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REVIEW

Elective Repair of Abdominal Aortic Aneurysm and the Risk of Colonic Ischaemia: Systematic Review and Meta-Analysis

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WHAT THIS PAPER ADDS

This is the largest and most contemporary analysis that demonstrates colonic ischaemia (CI) occurs more frequently in open repair (2.1–3.6%) than in EVAR (0.5–1%) in the elective setting. The majority of cases present within 7 days. There is insufficient evidence to determine whether there is a difference in rates of re-operation for CI between the two techniques but when colectomy is required, the mortality rate is high. Most randomised trials of OR versus EVAR do not specifically report colonic ischaemia and its sequelae and this should be addressed by future trials given the high morbidity and mortality.

Introduction: Colon ischaemia (CI) is a significant complication of open (OR) and endovascular (EVAR) repair of abdominal aortic aneurysm (AAA). With a rapid increase in EVAR uptake, contemporary data demonstrating the differing rates and outcomes of CI between EVAR and OR, particularly in the elective setting, are lacking. The aim was to characterise the risk and consequences of CI in elective AAA repair comparing EVAR with OR.
Methods: A systematic review and meta-analysis of the literature was performed using the Cochrane collaboration protocol and reported according to the PRISMA guidelines. PubMed, MedLine, and EMBASE were searched for studies reporting CI rates after elective AAA repair. Ruptured AAAs were excluded from analysis.
Results: Thirteen studies reporting specific outcomes of CI after elective AAA repair, containing 162,750 evaluable patients (78,151 EVAR and 84,599 OR) were included. All studies found a higher risk of CI with OR than with EVAR. Three studies performed confounder adjustment with CI rates of 0.5–1% versus 2.1–3.6% (EVAR vs. OR) and combined odds ratio of 2.7 (2.0–3.5) for the development of CI with OR versus EVAR. The majority of cases of CI occurred within 30 days and were associated with variable mortality (0–73%) and re-intervention rates (27–54%). GRADE assessment of evidence strength was very low for all outcomes. There was a high degree of heterogeneity between studies both methodologically and in terms of CI rates, re-intervention, mortality, and time to development of CI.
Conclusions: EVAR is associated with a reduced incidence of CI compared with OR.
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INTRODUCTION

Despite recent advances in the treatment of abdominal aortic aneurysm (AAA) the post-operative risk of colonic ischaemia (CI) remains. Colonic ischaemia is a serious complication and a significant cause of post-operative mortality.[1–3]

Reported rates of colonic ischaemia after intervention for AAA vary between trials, as does its relationship with mortality. It is currently unclear whether CI is more common after open repair or EVAR, with overlapping rates quoted in different trials.[4–7] Colonic ischaemia has previously been considered to be more common after OR than EVAR and, looking explicitly at ruptured AAA, a Cochrane review found a decreased risk of CI after EVAR compared with OR (odds ratio 0.39, 95% confidence interval 0.07–2.11); however, much of the data were produced by a single trial with only 116 patients.[8] Furthermore, the acceptance of EVAR has increased significantly in the last few years[9,10] and so the rate of colonic ischaemia may have changed.

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Recent randomised controlled trials of EVAR versus OR were powered to detect differences in survival and all cause mortality;[11] however CI is relatively rare and there are therefore few high quality or powered data to reflect contemporary rates of colonic ischaemia. Furthermore, the incidence of CI may increase with time after EVAR, especially with Type 2 endoleak intervention and embolisation of the inferior mesenteric artery.

The aim of this meta-analysis was to compare and pool data from the literature to identify the contemporary incidence of post-operative colonic ischaemia after elective EVAR and open AAA repair, and to assess whether there is a relationship between the type of AAA intervention and the time when CI develops.

METHODS

Data sources, search strategy, and selection criteria

A systematic review was undertaken utilising the Cochrane collaboration specified protocol,[12] and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement for the conduct of meta-analyses of interventional studies.[13] The following sources were searched without date restrictions: PubMed, Medline via OVID, Embase, the Cochrane Library Database, and the Current Controlled Trials register. Details of the protocol for this systematic review were registered on PROSPERO and can be accessed at www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42017069624.

Studies reporting CI rates after elective AAA repair were included. Exclusion criteria included articles where ruptured aneurysms could not be analysed separately and aneurysms involving the suprarenal aorta. Definition of colonic ischaemia was based on clinically detectable features of ischaemic colitis including abdominal pain and bloody diarrhoea with or without endoscopic confirmation. There was no limitation on publication type or language in the initial search. An extensive search was also conducted using the "related articles" function in PubMed, of which the results were limited to human research, with review articles excluded. The last search date was June 10, 2017. Outcome events were captured when two or more papers presented extractable data. Non-English language papers were subsequently excluded, as were papers arising, or suspected of arising, from duplicate publications.

Data extraction and outcome measures

Data extraction and assessment of methodological quality were performed independently by two of the authors. For cases of disagreement a consensus was reached among all authors. Extracted data consisted of first author, year of study, study type, and design (including whether retrospective or prospective, single or multiple centres, whether consecutive patients were enrolled), number of participants, modality of treatment (EVAR or OR), numbers of patients experiencing colonic ischaemia, confounder corrected odds ratio, or relative risk of colonic ischaemia, number, nature, and timing of re-interventions for treatment of CI. Where available, data regarding the perioperative patency, embolisation and/or endoleak intervention to visceral arteries were extracted. Data were extracted at the 1 year follow up where available, or if not given at maximum follow up.

Outcome measures were defined as

1. CI rate
2. Mortality related to CI
3. Re-intervention rate for CI and any consequences
4. Time to CI.

Assessment of study quality and evidence rating

Study quality was assessed using the Downs and Black checklist, which assigns points depending on the quality of design (maximum 11 points), external validity (maximum 3 points), study bias (maximum 7 points), confounding and selection bias (maximum 6 points), and study power (maximum 5 points).[14] Studies with a score $\geq$ 17 were considered to be of higher quality.

Rating of the quality of evidence and strength of recommendation was undertaken using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) system, according to Cochrane collaboration recommendations.[15] Quality was assessed and depended on risk of bias, indirectness of evidence, heterogeneity, imprecision of results, and publication bias. Cohort studies, by definition, have a "low" quality of evidence prior to further quality assessment. The presence of one or more serious limitations results in a "very low" grade of evidence. A serious effect on quality of evidence was considered to occur when >50% of included papers evidenced a risk of bias. Inconsistency was defined as an I^2 of greater than 50%. Indirectness was assumed not to occur in this setting. Imprecision was defined as fewer than 150 patients in either cohort. A serious effect on quality of evidence was considered to occur when greater than 50% of included papers evidenced a risk of imprecision.

Statistical analysis

Meta-analysis was undertaken in Review Manager version 5.3.5 (RevMan; Nordic Cochrane Centre, Copenhagen, Denmark). Meta-analysis was performed for dichotomous data where confounder corrected odds ratios or relative risks were available, using the odds ratio as the summary statistic, and reported with the 95% confidence interval, in line with the recommendations of the Cochrane Handbook.[12] Random effects models were used where significant heterogeneity between studies was detected. Heterogeneity was assessed using an I^2 calculation.[16]

The protocol specified that publication bias was to be assessed using funnel plots for outcomes with more than 10 studies,[17] although there were no outcomes which satisfied this criterion, so no funnel plots are presented.

RESULTS

Paper search and selection process

The initial search yielded 1190 results, and after initial screening for eligibility based on title and abstract 48 papers were retrieved for full evaluation. A total of 13 papers fulfilled the inclusion criteria and were included in the subsequent review[1,4–6,18–26] (Fig. 1). Excluded papers of note include five studies in which ruptured and elective AAA data could not be separated.[27–31] Also excluded were three randomised controlled trials[2,3,32] and four retrospective large case series[33–36] in which gastro-intestinal (GI) complications of AAA repair were reported but no specific data referring to ischaemic colitis were recorded. All included studies were case series reporting outcomes of ischaemic colitis after elective AAA repair either with EVAR, OR, or both. A total of 84,599 OR and 78,151 EVAR were available for evaluation.

Study design and baseline characteristics

Study characteristics are given in Table 1. There were six studies[1,4,5,24–26] comparing outcomes for patients treated by EVAR (76,520 patients) and OR (80,501). Three of these performed confounder adjustment, one by multivariate propensity matching of the cohorts[1] and the other two via multivariate modelling.[4,25] There were four studies reporting only EVAR[6,18,20,21] (1631 patients) and three studies reporting only OR outcomes[19,22,23] (4098 patients). Data for patients crossing over from EVAR to OR were not presented in any study. The diagnosis of colonic ischaemia was made on clinical grounds in all studies with endoscopic confirmation in four.[6,18,20,21]

There were three high quality papers as determined by the Downs and Black assessment presented in Table 1.[2,6,19] GRADE quality assessment was “very low” for all outcomes (Table 2).

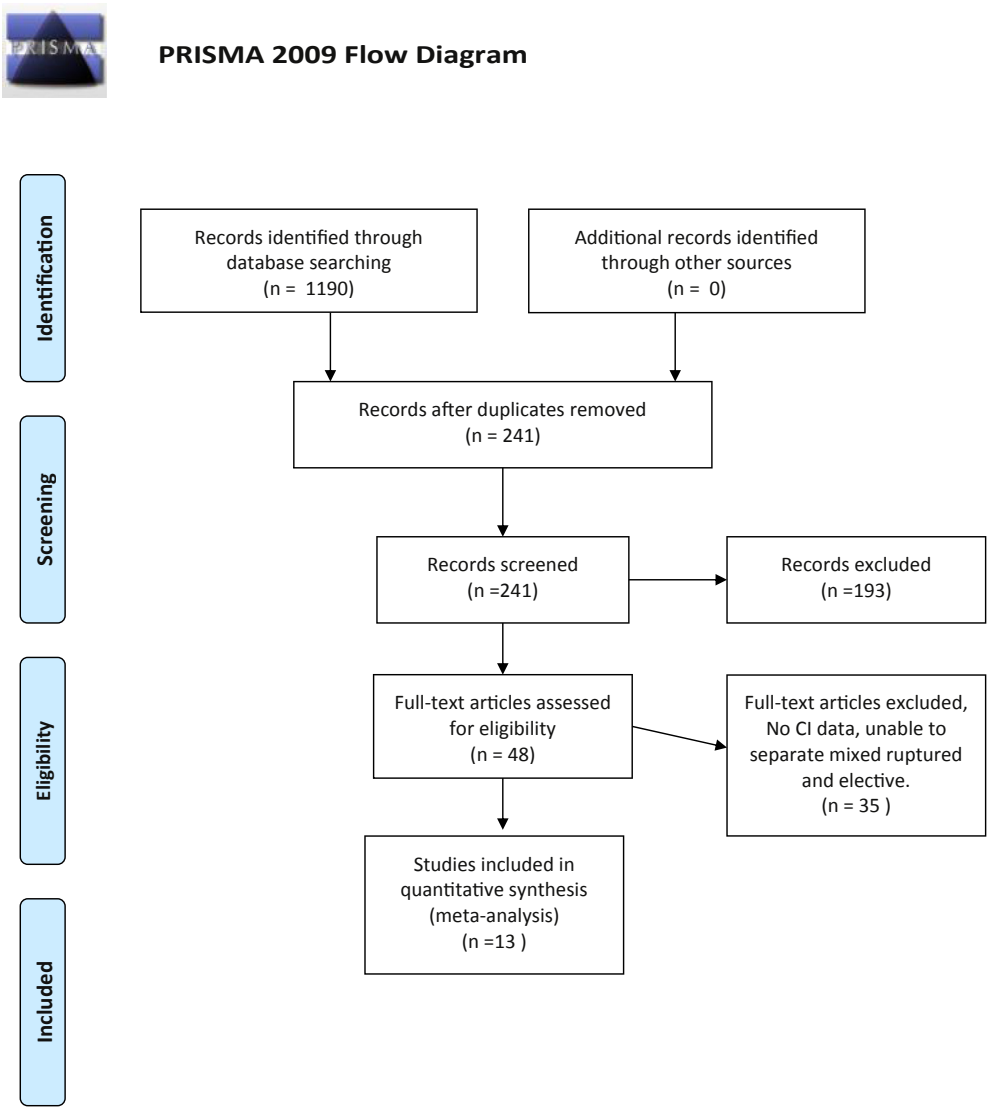

Figure 1. Inclusion process for identified studies.

Table 1. Study characteristics, demographic data, and Downs and Black scores for each paper.

Author (year)	Study period	Retro/prospective	No. of centres	Consecutive	Confounder correction	Intervention	Follow up (mo)	Patients (EVAR)	Patients (OR)	Diagnosis of CI	Outcomes	DB
Schermerhorn 2008	2001–2004	Retrospective	Multiple	N	Y	Both	48	29,542	32,056	CC	1, 2	17
Miller 2009	1996–2007	Retrospective	Single	Y	N	EVAR	12–120	809		E or C	1, 2, 3, 4	14
Valentine 1998	1994–1997	Prospective	Single	Y	N	Open	NS		120	C	1, 2, 3, 4	14
Dadian 2001	1992–2001	Retrospective	Single	Y	N	EVAR	12–108	278		E	1, 2, 3, 4	14
Geraghty 2004	2002–2004	Retrospective	Single	Y	N	EVAR	12	233		E	1, 2, 3, 4	14
Maldonado 2004	1994–2003	Retrospective	Single	Y	N	EVAR	22.5	311		E or C	1, 2, 3, 4	17
Perry 2008	2003–2004	Retrospective	Multiple	N	Y	Both	12	37,172	44,184	CC	1, 2, 3	21
Chiesa 2012	1993–2010	Retrospective	Single	Y	N	OR	Up to 17 years		3857	NS	1	9
Cruz 2001	1995–1998	Retrospective	Single	Y	N	OR	NS		121	NS	1, 2	12
Bonardelli 2012	2008–2011	Retrospective	Single	N	N	Both	36	12	303	NS	1, 2, 3, 4	7
Mehta 2005	2001–2003	Prospective	Single	Y	N	Both	18	175	232	NS	1, 3	9
Ultee 2016	2003–2014	Retrospective	Multiple	Y	Y	Both	1	4472	2196	E or C	1, 2, 3	15
Hynes 2017	2007–2013	Retrospective	Multiple	N	N	Both	48	5147	1530	NS	1, 3, 4	14

Note. Outcomes: 1, colon ischaemia (CI) rate; 2, CI mortality rate; 3, re-intervention rate; 4, time to CI. Mo = months; NS = not stated in the manuscript; DB = Downs and Black score. Diagnosis of CI: CC (clinical ICD code), E (endoscopic diagnosis), C (clinical diagnosis).

Outcomes

Outcome data for each study are presented in Table 3.

Colonic ischaemia rate

Thirteen studies reporting specific outcomes of CI after elective AAA repair, containing 162,750 patients (78,151 EVAR and 84,599 OR) were included. No randomised controlled studies reported specific CI outcomes. Six retrospective case studies directly compared CI in elective AAA between EVAR and OR. Confounder correction was performed in three of these studies, making them suitable for formal meta-analysis (Fig. 2). Colonic ischaemia rates in these three studies for EVAR (71,186 patients) versus OR (78,436 patients) were 0.5% versus 2.2%,[4] 1% versus 2.1%,[1] and 0.6% versus 3.6%.[25]

Odds ratios (95% confidence intervals) for the development of CI with OR versus EVAR were 2.19 (1.87–2.56),[1] 3.1 (2.7–3.7),[4] and 2.9 (1.8–4.7)[25] in the three studies which employed methods to correct for confounding, giving a combined odds ratio of 2.7 (2.0–3.5).

There was significant heterogeneity between these three studies, both methodologically and in terms of rates (I^2 = 80%). In the three studies which did not employ confounder correction, odds ratios were 1.003 (0.997–1.010),[5] 4.59 (0.55–38.5),[24] and 3.07 (1.17–7.98).[26]

A further seven retrospective case series were included in which three[19,22,23] reported CI rates in a total of 4098 elective open repairs and four[6,18,20,21] reported CI rates in a total of 1631 elective EVAR. Studies considering open repairs consistently published rates of CI which were higher than those studies considering EVAR.

CI mortality

There were three studies comparing EVAR to OR and of these, one reported no CI related mortality[5] and two reported significant mortality rates in the CI group: 25 out of 107 (23%) in one study[25] and 370 out of 1941 (19%) in the other.[4] In this latter paper, mortality associated with colectomy was significantly higher following EVAR than OR (73% vs. 51%, $p < .05$); however, conservative management was associated with increased survival following EVAR compared with OR (84% vs. 78%, $p < .05$). There were four studies reporting CI mortality in EVAR only patients[6,18,20,21] and of 27 cases of CI in these four papers, 11 patients (41%) died. There were two studies reporting CI mortality in OR only patients[19,23] and none of the three patients with CI died. See Table 3 for individual study mortality rates.

Re-intervention rate for CI

Re-intervention data were available in 11 papers (Table 3). Six papers reported re-intervention rates for patients undergoing both EVAR and OR and none demonstrated a significant difference in colectomy rates following EVAR compared with OR. Reported colectomy rates were variable between 27% and 100%. In one,[1] specific re-intervention rates for colonic ischaemia were not available. However,

Table 2. GRADE analysis and assessment of quality of evidence.

Outcome	EVAR (studies)	OR (studies)	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall quality of evidence
Colonic ischhaemia rate	78,151 (10)	84,599 (9)	No	Serious	Some	Serious	N/A	Very low
CI mortality	43,287 (7)	46,924 (5)	Serious	Serious	Serious	Serious	N/A	Very low
Re-intervention rate	78,151 (10)	80,412 (7)	Serious	Serious	Serious	Serious	N/A	Very low
Timing to CI	6790 (6)	1953 (3)	Serious	Serious	Serious	Serious	N/A	Very low

Risk of bias was assessed for each included paper, and was assumed to be present when a non-consecutive, or non-propensity matched cohort was analysed, or follow up did not reach 12 months.

rates of bowel resection as a complication of surgery were available and patients undergoing EVAR were less likely to undergo a small bowel resection than those undergoing OR in the first 4 years after aneurysm repair (3% vs. 3.4%, $p < .05$). In four papers reporting re-intervention rates in 1631 patients undergoing EVAR only,[6,18,20,21] 11 out of 27 with CI (41%) underwent emergency colectomy. A single paper[19] containing 120 patients reporting on OR only reported a single patient with CI treated surgically.

Time to colonic ischaemia

Seven studies reported the timing of initial signs and symptoms of colonic ischaemia. Hynes et al.[26] looked at the timing of re-operations within the first 30 days, finding that five out of 10 patients requiring intervention for CI following OR did so within the first 24 h and the remainder required intervention within the first week. Rates were similar following EVAR, with four of 14 in the first 24 h, 13 of 14 in the first week, and only one patient requiring re-intervention between 7 and 30 days. Four papers contained data on timing of development of CI after EVAR without comparison with OR.[6,18,20,21] Eighty-one per cent (22/27) of these cases occurred within 30 days and 19% (5/27) occurred after 30 days. Limited data were available for CI in OR without comparison with EVAR, with only two studies reporting on 423 patients undergoing OR. These reported two cases of CI, one of which was at 11 days and one was after 30 days.[5,19]

Peri-operative visceral arterial status

There was a single study reporting the effect of endoleak on CI and it found colonic ischaemia was associated with Type 3 but not Type 2 endoleak at the end of the procedure.[25] It was not possible to determine whether re-intervention was performed in these cases. Four studies recorded pre-procedure inferior mesenteric artery (IMA) patency and whether IMA embolisation had been performed.[6,18,21,25] It was not possible to extract data to draw specific comparisons of the effect of IMA embolisation on CI; however, in one paper, all patients who went on to develop CI following EVAR had a patent IMA pre-operatively[21] whereas the others reported between 62% and 91% of those who developed CI following EVAR had pre-existing IMA occlusions. Six studies reported on the effect of internal iliac artery (IIA) embolisation on CI. Of these, two reported a higher risk of CI with unilateral IIA embolisation,[18,25] whereas four studies reported no difference in risk of CI with either uni- or bilateral IIA embolisation.[6,20,21,24]

DISCUSSION

This analysis has identified several case series, which have compared CI rates between elective EVAR and OR. These studies are of variable quality, GRADE assessment was very low for all outcomes and only three performed any type of confounder adjustment. Meta-analysis of results from these studies suggests CI rates may be significantly higher for OR than EVAR. Outcome data for over 150,000 patients in 11 studies also demonstrated an advantage for EVAR in terms of reduced incidence of CI. It was not possible to consider comorbidities or patency of the IMA; however, in general EVAR demonstrates a lower risk of CI.

These results are similar to a recent review by Lee et al.,[37] who confirmed a reduced likelihood of CI after EVAR compared with OR (relative risk 0.22, 0.12—0.39, $p < .001$). However this analysis included both ruptured and elective AAA and contained older studies with a smaller number of patients and did not employ confounder correction. For ruptured AAA, a recent Cochrane review found a decreased risk of CI after EVAR compared with OR (odds ratio 0.39, 95% confidence interval 0.07—2.11); however, this relied upon a single randomised trial with only 116 patients.[8,38]

Peri-operative mortality was significantly lower in a recent meta-analysis of four randomised trials comparing EVAR with OR.[11] However, this early survival advantage is lost by 3 years, principally due to aneurysm specific complications, although patients with low ankle brachial pressure index experienced worse long-term survival with EVAR than with OR. There were insufficient data to determine whether colonic ischaemia was a factor in this. From this analysis, when CI occurs, it is usually identified within 30 days and is associated with a significant mortality rate, particularly when colectomy is required.

In several large randomised controlled trials, there were no available data for CI rates. Instead the authors reported less specific complications such as the need for re-laparotomy or GI intervention.[2,3,32,39,40] In one large series, there was an increased risk of small bowel resection following OR compared with EVAR and although the cause was not identified there was an associated increased risk of adhesion and hernia related bowel obstruction after OR and this is likely to be related. There were insufficient data to determine whether re-intervention rates for treatment of CI differed between OR and EVAR and were broadly similar in the larger series. Future randomised controlled trials should specifically report CI outcomes when comparing both procedures. This is particularly relevant as more patients with prohibitive risk factors for surgery are being offered EVAR.[41]

Table 3. Outcome data for each study.

Author (year)	Intervention	CI rate % (EVAR)	CI rate % (OR)	CI mortality rate	Re-intervention rate EVAR	Re-intervention rate OR	Time to CI	Pre-operative visceral arterial status	IMA intervention	IIA intervention
Schermerhorn 2008	Both	1	2.1	NS	"bowel resection" 3% $p = .02$	Bowel resection 3.4% $p = .02$	NS	NS	NS	NS
Miller 2009	EVAR	1.4	NS	4 of 11	3 of 11	NS	7/11 within 30 days, 4/11 after 30 days	IMA and IIA patency	10/11 with CI had pre-existing IMA occlusion	Unilateral IIA embolisation increased risk of CI. No comparable IMA data
Valentine 1998	OR	NS	0.83	0 of 1	NS	1 of 1	11 days	CA and SMA not IMA, IIA	No difference in GI complications	NS
Dadian 2001	EVAR	2.9	NS	3 of 8	2 of 8	NS	7 of 8 within 30 days, 1 within 6 months	IMA and IIA patency/ embolisation	5/8 with CI had preop occluded IMA. No comparable data without CI	No effect on CI rates with uni- or bilateral IIA embolisation
Geraghty 2004	EVAR	1.7	NS	2 of 4	3 of 4	NS	2 ± 1.4 days	IMA not reported. IIA patency/ embolisation reported	NS	No effect on CI rates with uni- or bilateral IIA embolisation
Maldonado 2004	EVAR	1.2	NS	2 of 4	3 of 4	NS	$3 < 12$ h, $1 < 7$ days	IMA and IIA patency/ embolisation	All with CI had patent IMA preop	No effect on CI with preop uni- or bilateral IIA embolisation
Perry 2008	Both	0.5	2.2	37.8%	27% colectomy $p < .01$	31% colectomy $p < .01$	NS	NS	NS	NS
Chiesa 2012	OR	NS	3	NS	NS	NS	NS	NS	NS	NS
Cruz 2001	OR	NS	1.6	0 of 2	NS	NS	NS	NS	NS	NS
Bonardelli 2012	Both	0	0.3	0 of 1	0 of 0	0 of 1	After 30 days	NS	NS	NS
Mehta 2005	Both	0.6	2.6	NS	1 of 1	6 of 6	NS	Data could not be extracted	NS	No patients developed CI where bilateral IIA sacrifice performed
Utlee 2016	Both	0.6	3.6	25/107 (23%)	14/26 (54%)	37/78 (47%)	NS	IMA and IIA patency/ embolisation/ reimplantation	Higher risk of CI if IMA reimplantation performed in OR	Higher risk of CI if unilateral IIA ligation/ embolisation in OR and EVAR
Hynes 2017	Both	0.3%	0.7%	NS	11/13	10/11	$9/24 < 24$ h, $18/19 < 7$ days	NS	NS	NS

IMA = inferior mesenteric artery; IIA = internal iliac artery; NS = not stated in the manuscript; CI = colonic ischaemia; CA = coeliac artery; SMA = superior mesenteric artery.

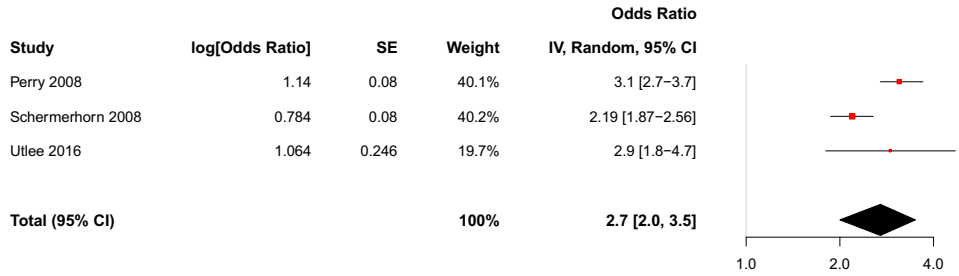

Figure 2. Forest plot comparing rates of colonic ishachemia between open repair (OR) and EVAR in studies employing techniques for multivariate confounder correction. Higher odds ratios imply higher rates among patients undergoing OR. Heterogeneity, tau-square = 0.05; chi-square = 10.06, d.f. = 2 ($p = .007$); $I^2 = 80\%$. Test for overall effect, $Z = 6.81$ ($p < .00001$).

The benefit of a selective approach to EVAR use in more frail patients is not clear[42] and the relative contributions of comorbidity and specific complications such as CI to survival and long-term outcomes from both EVAR and OR will be more difficult to interpret.

The physiological basis for CI after AAA repair is likely to be multifactorial and may explain the differences in CI rates. During open surgery a significant factor is aortic cross clamping causing ischaemia and reperfusion injury of the colon. One study found a threefold increase in colonic mucosal apoptosis in biopsies obtained immediately after surgery compared with EVAR. There were also significant rises in peripheral pro-inflammatory cytokines including tumour necrosis factor α compared with no evidence of apoptosis and much lower cytokine release following EVAR.[43] In the case of EVAR, a possible cause of CI is occlusion of the IMA. The effect of this on CI is unclear but is commonly performed in both EVAR and OR. One study attempted to address this by randomising 160 patients to IMA ligation or re-implantation during OR and found no difference in CI rates.[44] To perform EVAR, one and occasionally both internal iliac arteries need to be covered. A case control study demonstrated a tendency towards higher risk of CI after bilateral internal iliac artery ligation compared to unilateral ligation during open repair.[28] However, a review of 278 EVARs found that of eight developing CI, only one underwent internal iliac artery embolisation. The remaining 121 who underwent uni- or bilateral internal iliac embolisation showed no evidence of CI.[6] Furthermore, of the eight with CI, four had evidence of distal emboli within colonic arterioles because of embolisation from the aorta.

In the present analysis, data regarding the effect of peri-operative visceral arterial embolisation were limited and contradictory and no firm conclusions can be drawn from the available literature. Various techniques have been employed to improve detection and reduce the risk of CI including intra-operative intravenous fluorescein,[45] early post-operative sigmoidoscopy,[7] and intra-operative laser doppler flowmetry[46] although none is reliable for routine clinical practice.

Factors contributing to CI are emergency open repair for rupture and associated parameters such as blood loss, pre-existing renal and respiratory morbidity and length of surgery.[27,30,47]

The strengths of the analysis are that a large number of outcome parameters were available for analysis. All showed a higher rate of CI with OR. Unfortunately, most studies were poorly designed with limited or no evidence of cohort matching. Furthermore, the majority did not clearly describe how colonic ischaemia was diagnosed and definitions were largely based on clinical grounds with only limited descriptions of endoscopic confirmation.

It is notable many studies did not report the timing of onset of CI. Many studies did not use routine post-operative sigmoidoscopy and it is certainly possible minor and self limiting CI may not have been detected and only those with severe CI included in the analysis thereby increasing reported mortality and re-intervention rates. Several series reported onset of CI more than 30 days after initial treatment and may represent a different pathological process. Unfortunately, it was not possible to accurately confirm this from the data available. A sensitivity analysis was not possible due to the limited number of directly comparable studies. Furthermore, it was not possible to extract and meta-analyse data for confounding factors such as renal impairment, comorbidity, management of endoleaks, IMA ligation and/or re-implantation, transfusion requirements, length of stay, and operative time or technique including use of intra-operative Doppler monitoring of colonic perfusion or mesenteric artery re-implantation.

CONCLUSION

During elective procedures for treatment of AAAs, EVAR is associated with reduced frequency of CI compared with OR. When it occurs, CI is associated with significant mortality rates. Should emergency colonic resection be required mortality rises to over 50% in most studies. It is not clear if there is a difference in CI related mortality or colectomy rates between EVAR and OR; however, when it does occur, most cases present within 7 days for both procedures.

CONFLICT OF INTEREST

None.

FUNDING

None.

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