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.

Acute mesenteric 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 characterised 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 ‘occlusion of the mesenteric vessels is apt to be sally pessimistic view by surgeons for 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 Weinfurter, 2008) (Table 1). The superior mesenteric artery is the commonest mesenteric artery affected by emboli because of its acute angle of origin from the aorta. A superior mesenteric artery embolus characteristically lodges as the artery tapers distal to the origin of the middle colic artery; this usually allows preservation of the transverse colon in addition to the proximal jejunum as a result of sparing of the first few jejunal side branches (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 artery branches are also common (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 (Shoosh et al, 2004).

Non-occlusive mesenteric ischaemia

Intense vasopasm of the superior mesenteric arterial branches, in the absence of arterial occlusion, is the sine qua non of non-occlusive mesenteric ischaemia (Bassouli and Desai, 2005). Non-occlusive ischaemia, the most lethal form of acute mesenteric ischaemia, most commonly results from systemic hyperperfusion, 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; Stanley and Weinfurter, 2008). Neurohumoral substances such as arginine-vasopressin and angiotensin are the likely mediators of this sympathetic-induced vasoconstriction, in an effort to maintain cardiac and cerebral perfusion (Bassouli and Desai, 2005).

Over the past few years, non-occlusive ischaemia has been more frequently recognized among patients undergoing cardiac surgery and haemodialysis (Yasuahara, 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; Stanley and Weinfurter, 2008). For unknown reasons, once arterial vasospasm is initiated, it may persist even after correction 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 (Bassouli and Desai, 2005; Yasuahara, 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 unacceptable 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, 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...
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 patient 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 may present with sudden severe colicky 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 and diarrhea (Yasuhrara, 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 with selective mesenteric angiography in the 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 mesenteric ischaemia it usually implies unsealaguable 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 hyperamylasemia, raised creatine phosphokinase or alkaline phosphatase which may be detected in a large proportion of patients are often non-specific (Ritz et al, 2005; Stanely 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 with particular 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 abdominal pain. Radiographic findings of acute mesenteric ischaemia on abdominal X-ray are often non-specific (Oldenburg et al, 2004; Yasuhrara, 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, pneumatisos intestinals 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 mechanical small bowel obstruction or peptic ulcer perforation (Oldenburg et al, 2004; Yasuhrara, 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 embolism 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 dilation (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 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 acute abdominal pain.
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 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 arterial vasospasm which may persist, not only in the presence of dangerous bowel ischaemia, but also after treatment of systemic heparin anticoagulation is the treatment of choice (Yashura, 2005; Shanley and Weinberger, 2008). If the patient develops signs of bowel infarction such as t-t-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 (Yashura, 2005; Shanley and Weinberger, 2008). If the patient develops signs of bowel infarction such as t-t-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 (Yashura, 2005; Shanley and Weinberger, 2008).

**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 perfusion. Perioperative heparinization has been shown to reduce both postoperative recurrence of thrombosis, which is common, and the mortality rate (Abdu et al., 1987). Rhee et al., 1994). Although superior mesenteric venous thrombosis is rare, patients may need to be anticoagulated postoperatively well beyond the expected duration of heparin therapy. Propafenone and diltiazem 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. Ischaemic bowel resection is indicated after mesenteric revascularization and some authors recommend the use of oxygen free-radical scavengers (Gill et al., 1993). In addition, patients may need vasopressors which can worsen ischaemia in marginally viable bowel, in such cases, dopamine and adrenaline are preferred over pure t-blockers (Oldenburg et al., 2004).

**The second-look laparotomy**

Traditionally, a second-look 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 postoperative assessment of bowel viability (Ballard et al., 1993; Oldenburg et al., 2004), in addition to the frequent occurrence of mesenteric venous asperoemia 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, however, it depends on many factors. Young, age, general medical condition, early presentation and death are all correlated 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 the overall mortality rate of non-surgically treated patients was almost 95% compared to approximately 57% for surgically treated patients (Schwarcz 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 and that 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.

**KEY POINTS**

- Acute mesenteric ischaemia is mainly caused by superior mesenteric embolus 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.