Abdominal fat ratio – a novel parameter for predicting conversion in laparoscopic colorectal surgery

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ABSTRACT

INTRODUCTION Laparoscopic surgery has become the standard for colorectal cancer resection in the UK but it can be technically challenging in patients who are obese. Patients whose body fat is mainly inside the abdominal cavity are more challenging than those whose fat is mainly outside the abdominal cavity. Abdominal fat ratio (AFR) is a simple parameter proposed by the authors to aid identification of this subgroup.

MATERIALS AND METHODS All 195 patients who underwent elective, laparoscopic colorectal cancer resections from March 2010 to November 2013 were included in the study. For patients who were obese (body mass index greater than 30), preoperative staging computed tomography was used to determine AFR. This was assessed by two different, blinded observers and compared with conversion rate.

RESULTS Of the 195 patients, 58 (29.7%) fell into the obese group and 137 (70.3%) into the non-obese group. The median AFR of the obese group that were converted to open surgery was significantly higher at 5.9 compared with those completed laparoscopically (3.3, $P = 0.0001$, Mann-Whitney). There was no significant difference in conversion rate when looking at body mass index, tumour site or size.

DISCUSSION Previous studies have found body mass index, age, gender, previous abdominal surgery, site and locally advanced tumours to be associated with an increased risk of conversion. This study adds AFR to the list of risk factors.

CONCLUSION AFR is a simple, reproducible parameter which can help to predict conversion risk in obese patients undergoing colorectal cancer resection.

KEYWORDS

Colorectal – Conversion – Laparoscopic surgery – Cancer

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Introduction

As the proportion of patients with colorectal cancer undergoing laparoscopic surgery compared with open surgery has steadily increased, the poor performance of the conversion group is becoming an increasing problem. Data from the National Bowel Cancer Audit Project¹ show that, in the 2011–2012 audit year, 18% of procedures that were started laparoscopically were converted to an open procedure.

A 2014 Cochrane review² looked at the oncological outcomes of open versus laparoscopic surgery for rectal cancer and found no major difference in long-term survival, both disease-free and overall. However, the outcomes for laparoscopic (converted to open) operations have been repeatedly shown to be poor, both in terms of outcome and cost.

For colon cancer, in the Medical Research Council Conventional Versus Laparoscopic-Assisted Surgery in Colorectal

Cancer (CLASICC) study, both overall survival (hazard ratio [HR] 2.28, 95% confidential interval [CI] 1.47–3.53; $P < .001$) and disease-free survival (HR 2.20, 95% CI 1.31–3.67; $P = 0.007$) were significantly worse in the conversion group. Furthermore, the reported average cost of a conversion is up to 39% higher than an open procedure.

The aim of this study was to provide a simple parameter that could help to identify more accurately the subgroup within the obese group that would benefit from an open procedure owing to their high risk of conversion if laparoscopic approach was attempted. The reasoning behind abdominal fat ratio (AFR) is the observation that fat distribution is more important to the chance of laparoscopically completing a procedure than the absolute amount of fat present. In our experience, laparoscopic colorectal surgery is far more challenging in patients with a large amount of intra-abdominal fat, as this makes it difficult to access the root of the

mesentery, the planes are harder to identify and there tends to be more bleeding. By contrast, patients with a large amount of extra-abdominal fat make access slightly harder but the technical aspects of the surgery may not be greatly compromised.

AFR was developed by the authors as a readily reproducible ratio, based on measurements made on preoperative computed tomography (CT), which was routinely conducted.

Materials and Methods

A prospectively collected database of all major, elective, laparoscopic colorectal cancer resections by two surgeons trained on the laparoscopic fellowship programme was interrogated. Emergency procedures, planned open procedures and procedures where there was no resection were excluded.

Data were collected on age, sex, size of tumour, site of tumour, body mass index (BMI) and whether the procedure was converted from laparoscopic to open. Conversion was defined as any incision larger than that needed to extract the specimen. All patients underwent preoperative staging with CT of the chest and abdomen, in addition to pelvic magnetic resonance imaging (MRI) for those patients with rectal cancer. For all patients with a BMI > 30, we retrospectively calculated the AFR at the level of the umbilicus by measuring the distance from the front of the vertebral body to the anterior abdominal wall, divided by the largest distance from the external limit of the rectus sheath to the dermis at the same level (Fig 1). These measurements were made by two different blinded observers and the interobserver error assessed using two different methods.

Statistical analysis

Data were analysed using non-parametric testing and *P* values < 0.05 were considered to be significant. Contingency tables were analysed using Fisher's exact test to give a

Figure 1 Abdominal fat ratio is calculated by dividing intra-abdominal distance (Y) by the anterior wall fat distance (X)

Table 1 Patient characteristics

	Body mass index (BMI)	
	< 30 (<i>n</i> = 137) <i>n</i> (%)	30+ (<i>n</i> = 58) <i>n</i> (%)
Laparoscopic	115 (83.9)	42 (72.4)
Converted	22 (16.1)	16 (27.6)
Median age	71	68
Sex ratio–male	73 (53.3)	34 (58.6)
Median BMI	25.4	32.5
Site of tumour:		
Colon	82 ^a (59.9)	38 (65.5)
Rectum	56 ^a (40.9)	20 (34.5)
Tumour stage		
Adenoma:		
T0	26	12
T1	10	8
T2	22	13
T3	59	21
T4	20	4

^a one patient had synchronous tumours; one rectal and one at splenic flexure

relative risk and 95% confidence interval. Interobserver error was assessed using both nonparametric correlation and a Bland–Altman plot was constructed to determine the limits of agreement. All statistical analysis was performed using GraphPad Prism software (GraphPad Inc, La Jolla, CA, USA).

Results

The total number of patients undergoing laparoscopic resection for colorectal cancer during the study period was 195. Of these, 58 (29.7%) were classified as obese with a BMI of 30 or above. In the obese group, the total number of conversions was 16 (27.6%), compared with 22 (16.1%) in the non-obese group.

When looking at the patients in the obese group, there was a significantly higher median AFR in the converted group (5.9; 95% CI 4.8–8.1) compared with the non-converted group (3.3; 95% CI 3.2–4.2, *P* = .0001 Mann-Whitney). In contrast to AFR, there was no statistically significant difference between the median BMI of the patients in the obese laparoscopically completed group compared with the obese converted group, with medians of 33 (95% CI 32–33.3) and 32.8 (95% CI 31.9–36.1), respectively.

In the same group, more males than females were converted to open surgery (*P* = 0.002, Fisher's exact test). The AFR of male patients was significantly higher when compared that of the females (*P* = 0.0014, Mann-Whitney), with a median AFR for men of 4 (interquartile range [IQR] 4–7.5)

and for females of 3 (IQR 3–4). There was no significant difference in conversion rate when looking at tumour site, colon vs. rectum ($P = 0.543$ Fisher's) or when looking at tumour size ($P = .627$, Mann-Whitney), with a median size of tumour in both groups of 30 mm.

Where stated, the indications for conversion were noted. In the obese converted group, the single most common reason for conversion was adhesions, which were stated as at least part of the reason for conversion in seven cases. Inability to access the root of the mesentery and the retrocolic plane was stated as a contributing factor to conversion in six cases. Other reasons given for conversion were tumour stage (two), tumour site (three), narrow pelvis, bleeding not amenable to laparoscopic intervention (one) and patient not able to tolerate a steep Trendelenburg position (one). When looking at the number of contributing factors to conversion, seven of sixteen patients had one stated factor, six patients had two and two patients had three factors.

Previous abdominal surgery

Perhaps surprisingly, in this study previous abdominal surgery was not identified as an independent risk factor; 18/73 (25%) of those who had undergone previous surgery required conversion to open, compared with 20/114 (17.5%) who were completed laparoscopically ($P = 0.266$, Fisher's exact test). In eight patients it was not possible to ascertain whether they had previous surgery.

Interobserver variability

The AFR of 58 consecutive patients who were obese was calculated by two observers. AFR ranged from 1 to 14 with a mean of 4. There was an excellent correlation between the results of the two observers ($r = 0.900$, $P < .0001$, Spearman's; Fig 2). The mean difference between the two observers was 0.09 and the limits of agreement were -1.6 to 1.78 (Fig 3). No systematic bias was demonstrated by the Bland–Altman plot ($R^2 = 0.098$).

Discussion

This study aimed to define a simple parameter to aid prediction of conversion in patients who are obese when undergoing colorectal cancer resection.

Although obesity has been proven to be a risk factor for conversion, it could be argued that those who are obese have the most to gain from the laparoscopic approach. Obesity increases the risk of wound dehiscence, incisional hernia, stoma problems and has been linked to anastomotic leak.⁷ Laparoscopy offers the possibility of a quicker return of normal gut and lung function, as well as reduced risk of wound infections and incisional hernias. There is also burgeoning evidence that laparoscopic colorectal surgery can be safely completed in the obese with conversion rates varying from 7.3–46%.^{8,9} Thus, obesity itself should not be used as a reason not to offer laparoscopic surgery. Nonetheless, within the obese group, there are patients who are undoubtedly more challenging. While some centres report

Figure 2 Demonstrating good correlation of abdominal fat ratio measurement by two different blinded observers

Figure 3 Bland–Altman plot showing the limits of agreement between two blinded observers; the mean difference was close to zero, demonstrating a high degree of reproducibility

laparoscopic completion rates of over 90% overall¹⁵ we found a conversion rate of 16%, rising to 27% in the obese group using a strict definition of conversion as any incision larger than that required to extract the specimen.

There was a statistically higher AFR in patients in the obese group who underwent conversion, but not a statistically significantly higher BMI. This suggests that, within the obese group, BMI alone cannot be used to stratify risk of conversion. Other biometric parameters that have been evaluated include waist to hip ratio (WHR), which has been identified as a predictor of adverse events including conversion.¹⁶ However, it has been found to correlate poorly with changes in visceral fat.¹⁷

In our experience, the most challenging patients are those in whom there is a large amount of intra-abdominal fat rather than those who are simply overweight. Intra-abdominal fat causes difficulty for a number of reasons; tissues tear and bleed more easily, tissue planes are harder to find, the

mesentery is often shorter and wider and the shear bulk of abdominal contents makes access difficult. Many techniques have been developed to address the issue of access – further ports, specially designed retractors and magnetic retractors can all be used. Steep tilt of the operating table with suitable lateral and shoulder supports is routinely used but, despite this, there is a small number of patients whose operation cannot be safely completed laparoscopically. If a simple method could be developed to differentiate this group preoperatively then the increased cost and poorer outcomes of conversions could be avoided.

Previous studies have attempted to predict risk of conversion according to complicated volumetric studies of abdominal fat. Three Asian studies investigated a refined measure of obesity called visceral fat area (VFA) and found increased VFA to be associated with increased morbidity and operating time. Visceral obesity was calculated as visceral fat area on the basis of a CT scan using dedicated software to estimate the adipose area at one or more predefined levels.^{11,18,19} In contrast to visceral fat area, AFR is a simple ratio that illustrates the relationship between anterior abdominal wall fat and intra-abdominal fat. The ratio itself uses an intra-abdominal diameter at a given level (the level of the umbilicus) and is not an estimation of total intra-abdominal fat. It is not an attempt to find an accurate relationship between total extra-abdominal to intra-abdominal fat but a surrogate parameter that is easily calculated, without adding any cost in the form of further scans or complicated computer models.

In this study, AFR was statistically higher in men compared with women in the obese group, illustrating that men are more likely than women to have more intra-abdominal fat compared with anterior wall fat. This may explain why male gender has been found to be an independent risk factor for conversion to open surgery.²⁰ The other obvious difference is the narrow male pelvis, which has a profound effect on rectal surgery but less so for colonic surgery.

Previous abdominal surgery has been linked to an increased risk of conversion in several studies.^{21–25} Our data support this, as we found an increased percentage of conversions in patients who had previously had abdominal surgery in both the obese and non-obese converted groups, although this was not statistically significant.

We have not attempted to use AFR to define a cutoff value above which laparoscopic surgery should not be recommended based on our data. However, AFR is a measurement that could easily be applied retrospectively to other laparoscopic series making such a recommendation a possibility in the future.

Conclusion

We found AFR to be significantly higher in patients who were obese whose laparoscopic colorectal cancer operations had to be converted to open. It is clear that more studies need to be conducted to assess the reproducibility of our results. Calculating AFR is simple, cost effective and the degree of interobserver variability was very low.

As converted procedures are associated not only with additional costs to the hospital but also with increased morbidity and mortality for patients, it is vital to find ways of preoperatively defining the subgroup of those patients who are obese who are unlikely to benefit from a laparoscopic approach. It is our hope that in future, AFR can be a helpful parameter to define this subgroup of patients who are more likely to benefit from open surgery, thus improving patient outcome and reducing hospital costs.

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