The impact of age on outcome after surgery for colorectal adenocarcinoma

AL Widdison, S Wienand Barnett, N Betambeau

Department of Surgical Gastroenterology, Royal Cornwall Hospital, Truro, UK

ABSTRACT

INTRODUCTION The incidence of colorectal cancer (CRC) increases with age. The aim of this study was to investigate the impact of age and age-related factors on post-operative mortality and survival following CRC resections.

METHODS A prospectively collected database of 459 CRC resections was analysed.

RESULTS The mean age of the patients was 70 years (range: 25–95 years) and 54% were male. The relative proportion of female patients increased with age so that for patients aged over 77 more women were treated than men. The probability of undergoing an emergency resection (25%) did not change with age. In older patients the proportion of rectal cancers resected decreased and the proportion of hemicolectomies and Hartmann's operations performed increased. The 30-day mortality rate was 4% after elective and 11% after emergency resections. Most deaths were caused by medical complications, reflecting increased co-morbidity in the elderly. Post-operative mortality was 1% in patients under the age of 59. This increased by 3 percentage points every 10 years after elective resections and by 8 percentage points every 10 years after emergency resections. CRC-specific survival was independent of age whereas overall survival decreased so the likelihood of dying from CRC decreased with age: at age 50 half the deaths were from CRC, at age 70 a third and at age 80 a quarter.

CONCLUSIONS CRC stage and the probability of presenting as an emergency did not change with age but older patients were more likely to be female and have colon cancer. Post-operative mortality progressively increased with age. Most deaths were caused by medical complications, reflecting increased co-morbidity. Older patients were less likely to die from CRC.

KEYWORDS

Colorectal cancer – Surgery – Age – Survival

Accepted 16 May 2011

CORRESPONDENCE TO

Adam Widdison, Consultant Colorectal Surgeon, Royal Cornwall Hospital, Truro, Cornwall, TR1 3LJ, UK
E: adam.widdison@rcht.cornwall.nhs.uk

Colorectal cancer (CRC) is the third most prevalent cancer in Europe and the US with an age standardised rate in the UK of 44.3 per 100,000 population.^{1,2} The lifetime risk of developing CRC is about 1 in 18 for men and 1 in 20 for women.² Increasing age is the most important risk factor with only 5% of CRCs caused by familial cancer syndromes.² Cancer stage is considered the most important factor determining the outcome. With earlier detection and improved treatment, outcomes are improving and age standardised mortality rates for CRC have progressively declined in England and Wales, as they have in other countries.⁵

As the population gets older the incidence of CRC increases and more elderly patients present with CRC.^{1–4} It is therefore important to know the impact of age on outcome after CRC resections. There are many patient- and cancer-related factors that change with age,⁴ including the male to female ratio,⁵ patient selection,⁶ stage of cancer,⁷ proportion presenting as an emergency,⁸ cancer site⁹ and operation choice.¹⁰ Each or all of these may influence the outcome after surgery. The aim of this study was to investigate the impact of age and age-related factors on post-operative

mortality and long-term survival following resections for colorectal adenocarcinoma.

Methods

A prospectively collected database of all CRC resections undertaken by one surgical firm between January 1996 and June 2009 was analysed. The minimum follow-up period was six months. The indications for surgery remained the same throughout the study and age was not a contraindication for resectional surgery. Patients were excluded from the study if they refused surgery, were assessed as being medically unfit for surgery by the surgeon and anaesthetist, had unresectable cancer or were dying from carcinomatosis.

Resections were performed with curative intent when the tumour was macroscopically completely removed and there was no evidence of metastatic disease at the time of surgery. Palliative resections were undertaken in patients fit for surgery with metastases or when the cancer was locally advanced and macroscopic local clearance incomplete. Patients admitted as an emergency with peritonitis, bleeding or unrelieved bowel obstruction underwent an emergency

Figure 1 Change in relative proportion of men and women with colorectal cancer

Figure 2 Change in post-operative mortality with age ($p < 0.01$)

operation. Emergency admissions who responded to medical treatment or had their bowel obstruction relieved either by stenting or defunctioning were discharged and readmitted for elective surgery.

A resection and primary anastomosis was performed unless there was a contraindication such as peri-operative haemodynamic instability, unresectable cancer adjacent to or distal to the anastomosis, or pre-operative faecal incontinence. Most patients undergoing elective resection and primary anastomosis for left-sided CRC were given pre-operative bowel preparation. Low anterior resections with total mesorectal excisions were defunctioned. Patients presenting as an emergency with left-sided CRC were treated with a resection and primary anastomosis, Hartmann's procedure or, if caecal integrity was compromised, a subtotal colectomy and end ileostomy.

Data collection and analysis

Data pertaining to all CRC resections undertaken by one surgical firm between 1996 and 2009 were collected prospectively on a Microsoft® Excel® spreadsheet. Where data were incomplete the medical records were retrieved and

Figure 3 Colorectal cancer-specific survival for different age groups

reviewed. Data were collected on: age, sex, date of operation, site of cancer, type of operation, whether the operation was elective or emergency, whether the resection was curative or palliative, histology, stage, date of discharge, if dead the date of death and cause of death. Patients were divided into four age groups (≤ 59 , 60–69, 70–79 and ≥ 80 years) and results were expressed as mean $\pm$ standard error except where specified.

Descriptive statistics were calculated using Analyse-it® add-on software for Microsoft® Excel®. Fisher's exact test was used to analyse contingency tables. Quantitative variables were analysed using the unpaired Student's *t*-test. Data on survival were considered censored for patients who were alive. Estimates of survival were carried out using the Kaplan–Meier test and compared using the logrank test (GraphPad Prism®, GraphPad Software Inc, La Jolla, CA, US). Linear regression was performed using GraphPad Prism® to demonstrate age-related changes in sex distribution, cancer location, types of operation, 30-day mortality and changes in proportions. Figures were created using GraphPad Prism®. The level of significance was set at $p < 0.05$.

Results

CRC resections were performed on 485 patients, of whom 459 had adenocarcinomas, 11 squamous cell cancers, 5 carcinoids, 3 lymphomas, 3 metastases, 1 a gastrointestinal stromal tumour, 1 a leiomyosarcoma, 1 a mesothelioma and 1 a melanoma. A summary of the results is presented in Table 1.

The mean age of the 459 patients with adenocarcinomas was 70 ± 0.5 years (range: 25–95 years) and 54% were male. The proportion of women increased with age ($p = 0.009$) so that for patients aged over 77 more women were treated than men (Fig 1). On average the female patients were older (72 ± 0.7 years) than the male patients (69 ± 0.7 years) ($p = 0.005$). Most resections (75%) were performed electively. Elective patients tended to be younger (70 ± 0.6 years) than emergency patients (71 ± 1.1 years) but this was not statistically significant ($p = 0.060$). The probability of patients undergoing an emergency resection did not change with increasing age

Table 1 Raw data

	Age group (years)				
	Total	≤59	60–69	70–79	≥80
	459 (100%)	82 (18%)	111 (24%)	173 (38%)	93 (20%)
Men	247 (54%)	52 (63%)	61 (55%)	94 (54%)	40 (43%)
Women	212 (46%)	30 (37%)	50 (45%)	79 (46%)	53 (57%)
Elective	343 (75%)	62 (76%)	93 (84%)	125 (72%)	63 (64%)
Emergency	116 (25%)	20 (24%)	18 (16%)	48 (28%)	30 (36%)
Cancer stage					
Dukes' A	87 (19%)	18 (22%)	21 (19%)	33 (19%)	15 (16%)
Dukes' B	169 (37%)	23 (38%)	43 (38%)	62 (36%)	41 (44%)
Dukes' C	146 (32%)	29 (35%)	36 (32%)	54 (31%)	27 (29%)
Dukes' D	57 (12%)	12 (15%)	11 (10%)	24 (14%)	10 (11%)
Incomplete resection	8 (2%)	0 (0%)	3 (3%)	4 (2%)	1 (1%)
30-day mortality					
» Overall	27 (6%)	1 (1%)	3 (3%)	10 (6%)	13 (14%)
» Men	14 (6%)	1 (2%)	1 (2%)	7 (7%)	5 (13%)
» Women	13 (6%)	0 (0%)	2 (4%)	3 (4%)	8 (15%)
» Elective	14 (4%)	1 (2%)	1 (1%)	5 (4%)	7 (11%)
» Emergency	13 (11%)	0 (0%)	2 (11%)	5 (10%)	6 (20%)
5-year survival					
5-year overall survival	57(5)%	69(6)%	70(5)%	56(4)%	36(6)%
5-year CRC-specific survival	72(5)%	74(5)%	79(5)%	70(4)%	65(7)%
Cancer site					
» Rectum	218 (47%)	52 (63%)	62 (56%)	72 (42%)	32 (34%)
» Right colon	141 (31%)	16 (20%)	29 (26%)	60 (35%)	36 (39%)
» Left colon	93 (20%)	11 (13%)	18 (16%)	38 (22%)	26 (28%)
Operation type					
Abdominoperineal resection	28 (6%)	7 (9%)	9 (8%)	8 (5%)	4 (4%)
» 30-day mortality	1 (4%)	0 (0%)	0 (0%)	1 (13%)	0 (0%)
Hartmann's operation	47 (10%)	4 (5%)	8 (7%)	21 (12%)	14 (15%)
» 30 day mortality	6 (13%)	0 (0%)	0 (0%)	2 (10%)	4 (29%)
Anterior resection	173 (36%)	42 (51%)	49 (44%)	58 (35%)	24 (26%)
» 30-day mortality	7 (4%)	1 (2%)	1 (2%)	2 (4%)	3 (12%)
» Anastomotic leaks	14 (8%)	5 (12%)	3 (6%)	5 (9%)	1 (4%)
Left hemicolectomy	28 (6%)	6 (7%)	6 (5%)	10 (6%)	6 (6%)
» 30-day mortality	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
» Anastomotic leaks	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Right hemicolectomy	140 (31%)	15 (18%)	29 (26%)	59 (34%)	37 (40%)
» 30-day mortality	9 (6%)	0 (0%)	1 (3%)	4 (7%)	4 (11%)
» Anastomotic leaks	3 (2%)	0 (0%)	0 (0%)	1 (2%)	2 (5%)
Subtotal colectomy	18 (4%)	4 (5%)	3 (3%)	6 (3%)	5 (5%)
30-day mortality	3 (17%)	0 (0%)	0 (0%)	1 (17%)	2 (40%)
» Number of anastomoses	358 (78%)	68 (83%)	87 (78%)	135 (78%)	68 (73%)
» Anastomotic leaks	17 (5%)	5 (7%)	3 (3%)	5 (4%)	4 (6%)
Anastomotic leak deaths	4(24%)	1 (20%)	0 (0%)	2 (40%)	1 (25%)

Figure 4 Overall survival for different age groups

Figure 6 Change in location of colorectal cancer with age ($p<0.01$)

Figure 5 Effect of age on the probability of dying from all causes ($p<0.001$) or from colorectal cancer ($p=0.25$)

($p=0.118$). There was a similar distribution in CRC stage in the different age groups (Table 1). A palliative resection was performed in 14% (range for different age groups: 12–16%) of patients and was independent of age (Table 1).

The 30-day mortality rate was 6%, with a higher mortality after emergency resections compared to elective resections (11% vs 4%, $p=0.007$). The post-operative mortality was <1% for patients under the age of 59 and increased by 3 percentage points every 10 years for elective patients and by 8% every 10 years for emergency cases (Fig 2). Overall, 30-day mortality increased with age from 2% in patients younger than 70 to 11% in patients older than 70 years (Table 1). There was no difference in 30-day mortality between men and women ($p=0.691$) or between operation types for any age group (Table 1). Most post-operative deaths were from cardiopulmonary complications (Table 2). The mortality rate among the 17 patients (4.7% anastomotic leak rate) who had an anastomotic leak was 24%. There was no difference in the leak rate with increasing age (Table 1).

The median follow-up period was 3 ± 0.2 years with an overall 5-year survival rate of $57\% \pm 5$ percentage points and a CRC-specific 5-year survival of $72\% \pm 5$ percentage points. There was no difference between men and women in either CRC-specific survival (hazard ratio [HR]: 1.0, $p=0.991$) or overall survival (HR: 1.05, $p=0.724$). CRC-specific survival did not change with age whereas overall survival decreased (Figs 3 and 4) so that the likelihood of dying from CRC decreased with increasing age (Fig 5). At 50 years of age half of all deaths recorded during the period of follow up were due to CRC, at 70 a third and at 80 a quarter of deaths.

The proportion of rectal cancers resected decreased with increasing age from 65% in patients younger than 59 years to 33% in patients older than 80 ($p<0.001$, Fig 6 and Table 1). The proportion of right ($p=0.005$) and left ($p=0.006$) colon cancers increased with age at a similar rate (Fig 6 and Table 1). As a consequence, patients with rectal cancer were younger (68 ± 0.7 years) than those with colon cancer (72 ± 0.7 years) ($p<0.001$). For patients older than 82, more right-sided colon cancers were resected than rectal or left-sided colon cancers (Fig 6). Similarly, with increasing age there was a reduction in the proportion of anterior resections with a primary anastomosis ($p<0.001$) and an increase in the proportion of Hartmann's procedures performed ($p=0.026$) (Table 1). There was an increase in the proportion of right hemicolectomies with increasing age ($p=0.005$, Table 1). Overall, there was an inverse relationship between age and the probability of having an anastomosis ($p=0.037$). There was no difference in overall or CRC-specific survival between right- and left-sided colon cancers ($p>0.1$), or between rectal cancers and colon cancers ($p>0.1$).

Discussion

The overall (6%), elective (4%) and emergency (11%) 30-day mortality rates were similar to previous studies from population samples of a similar age group.^{6,7,9,11–21} In our study, 30-day mortality increased with age for both elective and emergency resections. There was a progressive in-

Table 2 Causes of death in the postoperative period

Significant complications	Age group (years)			
	≤59	60–69	70–79	≥80
Anastomotic leak	1		2	1
Stercoral perforation			1	
Small bowel volvulus		1		
Respiratory failure/chest infection		1	1	6
Heart attack			1	
Heart failure			1	1
Multiple organ failure			2	3
Stroke				2
Unknown		1	2	

crease in post-operative mortality with age for both men and women. Post-operative mortality was <1% among patients under 59 years of age but this increased by 3 percentage points every 10 years in elective patients and 8 percentage points in emergency cases. An increased 30-day mortality in older patients above and below a specific age has been previously reported but not a linear relationship.^{4,7-9,11,17,21-25} Our study shows that mortality above and below a cut off point, such as 70 years of age, will be strongly affected by the more favourable outcome in the younger patients and the adverse outcome in those more elderly.

As expected, most patients died due to cardiopulmonary complications related to their co-morbidity. Indeed, more patients died of medical complications than surgical complications. This supports previous observations that the increased 30-day post-operative mortality in older patients is due to the increasing prevalence of pre-existing co-morbidity and reduced ability to survive surgery or surgery-related complications.^{4,7,9,11,21,24}

The overall five-year survival in this study was 57% and the CRC-specific five-year survival was 72%. This was better than that at larger multi-centre studies in which overall five-year survival rates are about 45% and CRC-specific survival lies at 65%.^{1,11,15,25,26} The CRC-specific survival for each Dukes' stage was similar to previously reported studies.^{5,27,28} As anticipated, life expectancy decreased with increasing age, reflecting an increase in age-related co-morbidity. There was, however, little change in the risk of dying from CRC with age so that among patients aged 50 and over more were likely to die from causes other than CRC. Indeed, at 70 years of age patients were twice as likely to die from causes other than CRC and at age 80 they were nearly three times as likely.

Overall, 54% of patients in this study were male. However, the proportion of female patients treated increased with age so that for patients aged over 77 more women were treated than men. The increase in proportion of women with CRC with increasing age has been reported previously.^{5,8} The incidence of cancer among men increases with age at a higher rate than among women but the proportion of women in the population increases at an even faster rate so there is a larger population of women at risk in older age groups.⁵

This study has shown that post-operative mortality as well as overall and CRC-specific survival were independent of sex. This confirms the findings of previous studies.^{5,29-31}

In our study there was a decline in the proportion of rectal cancers and an increase in the proportion of colon cancers with age. Both right and left colon cancers increased with age at a similar rate. This has been reported previously by some^{4,7,9,21,28,52} but not by everyone.²⁰ The likelihood of having a Hartmann's operation rather than an anterior resection increased with age. A Hartmann's operation was only undertaken in the most seriously ill patients, which is reflected in the increased mortality for this procedure compared to anterior resections: 13% versus 4% for all age groups and 29% versus 12% in the over 80s. This reiterates the impact of increased co-morbidity in older patients.^{4,10,35} The 30-day mortality rate was similar and also increased with age for all types of operation. Changes in the location of cancers or the operation performed did not account for age-related changes in 30-day mortality or survival.

There was no difference in the cancer stage in the different age groups or in the proportion of patients undergoing a potentially curative resection with age. This result is similar to some previous studies^{4,20,21,28,52} although others have reported more^{7,54} or less advanced disease in the elderly.^{14,55} As has been previously reported,^{4,56} older age was not associated with a significantly increased risk of emergency surgery. Changes in cancer stage or presentation did not account for age-related differences in 30-day mortality or survival after resectional surgery.

The strength of this study lies in it being a large series of consecutive patients treated by a single firm in which all operations were either performed or directly supervised by one surgeon. The indications for surgery remained unchanged throughout the study. Age alone was not a contraindication to surgery, nor did it independently influence the choice of operation. The Royal Cornwall Hospital serves a stable population, allowing good long-term follow up. The demographic details of the study group and the age standardised rates of CRC in Cornwall exactly match the mean for both men and women in the rest of England and Ireland. It is notable that they are significantly less than in Scotland.²

This study has shown that post-operative mortality increases progressively with age and as patients get older they are less likely to die from their CRC following resection. This raises questions about how best to manage elderly patients with CRC. Given the increased post-operative mortality in the elderly and the reduced likelihood of them dying from CRC, should all elderly patients undergo a radical resection? More studies are needed to identify those with the most to gain from radical operations. Furthermore, since most post-operative deaths are caused by cardiopulmonary complications, it is likely that significant improvements could be achieved with better peri-operative care. This could include improved pre-operative assessment and pre-operative optimisation. It may be that time spent on such interventions would be of greater benefit than attempts to operate on patients as quickly as possible.

Increased provision of high dependency or intensive care for the elderly may also reduce post-operative morbidity and mortality. The elderly may be able to tolerate adjuvant chemotherapy^{12,15,18} but it might not have the same beneficial effect on overall survival as in younger patients. As the population grows older and more elderly patients present with CRC, there is a need for more studies to determine the best treatment in the elderly. Improved decision making algorithms, including assessment of life expectancy, are needed to identify which patients to treat radically and which to treat differently.²⁹

Conclusions

The 30-day mortality rate after CRC resection progressively increased with age. Most deaths were caused by medical complications, reflecting increased co-morbidity. Cancer-specific survival was independent of age so that the probability of dying from cancer declined with age.

References

- Westlake S. Cancer incidence and mortality in the United Kingdom and constituent countries, 2003–05. *Health Stat Q* 2008; **40**: 91–97.
- UK Bowel (colorectal) cancer – UK incidence statistics. Cancer Research UK. <http://info.cancerresearchuk.org/cancerstats/types/bowel/incidence/> (cited May 2011).
- Westlake S, Cooper N. Cancer incidence and mortality: trends in the United Kingdom and constituent countries, 1993 to 2004. *Health Stat Q* 2008; **38**: 33–46.
- Audisio RA, Veronesi P, Ferrario L *et al*. Elective surgery for gastrointestinal tumours in the elderly. *Ann Oncol* 1997; **8**: 317–326.
- McArdle CS, McMillan DC, Hole DJ. Male gender adversely affects survival following surgery for colorectal cancer. *Br J Surg* 2003; **90**: 711–715.
- McMillan DC, Hole DJ, McArdle CS. The impact of old age on cancer-specific and non-cancer-related survival following elective potentially curative surgery for Dukes A/B colorectal cancer. *Br J Cancer* 2008; **99**: 1,046–1,049.
- Marusch F, Koch A, Schmidt U *et al*. Impact of age on the short-term postoperative outcome of patients undergoing surgery for colorectal carcinoma. *Int J Colorectal Dis* 2002; **17**: 177–184.
- Tan E, Tilney H, Thompson M *et al*. The United Kingdom National Bowel Cancer Project – epidemiology and surgical risk in the elderly. *Eur J Cancer* 2007; **43**: 2,285–2,294.
- Capra F, Scintu F, Zorcolo L, Casula G. Surgical treatment for colorectal cancer in patients over 80 years. Short and long term results. *Minerva Chir* 2003; **58**: 515–522.
- Gastinger I, Marusch F, Koch A *et al*. Hartmann's procedure indication in colorectal carcinoma. *Chirurg* 2004; **75**: 1,191–1,196.
- Arnaud JP, Schloegel M, Ollier JC, Adloff M. Colorectal cancer in patients over 80 years of age. *Dis Colon Rectum* 1991; **34**: 896–898.
- Au HJ, Mulder KE, Fields AL. Systematic review of management of colorectal cancer in elderly patients. *Clin Colorectal Cancer* 2003; **3**: 165–171.
- Bailey C, Corner J, Addington-Hall J *et al*. Treatment decisions in older patients with colorectal cancer: the role of age and multidimensional function. *Eur J Cancer Care (Engl)* 2003; **12**: 257–262.
- Frizis H, Papadopoulos A, Akritidis G *et al*. Are there any differences in colorectal cancer between young and elderly patients? *Tech Coloproctol* 2004; **8 Suppl 1**: s147–s148.
- McArdle CS, Hole DJ. Outcome following surgery for colorectal cancer: analysis by hospital after adjustment for case-mix and deprivation. *Br J Cancer* 2002; **86**: 331–355.
- McArdle CS, Hole DJ. Emergency presentation of colorectal cancer is associated with poor 5-year survival. *Br J Surg* 2004; **91**: 605–609.
- McArdle CS, McMillan DC, Hole DJ. The impact of blood loss, obstruction and perforation on survival in patients undergoing curative resection for colon cancer. *Br J Surg* 2006; **93**: 483–488.
- Pasetto LM, Stefano T, Rossi E *et al*. Treatment of stage IV colorectal carcinoma in elderly patients. *Crit Rev Oncol Hematol* 2005; **54**: 145–155.
- Pavlidis TE, Marakis G, Ballas K *et al*. Safety of bowel resection for colorectal surgical emergency in the elderly. *Colorectal Dis* 2006; **8**: 657–662.
- Rerknimitr R, Ratanapanich W, Kongkam P, Kullavanijaya P. Differences in characteristics of colorectal neoplasm between young and elderly Thais. *World J Gastroenterol* 2006; **12**: 7,684–7,689.
- Zhang B, Fattah A, Nakama H. Characteristics and survival rate of elderly patients with colorectal cancer detected by immunochemical occult blood screening. *Hepatogastroenterology* 2000; **47**: 414–418.
- Iversen LH, Bülow S, Christensen IL *et al*. Postoperative medical complications are the main cause of early death after emergency surgery for colonic cancer. *Br J Surg* 2008; **95**: 1,012–1,019.
- Mitry E, Benhamiche AM, Jouve JL *et al*. Colorectal adenocarcinoma in patients under 45 years of age: comparison with older patients in a well-defined French population. *Dis Colon Rectum* 2001; **44**: 380–387.
- Hellinger A. Is oncological surgery contraindicated in the older patient? *MMW Fortschr Med* 2004; **146**: 22–24.
- McArdle CS, Hole DJ. Influence of volume and specialization on survival following surgery for colorectal cancer. *Br J Surg* 2004; **91**: 610–617.
- Rhodes JM. Colorectal cancer screening in the UK: Joint Position Statement by the British Society of Gastroenterology, The Royal College of Physicians, and The Association of Coloproctology of Great Britain and Ireland. *Gut* 2000; **46**: 746–748.
- Andreoni B, Chiappa A, Bertani E *et al*. Surgical outcomes for colon and rectal cancer over a decade: results from a consecutive monocentric experience in 902 unselected patients. *World J Surg Oncol* 2007; **5**: 73.
- Demetriades H, Kanellos I, Vasiliadis K *et al*. Age-associated prognosis following curative resection for colorectal cancer. *Tech Coloproctol* 2004; **8 Suppl 1**: s144–s146.
- Fazeli MS, Adel MG, Lebaschi AH. Colorectal carcinoma: a retrospective, descriptive study of age, gender, subsite, stage, and differentiation in Iran from 1995 to 2001 as observed in Tehran University. *Dis Colon Rectum* 2007; **50**: 990–995.
- Harten J, McCreath BJ, McMillan DC *et al*. The effect of gender on postoperative mortality after emergency abdominal surgery. *Genet Med* 2005; **2**: 35–40.
- Ratto C, Sofo L, Ippoliti M *et al*. Prognostic factors in colorectal cancer. Literature review for clinical application. *Dis Colon Rectum* 1998; **41**: 1,033–1,049.
- Quah HM, Joseph R, Schrag D *et al*. Young age influences treatment but not outcome of colon cancer. *Ann Surg Oncol* 2007; **14**: 2,759–2,765.
- Morris E, Quirke P, Thomas JD *et al*. Unacceptable variation in abdominoperineal excision rates for rectal cancer: time to intervene? *Gut* 2008; **57**: 1,690–1,697.
- Borie F, Tretarre B, Marchigiano E *et al*. Management and prognosis of colon cancer in patients with intestinal obstruction or peritonitis: a French population-based study. *Med Sci Monit* 2005; **11**: CR266–CR273.
- Chiang JM, Chen MC, Changchien CR *et al*. Favorable influence of age on tumor characteristics of sporadic colorectal adenocarcinoma: patients 30 years of age or younger may be a distinct patient group. *Dis Colon Rectum* 2003; **46**: 904–910.
- Curlless R, French JM, Williams GV, James OF. Colorectal carcinoma: do elderly patients present differently? *Age Ageing* 1994; **23**: 102–107.