

# Acute mesenteric ischaemia: facts and perspectives

**Acute mesenteric ischaemia is a catastrophic abdominal emergency with an extremely high mortality rate. This article discusses the aetiology, diagnosis and treatment of acute mesenteric ischaemia with emphasis on avoidance of common errors that contribute to the poor outcome inherent to this condition.**

**M**esenteric ischaemia occurs when the intestinal blood supply cannot meet the demand. It is divided into three main types: acute mesenteric ischaemia, chronic mesenteric ischaemia (intestinal angina) and colonic ischaemia (ischaemic colitis). Acute mesenteric ischaemia is a catastrophic abdominal emergency characterized by sudden critical interruption to the intestinal blood flow which commonly leads to bowel

infarction and death. This condition results from four main causes: acute arterial embolism, acute arterial thrombosis, non-occlusive mesenteric ischaemia and mesenteric venous thrombosis (Herbert and Steele, 2007) (*Table 1*).

Delays in diagnosis and treatment of acute mesenteric ischaemia, partly as a result of its relative infrequency and partly as a result of its non-specific clinical presentation, have contributed to an unacceptably high mortality rate estimated at 60–80% (Oldenburg et al, 2004). This high mortality has traditionally created an almost universally pessimistic view by surgeons for acute mesenteric ischaemia. The statement by AJ Cokkinis in 1926 regarding acute mesenteric ischaemia clearly illustrates this view: ‘occlusion of the mesenteric vessels is apt to be regarded as one of those conditions of which diagnosis is impossible, the prognosis hopeless and the treatment almost useless’ (Cokkinis, 1926).

Despite remarkable advances in medical and surgical aspects of patient care since Cokkinis’ time, the past 80 years have not witnessed an equally remarkable improvement of the grim prognosis associated with acute mesenteric ischaemia. This article reviews the aetiology, diagnosis and treatment of the four main causes of acute mesenteric ischaemia with emphasis on avoidance of diagnostic and therapeutic errors which may contribute to the poor outcome inherent to this condition.

## Aetiology

### Acute arterial mesenteric occlusion

The arterial blood supply to the gastrointestinal tract is provided by three main aortic branches: the coeliac, superior mesenteric and inferior mesenteric arteries. The superior mesenteric artery, the most commonly involved artery in acute arterial mesenteric ischaemia, can be occluded by an embolus or a thrombus (*Figure 1*).

### Embolism

Mesenteric arterial embolism is the most common cause of acute mesenteric ischaemia. The majority of mesenteric emboli originate from the heart, most commonly the left atrium in patients with atrial fibrillation (Bradbury et al, 1995; Stanley, 2002). However, other sources of embolization have been described (Williams, 1971; Sachs et al, 1982; Wilson et al, 1987; Shanley and Weinberger, 2008) (*Table 1*). The superior mesenteric

**Table 1. Causes, aetiology and incidence of acute mesenteric ischaemia**

Cause	Aetiology	Incidence (%)	
Embolism	Cardiac	Atrial fibrillation	Commonest (40–50%)
		Mural thrombus following myocardial infarction	
		Left atrial myxoma	
		Prosthetic heart valves	
	Proximal aortic disease, e.g. aneurysm, atheromas		
	Iatrogenic, e.g. arteriography		
Thrombosis	Mesenteric atherosclerosis	25–30%	
Non-occlusive mesenteric ischaemia	Low-flow states, e.g. shock	15–20%	
	Drugs, e.g. digitalis, vasopressors		
Mesenteric vein thrombosis	Inherited hypercoagulable states	Factor V Leiden mutation	Least common (5–10%)
		Protein C, S, antithrombin III deficiency	
	Acquired hypercoagulable states		
	Malignancy		
	Oral contraceptives		
	Portal hypertension		
	Intraabdominal sepsis, e.g. acute pancreatitis		
	Postoperative states, e.g. abdominal surgery		

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artery is the commonest mesenteric artery affected by emboli because of its acute angle of origin from the abdominal aorta. A superior mesenteric artery embolus characteristically lodges as the artery tapers distal to the origin of the middle colic artery; this usually allows perfusion of the transverse colon in addition to the proximal jejunum because the first few jejunal side branches are spared (Bergan, 1967; Herbert and Steele, 2007).

The intraoperative finding of a healthy proximal jejunum is an important factor differentiating between mesenteric arterial embolism and thrombosis, particularly if preoperative diagnostic studies have not been done (Figure 2). Nonetheless, emboli occluding the ostium or disintegrating and blocking distal superior mesenteric branches have also been described (Batellier and Kieny, 1990) (Figure 1). These distal emboli can cause segmental small bowel ischaemia and infarction.

**Thrombosis**

Atherosclerotic narrowing of the visceral arteries most commonly involves their orifices (Derrick et al, 1959) but localized areas of atherosclerotic disease in the peripheral arterial branches have also been described (Reiner et al, 1962). Acute thrombotic ischaemia typically results from thrombosis on top of atherosclerosis at the origin of the superior mesenteric artery resulting in ischaemia and consequent infarction of the entire midgut if untreated (Figure 2). Consequently, the prognosis of acute thrombotic ischaemia is worse than that of embolic ischaemia even after surgical restoration of mesenteric blood supply (Schoots et al, 2004).

**Non-occlusive mesenteric ischaemia**

Intense vasospasm of the superior mesenteric arterial branches, in the absence of arterial occlusion, is the sine qua non of non-occlusive mesenteric ischaemia (Bassiouny and Desai, 2005). Non-occlusive ischaemia, the most lethal form of acute mesenteric ischaemia, most commonly results from systemic hypoperfusion, or low-flow states, which is typically found in critically ill medical or surgical patients with severe congestive heart failure, and in those with cardiogenic, hypovolaemic or septic shock (Herbert and Steele, 2007; Shanley and Weinberger, 2008). Neurohormonal substances such as arginin-vasopressin and angiotensin are the likely mediators of this sympathetic-induced vasoconstriction, in an effort to maintain cardiac and cerebral perfusion (Bassiouny and Desai, 2005).

Over the past few years, non-occlusive ischaemia has been more frequently recognized among patients undergoing cardiac surgery and haemodialysis (Yasuhara, 2005). In addition, drugs such as digitalis glycosides and vasopressor agents, both commonly used in the intensive care unit, result in mesenteric arterial vasospasm causing non-occlusive ischaemia (Herbert and Steele, 2007; Shanley and Weinberger, 2008). For unknown reasons, once arterial vasospasm is initiated, it may persist even after correc-

tion of the initiating event. Persistent arterial vasospasm plays an important role in the maintenance of non-occlusive mesenteric ischaemia, the resultant bowel infarction and the poor prognosis associated with this condition (Bassiouny and Desai, 2005; Yasuhara, 2005).

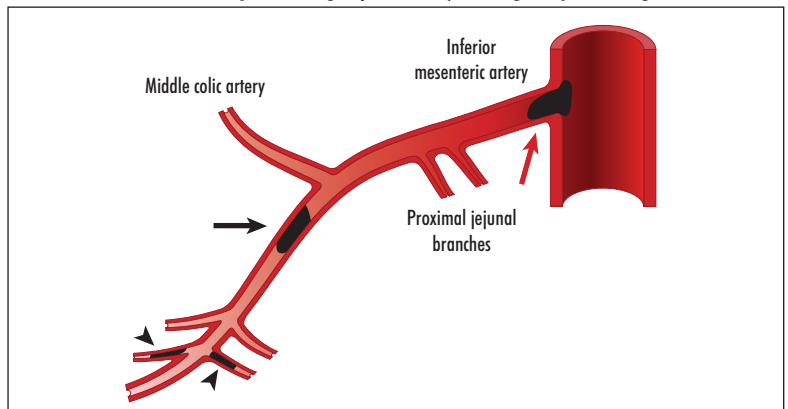
**Mesenteric venous thrombosis**

Acute mesenteric venous thrombosis, the least common cause of acute mesenteric ischaemia, typically affects the superior mesenteric vein and rarely the inferior mesenteric vein. This condition may be primary or idiopathic, or secondary to a variety of disorders (Kumar et al, 2001) (Table 1). Portal or splenic venous thrombosis can also occur but they usually result in a chronic rather than an acute presentation (Kumar et al, 2001).

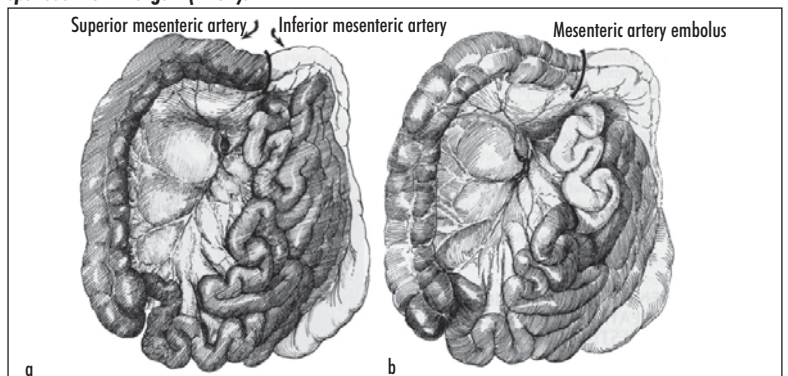
**Diagnosis**

Acute mesenteric ischaemia is uncommon; its estimated incidence is 1 in 1000 hospital admissions (Herbert and Steele, 2007). Nevertheless, its unacceptably high mortality rate, which is usually attributed to many factors including the aggressive nature of the disease itself, underlines the need for complete awareness of the causes,

**Figure 1. Schematic representation of superior mesenteric artery emboli and thrombosis. An embolus (black arrow) commonly blocks the artery distal to the middle colic and proximal jejunal branches. Occasionally, emboli block distal arterial branches (black arrow heads). A thrombus blocks the artery at its origin (red arrow) causing complete midgut ischaemia.**



**Figure 2. a. Distribution of intestinal ischaemia with superior mesenteric artery thrombosis. The entire small bowel and the proximal colon are ischaemic. b. Distribution of intestinal ischaemia with superior mesenteric artery embolism. Note that the proximal jejunum is spared. From Bergan (1967).**



presentations and treatment of acute mesenteric ischaemia because rapid diagnosis and treatment before bowel infarction occurs can positively impact survival. Unfortunately, however, most surgeons are familiar with the all too common scenario of unsalvageable infarcted bowel diagnosed at laparotomy.

### **Clinical presentation**

#### **Acute arterial mesenteric embolism**

Mesenteric embolism is twice as common in men than in women (Stanley, 2002). Patients classically present with sudden severe colicky abdominal pain followed by gut emptying (vomiting or diarrhoea). A cardiac source of emboli (e.g. atrial fibrillation) can usually be established from the history or the examination. Approximately 50% of patients presenting with mesenteric embolism have a history of previous episodes of embolization which usually involve the femoro-popliteal system (Stanley, 2002). The presence of bloody diarrhoea or progressive sepsis is consistent with bowel infarction (Yasuhara, 2005). Abdominal examination before bowel infarction sets in is often normal with no signs of peritoneal irritation (Stanley, 2002). In fact, the hallmark of acute mesenteric embolism is pain out of proportion to physical findings; there is a discrepancy between the intensity of pain and the findings on abdominal examination. The presence of abdominal tenderness, rigidity and other manifestations of peritonitis is an ominous sign as this indicates the presence of bowel infarction or perforation. The triad of pain, gut emptying and a source of emboli is a well-recognized feature of mesenteric embolism, and its presence should prompt immediate treatment.

#### **Acute mesenteric arterial thrombosis**

Mesenteric atherosclerosis is more common in women than in men. The typical patient with mesenteric arterial thrombosis is a woman in her sixties or seventies with atherosclerotic risk factors who presents with insidious and gradually progressive abdominal pain rather than the dramatic pain seen in embolic cases (Yasuhara, 2005; Shanley and Weinberger, 2008). Symptoms of chronic mesenteric ischaemia as a result of mesenteric atherosclerosis such as postprandial pain, food fear and weight loss are usually present; however, in a study by Endean et al (2001), only 19% of patients with acute mesenteric thrombosis had such symptoms, suggesting that many patients with mesenteric atherosclerosis may be asymptomatic. Intravascular volume depletion is the usual predisposing cause of arterial thrombosis of the superior mesenteric artery. Fluid losses from the gastrointestinal tract, during the postoperative period and from conditions such as acute pancreatitis are known causes of volume depletion in the elderly (Shanley and Weinberger, 2008).

#### **Non-occlusive mesenteric ischaemia**

Diagnosis of non-occlusive mesenteric ischaemia is difficult. This is usually attributed to the critical nature of the

underlying condition which dominates the clinical picture but also to the occasional absence of abdominal pain. If pain is present, it varies in character, intensity and location (Shanley and Weinberger, 2008). However, if pain is absent, unexplained abdominal distension, fever, gastrointestinal bleeding or unresolved sepsis in a critically ill patient may provide the earliest clues to the diagnosis (Shanley and Weinberger, 2008). Non-occlusive mesenteric ischaemia commonly affects patients in their sixties.

#### **Mesenteric venous thrombosis**

Mesenteric venous thrombosis may be acute or chronic. In the acute form, the duration of symptoms is less than 4 weeks whereas in the chronic form it is longer than that (Rhee and Gloviczki, 1997). A personal or family history of lower limb deep venous thrombosis may be present in up to 50% of patients (Rhee et al, 1994). Depending on the extent and location of the thrombus and consequently the degree of bowel ischaemia, patients with acute mesenteric venous thrombosis may present with sudden severe colicky central abdominal pain (Kumar et al, 2001) or, more commonly, vague intermittent abdominal discomfort for days or weeks which may be associated with anorexia, nausea, vomiting or diarrhoea (Yasuhara, 2005). Initial findings on abdominal examination may be entirely normal; however, the development of peritoneal signs is an indication of bowel infarction. It is important to distinguish between acute and chronic mesenteric venous thrombosis as in the latter, patients rarely present with abdominal pain but with complications of portal or splenic venous thrombosis such as variceal haemorrhage (Kumar et al, 2001).

### **Laboratory investigations**

It is important to recognize the limited role of laboratory tests in the diagnosis of acute mesenteric ischaemia. Despite the importance attached to leucocytosis and raised serum lactate by some authors (Ritz et al, 2005), the general consensus is that laboratory tests are unreliable (Stanley, 2002; Shanley and Weinberger, 2008). The general management of acute mesenteric ischaemia is based on clinical suspicion from the patient's presentation followed by immediate laparotomy if signs of peritonitis are present or obtaining diagnostic imaging tests if peritonitis is not present. Thus, laboratory tests are most commonly used to exclude other possible diagnoses (Oldenburg et al, 2004). The time-honoured association between bowel ischaemia and metabolic acidosis, although well documented in supporting the diagnosis, may lead to a false sense of security and even exclusion of mesenteric ischaemia in patients with a normal pH. This can be extremely dangerous for two reasons; first, acute mesenteric ischaemia can occur in the absence of metabolic acidosis and, second, if metabolic acidosis is present in a patient with acute mesenteric ischaemia it usually implies unsalvageable transmural bowel infarction. Hence, ruling out acute mesenteric ischaemia on the basis of a normal pH may

deprive some patients of a much needed operation. Likewise, findings such as hyperamylasaemia, raised creatine phosphokinase or alkaline phosphatase, which may be detected in a large proportion of patients, are often non-specific (Ritz et al, 2005; Shanley and Weinberger, 2008).

Recently, ischaemia modified albumin, a biochemical marker detected in a number of acute ischaemic conditions, was found to be elevated in patients with acute mesenteric arterial occlusion but not in healthy controls (Gunduz et al, 2008). This may provide hope for developing a biomarker for early detection of acute mesenteric ischaemia in the future.

### Imaging modalities

It is important to remember that in acute mesenteric ischaemia, as in other acute emergencies, time is of the essence. The choice to proceed to emergency laparotomy or to request diagnostic imaging tests is primarily dictated by the patient's presentation and availability of the specific imaging test (Chang and Stein, 2003). Studies have shown that both early diagnosis and prompt treatment are necessary for survival as the prognosis of acute mesenteric ischaemia is related to the duration and extent of bowel ischaemia (Chang and Stein, 2003).

#### Abdominal X-ray

An abdominal X-ray is a routine investigation in patients with acute abdomen. Radiographic findings of acute mesenteric ischaemia on abdominal X-ray are often non-specific (Oldenburg et al, 2004; Yasuhara, 2005). In addition, findings such as thumb printing or thickening of bowel loops occur in less than 40% of patients at presentation (Oldenburg et al, 2004). Pneumoperitoneum, pneumatosis intestinalis and portal venous gas are late findings which indicate bowel infarction. The role of abdominal X-rays should therefore be limited to excluding other diagnoses such as mechanical small bowel obstruction or peptic ulcer perforation (Oldenburg et al, 2004; Yasuhara, 2005).

#### Contrast angiography

The imaging modality of choice for suspected mesenteric arterial embolism or thrombosis is contrast aortography with selective superior mesenteric angiogram in the anteroposterior and lateral planes (Oldenburg et al, 2004; Shanley and Weinberger, 2008). Lateral-view mesenteric angiography usually differentiates embolic from thrombotic occlusion based on the site of obstruction in the superior mesenteric artery; obstruction at the origin of the artery denotes thrombotic occlusion whereas obstruction within a few centimetres of the artery's origin denotes embolic occlusion.

A patient with suspected non-occlusive mesenteric ischaemia should immediately undergo mesenteric angiography as this is the most sensitive investigation and serves a dual purpose. First, it confirms the diagnosis by demonstrating tapering of distal arterial branches or

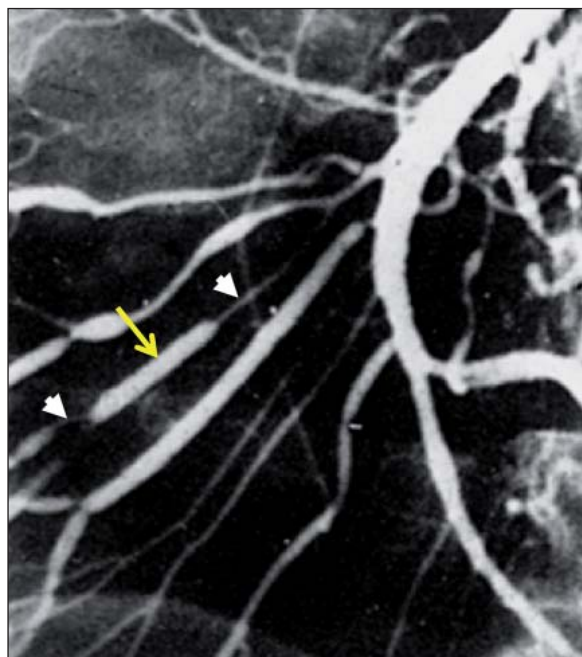
showing intermittent areas of narrowing and dilatation (the 'string of sausages' sign) (Boley et al, 1978) (*Figure 3*). Second, catheter-directed intra-arterial injection of vasodilators such as papaverine can be accomplished.

Despite its high sensitivity, angiography is an investigation that requires special skill, is time consuming and may not be available out of hours. In addition, some surgeons are reluctant to offer such an invasive procedure to patients presenting with non-specific symptoms.

#### Computed tomography

Abdominal computed tomography (CT) scan is an attractive option in patients with acute mesenteric ischaemia as it is rapid, non-invasive and widely available (Herbert and Steele, 2007). Advances in imaging technology with the introduction of thin-slice contrast-enhanced CT with three-dimensional reconstruction have greatly improved the resolution of CT images of both the mesenteric vessels and the bowel. Moreover, CT is a commonly requested investigation in patients with acute abdominal pain and can thus exclude other causes of abdominal pain when the clinical diagnosis is not clear. Thus, one should be aware of the CT findings in acute mesenteric ischaemia. These findings include increased mural thickness, pneumatosis intestinalis, bowel dilatation and lack of mural contrast enhancement (Horton and Fishman, 2007). Increased mural thickness is the most sensitive CT finding and lack of mural enhancement is the most specific (Levy, 2007). CT is the investigation of choice in suspected mesenteric venous thrombosis (Kumar et al, 2001).

**Figure 3.** Superior mesenteric angiogram showing the string of sausages sign in a patient with non-occlusive mesenteric ischaemia. Note the dilated segment (yellow arrow) alternating with narrowed segments (white arrow heads). Adapted from Boley et al (1978).



### Treatment

Acute mesenteric ischaemia is an extremely aggressive abdominal vascular emergency that must be suspected, diagnosed and treated quickly since the duration of bowel ischaemia is the most important determinant of outcome. Initial management of patients suspected of having bowel ischaemia includes aggressive fluid resuscitation and administration of empiric broad spectrum antibiotics (Herbert and Steele, 2007). An intravenous bolus of unfractionated heparin is given followed by heparin infusion to prevent further thrombosis within the mesenteric vessels (Mansour, 1999; Herbert and Steele, 2007). Subsequent management depends on the underlying cause of ischaemia.

### Arterial occlusion

Unless the patient is extremely moribund and not expected to survive, a patient with arterial occlusion should undergo an emergency laparotomy through a midline incision. More patients die of being denied a potentially life-saving laparotomy than die of a negative laparotomy (Shanley and Weinberger, 2008).

### Embolism

If angiography is used to establish the diagnosis, it is recommended that the angiography catheter should be left in the superior mesenteric artery for infusion of vasodilators such as papaverine. There is evidence that papaverine improves mesenteric blood flow by antagonizing the arterial vasospasm which may persist, not only in non-occlusive ischaemia, but also after treatment of embolic occlusion (Oldenburg et al, 2004; Bassiouny and Desai, 2005). At laparotomy, the surgeon's primary objectives are to assess intestinal viability and perform superior mesenteric embolectomy. Clinical assessment of colour and peristalsis, antimesenteric blood flow using hand-held Doppler, and examination under Wood's lamp after intravenous fluoroscein injection are all methods that may be used to evaluate the bowel.

Unless the bowel is frankly gangrenous, mesenteric embolectomy should be performed before bowel resection to re-establish blood flow and minimize the extent of resection (Park et al, 2002). The superior mesenteric artery is exposed at the base of the small bowel mesentery and its pulse is examined. A good proximal pulse at the origin of the vessel confirms embolic occlusion. A transverse arteriotomy is usually performed and standard balloon-catheter embolectomy is carried out.

### Thrombosis

Patients with arterial thrombosis have severe underlying atherosclerotic disease and therefore require mesenteric revascularization, preferably before bowel resection. This undoubtedly depends on the general condition of the patient and the degree of bowel ischaemia. Mesenteric bypass is performed in an antegrade (from the supraceliac

aorta) or a retrograde (from the common iliac) fashion. In the presence of gangrenous bowel or peritoneal contamination, the use of a vein graft for the bypass is recommended; otherwise, a prosthetic graft is used (Mansour, 1999).

### Non-occlusive mesenteric ischaemia

Unless bowel infarction is highly suspected clinically, patients with non-occlusive ischaemia are best managed by correction of the underlying cause of hypoperfusion. This can be challenging because although offending medications such as  $\alpha$ -blockers and other vasopressors should be stopped or altered, these same medications are necessary to treat the often life-threatening cause of low cardiac output that led to non-occlusive ischaemia in the first place. As angiography is the recommended imaging modality, intra-arterial infusion of papaverine at 30–60 mg/hour via the angiography catheter is the treatment of choice (Yasuhara, 2005; Shanley and Weinberger, 2008). If the patient develops signs of bowel infarction such as peritonitis, worsening sepsis or metabolic acidosis during treatment, laparotomy is indicated. Even if bowel resection is required, papaverine infusion should continue postoperatively to guard against persistence of vasospasm which may lead to further bowel ischaemia and infarction (Yasuhara, 2005).

### Mesenteric venous thrombosis

Systemic heparin anticoagulation is the treatment of choice for acute venous thrombosis unless the patient has evidence of bowel infarction, in which case laparotomy is indicated and heparin continued postoperatively. At laparotomy, the bowel is usually thickened, oedematous and dark-blue in colour with intact superior mesenteric pulsation. Perioperative heparinization reduces both postoperative recurrence of thrombosis, which is common, and the mortality rate (Abdu et al, 1987; Rhee et al, 1994). Although superior mesenteric venous thrombectomy and thrombolytic therapy have been reported, their use should be limited to highly selected cases in experienced centres (Shanley and Weinberger, 2008).

### Postoperative care

Patients surgically treated for acute mesenteric ischaemia are usually critically ill. Care should be taken to avoid hypovolaemia, and to correct acid–base and electrolyte imbalance. Ischaemia-reperfusion injury is a concern after mesenteric revascularization and some authors recommend the use of oxygen free-radical scavengers (Oldenburg et al, 2004). In addition, patients may need vasopressors which can worsen ischaemia in marginally viable bowel; in such cases, dopamine and adrenaline are preferred over pure  $\alpha$ -blockers (Oldenburg et al, 2004).

### The second-look laparotomy

Traditionally, a second laparotomy 24–48 hours after bowel resection with or without revascularization is recommended after laparotomy for acute mesenteric ischaemia.

The lack of accurate methods of intraoperative and post-operative assessment of bowel viability (Ballard et al, 1993; Oldenburg et al, 2004), in addition to the frequent occurrence of mesenteric vasospasm after revascularization, are the main reasons for a second-look operation. Nevertheless, some authors adopt a more selective approach where a second-look laparotomy is based on the intraoperative findings and the postoperative course of the patient, with particular attention to the postoperative lactate level (Ritz et al, 2005). Regardless of the approach, only frankly gangrenous bowel should be resected at the initial laparotomy; bowel with borderline viability should be left behind to be reassessed during the second-look laparotomy.

## Prognosis

The mortality rate among patients with acute mesenteric ischaemia remains high, but it depends on many factors. Young age, better general medical condition, early presentation and early diagnosis all correlate with a better prognosis (Ritz et al, 2005). With regards to the aetiology of ischaemia, a systematic review of survival based on the cause of ischaemia showed that patients with non-occlusive ischaemia and arterial thrombosis had a worse prognosis than those with arterial embolism and venous thrombosis. In addition, the overall mortality rate of non-surgically treated patients was almost 95% compared to approximately 57% for surgically treated patients (Schoots et al, 2004).

## Conclusions

Acute mesenteric ischaemia is a catastrophic abdominal emergency associated with an extremely high mortality rate. It is important to remember that survival is directly related to the degree of bowel ischaemia and the extent of bowel resection, both of which can be diminished by the timely diagnosis of this condition. Therefore, knowledge of the different types of acute mesenteric ischaemia and their associated clinical presentations is critical for rapid diagnosis, provision of prompt aggressive treatment and improved survival. **BJHM**

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Conflict of interest: none.

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## KEY POINTS

- Acute mesenteric ischaemia is mainly caused by superior mesenteric embolic or thrombotic occlusion, mesenteric venous thrombosis or non-occlusive mesenteric ischaemia.
- Emergency surgical treatment is the treatment of choice in arterial embolic or thrombotic occlusion.
- Non-surgical treatment is the treatment of choice in venous thrombosis and non-occlusive mesenteric ischaemia.
- Early diagnosis and prompt aggressive treatment are associated with improved survival.