

## ORIGINAL ARTICLE

## Laparoscopic colorectal surgery: learning curve and training implications

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*Postgrad Med J* 2005;81:537–540. doi: 10.1136/pgmj.2004.028100

**Aims:** This paper is a review of experience of laparoscopic colorectal surgery at a district general hospital with particular emphasis on the learning curve and training implications.

**Methods:** All patients undergoing colorectal surgery where laparoscopy was attempted between March 1998 and October 2003 were included in this study.

**Results:** There were 80 patients of which 49 had malignancy. Twenty eight stomas and 52 bowel resections were performed laparoscopically. The conversion rate for bowel resection was 32% (decreasing from 38% to 44% to 22%). This was significant ( $p=0.001$ ) when compared with stoma formation (7%). The firm has support from a specialist registrar and staff grade surgeon. In 22% of cases, one of the middle grades was the principal operating surgeon, mainly laparoscopic mobilisation and stoma formation. Only 6% of resections were performed by the middle grades. Conversely, a middle grade was the main operating surgeon in 66% of open resections and 61% of stoma formations during the same period. There were in all two deaths and 14 postoperative complications. All patients who had laparoscopic resections for malignancy had clear resection margins.

**Conclusion:** This audit highlights that there is a long learning curve in laparoscopic colorectal surgery with decrease in conversion rates with increasing experience. There is also a reduction in training opportunities in open surgery during the learning phase of the consultant, although this may be counterbalanced by the exposure to laparoscopic techniques. Laparoscopic colonic mobilisation, as a part of stoma formation, is a good starting point for specialist registrar training.

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Submitted 24 August 2004  
Accepted 21 October 2004

Laparoscopic surgery was first attempted in the field of the colorectal surgery in the early 1990s<sup>1,2</sup> and the introduction of laparoscopic staplers has contributed significantly to the development of these procedures. Initial results have highlighted potential benefits such as shorter hospital stay, less pain, and less postoperative ileus in all age groups especially in the elderly population.<sup>3–5</sup> However, issues around training in laparoscopic techniques, both for consultants and surgical trainees as well as the possible negative impact on training in open surgery<sup>6,7</sup> need to be tackled.

## AIMS

The aim of this study was to review our experience of laparoscopic colorectal surgery at a district general hospital over a five year period with particular emphasis on the learning curve and training implications for the consultant as well as the trainees.

## METHODS

All patients undergoing colorectal surgery where laparoscopy was attempted between March 1998 and October 2003 were included in this study. Data were collected from a review of patients' notes, pathology records, theatre database, and nursing records.

The variables looked at were: patient demographics, operating and assisting surgeons, pathology and site of the lesion, type of surgery, rate and reasons for conversion, morbidity, and mortality.

We included patients with benign disease as well as those with metastatic malignancy. In relation to patients with potentially curable malignancy, we excluded patients with synchronous tumours, transverse colon malignancy, pregnant women, patients with debilitating chronic obstructive airway disease, and patients with history of malignancy except skin and prostate (as per the exclusion criteria of the

CLASICC trial). We also did not offer laparoscopic surgery to patients who were obese or had multiple surgery in the past.

Informed consent was obtained routinely in all cases. Pneumoperitoneum was maintained between 10 mm Hg and 12 mm Hg. A 10–12 mm subumbilical port was predominantly used to introduce the laparoscope and other ports (10–12 mm or 5 mm) were used in various positions depending on the procedure.

Results were analysed using R statistical programming language. Statistical analysis was performed using  $\chi^2$  test and simulated  $p$  values via randomisation (when any cell total was  $\leq 5$ ).

## RESULTS

From March 1998 to October 2003, 80 patients (46 male) underwent laparoscopic colorectal procedures. Mean age of the patients at operation was 68 years (range 19–92). Thirty one patients had operations performed for benign pathology, whereas 49 patients had malignancy.

Overall, 52 patients underwent laparoscopic bowel resection and 28 had laparoscopic colonic mobilisation predominantly for stoma formation. Table 1 shows the different types of procedures undertaken laparoscopically as well as details of conversion rates. The overall conversion rate was 24% (19 of 80). The conversion rate for colonic resection was 32% (17 of 52), which included eight patients who had disease related complications before surgery such as pericolic abscess, internal fistulation, and subacute obstruction. The conversion rate for stoma formation was 7% (2 of 28), significantly less ( $p=0.001$ , by simulation) in comparison with the conversion rate for resection.

For the purpose of analysis, this series has been divided into three periods: period A, B, and C. Period A was the early part of the series (1998–2000) with 27 patients. Period B was the mid-part of the series (2001) with 25 patients and period

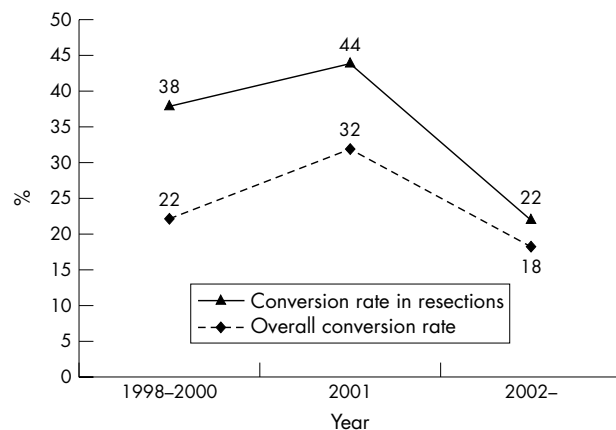
**Table 1** Various laparoscopic colorectal operations with conversions

Procedure	Laparoscopic	Converted	Total
Total colectomy with ileostomy	1	0	1
Total colectomy with ileorectal anastomosis	1	0	1
Proctectomy with ileoanal pouch formation	1	0	1
Right hemicolectomy/ileocolic resection	12	4	16
Sigmoid colectomy	7	4	11
Hartmann's procedure	2	4	6
Anterior resection	8	4	12
Abdominoperineal resection	3	1	4
<b>Total colonic resections (stoma excluded)</b>	<b>35</b>	<b>17 (32%)</b>	<b>52</b>
Rectopexy	1	0	1
Sigmoid colotomy	1	0	1
Stoma formation	24	2	26
<b>Total</b>	<b>61</b>	<b>19 (24%)</b>	<b>80</b>

C included 28 patients from the year 2002 onwards (latter part of series). The rate of conversion for colonic resection showed a decline from 38% (5 of 13) in period A and 44% (7 of 16) in period B to 22% (5 of 23) in period C. A similar trend was also seen in the overall rate of conversion, which declined from 22% (6 of 27) early in period A to 32% (8 of 25) in period B down to 18% (5 of 28) in period C. Figure 1 shows this trend graphically. The main reason for conversion in patients who underwent bowel resection (17 of 52) was intra-abdominal adhesions (10 patients). Other reasons included uncertain anatomy and tumour fixity (two patients each) and one case each was converted because of intraoperative haemorrhage, carbon dioxide narcosis, and equipment failure.

The consultant was scrubbed for all cases. The firm has support from a specialist registrar (SpR) and staff grade surgeon (SG) who are shared with another consultant, one of whom was always present at all these procedures. In most cases an SHO scrubs as a second assistant. Twenty two per cent (18 of 80) of cases, one of the middle grades was the principal operating surgeon (10 by SpR and eight by SG). Most of these cases (15 of 28) were laparoscopic colonic mobilisation and stoma formation (eight by SpR and seven patients by SG); however they did perform three laparoscopic resections (two by SpR and one by SG). The SpR was scrubbed as a first assistant in 63% (33 of 52) of bowel resections and 46% (13 of 28) of stoma formations. The SG was a first assistant in 33% (17 of 52) of bowel resections and 32% (9 of 28) stomas.

During the same period, the firm performed 334 open colonic operations (excluding emergencies and urgent cases)



**Figure 1** The declining trend in conversion rates in resected cases and overall.

of which there were 298 resections and 36 stomas. Thirty four per cent (100 of 298) of the open colonic resections were performed by the consultant in comparison with 66% (198 of 298) by the middle grades. This achieves statistical significance when compared with the distribution of the laparoscopic resections, 94% (49 of 52) and 6% (3 of 52) respectively ( $p = 0.00005$ , by simulation). In comparison, the middle grades performed a higher percentage of stoma formations (both laparoscopic and open). Table 2 summarises these data.

Of the 49 patients with malignancy, 20 had laparoscopic assisted stoma formation. The 29 patients who underwent laparoscopic resection for malignancy had clear margins on pathological examination. Twenty one of these patients had locally advanced disease (T3/T4) and five patients had distant metastases at the time of operation. There was no significant difference in the number of lymph nodes harvested in laparoscopic (median 11, range 6-51) and open cases (median 11, range 1-41).

The median time taken for the stoma formation was 72 minutes (range 45-120), whereas that for laparoscopic colonic resection was 180 minutes (range 120-345). The median resection time was 195 minutes, 175 minutes, and 210 minutes for periods A, B, and C respectively.

In 61 patients with successful completion of the procedure laparoscopically, there were two deaths and 14 complications. One death was attributable to postoperative myocardial infarction and the second was attributable to multiple organ failure after septicaemia secondary to anastomotic leak. Major morbidity included one case each with postoperative bleeding requiring re-exploration, injury to the prostatic urethra during an abdominoperineal resection, and deep venous thrombosis, three patients with postoperative pneumonia, and two patients with pulmonary oedema.

Morbidity was significantly higher in patients who underwent bowel resection, 27% (14 of 52) as compared with those who only had stoma 7% (2 of 28) ( $p = 0.04$ , by simulation). The morbidity rate in patients who had bowel resection declined from 38% (5 of 13) in period A to 31% (5 of 16) in period B. During period C, there was further improvement with only 4 of 23 patients (17%) having postoperative complications. The very low complication rate in laparoscopic stoma formation precluded similar comparative analysis.

There were no wound related problems in the 51 patients who had successful laparoscopic surgery whereas three of the 17 patients who had to be converted had wound infection.

To date, there have been no port site recurrences in our series in the patients with laparoscopic surgery for malignancy.

**DISCUSSION**

Successful laparoscopic colorectal surgery was first reported in 1991.<sup>2</sup> Since then a number of series have reported variable

**Table 2** Number of open and laparoscopic colorectal operations performed by middle grades and consultant

	Laparoscopic colonic resection (n = 52)	Open colonic resection (n = 298)	Laparoscopic stoma (n = 28)	Open stoma formation (n = 36)
Consultant	49 (94%)	100 (34%)	13 (46%)	14 (39%)
SpR and SG	3 (6%)	198 (66%)	15 (54%)	22 (61%)

p=0.00005 (by simulation)  
p=0.6 ( $\chi^2$ )

results.<sup>8,9</sup> The recent report from the Clinical Outcomes of Surgical Therapy Study Group in the United States of America has shown that laparoscopic surgery for colonic cancer is no worse than open surgery from an oncological perspective and carries some benefit in terms of reduced admission to hospital and analgesic requirements.<sup>5</sup>

It has been suggested that the assessment of the learning curve should not be based on the amount of blood loss or duration of surgery, but on the conversion rates, which should gradually decrease with increasing experience and eventually reach a plateau.<sup>9</sup> So far, the number of procedures required to reach proficiency in laparoscopic surgery has not been defined clearly.<sup>10</sup> Our study confirms reduction in conversion rates with experience and highlights that the learning curve is quite prolonged, with improvement noticeable even after several years. Similar learning curves have also been reported in laparoscopic Roux-en-Y gastric bypass<sup>11</sup> and hand assisted laparoscopic nephrectomy.<sup>12</sup> However, such results should be interpreted with some caution, as with increasing experience, surgeons tend to undertake more challenging cases, which may skew the results. In our study, although the conversion rates have decreased with experience, there has been no significant change in the duration of surgery. The main reason for conversion in this study was adhesions, which is similar to other series.<sup>8</sup> Better case selection may also contribute to reduction in conversion rates.<sup>13</sup> It is worth noting that eight of the 17 conversions in the resection group in our series had local complications of their disease related to sepsis or obstruction before surgery.

In our unit, trainees who are competent at laparoscopic cholecystectomy are further trained to perform laparoscopic colonic surgery, initially with colonic mobilisation and stoma formation. However, trainees have performed very few resections. This is because of a combination of factors: the consultant's own position on the learning curve, the rotational nature of trainee posts, and the fact that recent guidance from the National Institute of Health and Clinical Excellence precludes further dissemination of the laparoscopic surgical technique in cases with malignancy at the present time. Although there has been no standard technique of laparoscopic resection taught to trainees in our unit, all have gained some experience in colonic mobilisation. Literature searches have shown no ideal method for training surgeons in laparoscopic surgery.<sup>14</sup> The most common methods include studying videotapes, using pelvi-trainers or other simulators, animal laboratories, assisting during live surgery, and being mentored by an experienced surgeon.<sup>15-17</sup> One of the reasons for the low number of resections by trainees in our unit may be because we have not routinely used any of the above modalities.

In our series, as can be seen from table 2, a significantly higher proportion of resections are performed by the consultant when the case is done laparoscopically. It could be argued that many of these cases could be lost training opportunities in open surgery for the registrar. However, it is worth noting that a recent survey of the members of the Association of Colo-proctology of Great Britain and Ireland

by Harinath *et al* seems to show that an increasing number of surgeons are taking up laparoscopic colonic surgery (personal communication).<sup>18</sup> It is also worth noting that results from the American trial<sup>5</sup> as well as preliminary results from the CLASICC trial in the UK seem to suggest that this technique is safe in malignancy. These factors make it imperative that SpRs should have some exposure to these techniques during their training. As consultants gain expertise, more opportunities will be available to offer training to SpRs.

Complication rates in laparoscopic colorectal resection have been reported to vary widely between 5% and 40%.<sup>19,20</sup> Our study has confirmed the inverse relation between experience and complication rates, with a decline from 38% in period A down to 17% in period C. Similar trends have been observed in other series.<sup>21</sup> Urethral injury is a known complication in an abdominoperineal resection of the rectum and has previously been reported in laparoscopic assisted APER.<sup>22</sup> Our series had patients with pulmonary oedema and deep venous thrombosis, which are well known to occur after pneumoperitoneum. Insufflation related complications have been previously reported<sup>23</sup> and although all patients undergoing laparoscopic surgery were monitored for expired carbon dioxide levels, we had one patient who developed carbon dioxide narcosis towards the end of the surgery requiring conversion to open surgery. Laparoscopic surgery has been reported to have reduced incidence of wound related complications<sup>24</sup> and our experience in this series also confirms this. In this study, the types of resection carried out are of different magnitude making comparisons with open surgery difficult.

## CONCLUSION

This audit confirms that there is a comparatively long learning curve in achieving competence in laparoscopic colorectal surgery, with demonstrable decrease in the conversion and complication rates with increasing experience. There is a reduction in training opportunities in open surgery during the learning phase of the consultant, although this may be counterbalanced by the exposure to laparoscopic techniques. With increasing interest in this field, we feel that this is the appropriate time to incorporate these techniques into SpR training. Laparoscopic colonic mobilisation, as a part of stoma formation is a good starting point for surgical trainees.

## ACKNOWLEDGEMENTS

We thank Professor C Brunson, University of Glamorgan for providing us with statistical support.

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Funding: none.

Conflicts of interest: none declared.

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