Concurrent Colorectal Malignancy and Abdominal Aortic Aneurysm: A Multicentre Experience and Review of the Literature☆

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KEYWORDS
- Aortic aneurysm
- Colorectal cancer
- Endovascular aortic repair

Summary Objectives: There is lack of consensus regarding concurrent vs. staged approaches, and the prioritisation of staged procedures in cases presenting with colorectal carcinoma (CRC) and abdominal aortic aneurysm (AAA) synchronously. We aim to present our experience, review the literature on this therapeutic dilemma and examine the role of endovascular aortic repair (EVAR).

Design, materials and methods: An observational study of the experience of two centres and a systematic review of the published literature.

Results: Twenty-four patients were identified from the prospective databases of two tertiary referral centres between 2001 and 2006. Intervention for both malignancy and aneurysm was performed in 13 patients. In 10 patients, cancer resection was performed initially and was followed by open aneurysm repair (n = 3) or EVAR (n = 7). Two patients (AAA diameters: 7.0 and 8.0 cm) underwent EVAR prior to colonic resection. One patient was selected for synchronous surgery. There were no interval AAA ruptures, graft infection or postoperative mortalities.
The synchronous presentation of colorectal carcinoma (CRC) and abdominal aortic aneurysm (AAA) is uncommon. The true incidence is difficult to accurately ascertain, but has been reported as being between 0.49% and 2.1%. It is likely this incidence will increase in an ageing population. Concurrence may be attributable to similar patient demographics (increasing age) and common risk factors (smoking). Alternative postulated mechanisms include immunological responses and disturbances in the relationship of epithelia to the connective tissue matrix. Presentation with this dual pathology represents a significant surgical challenge in the absence of a clear consensus from the surgical literature on the optimal management of these patients. When surgery is indicated, a decision needs to be made on whether a combined or staged approach should be adopted. Advocates of combined surgery report excellent result with minimal delay in the treatment of either pathology, minimising the risk of disease progression or rupture. There is prevailing concern among critics with respect to this policy of the risk of graft infection and prolonged operative procedure time and trauma. A policy of staged procedures partially alleviates these concerns, but a decision on prioritising either pathology makes it a less straightforward option.

Initial resection of CRC followed by staged aneurysm repair is undermined by the potential risk of aneurysmal rupture after the cancer operation. Endovascular aortic repair (EVAR) is a promising alternative to open repair. Evidence from numerous multicentre trials demonstrate decreased perioperative morbidity and mortality, shorter hospital stays and reduced need for general anaesthesia when compared with open repair. Does EVAR introduce another variable into this already complex therapeutic paradigm, or does it negate some of the issues related to the management of concurrent CRC and AAA, thereby simplifying treatment planning?

This study aims to examine the recent experience at two centres in treating patients presenting with concurrent CRC and AAA, review the published literature on this subject and explore the role of EVAR in this context.

Materials and Methods

Consecutive patients with concurrent CRC and non-ruptured aorto-iliac aneurysmal disease were identified from the databases of prospective colorectal cancer from two units between 2001 and 2006. The patient demographics, aneurysm size and classification and site and stage of primary CRC were recorded. The planned and actual course of management, including the type of colonic resection and aneurysm repair, as well as outcomes, was identified.

Results

Patient Demographics

Twenty-four patients with median age of 74 years (range: 60–94 years) were presented over this 5-year period; of these, 83% were male. Five cases were tertiary referrals from outside centres. Median follow-up was 16.5 months (range: 0.5–176 months) (Table 1).

AAA and CRC Characteristics

All instances of CRC and AAA were diagnosed preoperatively and no new diagnoses were made at operation. Twelve of the 24 cases of AAA were incidental findings during investigations for CRC. In three patients, CRC was diagnosed on radiological assessment of a known aneurysm.

The AAA types were infrarenal (n = 14, 58%), juxtarenal (n = 5, 21%), suprarenal (n = 3, 13%) and thoraco-abdominal (n = 2, 8%). The median AAA size was 6.0 cm (range: 3.5–8.5 cm). The CRC stages diagnosed were Duke’s A (n = 2, 8%), Duke’s B (n = 10, 42%), Duke’s C (n = 9, 37.5%) and Duke’s D (n = 3, 12.5%). Left-sided CRC constituted 17 of the cases, while six were right sided and one CRC was located within the transverse colon.
<p>| Patient | Gender | Age (years) | Type | Size (cm) | Site | Stage (Duke) | AAA Intervention(s) | CRC Intervention(s) | Length of stay days | Post-CRC surgery | Post AAA repair | Complications | Interval (months) | Period of follow-up (months) | Death (months) |
|---------|--------|-------------|------|-----------|------|--------------|---------------------|---------------------|---------------------|------------------|-----------------|---------------|----------------|---------------------|---------------------|----------------|
| Male 72 | Male   | 72          | SR   | 8.5       | Distal| B            | Combined Open AAA then CRC | Staged EVAR then CRC | 11                  | 12               | —               | Intra-operative bleed delayed CRC resection | 2                   | 6                   | —                   |
| Male 83 | Male   | 83          | IR   | 7.0       | Descending | A | Staged EVAR then CRC | EVAR then CRC | 7                  | 49               | —               | Post-EVAR: distal type I EL re-explored and complicated by postprocedural MI, AF, ARF requiring CVVHDF, and a slow ventilatory wean; 14d ICU stay | 2                   | 17                  | 22.5 (unrelated) |
| Male 79 | Male   | 79          | IR   | 8.0       | Sigmoid | B | Staged EVAR then CRC | EVAR then CRC | 9                  | 6               | —               | —              | 1.5           | 16                  | —                   |
| Male 86 | Male   | 86          | JR   | 6.8       | Ascending | C | Staged CRC then EVAR | EVAR then EVAR | 5                  | 6               | —               | —              | 25           | 60                  | —                   |
| Male 75 | Male   | 75          | IR   | 6.0       | Transverse | C | Staged CRC then EVAR | EVAR then EVAR | 5                  | 6               | Palliative chemo at 1 year | EVAR stent-graft occlusion at 6 wks; left axillo-fem and fem-fem cross-over | 5.5          | 12                  | 21 (CRC recurrence) |
| Male 65 | Male   | 65          | IR   | 6.9       | Ascending | C | Staged CRC then EVAR | EVAR then EVAR | 57                 | 7               | Adjuvant chemo between interventions Post right hemi: MI and cardiac arrest; anastomotic leak with laparotomy. Post EVAR: type II EL managed conservatively; resolved at 12 m. | Adjuvant chemo between interventions Post EVAR: bilateral groin haematomas; further endovascular intervention at 1wk; left CIA occlusion; fem-fem cross-over | 13          | 176                 | —                   |
| Male 68 | Male   | 68          | IR   | 7.0       | Ascending | B | Staged CRC then EVAR | EVAR then EVAR | 13                 | 7               | Adjuvant chemo between interventions Post EVAR: bilateral groin haematomas; further endovascular intervention at 1wk; left CIA occlusion; fem-fem cross-over | Adjuvant chemo between interventions Post EVAR: bilateral groin haematomas; further endovascular intervention at 1wk; left CIA occlusion; fem-fem cross-over | 2           | 72                  | —                   |
| Male 70 | Male   | 70          | IR   | 6.2       | Rectum | C | Staged CRC then EVAR | EVAR then EVAR | 16                 | 8               | Adjuvant chemorad between interventions Post AR + rad: radiation proctitis; second laparotomy and proctectomy | Adjuvant chemorad between interventions Post AR + rad: radiation proctitis; second laparotomy and proctectomy | 22          | 72                  | —                   |</p>
<table>
<thead>
<tr>
<th>Gender</th>
<th>Age</th>
<th>Location</th>
<th>Stage</th>
<th>Diagnosis</th>
<th>Treatment</th>
<th>Follow-Up</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>60</td>
<td>Hepatic</td>
<td>D</td>
<td>Staged CRC then EVAR</td>
<td>Adjuvant chemo between interventions</td>
<td>Post EVAR: type II EL managed conservatively; resolved at 3 m</td>
<td>8</td>
</tr>
<tr>
<td>Male</td>
<td>72</td>
<td>Sigmoid</td>
<td>C</td>
<td>Staged CRC then EVAR</td>
<td>Adjuvant chemo post EVAR</td>
<td>Post EVAR: type I EL at 1 wk; aortic cuff applied</td>
<td>2.5</td>
</tr>
<tr>
<td>Male</td>
<td>73</td>
<td>Rectum</td>
<td>A</td>
<td>Staged CRC then Open AAA</td>
<td>–</td>
<td>Colovesical fistula managed conservatively</td>
<td>–</td>
</tr>
<tr>
<td>Male</td>
<td>73</td>
<td>Sigmoid</td>
<td>B</td>
<td>Staged CRC then Open AAA</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Male</td>
<td>75</td>
<td>Sigmoid</td>
<td>C</td>
<td>CRC Only</td>
<td>–</td>
<td>Colo-rectal cancer managed conservatively</td>
<td>–</td>
</tr>
<tr>
<td>Male</td>
<td>85</td>
<td>Mid</td>
<td>B</td>
<td>CRC Only</td>
<td>–</td>
<td>Post-CRC: wound infection with VAC dressing</td>
<td>–</td>
</tr>
<tr>
<td>Male</td>
<td>83</td>
<td>Caeccum</td>
<td>B</td>
<td>CRC Only</td>
<td>–</td>
<td>Neoadjuvant therapy</td>
<td>–</td>
</tr>
<tr>
<td>Male</td>
<td>69</td>
<td>Rectum</td>
<td>B</td>
<td>CRC Only</td>
<td>–</td>
<td>Neoadjuvant radiotherapy</td>
<td>–</td>
</tr>
<tr>
<td>Male</td>
<td>81</td>
<td>Hepatic</td>
<td>C</td>
<td>CRC Only</td>
<td>–</td>
<td>Palliative chemotherapy</td>
<td>–</td>
</tr>
<tr>
<td>Female</td>
<td>85</td>
<td>Splenic</td>
<td>B</td>
<td>CRC Only</td>
<td>–</td>
<td>Death prior to planned palliative chemotherapy</td>
<td>–</td>
</tr>
<tr>
<td>Male</td>
<td>87</td>
<td>Rectum</td>
<td>C</td>
<td>CRC Only</td>
<td>–</td>
<td>Palliative chemotherapy + de-functioning</td>
<td>–</td>
</tr>
<tr>
<td>Female</td>
<td>73</td>
<td>Rectum</td>
<td>C</td>
<td>Palliative</td>
<td>–</td>
<td>Palliative chemotherapy</td>
<td>–</td>
</tr>
<tr>
<td>Male</td>
<td>90</td>
<td>Rectum</td>
<td>B</td>
<td>Palliative</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Female</td>
<td>94</td>
<td>Rectum</td>
<td>D</td>
<td>Palliative</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Female</td>
<td>73</td>
<td>Sigmoid</td>
<td>D</td>
<td>Palliative</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

There was no incidence of graft infection or aneurysm rupture.

Surgical Management

Decisions regarding operation and the sequence of interventions were made between colorectal and vascular multidisciplinary teams (MDTs). It was a policy to consider EVAR in all patients in whom endovascular repair was technically feasible.

Intervention for both malignancy and aneurysm was indicated and performed in 13 patients (Fig. 1) with operable CRC and median aneurysmal diameter of 6.5 cm (range: 5.6–8.5 cm). In 10 patients, cancer resection was performed initially, followed by EVAR in seven patients and open aneurysm repair in three patients with juxtarenal aneurysms. The median aneurysmal size was 6.1 cm (range: 5.5–7 cm), and interval to AAA repair was 8 months (range: 2–25 months).

Two patients with AAAs measuring 7 and 8 cm, respectively, underwent aneurysm repair by EVAR prior to CRC resection. The intervals to CRC resection were 2 and 1.5 months, respectively. Combined surgery was attempted in one patient with an 8.5 cm suprarenal AAA and a descending colon carcinoma, but due to bleeding only the AAA was repaired. Successful left hemicolectomy was undertaken 2 months later. In total, AAA was repaired by endovascular technique in nine cases, and open surgery in four juxtarenal and suprarenal aneurysms.

Seven patients underwent potentially curative resection of their tumour alone. The median AAA size was 5.5 cm (range: 4.0–7.5 cm). In four of these patients, elective AAA repair was not indicated based upon aneurysmal diameter (4.0, 4.3 and 5.2 cm infrarenal and 5.5 cm thoracoabdominal). One patient with a 5.8 cm infrarenal AAA is having his aneurysm managed by best medical therapy and surveillance. The vascular MDT made this decision based upon a high cardiovascular risk for open aneurysm-repair surgery and anatomical unsuitability for EVAR. One patient developed cancer recurrence post-resection; therefore, repair of the 6.6 cm infrarenal AAA was not undertaken, with non-aneurysm-related death at 16 months. The final patient in this group had a complicated course post-CRC surgery and was subsequently deemed unfit for repair of his 7.5 cm infrarenal aneurysm, followed by unrelated death at 6 months. At median follow-up of 12 months (range: 3–72 months), none of these aneurysms exhibited significant dimensional changes. No patients had AAA repair performed alone.

Table 1 provides the factors delaying the second procedure in a staged plan, including chemoradiotherapy, length of stay (LoS) and postoperative complications. One patient with a 6.2 cm infrarenal AAA had adjuvant chemoradiotherapy between colon cancer and EVAR. Post-radiotherapy complications resulted in a time gap of 22 months, without interval aneurysmal rupture. There were no other significant delays in receiving adjuvant treatment, colorectal surgery or AAA repair.

Four patients with advanced malignancy (n = 2) or severe co-morbidities (n = 2) received palliative care only. In this group, the median AAA size was 5.9 cm (range: 3.5–8.5 cm).

Length of Stay

The median LoS was 13 days (range: 4–63 days) following CRC resection, 7 days following EVAR (range: 4–49 days) and 12.5 days following open AAA repair (range: 7–14 days). The median total LoS was 20 days for CRC resection followed by EVAR, 23 days for CRC resection followed by open AAA repair, 35.5 days for EVAR followed by CRC resection.

The management of concurrent colorectal malignancy and aorto-iliac aneurismal disease.

AAA abdominal aortic aneurysm; CRC colorectal cancer; EVAR endovascular aortic repair.

Concurrent disease N=24
  No surgery indicated N=4
  Palliation

  One procedure indicated N=7
  AAA repair N=0
  CRC resection N=7

  Two procedures indicated N=13
  CRC resection first N=10
  AAA repair first
  Planned N=2 (EVAR)
  Actual N=3
  Joint procedure Planned N=1
  Actual N=0
  Proceed to open repair N=3
  AAA rupture N=0
  Proceed to EVAR N=7
  Graft Infection N=0

Figure 1 The management of concurrent colorectal malignancy and aorto-iliac aneurismal disease. AAA abdominal aortic aneurysm; CRC colorectal cancer; EVAR endovascular aortic repair.
resection and 23 days for open AAA repair followed by CRC resection.

Morbidity and Mortality
With regards to EVAR, there were four cases of endoleak; of these, two were type II—treated conservatively and shown to have resolved on follow-up computed tomography (CT). There were two cases of stent-graft occlusion, with both requiring bypass.

Two patients had EVAR prior to CRC resection, one having a prolonged admission of 49 days for a distal type I endoleak with re-exploration and a complicated post-operative course. Combined resection was planned in one patient; however, bleeding during repair of the 8.5 cm suprarenal aneurysm prevented proceeding to CRC resection, which was safely performed 2 months later. There was no incidence of aortic graft sepsis in these three patients at 6, 16 and 17 months.

Ten of the 24 patients died at the median period of 16 months after the intervention (range: 2.5–74.5 months), including three of the four patients undergoing palliative care. Five of the seven patients who had CRC surgery alone died: one was an in-hospital mortality following complicated re-admission after anterior resection; two were due to recurrence of Duke C stage cancer and two were unrelated deaths. A patient who had EVAR followed by cancer resection died of unrelated causes at 2 years after the procedure. Another patient who underwent resection of Duke C CRC followed by EVAR died of metastatic recurrence at 21 months.

Aortic Surveillance
All patients had regular CT surveillance following EVAR (n = 9). In patients who had staged surgery with CRC resection initially (n = 10, median AAA size 6.1 cm) or colonic resection alone (n = 7, median AAA size 5.5 cm), there was no evidence of aneurysmal sac expansion or complications on surveillance CT scans.

Review of the Literature
A summary of the published literature on the management of concurrent colorectal malignancy and aorto-iliac aneurysmal disease is seen in Table 2. Large series, describing the management of greater than 10 cases, are outlined in Table 3.

The literature review revealed 38 publications involving 269 cases of co-existing CRC and AAA. Of these, 101 were treated by a combined approach. A staged approach was taken in a further 142 cases, with the priority being CRC in 80 and AAA in 28 of these cases. In the remaining 34 cases of staged management, the pathology treated first was not declared. Importantly, in 18 cases, the use of EVAR was described.

Mortality
Among the 269 cases, inpatient mortality rate was 4% (n = 11). A total of 18 (23%) mortalities, both early (within 30 days of intervention) and late, were recorded among the 80 patients who had CRC resection initially; six deaths (8%) were related to AAA. In cases where AAA repair was undertaken first (n = 28), there were seven mortalities (25%), including one late death from aortic graft infection (4%). Seven deaths were reported among the 101 patients who had combined surgery (7%); of these, three were early deaths (3%). Baxter et al. found that patients undergoing open AAA repair followed by CRC resection (n = 7) — compared with combined surgery or staged with CRC resection first — had the highest mortality rate (29%), although this was not statistically significant.

Morbidity
Interval Aortic Rupture in Staged Surgery
Hypotheses pertaining to interval AAA rupture include the induction of matrix metalloproteinases, which degrade extracellular matrix components in the aneurysm wall, cytokine release and activation, impaired nutrition, factors related directly to surgical dissection and steroid use and chemotherapy.1,2,6,7,16–18,23 Of the 80 reports of staged surgery where CRC was performed first, there were nine (11%) interval AAA ruptures. Four (5%) were in the early postoperative period (median size: 6.0 cm), and five (6%) were late ruptures (median size: 6.3 cm). There was also one late thrombosis of a 7.5 cm AAA (1%).2 Of these 10 complicated interval aneurysms, eight were 6 cm or larger (10% complication rate), whilst two were less than 6 cm (2.5% complication rate). There were no instances of interval rupture in AAAs less than 5 cm in size.

Aortic Graft Infection
Aortic graft infection is one of the most feared complications. Although a number of authors expressed concern over this potential risk with simultaneous surgery,14,15 in the context of concurrent CRC and AAA the risk appears low. Porcellini et al. reported a single mortality at 23 months from sepsis due to aortic graft infection. This followed a left hemicolectomy without anastomotic leak 15 days after open AAA repair.

CRC Morbidity
There were no documented cases of a CRC becoming non-resectable (due to local or systemic progression) following a delay in cancer treatment post-AAA repair. Baxter et al. found a significant delay from CRC diagnosis to resection in patients undergoing AAA repair performed first (median delay: 122 days), compared with those undergoing CRC resection first (median delays of 4 and 8 days, stratified by AAA size) and those undergoing combined surgery (15 days) (P < 0.0001).6 Clinical significance, such as stage migration and cancer-specific outcome differences while awaiting surgery, is not clear.

There were no published reports of sigmoid colon ischaemia following right-sided CRC resection followed by AAA repair. A total of six (2%) colonic anastomotic complications were reported — four (4%) with combined surgery, one (4%) following staged surgery with AAA repair first and one (1%) post staged intervention with CRC resection first.

EVAR in Concurrence
Five recent publications stated the importance and recommended the use of EVAR in concurrent AAA and CRC
### Table 2  Summary of the review of the published literature on the management of concurrent colorectal malignancy and aorto-iliac aneurysmal disease

<table>
<thead>
<tr>
<th></th>
<th>Combined repair</th>
<th>AAA repair first</th>
<th>CRC resection first</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of cases</strong></td>
<td>101</td>
<td>28</td>
<td>80</td>
<td>269 (including our series; not all intervened upon); 142 staged approach (priority of repair not declared in all cases);</td>
</tr>
</tbody>
</table>

#### Mortality

<table>
<thead>
<tr>
<th></th>
<th>Early (≤30 days)</th>
<th>Late (&gt;30 days)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AAA-related</td>
<td>AAA-related</td>
<td>Total</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3 (3%)</td>
<td>2 (7%)</td>
<td>6 (8%)</td>
</tr>
<tr>
<td></td>
<td>4 (4%)</td>
<td>5 (18%)</td>
<td>12 (15%)</td>
</tr>
</tbody>
</table>

#### Complications

<table>
<thead>
<tr>
<th></th>
<th>Early (≤30 days)</th>
<th>Late (&gt;30 days)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Colonic graft infection</td>
<td>Colonic graft infection</td>
<td>Colonic anastomotic</td>
</tr>
<tr>
<td><strong>Interval AAA rupture</strong></td>
<td>4 (4%)</td>
<td>5 (6%)</td>
<td>9 (11%) (note also 1 late thrombosis of 7.5 cm AAA (1%))</td>
</tr>
<tr>
<td></td>
<td>1 (4%)</td>
<td>1 (4%)</td>
<td>1 (4%)^31</td>
</tr>
<tr>
<td></td>
<td>4 (4%)</td>
<td>1 (4%)</td>
<td>4 (4%)</td>
</tr>
</tbody>
</table>

AAA abdominal aortic aneurysm; CRC colorectal cancer; EVAR endovascular aortic repair.
<table>
<thead>
<tr>
<th>Article</th>
<th>Ref.</th>
<th>Total number of cases</th>
<th>Number of combined repair</th>
<th>Total</th>
<th>CRC repair first</th>
<th>AAA repair first</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current study</td>
<td>17</td>
<td>1 (planned but not completed)</td>
<td>9 (EVAR not used)</td>
<td>5</td>
<td>5 (three AAA subsequently repaired by EVAR)</td>
<td>1 (unplanned)</td>
<td>See Discussion One-stage intervention is preferred due to the lower morbidity, avoiding a second surgical and anaesthetic insult. EVAR is a possible solution to aid the one-stage procedure.</td>
</tr>
<tr>
<td>Veraldi et al.</td>
<td>4</td>
<td>14</td>
<td></td>
<td>4</td>
<td>0</td>
<td>4 (three EVAR)</td>
<td>One-stage approach advocated as safe.</td>
</tr>
<tr>
<td>Georgopoulos et al.</td>
<td>10</td>
<td>11</td>
<td>11 (two unspecified complications)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>One-stage approach is well tolerated and can avoid the time, financial costs and patient anxiety. EVAR not used routinely in Japan due to cost considerations.</td>
</tr>
<tr>
<td>Matsumoto et al.</td>
<td>11</td>
<td>16</td>
<td>12 (no complications)</td>
<td>4</td>
<td>(not mentioned)</td>
<td>(not mentioned)</td>
<td>(continued on next page) Use a one-stage approach with AAA thrombo-exclusion with right-sided CRC or a temporary transverse colostomy for left-sided CRC. APR can be done simultaneously with AAA repair via a transperitoneal approach.</td>
</tr>
<tr>
<td>Baxter et al.</td>
<td>6</td>
<td>83</td>
<td>12</td>
<td>71</td>
<td>Total 6444 with AAA &lt;5 cm20 with AAA &gt;5 cm (complicated by two interval AAA ruptures)</td>
<td>7 (AAA &gt;5 cm)</td>
<td>Largest series of patients. Comments: 1. AAA &lt;5 cm: Resect CRC first, followed by AAA surveillance. 2. AAA &gt;5 cm: The authors recognise the risk of rupture vs. the delay to treat CRC. 3. Concomitant treatment of both may be beneficial, especially in right-sided CRC.</td>
</tr>
<tr>
<td>Matsumoto et al.</td>
<td>12</td>
<td>14</td>
<td>7 (no operative mortality or morbidity)</td>
<td>7</td>
<td>3</td>
<td>4</td>
<td>(continued on next page) Use a one-stage approach with AAA thrombo-exclusion with right-sided CRC or a temporary transverse colostomy for left-sided CRC. APR can be done simultaneously with AAA repair via a transperitoneal approach.</td>
</tr>
</tbody>
</table>

Concurrent Colorectal Malignancy & Aortic Aneurysm
Table 3 (continued)

<table>
<thead>
<tr>
<th>Article</th>
<th>Ref.</th>
<th>Total number of cases</th>
<th>Number of combined repair</th>
<th>Staged approach</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CRC repair first</td>
<td>AAA repair first</td>
</tr>
<tr>
<td>Robinson et al.</td>
<td>16</td>
<td>19</td>
<td>2 (1 postoperative death)</td>
<td>5</td>
<td>5 (two interval AAA ruptures, one leading to the only perioperative death)</td>
</tr>
<tr>
<td>Nora et al.</td>
<td>2</td>
<td>17</td>
<td>2</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>
managements.\textsuperscript{3,4,6,8,24} Porcellini et al. compared EVAR (n = 4) and open AAA repair (n = 5) in nine cases of concurrent AAA and CRC. The EVAR group had shorter median LoS (13.5 vs. 23 days), lower perioperative complication rate (25% vs. 80%, including an aortic graft infection) and perioperative mortality rate (0% vs. 20%).\textsuperscript{3} In the endovascular group, a staged approach was taken with EVAR sequenced first. In the open group, combined surgery was performed in three cases, with CRC resection performed first in one case and AAA repair first in the remaining case. Kiskinis et al. describe an intentional delay of 2 weeks for CRC resection following EVAR, thus allowing shrinkage of the aneurysmal sac and facilitating colectomy.\textsuperscript{8}

Complications described when EVAR preceded CRC resection include embolic occlusion of the popliteal artery,\textsuperscript{25} three cases of endograft limb thrombosis after rectal surgery in lithotomy position\textsuperscript{3,26} and one anastomotic leak following anterior resection.\textsuperscript{3}

**Discussion**

The co-existence of abdominal malignancy and aorto-iliac aneurysmal disease is uncommon, but may be increasing in incidence with an ageing population as CRC and AAA patients reside in the same age group and share other demographic similarities. The management of these concurrent pathologies continues to pose a therapeutic dilemma, as evidenced by the disparity in published case reports, series and recommendations. No prospective randomised controlled trials or other level-one evidence exist in order to form a standardised treatment algorithm or facilitate the decision-making process. This is not surprising given the numbers and heterogeneity in the group involved.

Most of the 38 publications reviewed offered clear recommendations without clear evidence to support them. Twenty papers promoted staged intervention; however, not all specified priority of management. Nine recommended treating life-threatening or symptomatic pathologies first. Eight suggested intervention of the AAA first if both pathologies were asymptomatic, including reduced risk of interval aneurysmal rupture as their rationale including reduced risk of interval aneurysmal complications with delayed AAA repair – with or without adjuvant chemoradiotherapy – and more rapid recovery of nutritional state. Only two groups recommended CRC resection first if both pathologies were asymptomatic, quoting low risk of interval aneurysmal rupture as their justification.\textsuperscript{6,27} Eighteen articles promoted simultaneous surgery for concurrent AAA and CRC, although one used thrombo-exclusion in AAA management.\textsuperscript{12} Interestingly, Baxter et al. recommend combined repair particularly in right-sided CRCs,\textsuperscript{6} whilst Shimada et al. comment on its safety and feasibility with left-sided CRC, particularly in the context of a Hartmann’s procedure.\textsuperscript{9} The reasons offered by publications for simultaneous surgery include: it being successful in a number of series and reports; its role in the unexpected finding of CRC during AAA repair;\textsuperscript{13,28} simultaneous surgery reducing the time, financial costs and anxiety of two separate operations;\textsuperscript{11} reduced morbidity\textsuperscript{4} and the facility to undertake concurrent surgery using EVAR.

EVAR has revolutionised aneurysm-repair surgery with benefits such as reduced hospital stay and short-term survival and quality of life benefits.\textsuperscript{20,29} EVAR expands management options in concurrence as it can form part of a combined or staged approach. In a study analysing outcomes following AAA repair in 13,902 patients, the overall risk of aortic graft infection was 0.44%, without a difference between EVAR and open repair.\textsuperscript{30} In the context of concurrent pathology, EVAR is likely to lower the risk of aortic graft infection as the endograft is inserted via distal access sites into the intact aortic sac without communication with the peritoneal cavity. The improved recovery period with EVAR has the potential to reduce the interval time to CRC resection and chemoradiotherapy and reduce the systemic trauma of major surgery, which may enhance tumour growth.\textsuperscript{31} As discussed, Porcellini et al. demonstrated the benefit of EVAR over open repair in concurrent disease in terms of LoS, morbidity and mortality, undertaking EVAR prior to CRC resection.\textsuperscript{3}

In the sub-population of patients deemed to be at high risk, yet fit for operative intervention on their AAA, EVAR should be considered as it has been shown to produce outcomes superior to that of open repair.\textsuperscript{32} EVAR has offered individuals unsuitable for open AAA repair, including those with previous laparotomy and adhesions, a therapeutic alternative.

In our series, the complication rate after EVAR is high and may be explained by the presence of a concurrent malignancy; for example, limb occlusions occurring due to the thrombophilia of a paraneoplastic syndrome. A potential disadvantage of a simultaneous approach includes the theoretical increased risk of aortic graft infection, carrying a mortality rate of 65%.\textsuperscript{33} This complication was not seen in our series and, although only a single case was reported among 269 patients in the world literature, the risk of undertaking AAA repair and potentially contaminating gastrointestinal surgery synchronously is highlighted in a series of 14 infected aortic prostheses, two being complications of concurrent abdominal surgery (gastrostomy and open cholecystectomy).\textsuperscript{34} With EVAR, groin wound infection is the most likely source of endograft infection. Although there are no published reports, the risk of endograft infection secondary to the transient bacteremia seen with CRC resection also necessitates consideration.\textsuperscript{30} and perioperative antibiotic prophylaxis is recommended.

Unrelated laparotomy is associated with risk of AAA rupture in up to 16–24% of cases,\textsuperscript{16,18,22} and is particularly true when aneurysmal diameter is greater than 5 cm,\textsuperscript{1,2,6,7,17,18} We favoured a staged approach in our series and encountered no cases of interval aneurysmal rupture, regardless of administration of adjuvant chemoradiotherapy. In the literature, delays in AAA repair due to adjuvant chemoradiotherapy or complications following colorectal surgery were not responsible for the observed interval aneurysmal complications. Our review shows no instances of interval rupture in AAAs less than 5 cm in size. Although not requiring elective repair, preceding CRC treatment has not caused significant expansion and rupture in aneurysms sized less than 5 cm. Only two interval complications occurred in AAAs less than 6 cm, with the remaining eight in those greater than or equal to 6 cm.
Therefore, asymptomatic aneurysms less than 6 cm may have CRC treatment initially. Our LoS following AAA repair is related to the significant proportion of juxtarenal, suprarenal and thoraco-abdominal aneurysms in this series, attributable to one of the centres having a thoracic vascular programme. The presence of non-infrarenal aneurysms was responsible for the necessity for open AAA repair in a number of individuals. Currently, fenestrated and branched stent-grafts are being introduced in such cases. Patients considered unsuitable for conventional infrarenal EVAR are likely to be at high risk by virtue of such aneurysmal characteristics. Furthermore, it is the policy at both centres to undertake inpatient CT, if serum creatinine levels permit, at days 5–7 post-EVAR to rule out endoleak requiring treatment prior to discharge. This fixes in-hospital LoS for our EVAR patients to some extent.

Adjuvant oncological therapies are an additional factor demanding consideration. Chemoradiotherapy, often accompanied by corticosteroids and aggressive hydration (expanding plasma volume), may result in enlargement and rupture of major vessels including both aneurysmal and non-aneurysmal aortas. Lauro et al. comment that chemotherapy may increase rupture risk in AAAs larger than 6 cm in size, and suggest that such aneurysms be treated first, as shown in a patient treated for pancreatic cancer. This may be due to inhibition of smooth muscle proliferation, and collagen and elastin productions. There are no reports of chemoradiotherapy-induced aneurysmal rupture in our review. In our series, one patient with a 6.5 cm AAA had adjuvant chemotherapy deferred until after EVAR, whilst other patients with 6.9 and 7.0 cm AAAs had adjuvant chemotherapy prior to EVAR without consequence. No patients had palliative chemoradiotherapy withheld due to concerns regarding AAA rupture.

Another risk inherent to staged surgery was the hostile abdomen faced at second laparotomy. If EVAR is technically feasible and CRC not urgently symptomatic, an approach whereby EVAR is undertaken first could minimise the delay to completion of surgical treatment of both conditions without significantly delaying adjuvant therapies. A counter-argument to this is if CRC resection is undertaken as the primary procedure, this could enable more accurate staging of the malignant disease and estimation of prognosis, such that the decision to proceed to AAA repair can be fully informed on this basis.

A suggested treatment algorithm for the common clinical encounters is shown in Fig. 2, and this is to be carefully applied. Where AAA repair is to be undertaken first as part of a staged management plan, the use of EVAR with its shorter recovery time may reduce the delay to treatment of the CRC. EVAR should also be employed where possible in individuals who are fit for surgery, but have high operative risk owing to improved outcomes.

A literature review revealed that published results following staged and simultaneous surgery were similar; therefore, combined intervention is an acceptable option, both in the context of open AAA repair and EVAR. In the case of obstructing CRC with an aneurysm 6 cm or larger in size, where the risk of interval AAA rupture is significant, both with and without adjuvant therapy, concurrent
intervention can be undertaken. Alternatively, the use of temporary colonic stenting prior to AAA repair with subsequent CRC resection may be considered. This is preferred to bowel de-functioning which may present a potential for infection from the anterior abdominal wall when undertaking open AAA repair or EVAR.

There is little reliable and validated evidence on this area due to the considerable heterogeneity which exists among the patients, as such a multispecialty, multidisciplinary approach remains essential in the formulation of a safe and effective management strategy, tailored on an individual basis. Most surgeons, however, agree that the symptomatic or most life-threatening lesion should be managed first. In this small observational series, following colonic resection, no aneurysmal ruptures were observed and as such staged management may be considered a safe approach. Our review of the literature reveals a number of such interval ruptures; hence, if this strategy is to be employed, subsequent AAA repair should be planned and undertaken as early as it is practical to do so. There is an evolving role for EVAR in this context, with a shorter recovery period and less pro-tumour effect.

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Not applicable.

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References


