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# Diagnostic laparoscopy in mesenteric ischemia

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With the development of laparoscopic surgical procedures, laparoscopy has become increasingly popular as a diagnostic tool. Commonly indications for diagnostic laparoscopy include preoperative findings of abdominal malignancies prior to major surgery, blunt and penetrating abdominal trauma, acute abdominal symptoms with equivocal history or physical findings, and undetermined abdominal symptoms when other diagnostic modalities are inconclusive or not available. In certain circumstances, laparoscopy may also be used to treat the underlying pathology.

Patients suffering from intestinal ischemia tend to be elderly. Frequently, they have comorbid conditions that allow only a narrow window of opportunity for a successful surgical intervention. Such patients will tolerate an unnecessary laparotomy poorly, and diagnostic laparoscopy may offer an attractive alternate modality. Additionally, laparoscopy can be done bedside if the patient is not transportable, as in intensive care unit patients [1, 2, 8–10, 12, 14]. This review describes the role and technique of diagnostic laparoscopy as an adjunct to the process of clinical decision making in the diagnosis and management of patients with mesenteric ischemia.

## Brief classification and pathophysiology of mesenteric ischemia

Mesenteric vascular disease can be broadly classified into acute and chronic forms and into conditions of venous and arterial origin. Acute mesenteric ischemia is much more common than the chronic type, and ischemia of arterial origin is more frequent than venous diseases [3, 7]. The arterial form of acute mesenteric ischemia includes occlusion of the superior mesenteric artery by emboli or thrombosis. Nonocclusive mesenteric ischemia (NOMI) is usually a consequence of a low flow state. Common causes of arterial emboli include atrial fibrillation and bacterial endocarditis, whereas NOMI is usually secondary to prolonged shock or low cardiac output. Venous forms of mesenteric ischemia are usually secondary to hypercoagulable states or abdominal sepsis, or they may be idiopathic.

The extent of bowel involvement also varies according to the underlying etiology. Emboli and thromboses of the superior mesenteric artery result in segmental ischemic damage to the small bowel and/or the right colon. Atherosclerotic narrowing with superimposed thrombosis of the main superior mesenteric artery trunk may also cause extensive damage. Nonocclusive mesenteric ischemia usually involves most of the small bowel and often part of the large bowel, but the injury is patchy in its distribution. Acute occlusion of the arterial supply or venous drainage of the small bowel causes a spectrum of pathologic features ranging from mucosal infarction to transmural gangrene with eventual bowel perforation. The bowel mucosa is the most sensitive layer to ischemia; the muscularis propria is more resistant.

Although pathologic changes are seen early in the mucosa, serosal changes appear only in a later phase [7]. Therefore, diagnostic laparoscopy, which mainly evaluates the external appearance of the intestine, may be misleading if performed early in the disease process. This potential disadvantage of the laparoscopic modality will be further discussed. In a more progressive phase, the infarcted bowel has a characteristic dusky appearance with tan granular fibrin deposits and hemorrhages. In early mesenteric vein thrombosis, venous congestion with good arterial pulsation may be seen, but as the process progresses, the findings may be indistinguishable from infarction of arterial origin. Due to the progressive nature of mesenteric ischemia, a second-look laparotomy is almost always indicated whether or not an anastomosis was constructed [3]. Thus, laparoscopy may again be useful for a second-look inspection of the abdominal cavity and the entire intestine [6, 11, 13].

## Diagnostic tests for intestinal ischemia

One of the most important factors determining the prognosis of patients suffering from mesenteric ischemia is early and prompt diagnosis. The history and physical examination are frequently nonspecific. Furthermore, because the patients

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tend to be elderly and frequently suffer from concomitant chronic disorders, the surgeon may be reluctant to use aggressive diagnostic methods. However, the two most important imaging studies are computed tomography and selective mesenteric angiography, both of which require contrast material injection. The many suggestive and typical findings of these studies and the wide range of laboratory blood tests are beyond the scope of this review and therefore will not be discussed.

Obviously, in straightforward cases when the diagnosis is confirmed (usually by computed tomography or angiography), or in cases where the patient develops signs of peritonitis, usually following bowel gangrene or perforation, laparoscopy is not indicated.

## Laparoscopy as a primary diagnostic tool in mesenteric ischemia

Although mesenteric angiography remains the gold standard for the diagnosis of mesenteric ischemia, it is not applicable in many situations. Patients with mesenteric ischemia frequently suffer from chronic diseases, such as congestive heart failure and chronic renal failure, making contrast angiography hazardous. Furthermore, because these patients are frequently severely dehydrated and acidotic, they require time-consuming correction before angiography can be performed. This time lag can be detrimental, as bowel viability is jeopardized.

Conversely, diagnostic laparoscopy is a quick and well-tolerated procedure [1, 2, 8, 9]. In certain conditions, it can be carried out under local anesthesia with light intravenous sedation. In patients who are unstable, precluding their transfer to the angiography suite, laparoscopy can be performed safely at their bedside in the intensive care unit or emergency department, although performing the procedure in the operating room is preferable. During laparoscopy, the entire small and large bowel can be inspected carefully for signs of ischemia or gangrene. If necessary, peritoneal fluid can be aspirated and sent for analysis. In addition, other acute abdominal conditions unrelated to mesenteric ischemia may also be diagnosed, enabling appropriate management. Once ischemia is confirmed, laparotomy is usually indicated. In some cases, the surgeon may choose not to proceed with laparotomy due to extensive intestinal gangrene involving the entire small bowel in an old, poor-risk patient.

Laparoscopy has several disadvantages as a primary diagnostic tool in acute mesenteric ischemia. Foremost is the fact that only the serosal surface of the bowel can be inspected during laparoscopy, and it may look normal during the early phases of intestinal ischemia. This fact, along with the inability to palpate the small bowel mesentery in order to appreciate the presence or absence of arterial pulsation, should be kept in mind whenever laparoscopy is used for very early diagnosis of intestinal ischemia. However, since the gross detectable changes of ischemic bowel, such as edematous congested intestine with patchy hemorrhages, dark peritoneal fluid, or frank gangrene, develop in a matter of hours, most affected patients can be diagnosed accurately by laparoscopy. Laparoscopy may have a special role in the diagnosis of nonocclusive mesenteric ischemia (NOMI), since angiography in these cases is sometimes normal or inconclusive, and the diagnosis is often based on the bowel's appearance.

Another concern related to the laparoscopic technique is the effect of pneumoperitoneum on mesenteric blood flow. Kleinhaus et al. [5] studied the effect of $CO_2$ insufflation at different intraperitoneal pressures on mesenteric blood flow in dogs. In the group of dogs not subjected to superior mesenteric artery (SMA) occlusion, mesenteric blood flow was reduced to 70% of baseline when the intraperitoneal pressure was 20 mm Hg. When this pressure was increased to 40 mm Hg, mesenteric flow was further reduced to 50% of baseline values. When a second group of dogs was subjected to partial balloon occlusion of the SMA, mesenteric blood flow was 50% of baseline at intraperitoneal pressures of 20 mm Hg and 40% at 40 mm Hg.

The effect of intraperitoneal pressure on femoral artery flow was even more pronounced. It seems that gas insufflation exerts its hemodynamic effect by two mechanisms. The first is a fall in cardiac output that occurs as venous return from the lower half of the body is reduced. Additionally, the impact on femoral blood flow suggests either a direct effect on the abdominal aorta and its branches or a differential response in peripheral resistance in various vascular beds. It is therefore prudent that laparoscopy in a patient with suspected mesenteric ischemia be performed expeditiously with an intraperitoneal pressure not exceeding 10–15 mm Hg.

Clinical experience with laparoscopy as a primary diagnostic tool in patients with suspected mesenteric ischemia is gradually increasing. In one of the earliest reports, Serryn et al. [12] performed an emergent laparoscopy in a female patient for presumed pelvic inflammatory disease. A tan segment of jejunum damaged by mesenteric vein thrombosis was diagnosed and confirmed by pathological examination. Other clinical reports have described bedside laparoscopy at surgical intensive care units for presumed intestinal ischemia [2, 9, 14].

In an attempt to increase the diagnostic accuracy of laparoscopy in intestinal ischemia, Kam and Scheeres [4] used fluorescein-assisted laparoscopy (FAL) in a canine model. Laparoscopy was performed with a standard light source, followed by FAL with an argon laser. The combination of laparoscopic evaluation with and without fluorescein injection allowed identification of all experimentally induced ischemic small bowel segments.

In cases where the diagnosis of mesenteric ischemia is made in the early stages, laparoscopy can obviate the need for a formal laparotomy. Regan et al. [3] described a patient with acute SMA occlusion diagnosed by angiography performed within 3 h of the patient's admission. Intraarterial urokinase was given. Forty-eight hours after the initiation of the fibrinolytic therapy, explorative laparoscopy was performed to assess bowel viability. No evidence of bowel infarction was found, and the patient made a full recovery.

Further clinical studies are warranted to define the efficacy and safety of primary diagnostic laparoscopy in mesenteric ischemia. As with other laparoscopic procedures where advanced instrumentation has improved both safety and outcome, specific devices such as laparoscopic Doppler and laparoscopic tissue oxygen saturation probes can increase the reliability and yield of this procedure.

## Performing diagnostic laparoscopy in mesenteric ischemia

The majority of patients with suspected mesenteric ischemia are referred from the emergency facility or the medical ward. In such cases, the patient can be transferred to the operating room. In high-risk patients, the procedure can be started under local anesthesia with light sedation if needed. When the patient is in the intensive care unit (ICU) and therefore probably not transportable, the diagnostic laparoscopy can be performed as a bedside procedure. Since most ICU patients are either ventilated and sedated or paralyzed, anesthesia is not required.

Regardless of where the procedure is performed, a thorough inspection of the abdominal cavity and the entire intestine should be done. Patients who have undergone previous abdominal surgery are usually not good candidates for this procedure unless the surgeon is willing to perform laparoscopic adhesiolysis before undertaking the inspection. In cases of dilated bowel, an open (Hasson) technique for establishing pneumoperitoneum is safer. The first trocar inserted into the abdominal cavity usually measures 10 mm, and a 0° laparoscope is used initially. Recently, small miniscopes have been introduced for diagnostic as well as surgical purposes. These scopes, which range in diameter between 3.5 and 1.7 mm, can be connected to ordinary laparoscopic cameras. However, the resolution of most of them is not acceptable.

Once the scope is in the peritoneal cavity, an initial inspection is performed for detection of obvious bowel ischemia, gangrene, perforation, or fecal content in the peritoneal cavity, all of which require prompt laparotomy. Other findings that may account for the patient's symptoms but are unrelated to mesenteric ischemia, such as diverticulitis, pancreatitis, etc., should be treated accordingly. If no obvious findings are noted at the initial inspection, two more 5- or 10-mm ports are placed on each side below the midline port. The inspection is performed using a two-hand technique with an atraumatic ring clamp or Babcock and frequent shifting of the operating table position according to the inspected area. It is important to work in a systematic order to reduce the chance of missed pathology. Peritoneal fluid is aspirated and sent for gram stain, culture, and biochemical analysis.

Intestinal inspection is started at the ligament of Treitz, which is identified after the greater omentum and transverse colon are retracted cephalad, and the patient is in a right tilt position. Once identified, the small intestine is inspected slowly and carefully, segment by segment, using the two atraumatic instruments. In arterial mesenteric ischemia (superior mesenteric artery occlusion) of early onset ($\leqslant$4 h), the affected bowel is in spasm. It appears pale and olygemic, and at this stage mucosal ischemic changes are present. As the ischemic process progresses, edema and congestion of the bowel wall are seen due to extravasation of plasma and blood in the ischemic bowel and distal thrombosis of smaller vessels [7]. Within 2–3 h, full-thickness infarction and gangrene of the intestine occur, followed by perforation as a later sequela. In a venous mesenteric event (superior mesenteric vein occlusion), venous congestion of the mesenteric vessels and bowel wall is observed, while good arterial pulsation can be seen or palpated. Later, secondary arterial thrombosis occurs. Therefore, at an advanced stage, the gross appearance of the bowel will be similar regardless of the arterial or venous origin of the mesenteric ischemia.

After small bowel inspection is completed, the large bowel from cecum to upper rectum is similarly inspected. Newly developed Doppler probes may be helpful in determining arterial mesenteric pulsation during the laparoscopic bowel inspection. In cases of equivocal findings, the lesser sac should be opened at the avascular plane along the transverse colon.

Formal laparotomy may be indicated by the findings of the diagnostic laparoscopy. If mesenteric ischemia is encountered, revascularization, with or without resection, is usually performed unless extensive gangrene is found in a high-risk patient and the surgeon decides to terminate the operation. If the diagnostic laparoscopy is negative in a high-risk ICU patient, one cannula may be left and secured by a suture to the abdominal wall to be used for a repeat inspection a few hours later. If other abdominal pathology is discovered during diagnostic laparoscopy, it is dealt with either laparoscopically or by open surgery based on the findings and the laparoscopic skills of the surgeon.

## The role of second-look laparoscopy

The need for second-look laparotomy after surgery for mesenteric ischemia is well established. Regardless of the origin—arterial or venous—and unrelated to the procedure—anastomosis or creation of a stoma—second-look laparotomy is mandatory to ensure bowel viability [3, 7]. At the time of initial laparotomy, bowel segments of marginal viability are often preserved in order to avoid short bowel syndrome. After revascularization by either embolectomy, thrombectomy, or vascular bypass, the questionable ischemic areas may be salvaged, but they need to be reinspected after 24–48 h. In venous mesenteric thrombosis, even after resection of the affected segment and institution of anticoagulation therapy, the process of venous thrombosis may progress. Therefore, additional resection may be required during the second look.

After resection and primary anastomosis, the need for reinspection of the anastomosis to ensure its viability is obvious. However, even in cases of double stoma creation where the two bowel ends are exteriorized, stoma viability alone may be misleading, because more remote areas can be affected by the ischemic process. Therefore, second-look laparotomy is still needed in such instances. The only exception, where a second-look laparotomy may not be necessary, is when only a short segment of bowel was involved due to focal ischemia. In such instances, resection with primary anastomosis can be safely performed. It is important to emphasize that the decision to perform a second-look laparotomy is made during the initial operation and carried out regardless of the patient's postoperative clinical status.

The choice of laparoscopy instead of laparotomy for the second look may avoid the increased risk of an additional surgical procedure for patients who do not require further resection. Several techniques have been proposed for performing second-look laparoscopy. Eypasch et al. [1] reported six patients with peritonitis or bowel necrosis at the initial operation who underwent laparoscopic reexploration

96 h after primary laparotomy. At the initial laparotomy, a 12-mm trocar was inserted opposite the area of original pathology. The inner tip of the cannula was partially withdrawn and left within a pocket of the rectus muscle in order to avoid injury to intraabdominal organs. On reexploration, the cannula was reinserted into the abdominal cavity and the abdomen insufflated through it, allowing for laparoscopic reassessment of the bowel and peritoneal cavity. Additional ports may be inserted if necessary. Open reexploration was performed in three patients based on the laparoscopic findings; the other three patients were cleared by the second-look laparoscopy with no adverse outcome.

MacSweeney and Postelthwaite [6] reported another technique of second-look laparoscopy in which a plastic drain was left in the abdominal cavity and removed through the abdominal wall near the midline incision. After 24–48 h, the patient was brought to the operating theater, and a Veress needle was inserted into the cut end of the drain near the abdominal wall. After insufflation, a 10-mm trocar was introduced through an umbilical incision to allow laparoscopic exploration. Laparotomy was performed according to the findings.

Sackier [11] suggested leaving a cannula placed under direct vision during the initial laparotomy with only a short length protruding into the abdominal cavity, thus avoiding inadvertent visceral injury. The cannula is secured to the fascia with a pursestring suture.

In a recent report by Slutzki et al. [13], five patients with acute mesenteric ischemia underwent a planned second-look laparoscopy. At the primary operation, two 10/12 mm ports were placed in the lower abdominal quadrants and covered with sterile gloves. After 48–72 h, the abdomen was inflated via the cannula, and laparoscopic inspection was carried out. In two patients, the omentum was found to cover the cannula tips, but it was rolled off using an endo-Babcock forceps to allow full visualization and exposure of the remaining bowel. The authors thus suggested that omentectomy during laparotomy can facilitate the laparoscopic second look. In two other patients, negative laparoscopy prevented a formal second-look laparotomy. In one patient, however, the bowel seemed viable and normal, but due to the surgeon's lack of experience with the technique, formal laparotomy was performed and the negative laparoscopy was confirmed.

These reports attest to the feasibility of second-look laparoscopy in patients with mesenteric ischemia. The same limitations that pertain to diagnostic laparoscopy as a primary diagnostic tool in patients with suspected mesenteric ischemia are also valid for second-look laparoscopy.

## Summary

The role of laparoscopy in the diagnosis of mesenteric ischemia is not yet fully established. The recent increase in the number of publications in this area reflects greater experience with this modality. As with other new and innovative laparoscopic procedures, more study is required before final conclusions can be reached. It is crucial, however, to be aware of the present limitations and potential disadvantages of this technique in order to avoid any adverse outcome.

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