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FULL PAPER

Non-occlusive mesenteric ischaemia: CT findings, clinical outcomes and assessment of the diameter of the superior mesenteric artery

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Objective: Review of the experience of a tertiary care centre for almost 10 years in the CT diagnosis of non-occlusive mesenteric ischaemia (NOMI). Analysis of CT findings, correlation with clinical outcomes and evaluation of the usefulness of measuring the superior mesenteric artery (SMA) diameter for the diagnosis of NOMI.

Methods: 106 patients were diagnosed with NOMI in a biphasic CT examination from 2008 to 2017 in our hospital. Clinical outcomes and CT findings were reviewed. In 55 patients, the diameter of the SMA was compared with a previous CT scan where NOMI was not the diagnosis, and statistical analysis using paired *t*-test was performed.

Results: 81 patients (76%) had findings consistent with small bowel ischaemia and the ileum was the segment most commonly involved (47%). Lack of wall enhancement, pneumoperitoneum, pneumatosis intestinalis and portal venous gas were all considered signs of bowel necrosis and surgery was performed promptly. 70 patients had signs of vascular narrowing of the SMA branches and in the 55 cases with a previous CT scan, there were statistically significant differences regarding the SMA diameter with a mean reduction of the artery calibre and standard deviation of 1.93 ± 1.1 mm between the NOMI and non-NOMI scans ($p < 0.001$).

Conclusion: Acknowledgment of characteristic bowel necrosis CT findings is crucial for determining the therapeutic attitude and the use of previous CT scans to compare the SMA diameter may help the radiologist to achieve an early diagnosis of NOMI in an often critically ill patient population.

Advances in knowledge: Diagnosis of NOMI can be difficult in cases of partial mural ischaemia, thus objective data (diameter of the SMA) should be useful for the radiologist to include NOMI as the first diagnostic option in the differential diagnosis.

INTRODUCTION

With the increase in average life expectancy over the past years, mesenteric ischaemia has become a well-recognized clinical entity among the elderly and one of the most threatening abdominal conditions in these patients.[1,2] Acute mesenteric ischaemia may be segmental or diffuse, and in a histological point of view, partial or transmural wall involvement may be encountered, whether it involves only the internal layers (mucosa and submucosa), or there is necrosis of all the wall layers, respectively.[3]

Non-occlusive mesenteric ischaemia (NOMI) was first reported by Ende.[4] NOMI is a subtype of mesenteric ischaemia where occlusion of the mesenteric vessels is not demonstrated. It compromises 20–30% of all cases of acute mesenteric ischaemia.[5]

The pathogenesis of NOMI is a splanchnic hypoperfusion commonly caused by a decreased cardiac output. Patients are mostly older than 50 years, with history of ischaemic heart disease, congestive heart failure, renal and peripheral artery disease and patients following cardiac/vascular surgery.[5,6] After a decrease of approximately 50% of the blood flow through the superior mesenteric artery (SMA), the splanchnic circulation promptly responds with a compensatory vasodilation. After several hours with low flow through the SMA, this compensation ceases to be effective and begins a mesenteric vasoconstriction with a progressive increase of the artery resistance. In the event

that this 50% decrease in flow is corrected rapidly, vasoconstriction is reversible. However, if the splanchnic vasoconstriction lasts more than 30 min, it becomes irreversible, even if 100% of the blood flow through the SMA is re-established.[7]

NOMI is a disease characterized by high morbidity and low survival rates.[8] Reasons for this high mortality rate are advanced age and the difficulty of early diagnosis. Patients complain of severe non-remitting abdominal pain out of proportion compared to the physical examination findings. In the initial stage, laboratory investigations may demonstrate lactic acidosis and mild leukocytosis.[9–11] As there is a progression of the disease to bowel necrosis, inflammation laboratory markers increase and the physical examination reveals a distended rigid abdomen with rebound tenderness.[12] However, in patients who are admitted to the intensive care unit, severely ill patients with low level of consciousness, ventilated, sedated, or in severe acute clinical situations, clinical signs and symptoms are very difficult to assess.

The intestine tolerance to ischaemia becomes critical after 3–6 h, therefore, early diagnosis for immediate therapy is essential to reach a successful outcome.[13,14] Contrast-enhanced multidetector CT (MDCT) is quick and easily accessible and allows the evaluation of the arterial and venous mesenteric vessels and the presence of intestinal necrosis. The purpose of our study is to review the medical records and CT scans of over a hundred patients with final diagnosis of NOMI, define the spectrum of CT findings and evaluate the effect of CT imaging on the patient management and their clinical outcomes. To our knowledge, it is the first time that the diameter of SMA is measured during ischaemia and compared to the diameter in a previous CT of the same patient. We believe that this information is very useful since many patients have previous CT scans and the use of objective data could help us in the early diagnosis of NOMI.

METHODS AND MATERIALS

Patients

This is a retrospective study, performed on a single tertiary care centre, of all the adult patients who underwent CT examination to exclude acute mesenteric ischaemia from January 2008 (when the RIS-PACS system was installed in our centre) to March 2017. The population of the catchment area of our hospital consists in approximately 320,000 people. Patients underwent imaging with a biphasic ischaemic bowel MDCT protocol. We used the search engine of our report system Medavis RIS (Karlsruhe, Germany) typing the words "mesenteric ischaemia", "intestinal ischaemia" and "ischaemic colitis". In all cases, anonymous search was performed and each patient was coded with a number so that no name or medical history number was included and the confidentiality of patient data was maintained. The institutional review board of our hospital approved this study.

Eventually, we had 563 patients and afterwards we reviewed the operative notes, endoscopic and pathological findings and the original CT reports. In first instance, 283 were excluded because CT was not performed or in spite having a confirmed surgical diagnosis, CT was not performed at least 24 h within the surgical date or 10 days within the colonoscopy date. From the remaining 280 patients, 174 were excluded for various reasons: cases where occlusion of the SMA was noted or bowel obstruction was the primary cause of bowel ischaemia; the CT examination did not have either an angiographic phase or a portal venous phase both of which, we believe, are indispensable for a correct mesenteric ischaemia diagnosis; or surgical, endoscopic and histological findings were not consistent with NOMI. Eventually, 106 patients with confirmed NOMI were diagnosed by either endoscopic or operative findings. In 55 cases, the patients had a CT performed where NOMI was diagnosed and at least a previous abdominal CT, performed for another reason, non-consistent with NOMI and in the absence of a clinical context of low cardiac output. Table 1 summarizes the inclusion and exclusion criteria of this study.

Table 1. Summary of inclusion and exclusion criteria of our study

Inclusion criteria	Exclusion criteria
Age > 18 years	SMA occlusion at angiographic CT phase
Treated in our hospital from January 2008 to March 2017	SMV occlusion at portal venous CT phase
Operative or histological diagnosis of mesenteric ischaemia/ischaemic colitis	Bowel obstruction at CT
Biphasic abdominal CT[a]	Surgery performed after at least 24 h since the CT
	Colonoscopy performed after at least 10 days since the CT

SMA, superior mesenteric artery; SMV, superior mesenteric vein.
[a]CT with both angiographic and portal venous phases.

The mean age of the final 106 patients included in our study was 77.5 years, with 56 females and 50 males. The patient age ranged from 50 to 100 years.

CT protocol

During the study period, all patients underwent MDCT scanning on a 16- or a 64-channel CT (Brilliance CT, Philips Healthcare, Cleveland, OH). They received 1.5 ml kg^{-1} (maximum of 120 ml) of non-ionic intravenous contrast agent (containing 300 mg I ml^{-1} iopamiron; Bracco Diagnostics) followed by 10 ml of saline solution administered by power injection through an indwelling intravenous cannula, at a rate of 4 ml s^{-1}. No oral/rectal contrast material was administered to any of the patients.

The CT parameters in the NOMI scans were as follows: 150–350 mA, 100–120 kVp, 0.8 s rotation, slice thickness of 2 mm and pitch of 0.981:1. Our institution standard biphasic bowel ischaemia protocol consists of initially an angiographic phase acquisition of the abdomen and pelvis from the lower third of the thorax to the ischial tuberosities level with a region of interest placed in the abdominal descending aorta (above the coeliac trunk) with a 10-s delay when the Hounsfield units reaches the threshold of 150. After this, a conventional 2-mm-slice portal phase acquisition is obtained 70 s after the beginning of contrast injection.

All 106 proved NOMI CT were performed in an emergency basis whether the patient was hospitalized or in the Emergency Room and the clinical/laboratory indications for a bowel ischaemia CT protocol consisted in diffuse abdominal pain without response to analgesia or after recent cardiorespiratory arrest/haemodialysis session/vascular or cardiac surgery, signs of hypoperfusion and elevation of serum lactic acid, without evidence of another diagnosis that justified these findings.

The CT protocol of the non-NOMI scans was variable since it was performed for various reasons, essentially tumour extension study, to assess response to oncologic/surgical treatments or evaluation of abdominal aorta. CT protocols consisted in an angiographic phase and/or arterial abdominal phase and/or portal venous phase. Nevertheless, the CT parameters of these 55 scans and the amount of intravenous contrast agent received by these patients were the same as the stated for the NOMI scans.

CT findings analysis

Images were reviewed retrospectively by a radiologist with more than 20 years of experience in abdominal imaging on a PACS digital workstation using Philips IntelliSpace Software (Philips Medical Systems, Foster City, San Francisco, CA). This experienced radiologist reviewing the NOMI and non-NOMI CT scans was blinded for the clinical outcomes of the patients.

CT portal venous phase was evaluated for evidence of bowel wall thickening (wall thickness > 3 mm), mucosal hyperenhancement (focal, segmental or diffuse mucosal enhancement out of proportion compared to the rest of the bowel), bowel dilatation (diameter of small bowel > 3 cm or diameter of the colon > 8 cm), diminished or lack of bowel wall enhancement, solid organ infarction (wedge-shape areas of lack of parenchymal enhancement of the liver, spleen and kidney), ascites, pneumoperitoneum, pneumatosis intestinalis and portal venous gas.

The angiographic CT phase ruled out occlusion of the coeliac trunk and the SMA. In addition, multiplanar reconstruction and maximum intensity projection images were obtained to demonstrate irregularities at the origins of the major SMA branches and impaired filling of intramural vessels. The experienced radiologist also measured the maximum diameter of the SMA, immediately inferior to the first branch in both the NOMI and the non-NOMI CT scans to assess whether there have been differences in diameter (Figure 1). The diameter was measured using the advanced vessel analysis application (Intellispace Portal v8.0, Phillips) to minimize operator bias since a single radiologist was performing the measurement and it was performed at the same exact point, repeated twice (in different sessions of image analysis) and averaged.

Clinical outcome

Patients were divided in three groups depending on their clinical outcome: patients who were treated surgically and resection was performed, those who underwent abdominal surgery but no resection was performed due to very extensive ischaemia and finally patients who were treated conservatively.

Statistical analysis

In each of the 55 patients with a previous CT scan the SMA diameters of NOMI CT and the non-NOMI CT were statistically compared by using Student's *t*-test for paired data. Differences with $p < 0.05$ were considered significant. We performed all statistical analysis with SPSS v20 (SPSS Inc, Chicago, IL).

RESULTS

CT findings

All patients ($N = 106$) had CT evidence of mesenteric ischaemia. In our study, 81 (76%) patients had findings consistent of small bowel ischaemia, the jejunum was affected in 31 (29%) cases and the ileum in 50 (47%). The most frequent area of large bowel ischaemia was the left colon, accounting for 57 cases (54%), whereas the right colon was affected in 39 (37%). The stomach had signs of mucosal ischaemia in five patients. We found pneumatosis intestinalis in 41 cases and portal venous gas was reported in 23. Bowel perforation was detected in our study in 10 patients. In addition, 17 patients had areas of liver infarction, in 24 cases spleen infarctions, bilateral renal infarctions in 13 patients and one strange case of histologically confirmed emphysematous cholecystitis.

74 patients (70%) had signs of vascular narrowing of the SMA branches, better assessed in MIP images (Figure 2). In the 55 patients with a previous CT scan, the mean and standard deviation (SD) of the SMA diameter in the NOMI CT was 5.39 ±1.21 mm, whereas in the non-NOMI CT was 7.32 ± 1.21 mm. The mean and SD of the difference between the SMA diameter in the NOMI CT and the non-NOMI CT in each case was 1.93 mm ±1.1 mm. This difference was statistically significant, $p < 0.001$. In all 55 cases the SMA diameter was smaller in the NOMI scan, with a minimum difference of 0.2 mm, whereas the maximum difference was 2.8 mm (Table 2).

Clinical outcome

80 patients (75%) had major abdominal surgery within the first 24 h after CT examination, 43 females and 37 males, with an average age of 76.4 years. The mean time between the CT and surgery was 4.5 h. 47 patients had bowel resection at surgery, whereas in 33 cases, although surgeons found signs of mesenteric ischaemia, no resection was performed. Reasons for this "exploratory laparotomy" were that six patients died in the surgical table and the other 27 had too extensive ischaemia, affecting more than two thirds of the whole bowel. All 33 patients who did not undergo intestinal resection had findings consistent with mesenteric ischaemia at the surgical act. Patients with bowel resection had histologically confirmed mesenteric ischaemia.

The 26 patients remaining were treated conservatively. Only three of these patients had small bowel signs of ischaemia on CT (bowel wall thickening, mucosal hyperenhancement and bowel dilatation), none of them had lack of wall enhancement, pneumoperitoneum, pneumatosis intestinalis or portal venous gas. All of these conservatively treated patients underwent a colonoscopy and the suspected diagnosis of ischaemic colitis was confirmed histologically.

Figure 1. A 71-year-old female with ischaemic colitis at the sigmoid–rectal junction. (a) Contrast-enhanced MDCT image at angiographic phase shows the maximum and minimum diameters of the SMA (automated measuring using AVA application) immediately distal to the origin of its first branch, in a transverse plane of the vessel. (b) Contrast-enhanced MDCT image at angiographic phase of the same patient but in a previous CT performed to assess a liver focal lesion. Note that the maximum diameter of the SMA is greater than in (a), with a difference of 1.37 mm. AVA, advanced vessel analysis; MDCT, multidetector CT; SMA, superior mesenteric artery.

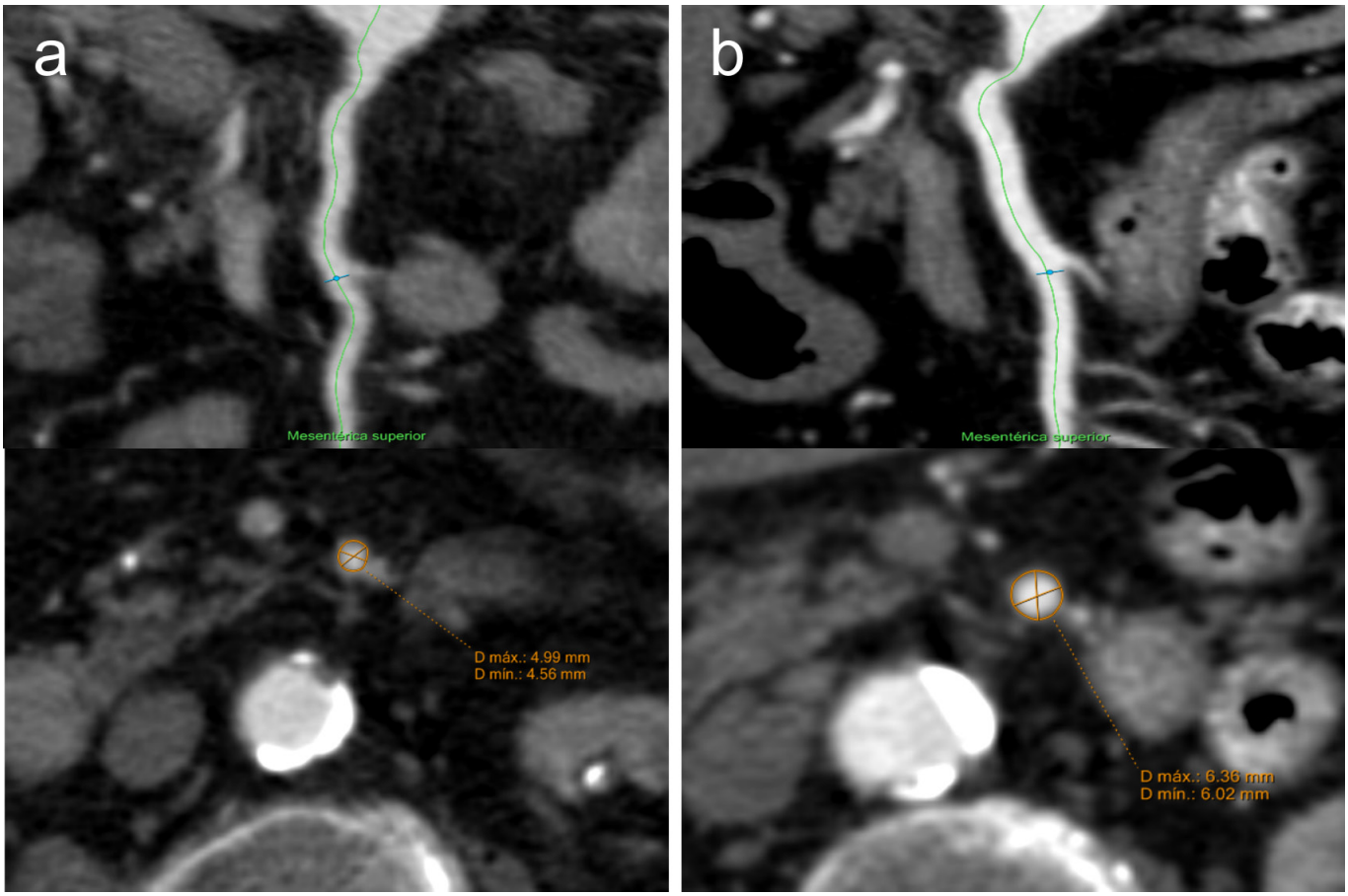


Table 3 summarizes the correlation between the portal venous phase CT findings and the clinical outcomes of the patients included in this study.

DISCUSSION

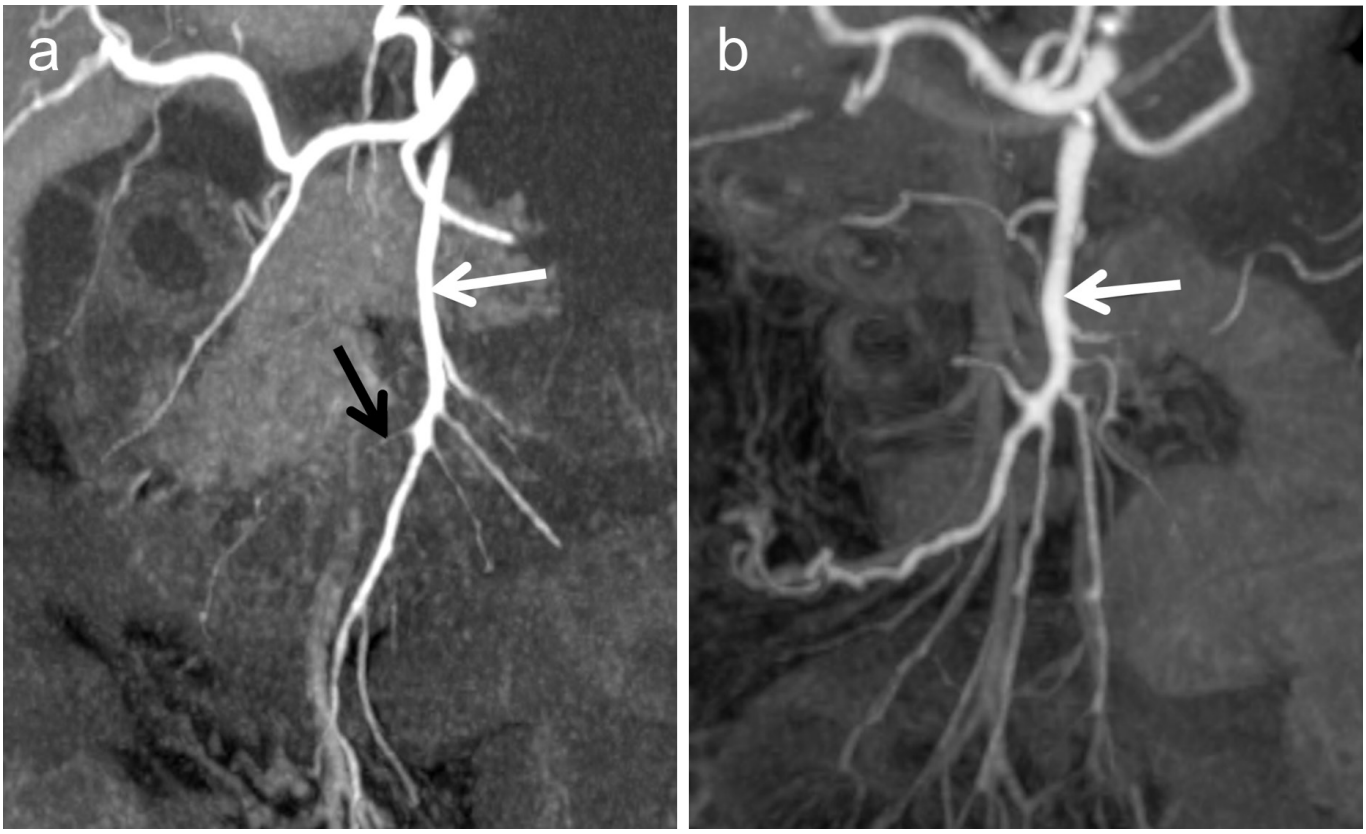
Imaging findings

Small bowel ischaemia usually presents as lack of wall enhancement, dilation and in more advanced cases, pneumatosis intestinalis and portal venous gas (Figure 3).[15] According to the literature, wall thickening is the most common CT finding in acute mesenteric ischaemia.[16] We also identified wall thickening as the most common CT finding, accounting for 82 cases. Absence or diminished contrast enhancement is a very specific but not sensitive finding in bowel ischaemia.[17] Pneumatosis intestinalis refers to gas within the wall of the bowel and represents a mucosal injury secondary, in these cases, to mucosal necrosis and leads to leakage of gas within the bowel wall. Portal venous gas is the accumulation of gas in the portal vein and its branches, representing a progression of the pneumatosis intestinalis gas to the mesenteric veins and finally to the portal venous system.[18] In a study by Schieda et al,[19] pneumatosis intestinalis and portal venous gas had a specificity and positive predictive value of 100% in the diagnosis of mesenteric ischaemia. Nevertheless, these imaging findings can be found in various diseases, ranging from benign to life threatening.[20]

On the other hand, large bowel non-occlusive ischaemia normally appears as ischaemic colitis. CT findings include mural thickening, pericolic fat stranding, and mucosal hyperenhancement.[21] There are two high-risk "watershed" areas for ischaemic colitis; the Sudeck critical point at the sigmoid–rectal junction,[22] representing the distal portion of the inferior mesenteric artery irrigation area, and the splenic flexure Griffiths' point,[23] at the "border territory" between SMA and inferior mesenteric artery blood supplies (Figure 4).

Solid organ infarction (Figure 5) is another CT finding that help us include NOMI as the first diagnostic option in a differential diagnosis of acute abdominal pain, due to its high specificity in the diagnosis of mesenteric ischaemia.[20] The spleen was the most frequent solid organ involved as we identified it 24 patients (23%), followed closely by the liver (17), kidneys (13) and we encountered a rare case of ischaemic cholecystitis.

Figure 2. An 83-year-old female with distal ileum non-occlusive mesenteric ischaemia. (a) MIP coronal contrast-enhanced MDCT image at angiographic phase shows the SMA (white arrow), narrowing of the major SMA branches (black arrow) and impaired filling of intramural vessels. (b) MIP coronal contrast-enhanced MDCT image at angiographic phase of the same patient but in a previous CT performed to rule out hepatocellular carcinoma. The SMA (white arrow) and its branches have a normal morphology, with no irregularities and distal intramural vessels are depicted. MDCT, multidetector CT; SMA, superior mesenteric artery; MIP, maximum intensity projection.



Siegelman et al[24] depicted the angiographic criteria for the diagnosis of NOMI, which included narrowing at the origins of the major mesenteric branches with the involvement of segments of the SMA; irregularities at the origins of the SMA branches; spasm of the arcades of mesenteric artery; and impaired filling of intramural vessels. Despite formerly being considered the gold standard for the imaging diagnosis of acute mesenteric ischaemia, nowadays, digital subtraction angiography is an invasive diagnostic imaging tool that takes time to perform. CT has demonstrated to be the best imaging test for an early detection and localization of acute mesenteric ischaemic changes.[25,26] Woodhams et al[27] analysed the morphology and diameter of the SMA in order to assess whether CT was as useful as angiography for the diagnosis of NOMI. They compared the SMA diameter of 4 patients with 13 control cases, with statistically significant differences. In our study, 70 patients had signs of SMA vasospasm (irregularities at the origins of the major SMA branches and impaired filling

Table 2. Statistical analysis of measurements of the SMA diameter based on the angiographic CT phase findings

CT measurement	Number of patients	Mean	Median	Standard deviation	Min.	Max.	*p*
Diameter of SMA (NOMI CT) of all patients	106	5.52	5.5	1.26	3.0	9.1	NA
Diameter of SMA (NOMI CT) in patients with a previous CT	55	5.39	5.4	1.21	3.1	8.9	NA
Diameter of SMA (previous non-NOMI CT)	55	7.32	7.4	1.21	4.9	9.4	NA
Difference of SMA diameter between NOMI CT and previous non-NOMI CT	55	1.93	NA	1.1	0.2	2.8	<0.001[a]

NA, not applicable; NOMI, non-occlusive mesenteric ischaemia; SMA, superior mesenteric artery.
Note: All values are in millimetres.
[a]$p < 0.05$ was considered significant.

Table 3. Correlation between the portal venous phase CT findings and the patient's clinical outcomes

CT finding	Patients diagnosed with NOMI $n = 106$	Patients with bowel resection in surgery $n = 47$	Patients without bowel resection in surgery $n = 33$	Patients treated conservatively $n = 26$
Gastric ischaemia	5	2 (40)	3 (60)	0 (0)
Jejunum ischaemia	31	16 (52)	15 (48)	0 (0)
Ileum ischaemia	50	27 (54)	20 (40)	3 (6)
Right colon ischaemia	39	14 (36)	18 (46)	7 (18)
Left colon ischaemia	57	16 (28)	17 (30)	24 (42)
Wall thickening	82	30 (37)	27 (33)	25 (30)
Mucosal hyperenhancement	25	3 (12)	10 (40)	12 (48)
Lack of wall enhancement	56	33 (59)	23 (41)	0 (0)
Bowel dilatation	54	33 (61)	20 (37)	1 (2)
Ascites	29	12 (41)	17 (59)	0 (0)
Pneumoperitoneum	10	6 (60)	4 (40)	0 (0)
Pneumatosis intestinalis	41	31 (76)	10 (24)	0 (0)
Portal venous gas	23	14 (61)	9 (39)	0 (0)
Solid organ infarction	17 liver, 24 spleen, 13 kidneys, 1 gallbladder	5 liver, 13 spleen, 4 kidneys, 1 gallbladder	11 liver, 11 spleen, 7 kidneys	1 liver, 2 kidneys

Note: Numbers in parentheses are the percentage of patients with the CT finding in each of the clinical outcomes groups of the total number of patients where the CT finding is described.

of intramural vessels) and we also found statistically significant differences between the SMA diameter in the NOMI CT and previous CT of the same patient. We believe that it is more accurate to compare the diameter of the SMA in the same patient, since we measured the diameter at exactly the same point of the artery (using an automated measuring system), especially considering the anatomic variability of the SMA and its branches. In cases in which no clear signs of intestinal necrosis are identified, the findings are very non-specific and vary between wall thickening and bowel dilatation. In these cases, and more commonly in cases of ischaemic colitis, the measurement of the superior mesenteric artery (a mean reduction of 1.93 mm of the diameter) and the visualization of signs of vasospasm would help us to include NOMI as the first diagnostic option in the differential diagnosis.

Clinical outcome

Unlike acute occlusive mesenteric ischaemia, in the initial stages of NOMI when bowel wall ischaemia is partial, surgical treatment is not indicated.[28] The patient is promptly referred to surgery if CT is consistent with intestinal wall necrosis, elevation of intestinal wall necrosis serum markers (persistent or worsening metabolic acidosis) or despite intensive medical support there is no clinical improvement over a 12 to 24 h period. In these cases, the sooner the surgery is performed, the better the long-term results.[29] 80 patients underwent urgent surgery which confirmed the suspected diagnosis of bowel ischaemia. In 47 cases the surgeons performed bowel resection of the intestine segments with signs of transmural ischaemia and in these cases, mesenteric ischaemia was confirmed histologically. On the other hand, in 33 (31%) patients although surgery was performed, they were rejected for bowel resection mainly because of very extensive ischaemia, and all died within a week. This fact reflects the high morbidity and mortality of NOMI if no early treatment is established. Lack of bowel wall enhancement, pneumatosis intestinalis, portal venous gas and pneumoperitoneum are CT findings closely related to intestinal necrosis (Figure 6). In our study these findings were observed in 56 (53%), 41 (39%), 23 (22%) and 10 (9%) cases respectively, with a total of 65 patients with bowel necrosis CT findings and all of them underwent urgent abdominal surgery which confirmed the transmural ischaemia.

In our study, all patients treated conservatively ($n = 26$) were diagnosed of ischaemic colitis histologically after the accomplishment of a colonoscopy. 92% of these cases had ischaemic findings in the left colon and none of them had CT findings suggestive of transmural ischaemia. In addition, these patients had high survival rates. The results of this study bear out that ischaemic colitis is commonly non-occlusive and often self-limited.

Our study has limitations. Firstly, since part of the patient selection was performed according to the radiological report and therefore according to the imaging findings, there could be a selection bias as there may be cases where ischaemia was

Figure 3. Typical CT findings of small bowel ischaemia. (a) An 88-year-old female with ileum and jejunum ischaemia. Sagittal MPR contrast-enhanced MDCT image at portal venous phase demonstrates lack of wall enhancement, dilatation, mural thinning and pneumatosis intestinalis in a large segment of small bowel (white arrow). Notice the gas within the mesenteric veins and portal venous gas (black arrow). No surgery was performed and the patient died within 24 h since the symptoms onset. (b) An 82-year-old female with ileum and caecum ischaemia. Axial contrast-enhanced MDCT image at portal venous phase shows lack of wall enhancement, pneumatosis intestinalis and mural thickening (unlike image a) of a segment of ileum (white arrow). Bowel resection was performed at surgery and histological findings were consistent with mesenteric ischaemia. MDCT, multidetector CT; MPR, multiplanar reconstruction.

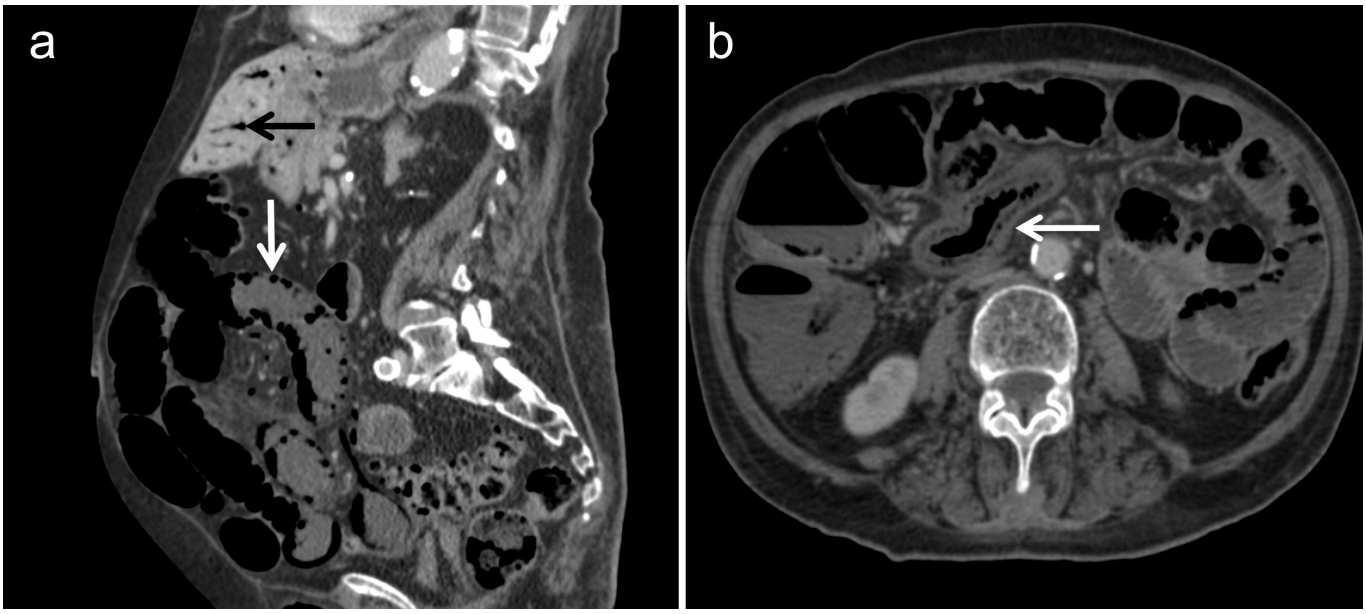


Figure 4. Ischaemic colitis in watershed areas. (a) A 74-year-old female with splenic flexure ischaemic colitis. Axial contrast-enhanced MDCT image at portal venous phase shows wall thickening, fat stranding and mucosal hyperenhancement (white arrow) of the left colon splenic flexure. Colonoscopy was performed 8 days after CT and histological findings were consistent with ischaemic colitis. (b) An 84-year-old male with sigmoid–rectal ischaemic colitis. Axial contrast-enhanced MDCT image at portal venous phase depicts sigmoid–rectal junction wall thickening and fat stranding. Due to the instability of the patient, urgent surgery was performed with left hemicolectomy. Histology confirmed the diagnosis of ischaemic colitis. MDCT, multidetector CT.

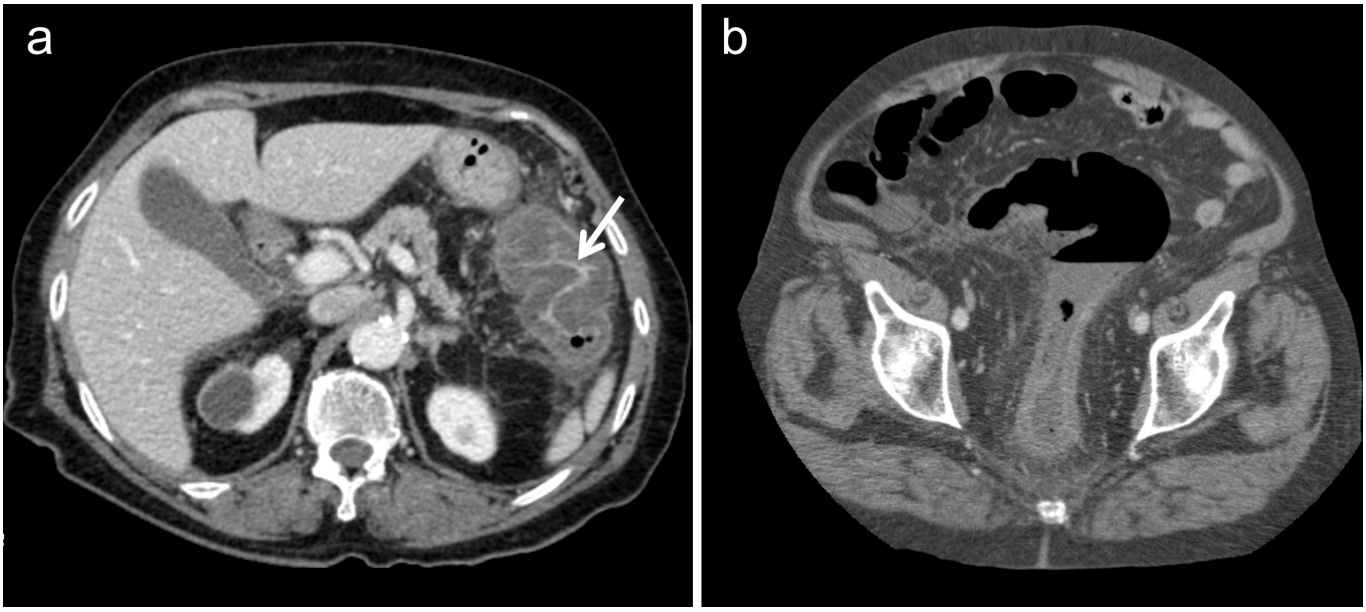
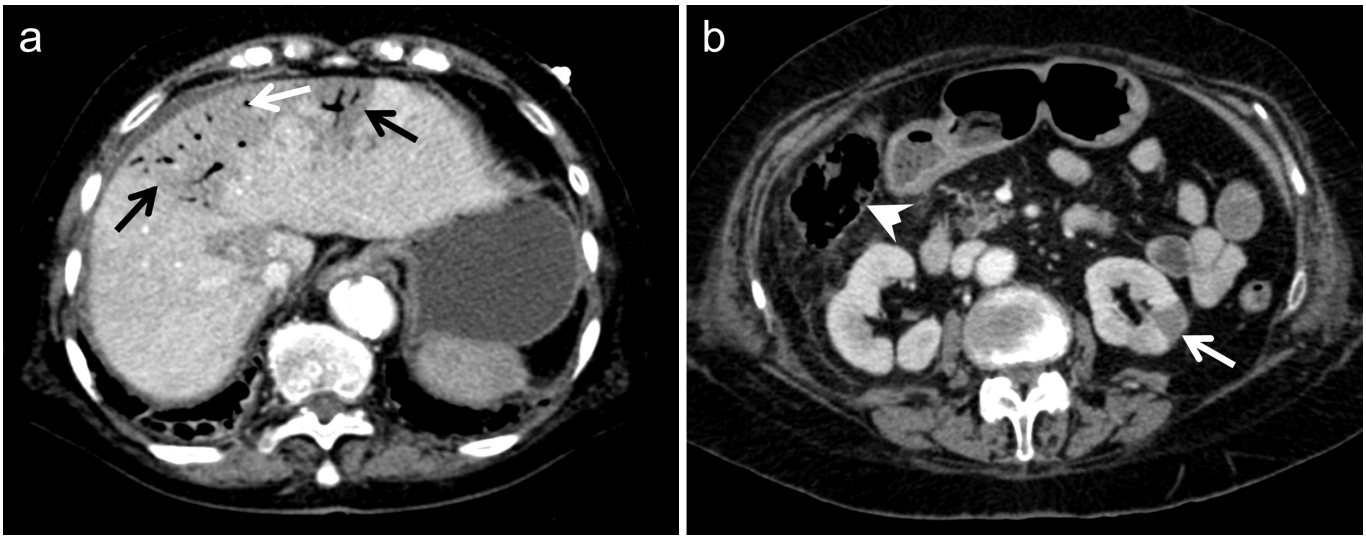
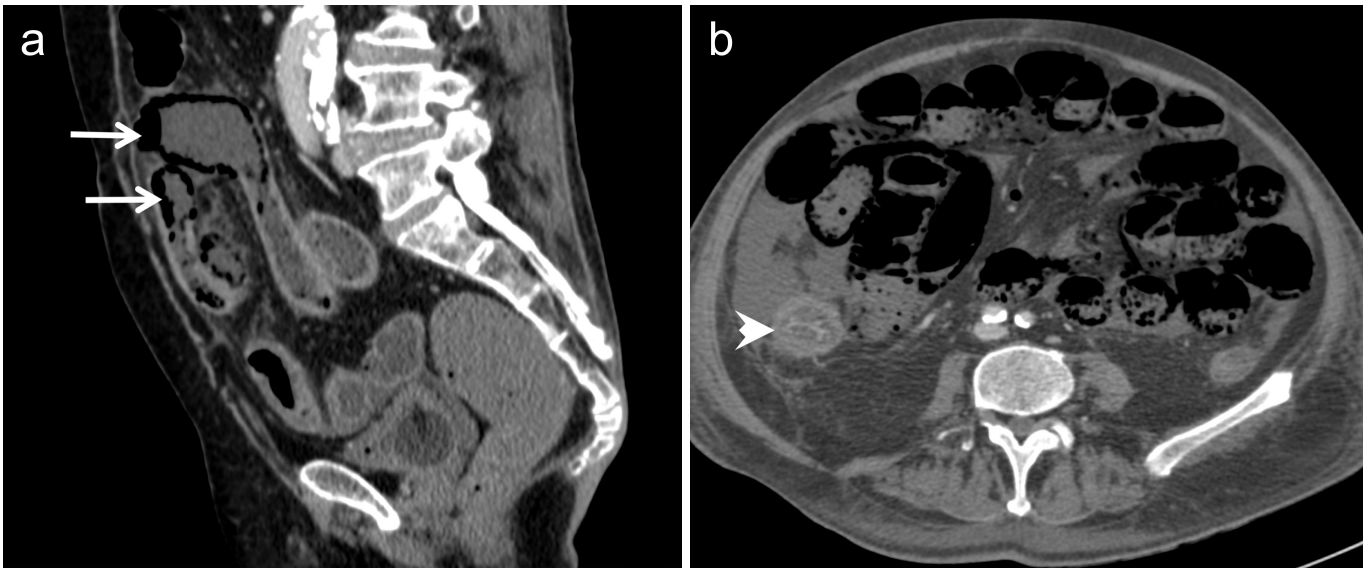


Figure 5. A 67-year-old female with right colon non-occlusive mesenteric ischaemia. (a) Axial contrast-enhanced MDCT image at portal venous phase shows a large hypodense wedge-shape area in liver segments VIII and IVA (black arrows) consistent with parenchymal infarction. Notice the portal venous gas (white arrow). (b) Axial contrast-enhanced MDCT image at angiographic phase depicts a wedge-shape area of lack of cortical enhancement in the left kidney consistent with renal infarction (white arrow). Notice the wall thinning, lack of mural enhancement and fat stranding in the right colon (white arrowhead). Surgery and histological findings confirmed the suspected diagnosis of right colon transmural ischaemia. MDCT, multidetector CT.



not suspected and the radiologist did not mention it in the differential diagnosis and eventually in surgery or in the colonoscopy was the final diagnosis, therefore without being able to include them in the present study. Furthermore, there may be an operator bias as the measurement of the SMA diameter was made by a single radiologist, nevertheless, we believe that by using an automated measuring system (*e.g.* advanced vessel analysis application) and performing the measurements twice would help to minimize this bias in the present study. In addition, only patients with a bowel ischaemia protocol CT were included in the study, which it may underestimate less severe cases of bowel ischaemia that may have been imaged with more routine CT protocols. Finally, not all patients have a previous CT to make the SMA measurement comparison which limits

Figure 6. A 69-year-old male with small and large bowel ischaemia. (a) Sagittal MPR contrast-enhanced MDCT image at portal venous phase shows patchy areas of absence of mural enhancement and pneumatosis intestinalis in the jejunum (white arrows). (b) Axial contrast-enhanced MDCT image at portal venous phase demonstrates findings consistent with an extensive mesenteric ischaemia affecting the jejunum and ileum. There is gas in the mesenteric veins, ascites and mural thickening of the right colon consistent with ischaemic colitis (white arrowhead). The patient underwent surgery, nevertheless due to the extent of the intestinal necrosis no bowel resection was performed. MDCT, multidetector CT; MPR, multiplanar reconstruction.



the clinical application of this finding, however, with the aging of the population and greater accessibility to imaging tests, it is increasingly common for patients to have one or multiple abdominal CT scans performed, more so in patients with cardiovascular risk factors with a higher probability of having a decrease in cardiac output and therefore with a greatest risk of suffering NOMI.

CONCLUSION

Recognition of transmural bowel necrosis is the most important NOMI CT finding in regard to the management of the patient by surgeons and gastroenterologists, whether is surgery or conservative treatment.

For a correct diagnosis of NOMI an angiographic phase is useful not only to discard arterial occlusion but it provides more information that guide the diagnosis to NOMI, such as signs of vasospasm of the SMA branches and objective data regarding the reduction of the calibre of the SMA when compared with a previous CT scan.

INFORMED CONSENT

This is a retrospective study and each patient was coded with a number so that no name nor medical history number were included and the confidentiality of patient data was maintained. Therefore, informed consent was waived and the institutional review board of our tertiary care centre approved this study.

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