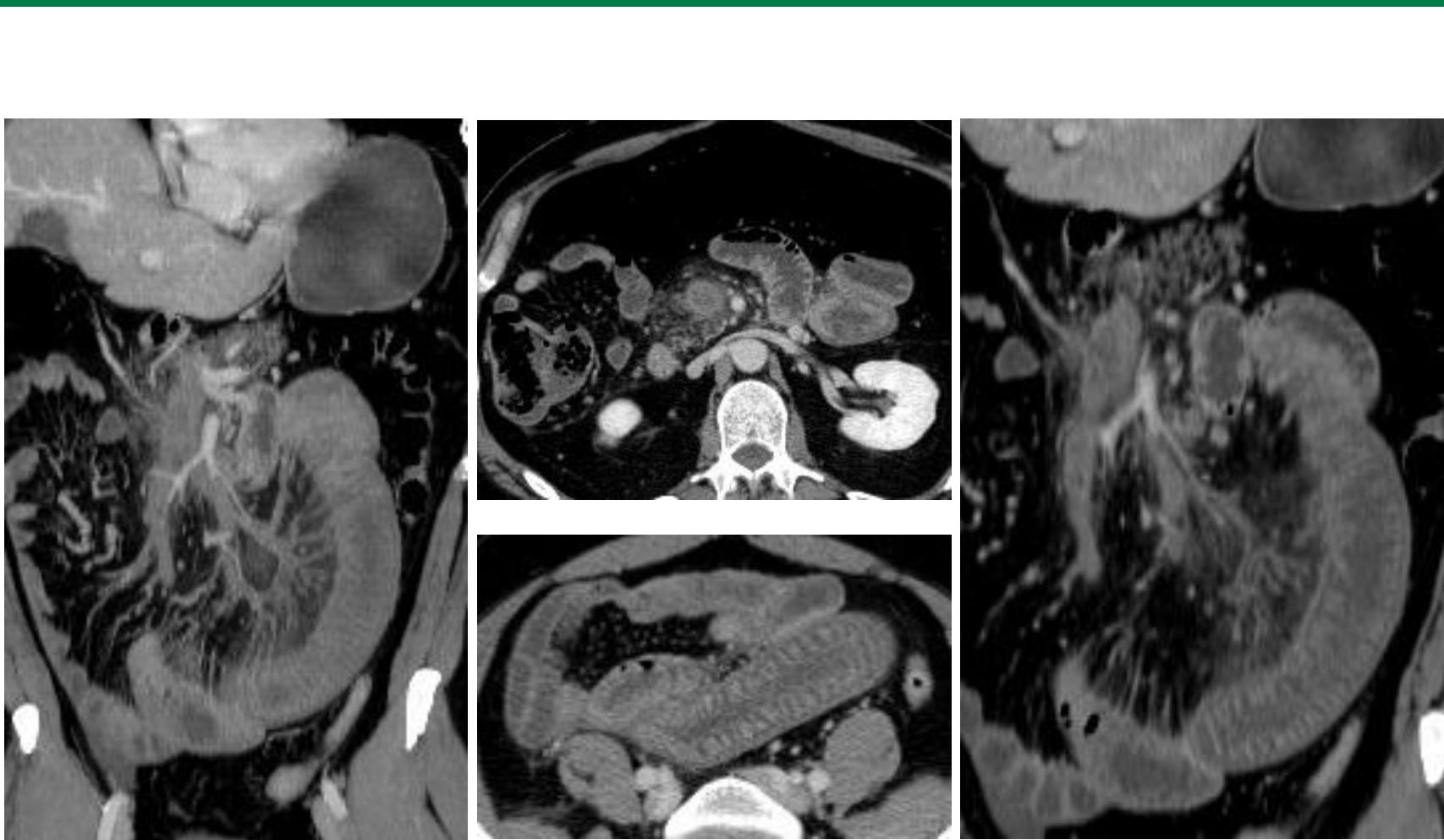
**Pz di 44 aa con M.di Bechet**

**Algie in fossa iliaca dx. Alvo chiuso da 24h. Vomito  
Leucocitosi (21.61)**





## Case 2



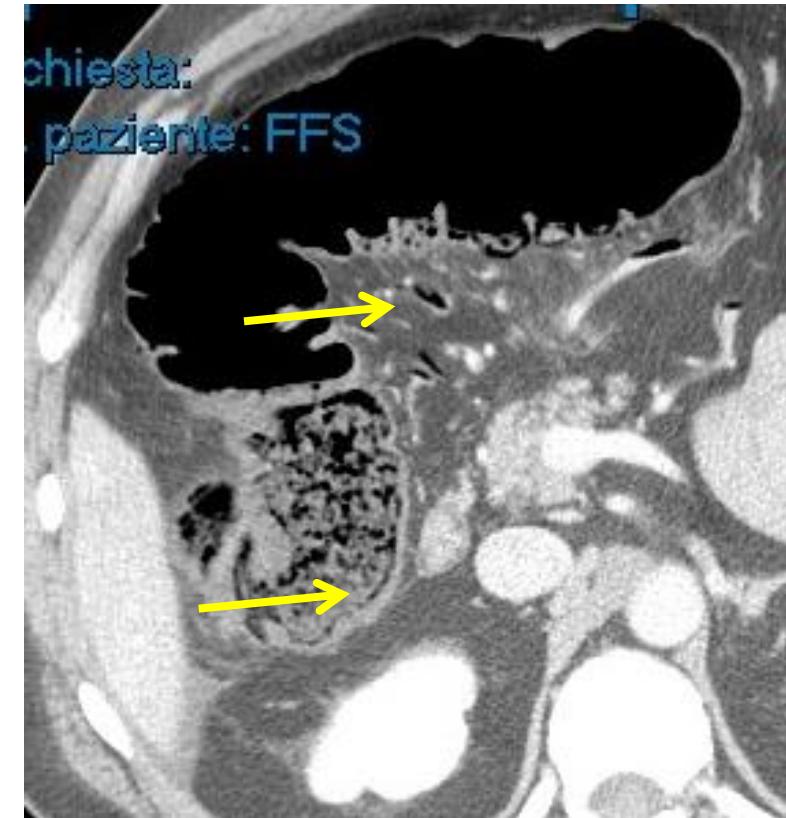
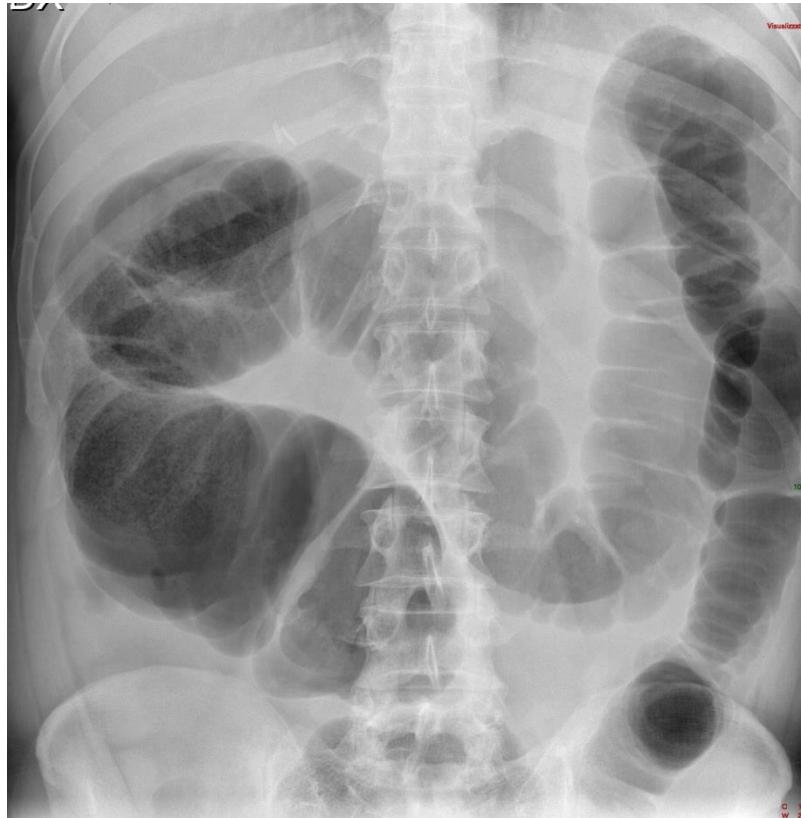
***Terapia conservativa***

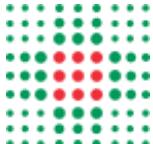
***Progressiva ricanalizzazione parziale della TVP ai controlli  
CEUS e TC.***



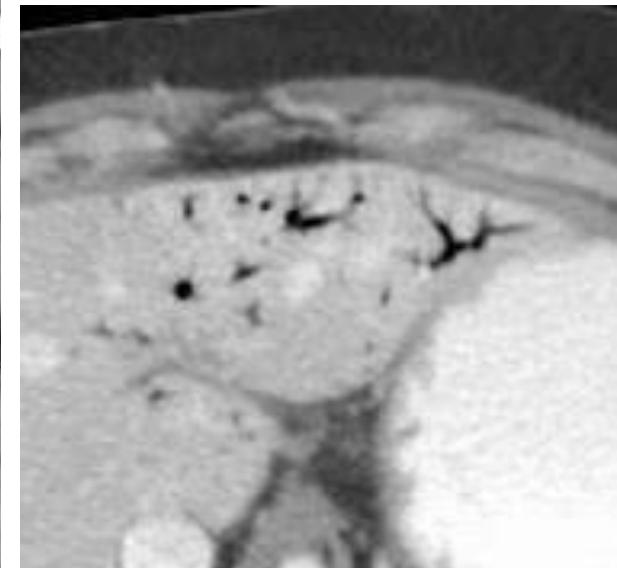
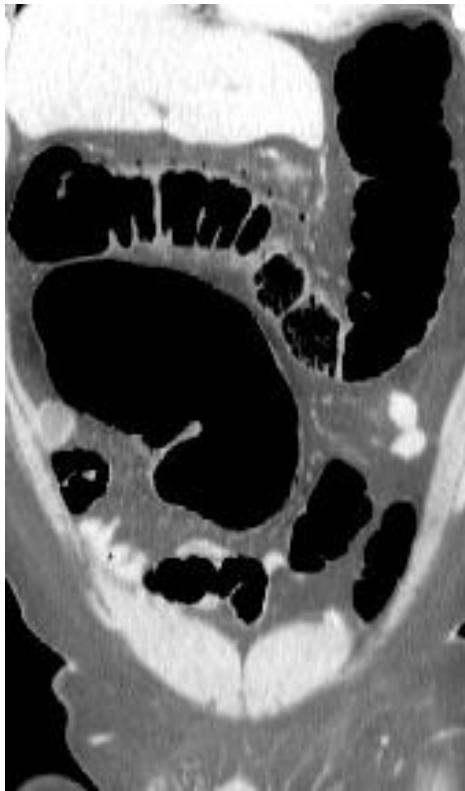
# Case 3

**Pz di 48 aa  
Addome acuto con diarrea. Peristalsi assente.**

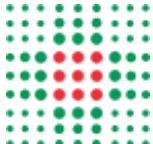




# Case 3



**Anatomia Patologica: Resezione ileo-colica (90 cm) con necrosi ed ulcerazioni parietali + flogosi granulocitaria e congestione**



# Case 4

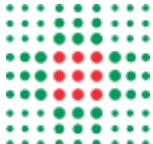
*Pz di 82 aa*

*Dolore addominale (> fianco sn)*

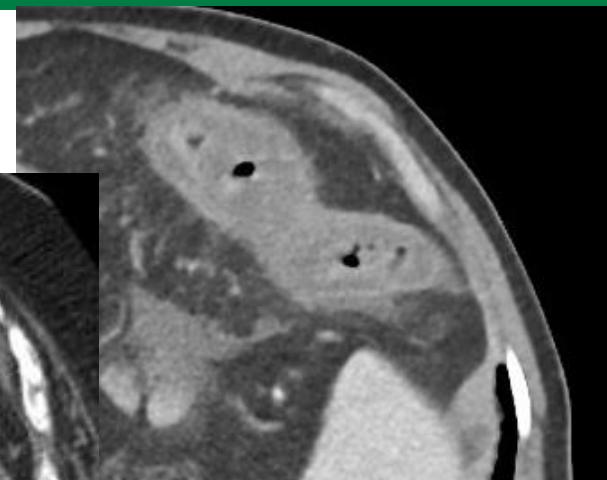
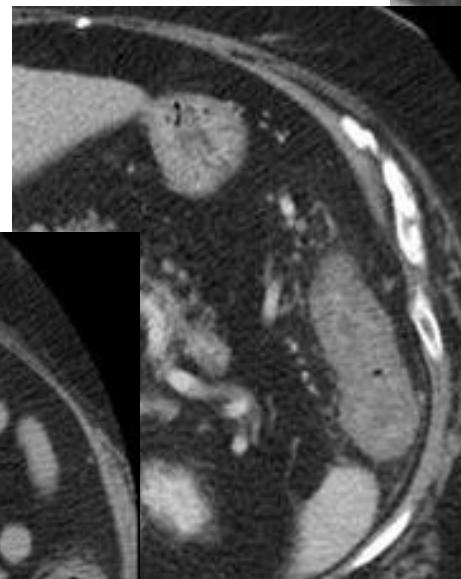
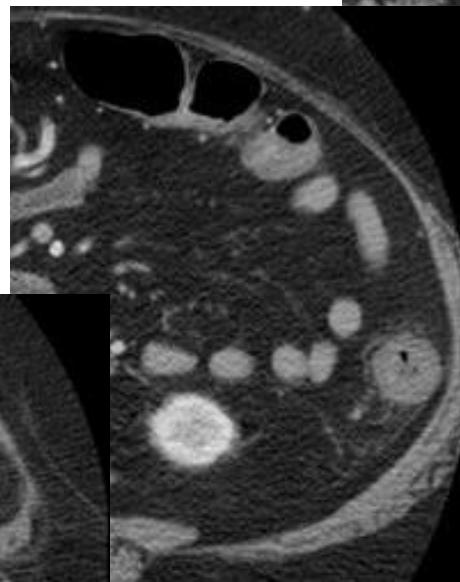
*Episodi di diarrea ematica*

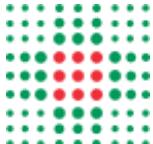
*Leucocitosi*



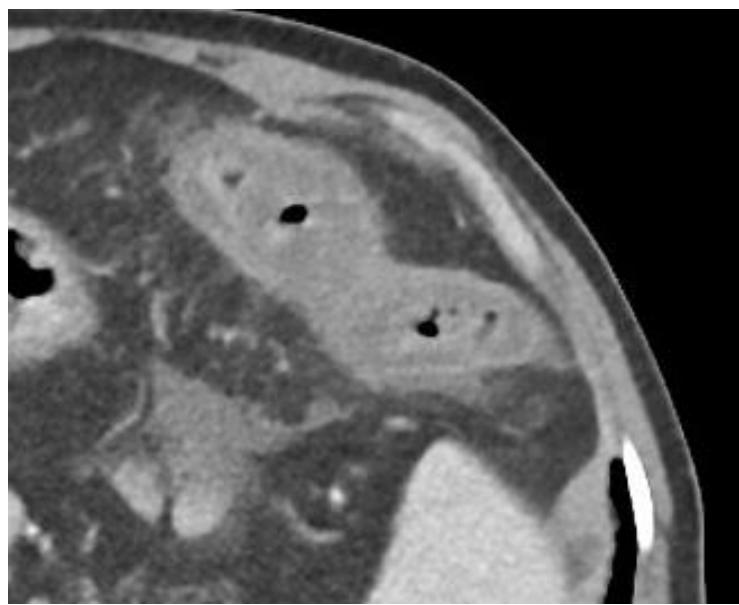


# Case 4





# Case 4

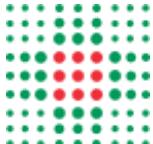


**Flessura  
splenica**



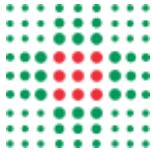
*Mucosa colica congesta  
con aspetti microerosivi,  
facilmente sanguinante*

**Terapia conservativa**



# *What about Ischemic Colitis ?*





# *Ischemic colitis (IC)*

***Severe gangrenous  
(20%)***

***Non-gangrenous  
(80%)***



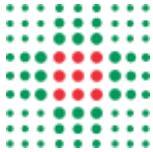
***Reversible***

***Irreversible***

***Acute***

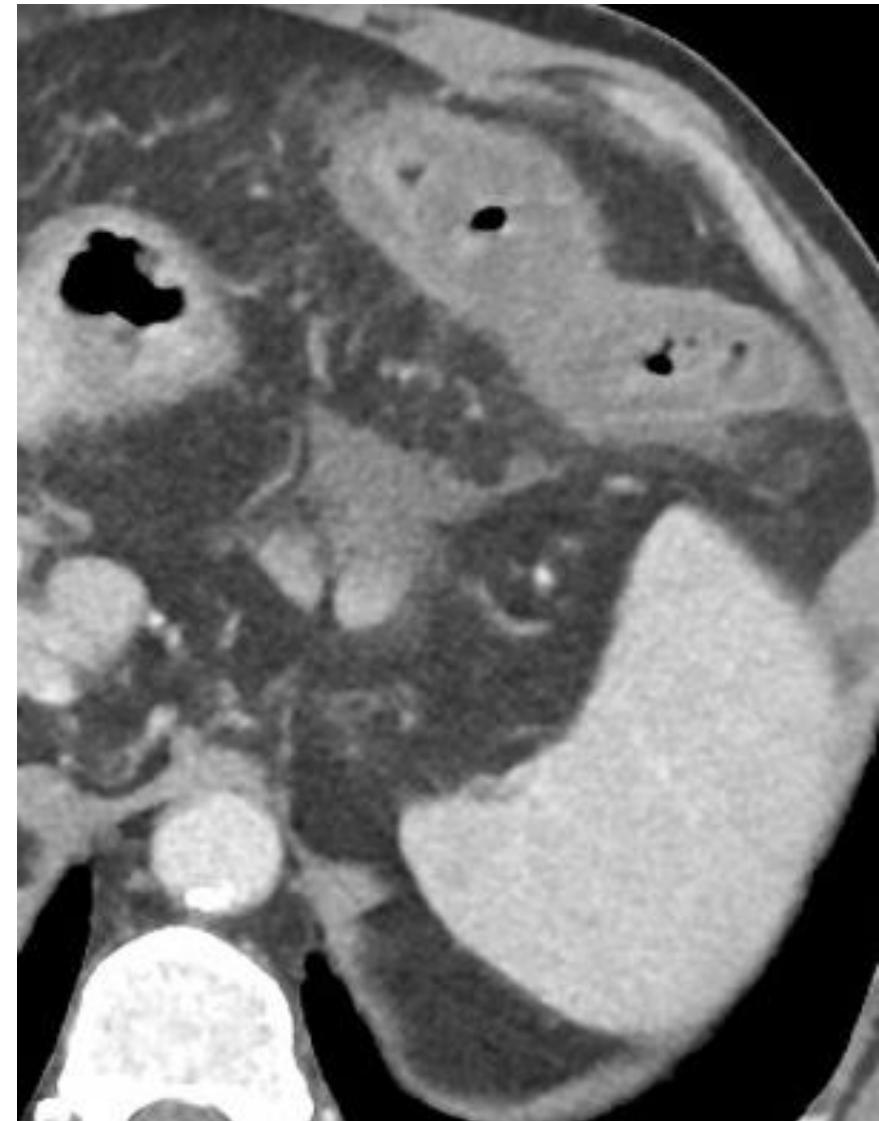
***Sub-acute***

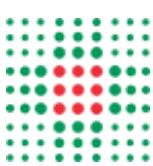
***Chronic***



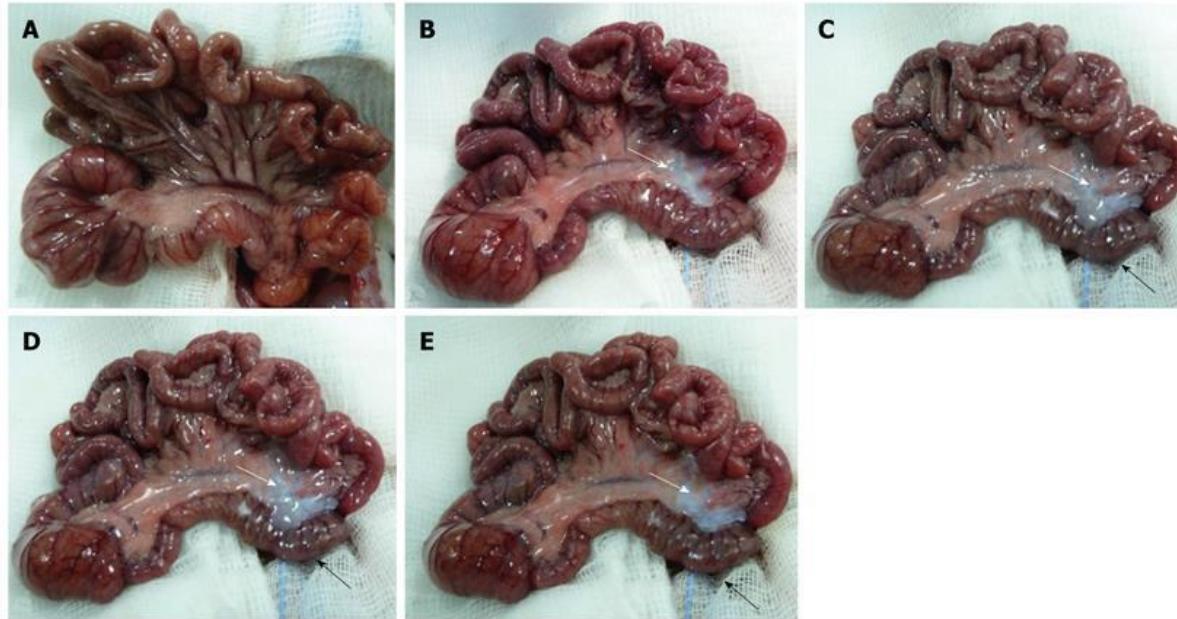
# *Ischemic colitis (IC)*

"Watershed" area





# *Ischemic colitis (IC)*

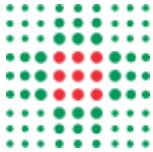


World J Gastroenterol. Apr 7, 2012; 18(13): 1496-1501  
Published online Apr 7, 2012. doi: 10.3748/wjg.v18.i13.1496

**Magnetic resonance imaging: A new tool for diagnosis of acute ischemic colitis?**

Francesca Iacobellis, Daniela Beritto, Francesco Somma, Carlo Cavaliere, Marco Corona, Santolo Cozzolino, Franco Fulciniti, Salvatore Cappabianca, Antonio Rotondo, Roberto Grassi





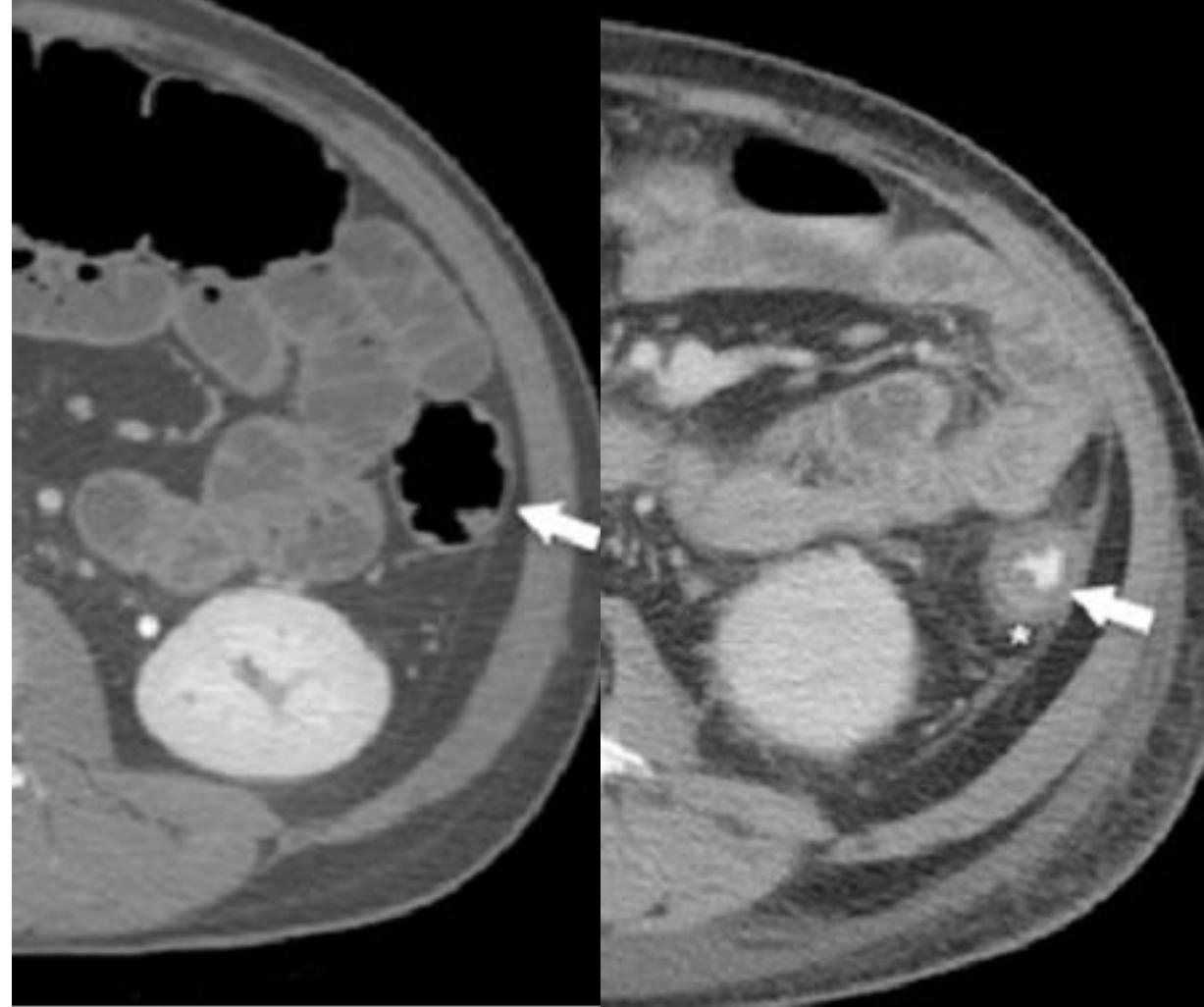
# *Ischemic colitis (IC)*

**Acute**

*Hypotonic wall*

*"Paper-thin wall"*

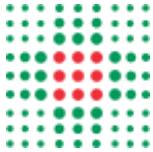
*Pericolic fluid*



BioMed Res INT 2014

**CT Findings in Acute, Subacute, and Chronic Ischemic Colitis: Suggestions for Diagnosis**  
F.Iacobellis, D.Berritto, D. Fleischmann, G.Gagliardi, A.Brillantino, M.A Mazzei, and R.Grassi





# Ischemic colitis (IC)

Sub-acute



Uneffective Reperfusion

Bowel wall remains  
hypodense,  
unthickened or  
thinned

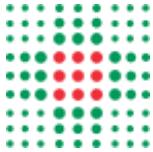
Fluid increases



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# Ischemic colitis (IC)

Sub-acute



Effective Reperfusion

Peritoneal fluid resorption

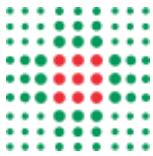
Wall thickening  
(target sign)



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# Ischemic colitis (IC)

**Chronic**

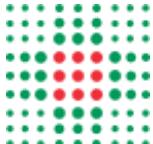
No pericolic fluid

Wall fibrotic thickening



BioMed Res INT 2014

**CT Findings in Acute, Subacute, and Chronic Ischemic Colitis: Suggestions for Diagnosis**  
F.Iacobellis, D.Berritto, D. Fleischmann, G.Gagliardi, A.Brillantino, M.A Mazzei, and R.Grassi



# *Future trends*

*Imaging findings often suggest advanced ischemia (second or third stage)*

*A 24-h delay on diagnosis decreases survival rates by 20%*

*Need of new tests for better and earlier detection of ischemia*



# Bowel enhancement ??

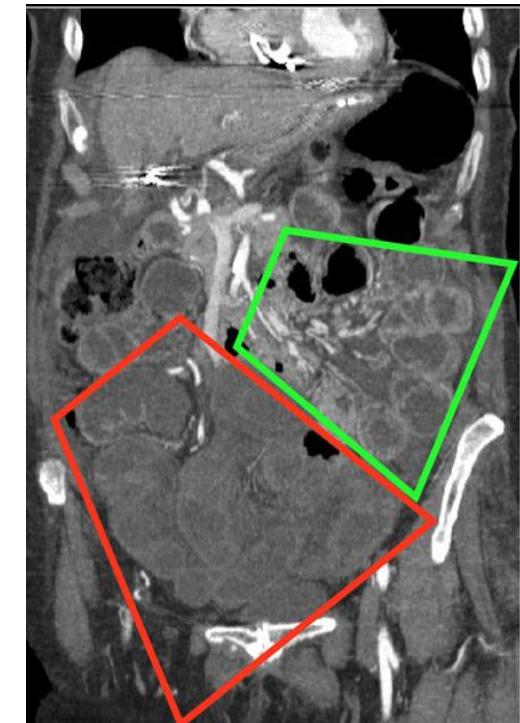
Comparison of Ischemic and Nonischemic Bowel Segments in Patients With Mesenteric Ischemia: Multidetector Row Computed Tomography Findings and Measurement of Bowel Wall Attenuation Changes

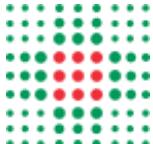
Ya-Cheng Chen, MD, Tien-Yu Huang, MD, PhD, Ran-Chou Chen, MD, Shih-Hung Tsai, MD, PhD, Wei-Chou Chang, MD  Hsiu-Lung Fan, MD, Guo-Shu Huang, MD, Kai-Hsiung Ko, MD, Yu-Ching Chou, PhD, Hsian-He Hsu, MD

Mayo Clin Proc. Jan 2016

**Quantitative MDCT measurements of bowel wall attenuation  
(Enhancing Ratio)**

**Low Enhancing Ratio value predicts the presence of an ischemic bowel segment.**





# Dual-energy CT

## Radiology

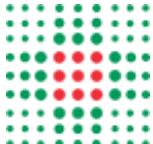
April 2015  
Volume 275, Issue 1

### Early Small-Bowel Ischemia: Dual-Energy CT Improves Conspicuity Compared with Conventional CT in a Swine Model

Theodora A. Potretzke, MD Christopher L. Brace, PhD Meghan G. Lubner, MD Lisa A. Sampson, BS Bridgett J. Willey, MS Fred T. Lee, Jr, MD

*Dual-energy CT significantly improved the conspicuity of the ischemic bowel compared with conventional CT*





# ....and MRI ??



**JMRI**  
Journal of Magnetic Resonance Imaging

ISMRM ONE  
COMMUNITY FOR CLINICIANS AND SCIENTISTS

*Explore this journal >*

Original Research

## Gadolinium-enhanced MR angiography of visceral arteries in patients with suspected chronic mesenteric ischemia

James F. M. Meaney , Martin R. Prince , Timothy T. Nostrant,  
James C. Stanley

*Overall sensitivity and specificity were 100% and 95%*

*Risk of overgrading*

*MRA is useful in evaluation of pts with suspected mesenteric ischemia.*



# ....and MRI ??

Abdominal Imaging

October 2015, Volume 40, Issue 8, pp 3020-3028

First online: 24 June 2015

## Limited utility of MRA for acute bowel ischemia after portal venous phase CT

Anup S. Shetty  , Vincent M. Mellnick, Constantine Raptis, Ronald Loch, Joseph Owen, Sanjeev Bhalla



*High concordance CT/MRA for vascular evaluation.*

*Reviewed CT scans were sufficient to assess patency of the mesenteric vasculature, but vascular findings were not reported in most cases.*

*A direct description within the report may have obviated the request for further MR imaging.*

*MRA adds little value after portal venous CT in assessing bowel ischemia.*



# ....and MRI ??

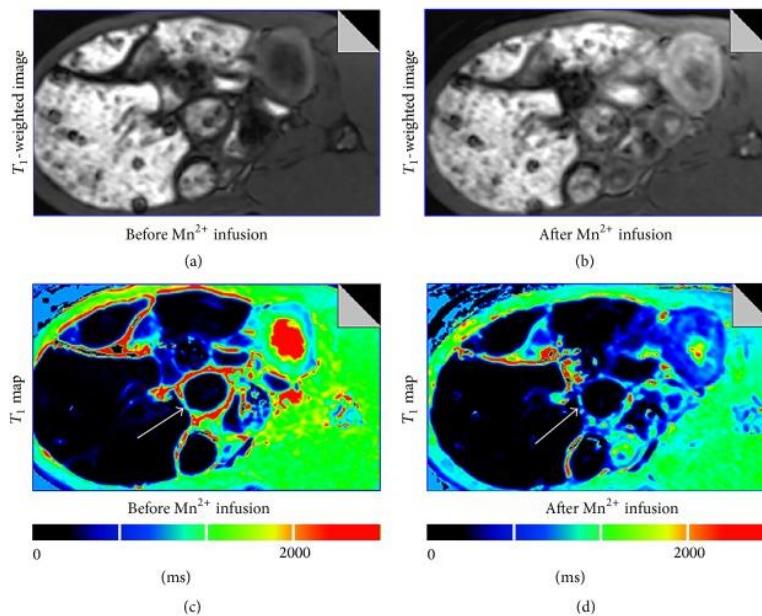
Biomed Res Int. 2015; 2015: 579639.

Published online 2015 Nov 26. doi: [10.1155/2015/579639](https://doi.org/10.1155/2015/579639)

PMCID:

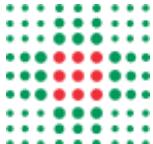
## A New Approach Using Manganese-Enhanced MRI to Diagnose Acute Mesenteric Ischemia in a Rabbit Model: Initial Experience

Da-wei Zhao, Cheng Cheng, Lian-qin Kuang, Yu-long Zhang, Hai-yun Cheng, Jia-yan Min, and Yi Wang \*



*MEMRI: able to distinguish between normal and ischemic small bowel for AMI.*

*MEMRI at a low dose of  $Mn^{2+}$  reveals differences of relaxivity between normal and ischemic small intestines after occlusion of SMA.*



# ....and DWI ??

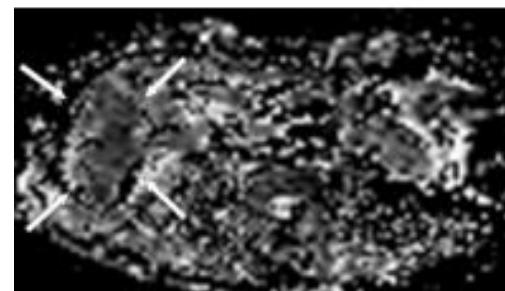
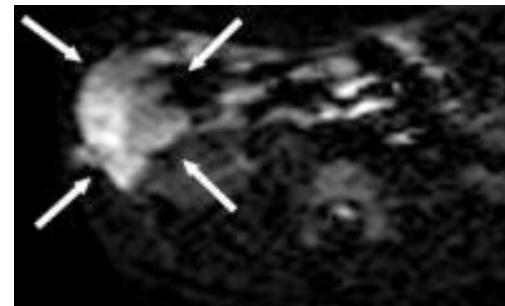
Early Detection of Acute Mesenteric Ischemia  
Using Diffusion-Weighted 3.0-T Magnetic  
Resonance Imaging in a Porcine Model

Bruhn et al. Invest. Radiol. 2013

Experimental Early Detection of Acute  
Mesenteric Ischemia with Functional MRI  
(DWI) and Parallel Imaging

Schwartz et al Rofo 2012

**DWI should detect earlier  
detection (after 30 min.) of  
acute mesenteric ischemia**



# ....biomarkers ??

**BJS**

Original article

**Diagnostic performance of plasma biomarkers in patients with acute intestinal ischaemia**

S. Matsumoto<sup>1,\*</sup>, K. Sekine<sup>2</sup>, H. Funaoka<sup>3</sup>, M. Yamazaki<sup>1</sup>, M. Shimizu<sup>1</sup>, K. Hayashida<sup>1</sup> and M. Kitano<sup>1</sup>

Article first published online: 8 JAN 2014  
DOI: 10.1002/bjs.9331  
© 2014 BJS Society Ltd. Published by John Wiley & Sons Ltd

Issue

**British Journal of Surgery**  
**Volume 101, Issue 3, pages 232–238, February 2014**



Intensive Care Medicine

July 2015, Volume 41, Issue 7, pp 1376-1377

First online: 18 June 2015

## New biomarkers for outcomes of acute mesenteric ischemia

C. Cossé, E. Zogheib, H. Dupont, J.-M. Regimbeau 

10.1007/s00134-015-3852-8

Acute Mesenteric Ischemia Biomarkers  
like fatty acid binding protein (I-FABP) or procalcitonin (PCT)  
shows promise for detecting vascular ischaemia





**Grazie per l'attenzione**