

## Postoperative ischemic bowel in the cardiovascular patient

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### A B S T R A C T

Post-operative bowel ischemia in cardiovascular patients is a difficult surgical problem as this population of patients due to their age, multiple co-morbidities and medication profile. Studies have shown that bowel ischemia increases the mortality of these patients after AAA repair and open cardiac surgery significantly. The etiology of bowel ischemia in these patients can be multifactorial but most often due to a “low flow” state which is often an unavoidable outcome of severe cardiovascular compromise. A high index of suspicion and a low threshold to investigate followed by a prompt diagnosis and treatment is key to decreasing mortality. In this chapter will discuss diagnosis and treatment of ischemic bowel after AAA repair and open cardiac surgery.

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### Postoperative colon ischemia after repair of abdominal aortic aneurysms

The most common vascular patient population affected by colon ischemia are those who have recently undergone repair of abdominal aortic aneurysm (AAA). The management of postoperative colon ischemia (CI) in this cohort can be particularly challenging based on the patient's underlying vasculopathy, frequent significant comorbidities, length and complexity of index surgery and common hemodynamic instability in the perioperative period. CI occurs more frequently and its related mortality is significantly greater in the emergent repair than in the elective setting. The incidence and mortality associated with CI after open repair of ruptured and intact AAA are well established. Similar data surrounding endovascular aneurysm repair (EVAR) are becoming increasingly well known as the technique has become accepted and utilized more frequently. Recently, studies have taken a closer look at the potential pathogenesis, overall incidence and postoperative mortality specific to open or endovascular repair techniques in the elective (intact) and emergent (ruptured) settings. Each will be discussed in the following chapter in regards to incidence, diagnosis, non-operative and operative management.

The mortality associated with CI after AAA repair is significantly higher than in its absence. In the intact AAA cohort who has undergone repair, operative mortality following exploration and resection for CI can range from 38–50%.<sup>1–5</sup> This is in contrast to an operative mortality without colon ischemia to be less than 2%.<sup>6</sup> In the setting of repair of a ruptured AAA, operative mortality in patients requiring exploratory laparotomy for CI can reach as high as 90%,<sup>7</sup> however,

most studies show mortality rates of 50–70%.<sup>8,9</sup> This describes a mortality risk that is 2–3x that of patients without CI.

As a result, many studies have analyzed preoperative, intraoperative and postoperative data points to elucidate potential risk factors for CI. Variables that have been analyzed include perioperative hypotension, length of surgery, intraoperative blood loss, cross-clamp time and location, IMA ligation and replantation, rupture status, unilateral/bilateral hypogastric artery occlusion.<sup>10–13</sup> Postoperative data points investigated include lactic acidosis, amount of fluid sequestration, bandemia.<sup>14</sup> Unfortunately, the sensitivity of these variables alone or in aggregate have not yet reached clinical significance. That being said, further research is needed to establish a clinically reliable peri-operative algorithm to predict which patients will or will not suffer from colonic ischemia or require exploratory laparotomy as a result. Nonetheless, the physician should harbor an extremely high index of suspicion for colon ischemia in the postoperative period following AAA repair.

### Pathogenesis

There has been intense investigation into the pathogenesis of postoperative colon ischemia with hopes of prevention, improved detection and earlier intervention. The etiology and pathogenesis of CI in both the endovascular and open repair patient populations are multifactorial. For patients undergoing endovascular aneurysm repair (EVAR), CI is currently thought to be in part due to macro and micro-embolization. Multiple studies have found pathologic evidence of underlying atheroembolism associated with areas of colon ischemia.<sup>1,15</sup> The embolic origin is thought to be from dislodged debris from the aneurysm sac or iliofemoral access.<sup>1–4</sup> Open repairs typically cause a larger physiologic insult and can produce atheroemboli from cross-clamping, suture lines and manual dislodgement of

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intimal plaques. This combination likely contributes to the increased risk of CI for patients undergoing open repair in both the elective and emergent setting, as compared to endovascular repair. In addition, the pathophysiologic importance of IMA occlusion preoperatively or post stent placement, as well as the benefit of measuring IMA stump pressure and the decision of replantation versus ligation remains controversial.<sup>9,10,16–18</sup>

### Emergent repair of ruptured AAA

Historically, the operative mortality of emergent open repair of a ruptured AAA has been shown to be as high as 50–70%.<sup>8,9</sup> Multiple factors contribute to this elevated mortality including the contained or free ruptured nature of the aneurysm, preoperative hypotension and severity of shock, the patient's underlying comorbidities including multifocal vasculopathy, intraoperative blood loss, length of surgery and cross clamp time, elevated postoperative rates of stroke, myocardial infarction, colon ischemia and multi-organ system failure. The incidence of colon ischemia in this specific patient population has been shown to range from 7–60%<sup>7,13,14,19,20</sup> with mortality reaching as high as 90% in the setting of transmural necrosis.<sup>7</sup> Perry et al. found a higher incidence of operative intervention for CI in patients who underwent repair for rAAA compared to elective repair. Typically patients have had a larger physiologic insult secondary to rupture and this likely contributes to the increased incidence of transmural necrosis and need for operative intervention.<sup>5</sup> Champagne et al. performed a prospective study of patients presenting with ruptured AAAs that underwent open repair and offered all of them endoscopic screening within 48 h postoperatively. All patients were given fleet enema prior to endoscopy up to 40 cm. These investigators found that 38.7% of patients were found to have mucosal ischemia on their first postoperative colonoscopy. Six of the 18 (33%) patients initially were found to have grade III mucosal ischemia requiring emergent laparotomy and partial colon resection, and 2 of the 18 progressed to grade III ischemia at the follow-up endoscopy in 48 h, also requiring operative intervention. The overall colon ischemia related mortality was 27% and post colectomy related mortality was 55%.<sup>14</sup>

Champagne et al. used similar methodology as in their previously mentioned study and looked specifically at the incidence and mortality associated with CI after EVAR in the ruptured setting. In this study, patient who were hemodynamically stable were evaluated for EVAR suitability based on anatomy found on CT scan. In the hemodynamically unstable patient, the decision for EVAR was dependent on the surgeon. All patients were offered endoscopy within 24 h postoperative. Excluding those patients who had an intraop or immediate postoperative mortality or who refused endoscopy, colon ischemia was found in 23% of patients (8 of 36) and 2 patients required laparotomy and colon resection for grade III colon ischemia, with an overall 0% mortality.<sup>15</sup> The exceedingly low operative mortality may be explained by factors including the limited number of patients accrued, mandatory early endoscopy and non-standardized repair technique in the hemodynamically unstable patient. However, this study does begin to shed light on the true incidence of postoperative mucosal ischemia. Multiple investigators have included patients who have undergone EVAR for rAAA as part of larger cohorts but very few have sub-selected this population for further analysis likely due to the substantial selection bias, variability in the surgeon's endovascular experience and inability to randomize in the emergent setting.

### Elective repair for intact AAA

The incidence of colon ischemia in the setting of open elective AAA repair has been found to be between 1–6%,<sup>7,21,22</sup> with mortalities as high as 50%.<sup>1–5</sup> Similar incidence of CI and mortality has been found in smaller studies looking at elective endovascular AAA repair. The small sample sizes of these studies and overall low incidence

limited their ability to show statistical significance when comparing open and endovascular techniques. Perry et al. utilized a national database in 2007 and analyzed over 8,00,000 patients who underwent both open or endovascular repair of their intact AAAs. They were able to show a significant difference of CI incidence of 2.2% for open repair and 0.5% for endovascular repair. Overall, 35.7% of patients underwent a colectomy and the colectomy related mortality was 53.5%. Utilizing the NSQIP database, Zhubin et al. analyzed over 3000 patients who underwent AAA repair from 2011–12 with an overall mortality of 38.7%. Endovascular technique was used in most of the patient (80%), and they reported a CI incidence of 5.2% for open repair and 1.8% for EVAR.<sup>23</sup> However, the open repair population included patients who had ruptured aneurysms, higher complexity of aneurysmal anatomy, and/or required more perioperative transfusions. It is important to note that only 4% of the EVAR patients had a ruptured AAA, therefore this data more accurately reflects outcomes for endovascular techniques in the elective setting. A recent meta-analysis was performed which included 13 studies looking at the incidence of CI after open versus endovascular repair of intact AAAs. Three of the studies performed multivariate analyses and found the incidence of CI to be higher in the open repair group when compared to EVAR (2.1–3.6% versus 0.5–1%).<sup>24</sup>

### Clinical parameters

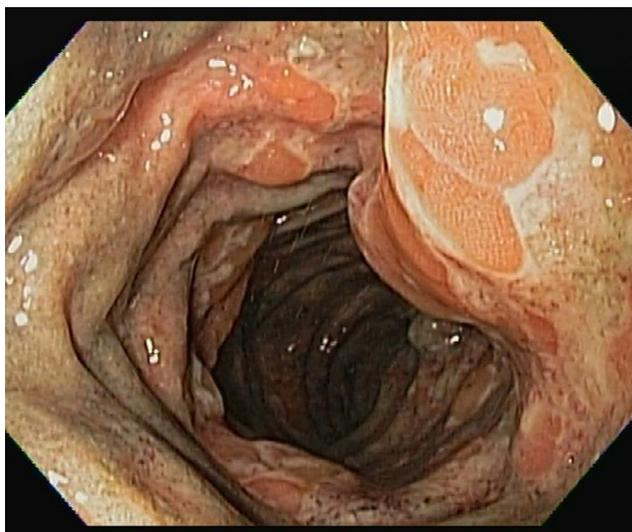
#### *Diagnosis & imaging*

The incidence of colon ischemia following AAA repair is highest in the first 48 h with 77% diagnosed within the first 4 days.<sup>23</sup> Clinical parameters that have been associated with CI include fever, tachycardia, leukocytosis, lactic acidosis, hemodynamic instability, worsening abdominal pain and bloody bowel movements. However, these clinical indicators have been found to be normal in up to 20% of patient shown to have endoscopic evidence of colon ischemia.<sup>14,15</sup>

Utilizing CT scan in a routine manner to diagnose colon ischemia is not recommended. Although CT scan is quite sensitive to diagnose bowel ischemia with the typical findings of bowel wall thickening, mucosal enhancement, mesenteric edema, pneumatosis and free air, it is not recommended for expeditious and direct evaluation of the colon. Endoscopy is the more direct and easily repeatable modality that can be performed at bedside and obviates the need for the transportation of a critically ill patient.

#### *Endoscopy*

The first study to investigate the use of flexible sigmoidoscopy in diagnosing colon ischemia after repair of AAA was performed by Hagihara et al. Forde et al. later published a paper showing the accuracy of endoscopy to assess and characterize the mucosa in the setting of colon ischemia. As described by Champagne, endoscopy reaching 40–60 cm following tap water enemas is safe within 24–48 h following emergent open or endovascular repair and it is recommended as first-line modality for the diagnosis and detection of colon ischemia. The severity of ischemia can be endoscopically described using a well-accepted grading system. Grade I describes evidence of mucosal ischemia with an elevated, edematous mucosa. (Fig. 1) Ischemic involvement of the mucosa and partial muscularis propria is described as Grade II, with evidence of mucosal edema, ulceration and sloughing. (Fig. 2) Grade III ischemia is transmural, gangrenous ischemia showing deep ulcerations, black mucosal discoloration and lack of bleeding on biopsy.<sup>14,15</sup> A recent meta-analysis by von Meijenfeldt included data from 12 studies that described routine postoperative colonoscopy or sigmoidoscopy following emergent or elective repair. The analysis included a total of 718 patients, 44% of which underwent elective repair, 56% emergent repair and 6% endovascular repair. The sensitivity and specificity for endoscopy to



**Fig. 1.** Image depicts evidence of grade I describes evidence of mucosal ischemia with an elevated, edematous mucosa.

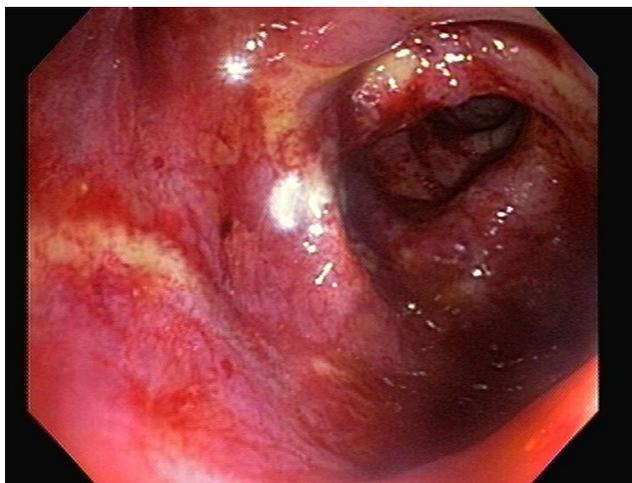
detect grade III mucosal ischemia was 0.52 (95% CI 0.31–0.73) and 0.97 (95% CI 0.95–0.99), respectively. The authors concluded “routine endoscopy is highly accurate for ruling out CI after AAA repair.” Also of note, there were no endoscopy-related adverse events found on their analysis.<sup>25</sup>

#### Management

Typically Grade I/II colon ischemia is managed non-operatively with NPO status, parenteral nutrition, intravenous antibiotics, serial abdominal exams and repeat endoscopy in 24–48 h. A monitored setting is recommended to allow for close observation of clinical status and allow rapid detection of clinical deterioration or changes warranting repeat endoscopy or surgical intervention. Approximately 10–20% of patients will progress to grade III and be considered for exploratory laparotomy.<sup>14,15</sup>

#### Surgical intervention

Patients with grade III ischemia should be offered an emergent exploratory laparotomy. An open technique is recommended to allow



**Fig. 2.** Image depicts ischemic involvement of the mucosa and partial muscularis propria is described as Grade II, with evidence of mucosal edema, ulceration and sloughing.

for expeditious resection of the ischemic colon segment with minimal hemodynamic disturbance. Laparoscopy would require insufflation of the abdomen, more radical patient positioning and typically a longer operative time, all of which can negatively impact the physiology of a critically ill patient. Surgical resection should be based on visualization of gross colonic demarcation, which typically involves the inferior mesenteric artery (IMA) distribution, i.e. the splenic flexure to the level of rectosigmoid junction. However, more extensive ischemia can be encountered which may include the more proximal colon, the rectum and the small intestine. If the ischemia is more subtle, techniques to aid in better defining the extent of ischemia include visualizing active bleeding from the serosa or cut mesenteric edges, visible and palpable pulsatile mesenteric vessels, doppler ultrasound of mesenteric vessels at the colon margin and indocyanine green (ICG) fluorescence angiography. Resection should be followed by end colostomy creation in these critically ill patients.

#### Post-operative recovery

Patients who are diagnosed with postoperative CI and require emergent colectomy, have a significantly longer length of hospital stay (up to 12 days difference).<sup>5,23</sup> In the cohort study by Perry et al., only 36% of patients with CI were discharged home, while 71% of patient without CI were discharged home. Additionally, the financial burden of CI was found to be double that of patients without CI.<sup>5</sup>

#### Conclusion

Postoperative colon ischemia in both the elective and emergent setting after AAA repair has been shown to confer a significant increase in patient morbidity and mortality. Also of note, there is an increase in length of stay, discharge to nursing facilities and overall healthcare costs. Currently there is no reliable predictive model to aid in prevention or earlier diagnosis. As a result, clinical suspicion should remain high following elective repair and routine endoscopic surveillance should be strongly considered after emergent repair. Prompt surgical management is a priority but still yields a high mortality even when expeditious.

#### Postoperative bowel ischemia after cardiac surgery

After open-heart surgery, bowel ischemia is a rare but serious complication. Studies have found the incidence to be less than 1% with an associated mortality ranging between 70–100%.<sup>26–28</sup> The diagnosis of acute mesenteric bowel ischemia can be challenging after cardiac surgery as the exam may be unreliable due to sedation and the onset of clinical signs can be subtle and variable.<sup>26–28</sup> Patients may present with an array of clinical signs and symptoms including of non-specific abdominal pain, leukocytosis, acidosis, elevated lactate, hyperosmolality, gastrointestinal bleeding, renal failure and often as a late sign, hemodynamic instability and peritonitis. In the hemodynamically stable patient, I recommend starting the work up with a CT angiogram or mesenteric angiogram. Acute mesenteric ischemia may be classified as non-obstructive or obstructive, with the latter being related to arterial embolus, atheroma-related vascular narrowing, or venous thrombosis. The most common cause of acute mesenteric ischemia after cardiac surgery is non-obstructive in nature, caused by low flow or vascular spasm. Infusion of continuous papaverine during or after angiography has been shown to be effective in counteracting non-obstructive acute mesenteric ischemia.<sup>28</sup> In occlusive mesenteric ischemia, arterial obstruction may be resolved by embolectomy or re-vascularization.<sup>28</sup> If there is venous thrombosis then the patient needs systemic anticoagulation.<sup>28</sup> In the hemodynamically unstable patient, I recommend proceeding to surgery immediately for an exploratory laparotomy with bowel resection,<sup>26</sup> Performing mesenteric angiography may delay laparotomy and

increase mortality.<sup>26</sup> I also recommend using a temporary closure so that a second look approach can be done to further assess evolution of mesenteric ischemia.

## References

1. Dadian N, Ohki T, Veith FJ, et al. Overt colon ischemia after endovascular aneurysm repair: the importance of microembolization as an etiology. *J Vasc Surg.* 2001;34:986–996.
2. Geraghty PJ, Sanchez LA, Rubin BG, et al. Overt ischemic colitis after endovascular repair of aortoiliac aneurysms. *J Vasc Surg.* 2004;40:413–418.
3. Maldonado TS, Rockman CB, Riles E, et al. Ischemic complications after endovascular abdominal aortic aneurysm repair. *J Vasc Surg.* 2004;40:703–709.
4. Zhang WW, Kulaylat MN, Anain PM, et al. Embolization as cause of bowel ischemia after endovascular abdominal aortic aneurysm repair. *J Vasc Surg.* 2004;40:867–872.
5. Perry RT, Martin MJ, Eckert MJ, et al. Colonic ischemia complicating open vs endovascular abdominal aortic aneurysm repair. *J Vasc Surg.* 2007;48:272–277.
6. Ultee KJ, Zettervall KJ, Soden PA, et al. Incidence of and risk factors for bowel ischemia after abdominal aortic aneurysm repair. *J Vasc Surg.* 2016;64:1384–1391.
7. Brewster DC, Franklin DP, Cambria RP, et al. Intestinal ischemia complicating abdominal aortic surgery. *Surgery.* 1991;109:447.
8. Hsiang YN, Turnbull RG, Nicholls SC, et al. Predicting death from ruptured abdominal aortic aneurysms. *Am J Surg.* 2001;181:30–35.
9. Ernst CB, Hagihara PF, Daughtery ME, et al. Ischemic colitis incidence following abdominal aortic reconstruction: a prospective study. *Surgery.* 1976;80:417–421.
10. Piotrowski JJ, Ripepi AJ, Yuhus JP, et al. Colonic ischemia: the Achilles heel of ruptured aortic aneurysm repair. *Am Surg.* 1996;62:557–561.
11. Meissner MH, Johansen KH. Colon infarction after ruptured abdominal aortic aneurysm. *Arch Surg.* 1992;126:979–985.
12. Poeze M, Froom AH, Greve JW, et al. D-lactate as an early marker of intestinal ischemia after ruptured aortic aneurysm repair. *Br J Surg.* 1998;85:1221–1224.
13. Levison JA, Halpern VJ, Kline RG, et al. Perioperative predictors of colonic ischemia after abdominal aortic aneurysm. *J Vasc Surg.* 1999;29:40–45.
14. Champagne BJ, Darling C, Daneshmand M, et al. Outcome of aggressive surveillance colonoscopy in ruptured abdominal aortic aneurysm. *J Vasc Surg.* 2004;39:792–796.
15. Champagne BJ, Lee EC, Valerian B, et al. Incidence of colonic ischemia after repair of ruptured abdominal aortic aneurysm with endograft. *J Am Coll Surg.* 2007;204:597–602.
16. Sheridan WG, Lowndes RH, Young HL. Intraoperative tissue oximetry in the human gastrointestinal tract. *Am J Surg.* 1990;159:314–319.
17. Senekowitsch C, Assadian A, Assadian O, et al. Replanting the inferior mesentery artery during infrarenal aortic aneurysm repair: influence on postoperative colon ischemia. *J Vasc Surg.* 2006;43:689–694.
18. Seeger JM, Coe DA, Kaelin LD, et al. Routine implantation of patent inferior mesenteric arteries limits colon infarction after aortic reconstruction. *J Vasc Surg.* 1992;15:635–641.
19. Bjorck M, Bergqvist D, Troeng T, et al. Incidence and clinical presentation of bowel ischaemia after aortoiliac surgery – 2930 operations from a population-based registry in Sweden. *Eur J Vasc Endovasc Surg.* 1996;12:139–144.
20. Becquemin JP, Majewski M, Fermani N, et al. Colon ischemia following abdominal aortic aneurysm repair in the era of endovascular abdominal aortic repair. *J Vasc Surg.* 2008;47:258–263.
21. Cohen JD, Singer P, Grunberg G, et al. outcome after elective infrarenal aortic aneurysm surgery. *World J Surg.* 1998;22:278–282.
22. Johnston KW. Multicenter prospective study of nonruptured abdominal aortic aneurysm, part II: variables predicting morbidity and mortality. *J Vasc Surg.* 1989;9:437–447.
23. Zhubin M, Sgroi M, Chen SL, et al. Risk factors and outcomes of postoperative ischemic colitis in contemporary open and endovascular abdominal aortic aneurysm repair. *J Vasc Surg.* 2016;63:866–872.
24. Williamson JS, Ambler GK, Twine CP, et al. Elective repair of abdominal aortic aneurysm and the risk of colonic Ischaemia: systematic review and meta-analysis. *Euro J Vasc Endovasc.* 2018;56:31–39.
25. von Meijenfeldt GC, Vainas T, Mistriotis, et al., et al. Accuracy of routine endoscopy diagnosing colonic ischaemia after abdominal aortic aneurysm repair: a meta-analysis. *Euro J Vasc Endovasc.* 2018;56:22–30.
26. Addoud B, Daher R, Sleilaty G. Is prompt exploratory laparotomy the best attitude for mesenteric ischemia after cardiac surgery? *Interact Cardiovasc Thorac Surg.* 2008;7:1079–1083.
27. Schutz A, Eichinger W, Breuer M, Gansera B, Kemkes BM. Acute mesenteric ischemia after open heart surgery. *Angiography.* 1998;49(April (4)):267–273.
28. Lorusso R, Giovanni M, Vizzardi E, Bonadei I, Rensulli A, Gelsomino S. Acute bowel ischemia after heart operations. *Ann Thorac Surg.* 2014;97:2219–2227.