

УДК 616.13-089.819:616.134-005.4

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## Use of endovascular methods in the treatment of acute mesenteric ischemia

ТЕХНОЛОГІЇ  
ДІАГНОСТИКИ  
ТА ЛІКУВАННЯ

Gastrointestinal complications are relatively rare complications of cardiac surgery but are nevertheless associated with high mortality. The absolute number of gastrointestinal complications (GI) varies from 0.21 % to 2.9 %. However, the overall mortality in available analyses ranges from 4 % to 100 %, mainly related to mesenteric ischemia. Over the past decade, the greatest attention among GI complications has been paid to ischemic intestinal injury. The frequency of this complication is quite low – from 0.06 to 1.15 %, but the mortality reaches 50–70 %, and according to some authors, even 100 %. Usually, acute intestinal ischemia is caused by embolism caused by thrombi of various origins. However, hypoperfusion as a result of various factors can lead to non-occlusive ischemia.

Thus, the morbidity and mortality because of mesenteric ischemia remain high even in the era of modern advances in diagnostic and therapeutic modalities, and the best treatment method is still debated among surgeons and interventionists. Recently, interventionists have increasingly preferred endovascular approaches to open surgery, probably due to the apparent reduction in mortality and perioperative complications. However, despite the high technical success rates, further exploratory laparotomy for resection of necrotic bowel is necessary in a significant proportion of patients. Most evidence suggests that hybrid approaches involving primary endovascular interventions followed by open laparotomies for bowel resection may be superior to either approach alone. An exceptional factor dramatically affecting outcome and mortality is early diagnosis. Given the relative rarity of mesenteric ischemia in intensive care practice, awareness and vigilance regarding this complication, as well as early multispiral computed tomography with subsequent referral to cathlab may be a key.

**Key words:** gastrointestinal complications, acute mesenteric ischemia, endovascular therapy, endovascular revascularization, stenting, angioplasty

**G**astrointestinal disorders are relatively rare complications of cardiac surgery but are nevertheless associated with high mortality [2–9]. Over the past two decades, a considerable amount of data has been accumulated regarding the quantity and quality of such complications (*Table*). The absolute number of gastrointestinal complications (GIC) ranges from 0.21 % to 2.9 %. However, the overall mortality in the analysed groups ranges from 4 % to 100 % [1, 27].

The main preoperative risk factors are arterial hypertension [7], renal failure [4, 7, 9], old age [6,

9], congestive heart failure [6, 7], and a known previous history of gastrointestinal diseases [5–6]. Risk factors during surgery and the early postoperative period are the use of vasopressors [5, 7, 9], prolonged «skin-to-skin» operation time [4], cardiopulmonary bypass time [4, 6, 9], and aortic clamping time [6]. Patients after complex and combined procedures, such as CABG and valve replacement, have an increased risk of GIC [6–9]. Prolonged mechanical ventilation and the need for dialysis are the most significant risks in the postoperative period [5, 6, 9].

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Стаття надійшла: 14.12.2025  
Прийнята після рецензування: 11.02.2026  
Опублікована: 01.04.2026

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Received on: 14.12.2025  
Accepted after review: 11.02.2026  
Published: 01.04.2026

The complication with the highest mortality rate, reaching 100 %, is mesenteric ischemia. Over the last decade, most attention among GICs has been paid precisely to ischemic intestinal injury. The incidence of this complication is quite low – from 0.06 to 1.15 %, but mortality reaches 50–70 %, and according to some authors, even 100 %. Usually, acute intestinal ischemia is caused by embolism due to thrombosis of various origin. However, hypoperfusion as a result of various factors can lead to non-occlusive ischemia.

Among the most important risk factors for small intestinal ischemia are peripheral vascular disease, old age, cardiogenic shock, the use of blood components and preparations, the use of vasopressors in the perioperative period, renal failure, and the use of an intra-aortic balloon pump. The analysis of cohorts of patients after operations without and with the use of CPB (cardiopulmonary bypass) showed that the latter demonstrate a significantly more frequent intestinal ischemia, which is associated with survival rate of only 7 %.

Among other peri- and postoperative factors, the most significant are ventilation support for more than 24 hours, the use of vasopressors, blood products and components, intra-aortic balloon pump, and reoperations. Additional factors that are important are increased creatinine and blood lactate.

## Diagnosis

A key for the radical reduction of mortality in acute intestinal ischemia is the possibility of earliest diagnosis. Late diagnosis contributes to high mortality – 30–70 % [2]. Every 6 hours of delay in diagnosis (usually a delay in CT scanning) doubles mortality [38]. Patients after cardiovascular operations in the early postoperative period usually receive pain relief and sedation, may be on prolonged mechanical ventilation, and in severe cases, unconscious. Therefore, pain syndrome may be completely absent. The only symptoms of an impending disaster may be abdominal distension and lack of peristaltics.

Lack of improvement in the patient's condition in the early postoperative period, when cardiac causes are excluded and with adequate intensive care, should lead to the idea of the possibility of GIC (gastrointestinal complications/ischemia). Intestinal ischemia in any severely ill patient should be considered with any unexplained deterioration [10]. High clinical suspicion of GIC, even in the absence of peritoneal symptoms, should prompt urgent advanced imaging [10].

## Computed tomographic angiography

Any patient with suspected GIC should undergo immediate computed tomography angiography (CTA) (Class of recommendation 1, level of evidence A). Standard abdominal radiography is not recommended due to its low informativeness (Class of recommendation 1, level of evidence B).

A two-phase CTA protocol is a gold standard because of its high sensitivity and specificity in the diagnosis of GIC [10]. Pre-contrast scanning can detect vascular calcifications, hyperattenuating intravascular thrombi, and intramural haemorrhage [10]. A subsequent arterial phase with contrast can detect arterial filling defects in arteries or areas of infarct in tissues, which are the initial visible signs of acute mesenteric ischemia (AMI) [10]. The venous phase may reveal hyperattenuation within the venous system, consistent with thrombus [10]. Oral contrast should not be used as it may impair visualization [10].

CT should be performed regardless of the presence of renal failure, as the consequences of delayed diagnosis of GIC are much more detrimental to patients than the effects of iodinated contrast. A recent study showed that in 27 of 28 patients (96.4 %), MSCT correctly diagnosed GIC (specificity 97.9 %) [12, 39]. A sensitivity of 93 %, specificity of 100 %, and positive and negative predictive values of 100 % and 94 %, respectively, were achieved [40, 41].

Multiphase reconstructions can also help to identify features of the anatomy of the mesenteric arteries [10].

## Laboratory diagnostics

There are no laboratory parameters that are sufficiently precise to definitively determine the presence or absence of ischemic or necrotic intestinal injury, although elevated l-lactate, leukocytosis, and D-dimer may be helpful (Class of recommendation 2, level of evidence B).

No precise biomarkers have been identified for the diagnosis of GIC [31, 32]. D-dimer has been observed to be an independent risk factor for intestinal ischemia [33], reflecting clot formation and endogenous degradation through fibrinolysis. No patient with normal D-dimer had intestinal ischemia, and D-dimer > 0.9 mg/L had a specificity, sensitivity, and accuracy of 82 %, 60 %, and 79 %, respectively [33]. Thus, D-dimer may be useful in early diagnosis.

Elevated amylase levels have been reported in approximately half of patients with AMI [34]. However, this is important to consider because

patients may be misdiagnosed with acute pancreatitis and delaying critical interventions may impact survival outcomes.

Other biomarkers that have been reported to be useful in the diagnosis of AMI include intestinal fatty acid binding protein (I-FABP), serum alpha-glutathione-S-transferase (alpha-GST), and cobalt albumin binding assay (CABA) [35, 36]. A cross-diagnostic study of 129 patients hospitalized for acute abdominal pain showed that three most promising circulating biomarkers of AMI – citrulline, I-FABP, and d-lactate – were neither sensitive nor specific enough for the differential diagnosis of AMI [37].

### Surgical diagnostic modalities

The presence of peritoneal signs, such as guarding tension or rigidity, is an indication for urgent surgical exploration of the abdomen to evaluate for intestinal perforation, necrosis, and other complications [10]. If exploratory laparotomy is indicated based on peritoneal symptoms, directed palpation of the superior mesenteric artery by placing the fingers behind the mesenteric root can be performed to determine the presence of thrombi [10]. Intraoperative arteriograms may be used and recommended when the diagnosis is uncertain. Intraoperative duplex ultrasonography or fluorescein flowmetry can also be used quickly and reliably [10].

### Treatment

Early revascularization of ischemic intestine is essential to improve survival [10]. The traditional approach to the treatment of AMI has been open surgery, due to the ability to simultaneously remove arterial occlusions or venous thrombi and assess and resect any necrotic bowel [10]. The advent of minimally invasive endovascular techniques over the past few decades has challenged open revascularization techniques as a gold standard of intervention [10]. Several recent studies have shown lower mortality and bowel resection rates with newer techniques, but many surgeons and interventionalists still prefer the open approach [10].

Endovascular revascularization is a primary option for arterial occlusions when the clinic has the appropriate equipment and experienced operators (Class of recommendation 1, level of evidence C).

Specialized «intestinal stroke treatment centers» are becoming increasingly common in France and China, with recent evidence suggest-

ing improved outcomes [10]. In these centers, a multidisciplinary team consisting of a general surgeon, vascular surgeon, interventional radiologist, and critical care physician focuses on removing the nonviable small bowel, preserving the remaining bowel with revascularization, and providing intensive care to prevent progression of multiple organ failure [10]. This approach is associated with improved time to reperfusion and survival [10, 20, 22].

The optimal management of patients with AMI may include open, endovascular, or hybrid access in a vascular surgery center [11, 33]. If acute peritonitis is suspected, urgent laparotomy is indicated to assess the severity of intestinal ischemia [11].

Endovascular revascularization techniques have gained popularity over the past few decades. Ongoing studies have consistently demonstrated their utility as an alternative to open revascularization in appropriate patient populations. For example, in a study were compared the immediate and long-term outcomes of endovascular revascularization in 50 elderly patients with GIC versus no revascularization attempt in 16 [13]. Endovascular revascularization was technically successful in 88 % of cases, and three patients underwent open revascularization after failure [13]. 33 % of patients required open resection of necrotic bowel after the endovascular procedure [13]. The 30-day mortality rate was 32 % in those who received intervention and 81 % in those who did not [13]. The 1-year survival rate was 52 % in the intervention group and 19 % in the no intervention group [13]. In another study, U. Altintas et al. analysed survival, bowel resection rates, complications, reoperation rates, and improvement in clinical symptoms in 67 patients who underwent endovascular intervention for acute or chronic mesenteric ischemia [46]. One- and three-year survival rates were 67 % (95 % CI 54–77) and 54 % (95 % CI 41–65), respectively. Only 59 % of patients reported clinical improvement in symptoms [46]. Thirty patients (45 %) underwent subsequent bowel resection ( $p < 0.001$ ) with a median hospital stay of 7 days.

Another study performed endovascular interventions in 50 patients with GIC due to embolic or thrombotic obstruction of the superior mesenteric artery [15]. Endovascular interventions were technically successful in 44 (88 %) patients [15]. Mortality after successful or failed endovascular intervention was 32 % [15]. The incidence of emergency laparotomy, bowel resection, and endovascular complications was 40 %, 34 %, and 10 %, respectively [15]. Three of the six patients

**Table**  
**Types of endovascular interventions for GIK, advantages and disadvantages**

| Procedures             | Advantages and problems  | Reference |
|------------------------|--|-----------|
| Aspiration embolectomy | Lower mortality<br>Patients without peritonitis<br>Repeated procedures   | [16, 20]  |
| Selective thrombolysis | Bleeding<br>Need for laparotomy in 38 % of cases<br>Patients without peritonitis<br>Contraindicated after recent surgery, trauma, stroke, GI bleeding, uncontrolled hypertension | [12]      |
| Antegrade stenting     | Risk of dissection<br>Anatomical difficulties  | [22, 32]  |
| Retrograde stenting    | Need for laparotomy<br>Avoiding bypass in necrotic bowel<br>94 % success rate  | [41]      |

with failed endovascular interventions were subsequently treated with surgical bypass [15]. Endovascular failure did not significantly affect survival [15]. Finally, a 12-year retrospective analysis of endovascular treatment of AMI at a single center was performed by J. Raupach et al. [47]. A total of 37 patients underwent primary endovascular intervention followed by laparotomy for AMI [47]. Successful recanalization occurred in 91.9 % of patients [47]. One patient was successfully treated with surgical embolectomy due to failed endovascular access [47]. Further exploratory laparotomy was performed in 73.0 % of cases and necrotic bowel resection in 40.5 % [47]. In-hospital mortality was 27.0 % [47].

A study by L. Garzelli et al. demonstrated that reperfusion injury may be a common complication of endovascular revascularization of AMI, especially in those with reduced bowel wall density and complete occlusion of the superior mesenteric artery on previous CT [16]. However, this does not appear to negatively affect short-term survival [16].

Endovascular procedures have generally shown superior outcomes to no intervention and can be considered an alternative to open surgery in nonsurgical candidates. However, this approach does not reduce the morbidity and mortality associated with GIC. Subsequent open bowel resection may still be indicated regardless of the initial intervention technique. A retrospective study by A. Serracant Barrera et al. demonstrated improved survival rates in patients with GIC without peritoneal irritation at the time of diagnosis compared with other interventions [48]. This study suggests that endovascular intervention may be beneficial especially in the early stages of GIC. The techniques of endovascular

procedures vary depending on availability, institution, and skill of the interventionist, but may include thrombectomy, stenting, thrombolysis, or a combination of the three, as summarized in *Table*.

In a retrospective and prospective analysis of long-term outcomes of endovascular recanalization by type of intervention [19]. Overall, 51 of 58 patients (88 %) underwent successful endovascular intervention, and 10 (17 %) experienced complications [19]. Stenting and in situ thrombolysis were performed in the majority of patients (n = 33 and n = 19, respectively) [19]. Overall, 55 % of patients required no further treatment after the procedure, while 16 %, 9 %, and 9 % underwent second-line bowel resection, surgical revascularization, or both [19]. Overall, 79 %, 78 %, and 63 % were alive at 3 months, 1 year, and 3 years [19]. There were no significant differences between interventional techniques [19].

In a single-center retrospective cohort study the outcomes of thrombectomy + stenting combined with aspiration versus aspiration alone in the endovascular treatment of GIC were investigated [24]. A total of 14 patients underwent thrombectomy + stenting with aspiration and 27 underwent aspiration alone [24]. The combination therapy was associated with a higher complete cure rate (44.4 % vs. 78.6 %, p = 0.04), fewer additional local thrombolysis (48.1 % vs. 14.3 %, p = 0.03), and a shorter length of hospital stay (10.7 days ± 9.0 vs. 5.7 days ± 4.7, p = 0.03), compared with aspiration alone [24]. Estimated survival rates at 1 month, 3 months, 6 months, 1 year, and 2 years were 73.2 %, 72.5 %, 71.4 %, 65.3 %, and 59.8 %, respectively [24]. There was no significant difference in survival between groups (log-rank test, p = 0.96) [24]. Recurrence rates were

8.3 % and 4.0 %, respectively [24]. Combination therapy with stent thrombectomy and aspiration should be considered because of improved outcomes compared with aspiration alone [24]. Different stents are available: bare metal and covered, drug-eluting or non-drug-eluting, and self-expanding and balloon-expandable.

A prospective study by A. Girault et al. published interim results in 2021 comparing bare metal stents and stent grafts in both acute and chronic mesenteric ischemia [25]. A total of 86 patients were enrolled between January 2014 and October 2019 [25]. 42 patients had a clinical presentation of GIC, 31 had chronic mesenteric ischemia, and 13 were asymptomatic [25]. The technical success rate was 97 % [25]. A total of 96 stents were implanted, including 86 proximal covered stents (Advanta V12,  $n = 73$ ; Lifestream,  $n = 13$ ) [25]. The mean length and diameter of the covered stents were  $31.5 \pm 6.3$  mm and  $6.9 \pm 0.5$  mm, respectively [25]. Additional distal bare metal stents were used in 10 patients (12 %) to repair kinking ( $n = 9$ ) or dissection ( $n = 1$ ) [25]. All postoperative deaths were due to AMI ( $n = 11$ , 13 %) [25]. During a median follow-up of 15.6 months (95 % CI  $15.6 \pm 3.6$  months), 12 patients (14 %) underwent reintervention for stent malposition ( $n = 3$ ), stent recoil ( $n = 3$ ), stent thrombosis ( $n = 2$ ), de novo stenosis at the distal edge of the covered stent ( $n = 2$ ), or gastric ischemia ( $n = 1$ ) [25]. After 1 year of follow-up, the overall primary patency, primary assisted patency, and secondary patency rates were 83 % (95 % CI  $83 \% \pm 9 \%$ ), 99 % (95 % CI  $99 \% \pm 3 \%$ ), and 99 % (95 % CI  $99 \% \pm 3 \%$ ), respectively [25]. At 2 years, the overall primary patency, primary assisted patency, and secondary patency rates were 76 % (95 % CI  $76 \% \pm 13 \%$ ), 95 % (95 % CI  $95 \% \pm 8 \%$ ), and 95 % (95 % CI  $95 \% \pm 8 \%$ ), respectively [25]. Overall, stenting demonstrated a good primary assisted patency rate at 2 years at the cost of a significant re-intervention rate [25].

A retrospective study by R. Forbrig et al. investigated the feasibility and outcomes of primary percutaneous revascularization (stenting) in atherosclerotic GIC [23]. The study included 19 consecutive patients with GIC who underwent this type of revascularization [22]. The technical and clinical success rates were 95 % and 53 %, respectively [22]. Seven patients underwent subsequent laparotomy with bowel resection [22]. The 30-day mortality was 42 % [28]. Another study identified 141 patients who underwent primary mesenteric artery stenting over an 8-year period and analysed their long-term patency [29]. The median follow-up was 32 months [29]. The primary paten-

cy at 12 and 60 months was 77.0 % and 45.0 % [29]. The primary assisted patency rate was 90.3 % and 69.8 % [29]. The secondary patency rate was 98.3 % and 93.6 % [29]. The results of this study show exceptional long-term patency of target vessels after percutaneous stenting [26, 29].

A systematic review with meta-analysis identified a total of 3362 patients from 19 observational studies who underwent endovascular treatment for GI. The mortality rate after intervention was estimated to be 0.245 (95 % CI 0.197–0.299), and the need for bowel resection was 0.326 (95 % CI 0.229–0.439) [37]. The study also compared 3187 patients who underwent endovascular interventions with 4998 patients who underwent open surgery for GIC. Endovascular therapy was associated with a lower risk of 30-day mortality (OR 0.45, 95 % CI 0.34–0.59,  $p < 0.00001$ ), bowel resection (OR 0.45, 95 % CI 0.34–0.59,  $p < 0.00001$ ), and acute renal failure (OR 0.58, 95 % CI 0.49–0.68,  $p < 0.00001$ ) [37]. No differences were found in septic complications or the development of short bowel syndrome [37]. Another systematic review with meta-analysis attempted to compare the clinical outcomes of open surgical, endovascular, and conservative interventions in patients with AMI due to superior mesenteric vein thrombosis [23]. 667 patients from eighteen studies were identified [38]. Endovascular treatment demonstrated significantly higher efficacy than the surgical group (94.8 % vs. 75.2 %, OR = 4.11, 95 % CI 1.67–10.10,  $p < 0.05$ ) [38].

In a retrospective study 10,381 patients hospitalized for GIC from 2004 to 2014 were identified using the National Inpatient Sample [39]. A total of 4,543 patients underwent endovascular interventions and 5,839 underwent open surgery [39]. Although a higher proportion of patients in the endovascular group had a moderate or severe Charlson Comorbidity Index compared with the open surgery group (28 % vs. 14 %,  $p < 0.0001$ ), the endovascular group was associated with a lower mortality rate (12.3 % (97.5 % CI, 9.8–14.8 %) vs. 33.1 % (97.5 % CI, 29.9–36.2 %) and a lower mean cost of hospitalization (\$41,615 (97.5 % CI, \$38,663–\$44,567) vs. \$60,286 (97.5 % CI, \$56,736–\$63,836)  $p < 0.0001$ ) [40]. After logistic regression analysis on pseudorandomized data (propensity-adjusted logistic regression analysis) the open group maintained a significantly higher mortality rate (OR 3.0; 97.5 % CI, 2.2–4.1) and cost (mean, \$9196; 97.5 % CI, \$3797–\$14,595) compared with the endovascular intervention group [40]. Patients in the open group also had a significantly higher risk of acute kidney injury ( $p < 0.0001$ ) and transfer to a higher-skilled medical facil-

ity than home ( $p < 0.0001$ ) [41]. In a retrospective study major complications and 30-day mortality between open and endovascular interventions in patients with GIC from several centers between 2010 and 2020 were compared [41]. Of the 148 patients, 28 underwent endovascular interventions [41]. There were no statistically significant differences in postoperative major complications between open and endovascular interventions, but open revascularization was associated with a significantly lower need for bowel resection (OR 0.23, 95 % CI 0.13–0.61) [41].

A retrospective study aimed to analyse the outcomes of GIC treatment using an open or endovascular approach, combined with laparotomy, and to evaluate the «endovascular-first strategy» in similar clinical situations. A total of 74 patients treated for GIC between 2007 and 2021 were included in the study. Of these patients, 61 underwent open surgery and 13 underwent endovascular surgery with subsequent laparotomy. Overall in-hospital mortality was 43 % (open surgery 41 % vs. endovascular 53.8 %,  $p = 0.54$ ) [42].

Independent risk factors for in-hospital mortality were pneumatosis intestinalis ( $p = 0.01$ ), elevated lactate concentration ( $p = 0.04$ ), and ischemic bowel ( $p = 0.01$ ). Congestive heart failure (New York Heart Association class II or higher) and atrial fibrillation were associated with higher mortality [42]. Overall, in this study, the outcomes of endovascular and open surgical interventions were similar. Another systematic review with meta-analysis retrospectively compared the outcomes of open surgery, endovascular procedures, and retrograde stenting of the superior mesenteric artery [42]. A total of 2369 patients from 39 studies were included [42]. The pooled mortality estimates have tended to be similar over the past 20 years: 40 % for open surgery (95 % CI 0.33–0.47,  $I^2 = 84$  %), 26 % for endovascular procedures (95 % CI 0.19–0.33;  $I^2 = 33$  %), and 32 % (95 % CI 0.21–0.44;  $I^2 = 26$  %) for retrograde stenting of the superior mesenteric artery [42].

A working group of the Journal of Trauma and Acute Care Surgery Emergency General Surgery Algorithms working group developed an algo-

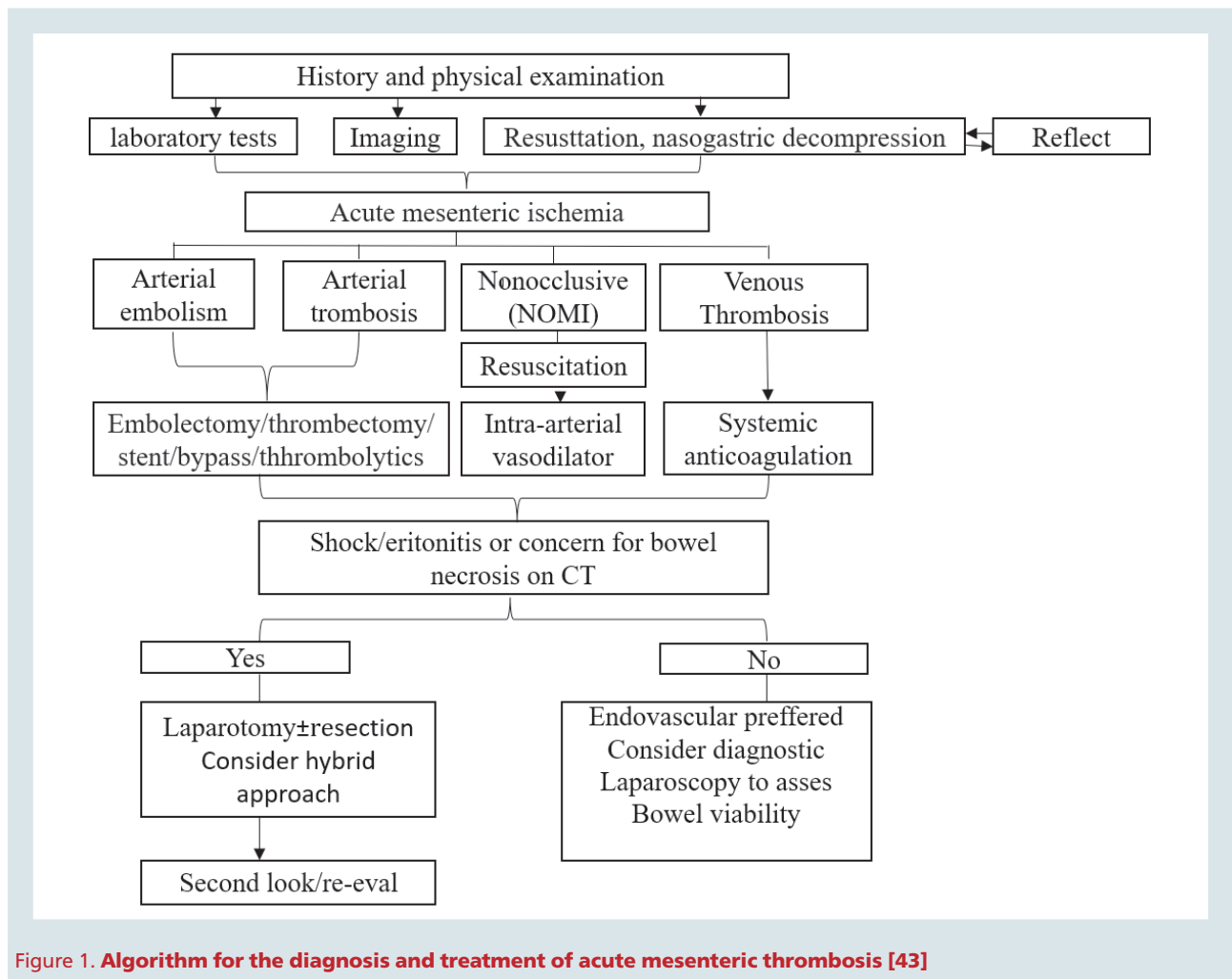


Figure 1. Algorithm for the diagnosis and treatment of acute mesenteric thrombosis [43]

rhythm for providing assistance in management of treatment of AMI (*Figure 1*).

### Technical features of performing interventional procedures in acute intestinal ischemia

The technique of interventional intervention in acute intestinal ischemia is generally based on the already known principles of intervention and is as follows.

**Access.** The most commonly used access is transfemoral, which allows the use of instruments of different diameters and lengths. Other accesses are transradial and through the brachial artery. Arterial puncture is performed according to the generally accepted Seldinger method. The diameter of the instruments is 6–7 French.

**Instruments.** Transradial and transfemoral introducers are used for arterial access. Diagnostic catheters – Pig Tail for abdominal aortography, catheters as a Judkins right, multipurpose, Amlatz right and left, Simmons and others for selective arteriography.

**Angioplasty, thrombus aspiration, stenting.** When an occluded or critically narrowed segment is detected, the main stage of the intervention is initiated. Coronary recanalization conductors are used. Then, when blood flow is restored after balloon angioplasty and/or thrombus aspiration, the procedure is completed. If blood flow is limited, stenting is initiated. The sizes of balloons and stents are selected according to the diameter of the native artery, and are usually more than 4 mm (4–10 mm). Most common are balloon-expandable stents, rarely – self. The procedure is completed with haemostasis. Drug therapy includes dual antiplatelet therapy, an anticoagulant in combination with 1 or 2 antiplatelet drugs.

### Own experience

During 2015–2025, the authors performed 47 interventions for acute intestinal ischemia in patients after cardiac surgery. The age of the patients ranged from 55 to 85 years (average 63.7). The indications for angiography and intervention were the data of the MSCT, the duration of which was from 2 to 14 hours (average 4.7 hours). Angiographic examination revealed occlusive lesions of the branches of the celiac trunk in 17 patients (36.2 %), the superior mesenteric artery in 26 (55.3 %) and the inferior mesenteric artery in 4 (8.5 %). All patients

underwent angioplasty and thrombus aspiration (successful in 44 cases – 95.8 %). In 12 patients, the intervention was completed with a good result. The remaining patients with stenotic lesions and dissections after angioplasty and thrombus aspiration underwent stenting. The celiac trunk was stented in 12 cases (34.3 %), the superior mesenteric artery in 20 (57.1 %), and the inferior mesenteric artery in 3 (8.6 %). In all cases we used bare-metal stents (BMS). 21 (60 %) patients received 1 stent, 11 patients (31.4 %) received 2 stents, and 3 patients (8.6 %) received 3 stents. The total number of stents was 46. The average number of stents per patient was 1.3. A good angiographic result was achieved in a total of 45 of 47 patients (95.7 %). Unsatisfactory results were achieved in 2 patients (no reflow phenomenon). Clinical improvement with complete reduction of symptoms and uncomplicated postoperative course was observed in a total of 18 patients (38.3 %). The remaining patients required further laparotomy, bowel revision, and resection of certain areas of the small intestine. In total, 8 (17 %) patients recovered from this group. The overall mortality was 21 patients (44.7 %). The main direct causes of mortality were the development of multiple organ failure and septic shock.

Below are three images of selective AMI angiography (*Figure 2*), angioplasty and stent implantation (*Figure 3*), and the final angiographic image (*Figure 4*).

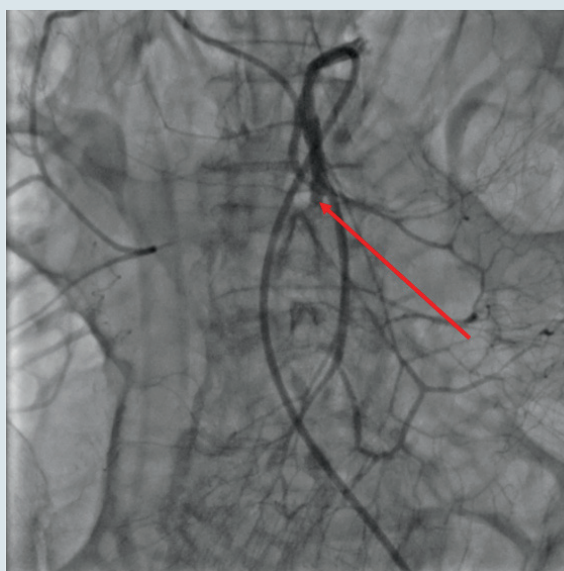


Figure 2. Angiography of arteria mesenterica superior, the red arrow indicates occlusion

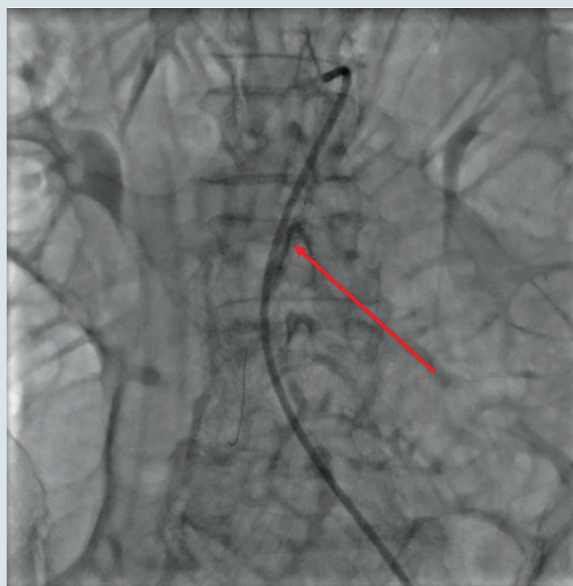


Figure 3. Angioplasty and stenting of occlusion of arteria mesenterica superior, the red arrow indicates stent



Figure 4. Final angiographic image, red arrows indicates open artery

## Conclusions

The morbidity and mortality because of mesenteric ischemia remain high even in the era of modern advances in diagnostic and therapeutic modalities, and the best treatment method is still debated among surgeons and interventionists. Recently, interventionists have increasingly preferred endovascular approaches to open surgery, probably due to the apparent reduction in mortality and perioperative complications. However, despite the high technical success rates, further exploratory laparotomy for resection of necrotic

bowel is often needed in a significant proportion of patients. Most evidence suggests that hybrid approaches involving primary endovascular interventions followed by open laparotomies for bowel resection may be superior to either approach alone.

A factor that dramatically affects outcome and mortality in a large cardiac surgery center is early diagnosis. Given the relative rarity of mesenteric ischemia in intensive care practice, awareness and vigilance regarding this complication, as well as early MSCT with subsequent referral to cathlab, may be a key.

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| Доступність даних:   | Data availability:   |
| Дані взято із джерел, що є у вільному доступі. Всі посилання на використані джерела наведено в статті.                                 | The data have been obtained from freely available sources. All references to the sources used are listed in the article.                       |
| Джерела фінансування:  | Sources of funding:  |
| Написання статті не вимагало спеціального фінансування.  | Writing the article didn't require special funding.  |
| Конфлікт інтересів:  | Conflict of interest:  |
| Конфлікту інтересів немає.   | There is no conflict of interest.  |
| Участь авторів:  | Authors' participation:  |
| Ідея та дизайн дослідження – А.Х.; лікування хворих – А.Х., М.С., О.З.; збір і обробка матеріалів, написання тексту – М.С., О.С., С.С. | Study concept and design – A.K.; patient treatment – A.K., M.S., O.Z.; collection and processing of materials, writing text – M.S., O.S., S.S. |
| Етичне схвалення:  | Ethical approval:  |
| Не передбачене темою і концепцією роботи.  | Not provided for by the topic and concept of the work.   |
| Інформована згода:   | Informed consent:  |
| Не передбачена темою і концепцією роботи.  | Not provided for by the topic and concept of the work.   |
| Подяка:  | Gratitude:   |
| Автори статті дякують персоналу клініки та колегам, відповідальним за ведення пацієнтів.   | The authors of the article thank the clinic staff and colleagues responsible for patient management.   |

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## Використання ендоваскулярних методів у лікуванні гострої мезентеріальної ішемії

Шлунково-кишкові ускладнення є досить рідкісними ускладненнями в кардіохірургії, однак пов'язані з високою смертністю. Частота виявлення шлунково-кишкових ускладнень, основним серед яких є мезентеріальна ішемія, варіюється від 0,21 до 2,9 %, а загальна смертність у доступних аналізах пацієнтів становить 4–100 %. Протягом останнього десятиліття найбільша увага серед ускладнень шлунково-кишкового тракту приділяється ішемічному пошкодженню кишківника. Частота цього ускладнення досить низька – від 0,06 до 1,15 %, але смертність сягає 50–70 %, а за даними деяких авторів, навіть 100 %. Зазвичай гостра кишкова ішемія викликана емболією, спричиненою тромбами різного походження. Однак гіперперфузія в результаті різних факторів може призвести до неоклюзійної ішемії.

Таким чином, захворюваність та смертність при розвитку мезентеріальної ішемії залишаються високими навіть в епоху сучасних досягнень діагностичних та терапевтичних методів, а найкращий метод лікування все ще обговорюється серед хірургів та інтервенціоністів. Останнім часом інтервенціоністи все частіше віддають перевагу ендоваскулярним підходам над відкритими хірургічними втручаннями, ймовірно, через очевидне зниження смертності та періопераційних ускладнень. Однак, незважаючи на високі показники технічного успіху, потреба в подальшій дослідницькій лапаротомії для резекції некротичної кишки часто залишається у значної частини пацієнтів. Більшість даних свідчать про те, що гібридні підходи, зокрема первинні ендоваскулярні втручання з подальшою відкритою лапаротомією для резекції кишки, можуть бути кращими за будь-який з цих підходів окремо. Винятковим фактором, який суттєво впливає на результат та смертність у великому кардіохірургічному центрі, є рання діагностика. З огляду на відносну рідкість мезентеріальної ішемії в практиці інтенсивної терапії, ключовими можуть бути обізнаність та пильність щодо цього ускладнення, а також проведення ранньої мультиспіральної комп'ютерної томографії з подальшим скеруванням до катетеризаційної лабораторії.

**Ключові слова:** шлунково-кишкові ускладнення, гостра мезентеріальна ішемія, ендоваскулярна терапія, ендоваскулярна реваскуляризація, стентування, ангіопластика