Laparoscopic cholecystectomy: a prospective cohort study assessing the impact of grade of operating surgeon on operative time and 30-day morbidity

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ABSTRACT

INTRODUCTION There is an increasing trend towards day case surgery for uncomplicated gallstone disease. The challenges of maximising training opportunities are well recognised by surgical trainees and the need to demonstrate timely progression of competencies is essential. Laparoscopic cholecystectomy provides the potential for excellent trainee learning opportunities. Our study builds upon previous work by assessing whether measures of outcome are still affected when cases are stratified based on procedural difficulty.

MATERIAL AND METHODS A prospective cohort study of all laparoscopic cholecystectomies conducted at a district general hospital between 2009 and 2014, performed under the care of a single consultant. The operative difficulty was determined using the Cuschieri classification. The primary endpoint was duration of operation. Secondary endpoints included length of hospital stay, delayed discharge rate and 30-day morbidity.

RESULTS A total of 266 laparoscopic cholecystectomies were performed during the study period. Mean operative time for all consultant-led cases was 52.5 minutes compared with 51.4 minutes for trainees ($P = 0.67$ unpaired t-test). When cases were stratified for difficulty, consultant-led cases were on average 5 minutes faster. Median duration of hospital stay was equivalent in both groups and there was no statistical difference in re-attendance (12.9% vs. 15.3% $P = 0.59$) or re-admission rates (3.2% vs. 8.1% $P = 0.10$) at 30 days.

CONCLUSIONS Our study provides evidence that laparoscopic cholecystectomy provides a good training opportunity for surgical trainees without being detrimental to patient outcome. We recommend that, in selected patients, under consultant supervision, laparoscopic cholecystectomy can be performed primarily by the surgical trainee without impacting on patient outcome or theatre scheduling.

KEYWORDS

Laparoscopic cholecystectomy – Surgical training – Operative time – Length of stay – Patient care – 30-day morbidity

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Introduction

The British Association of Day Surgery recommends that 60% of laparoscopic cholecystectomies should be performed as a daycase procedure.¹ In 2013, a Cochrane review suggested that daycase surgery for laparoscopic cholecystectomy was as safe as an overnight admission² and in 2002 the Department of Health anticipated that 75% of elective procedures would be performed in the daycase setting in the near future.³ With increasing pressure for inpatient beds in a financially struggling NHS, daycase surgery has become an extremely attractive proposition with its potential to release inpatient beds, provide cost savings in terms of staffing and

resources and improve the patient experience. There may be concern from some groups, including consultants and hospital managers, that surgical training may detract from the throughput of operating lists by increased operative times or higher overnight admission rates, resulting in loss of funding from tariffs and greater strain on limited resources.⁴

A move towards performing laparoscopic cholecystectomy during emergency admission in patients with symptomatic gallstone disease⁵ may also result in a change in the composition of elective cholecystectomy lists. These potentially more challenging cases are not always suitable for training purposes. If these cases are performed acutely,

fewer delayed cholecystectomies will be placed on elective lists, making these sessions even more suitable for providing training opportunities while still maintaining the daycase throughput.

Several studies have looked at various daycase procedures together with laparoscopic cholecystectomy to assess the effect of the trainee surgeon on operative time.^{6–8} Cases performed by a trainee have been shown to be associated with increased operative times but these studies had not stratified the cases according to difficulty. European studies assessing patient outcomes following laparoscopic cholecystectomy performed by trainees under consultant supervision described increased operative times but no difference in length of stay or 30-day morbidity.^{9–11}

Alfred Cuschieri proposed a classification system to stratify the difficulty of a laparoscopic cholecystectomy based on the anatomical and intraoperative findings.¹² We proposed that when stratified cases are compared by equal difficulty using the Cuschieri classification (Table 1), the difference in operative time between surgical trainee and consultants may be less than demonstrated in previous studies.

Material and Methods

A prospective cohort study was conducted of consecutive laparoscopic cholecystectomies performed under the supervision of a single consultant at a district general hospital, over a five-year period between 2009 and 2014. Intraoperative details were collected and the difficulty of the procedure was categorised by a single consultant using the Cuschieri classification.

In total, 10 trainees rotated through the department during the study period. Most of the trainees were year 2–5 registrars except one, who was a year 1 registrar. This registrar started by assisting with 20 procedures before being allowed to perform one himself. The majority of the trainees had some experience in laparoscopic surgery before coming to the department but their exact experience was not recorded.

Table 1 Cuschieri scale of difficulty for cholecystectomy	
Difficulty grade	Definition
1	Easy or uncomplicated procedure
2	Medium difficulty – either mild cholecystitis; cystic duct or artery obscured by adhesions or fatty tissue; mucocele may be present
3	Difficult cholecystectomy – either chronic cholecystitis; shrunken fibrotic gallbladder; severe cholecystitis; Hartmann’s pouch adherent to the common hepatic duct; cases in which the cystic duct or artery are difficult to dissect.
4	Conversion to open procedure is required such as in cases of Mirizzi’s syndrome; gangrenous gallbladder; gallbladder or liver densely adherent to duodenum or transverse colon

A trainee-led case was defined as a case where the primary listed surgeon was either in a surgical training programme or held a staff grade post at the hospital but required supervision to perform the procedure. If the trainee required help during the procedure, the consultant would assist and the trainee would complete the remainder of the case. This was recorded as being a trainee case. If, however, the trainee started the procedure but it was taken over and completed by the consultant, this was considered as a consultant case.

The consultant was assisted by junior doctors (SHO, FY1, FY2 and core trainees) for most of the consultant led cases. The majority of the trainee cases were performed with the consultant assisting. There were some cases where they were assisted by other trainees or a core trainee with the consultant not scrubbed but present in theatre. All cholecystectomies completed laparoscopically were included in this cohort, including both elective and emergency cases. As the aim of the study was to assess the difference in operator time between consultant and trainee in laparoscopic procedures, all cases requiring conversion to an open procedure (Cuschieri grade 4) were excluded. The clinical end points were categorised into primary and secondary. The primary endpoint was the length of operative time (in minutes), defined as time from skin incision to skin closure. Secondary endpoints were length of hospital stay post-surgery (in days), delayed discharge (defined as an admission of more than two days post-surgery), 30-day all-cause re-attendance, 30-day all-cause readmission and 30-day mortality.

Data were analysed for statistical significance using Graphpad Prism 6 statistical software. End points were assessed for Gaussian distribution and then parametric or non-parametric tests applied appropriately. An Unpaired t-test was applied to the primary endpoint of length of operation. Post-operative length of hospital stay was analysed using the Mann Whitney test and the 30-day morbidity criteria and proportion of delayed discharges was compared using the Fisher’s exact 2-tail test.

Results

A total of 279 laparoscopic cholecystectomies were performed. Of these, 13 (4.7%) were converted to open (Table 2). Of the 266 cases that were completed laparoscopically, 155 operations were consultant-led, with the remaining 111 cases being completed by a trainee under supervision (58% vs. 42%). Patients had a mean age of 46.4 years (range 18–83 years) for consultant cases and 45.5 years (range 19–83 years) for trainee cases. Acute gallbladder accounted for 11 (7.1%) of the consultant cases and 4 (3.6%) of the trainee cases. The remaining cases were either delayed or elective operations.

Some 266 cases were completed in the study period, (155 consultant-led cases vs. 111 trainee-led). The mean length of operative time (Table 3) for all consultant cases was 52.5 minutes (95% confidence interval, CI, 49.0–55.9 minutes, standard deviation, SD, 22.0) vs. 51.4 minutes for trainees (95% CI 48.2–54.6 minutes, SD 16.6) ($P = 0.67$ unpaired t-test). Median length of stay (Table 4) was 1 day for both

Table 2 Cases converted to open procedure (Cuschieri grade 4)

Reasons for conversion	Cases (n)
Dense adhesions from gallbladder to bowel or other structures	4
Emergency cases with gangrenous or already perforated gallbladder	3
Adhesions associated with previous surgery	2
Large impacted stone in Hartmann's pouch	2
Mirizzi's syndrome	2
Total	13

groups (95% CI 1–1 day vs. 0–1 day) ($P = 0.14$ Mann-Whitney test). There was no difference in the number of delayed discharges from hospital (Table 5) based on grade of surgeon, 16.1% vs. 9.0% ($P = 0.10$ Fisher's exact 2-tail).

There was no statistical difference in 30-day morbidity demonstrated in all-cause rates of re-attendance (Table 6) at the emergency department, which was 12.9% for consultant cases, compared with 15.3% for trainee-led cases ($P = 0.59$ Fisher's exact 2-tail). Subsequent re-admission (Table 6) was higher in trainee cases but this was not statistically significant. Readmission occurred in 3.2% of consultant cases compared with 8.1% of trainee cases ($P = 0.10$ Fisher's exact

2-tail). Duration of re-admission was different between the groups but not significant; median re-admission for consultant cases was 10 days (95% CI 1–21 days) compared with 2 days for trainee cases (95% CI 1–6 days, $P = 0.20$). The difference in re-admission time may be explained by the difference in case complexity. Three of the five consultant re-admissions were due to bile leaks, requiring prolonged admissions of 10, 17 and 21 days. Two (40%) of the consultant cases that were re-admitted had required intraoperative drains at time of surgery. Patients who were readmitted did not have an increased length of stay at the time of their initial surgery. There was no 30-day mortality during this study.

Interpretation by Cuschieri classification

Figure 1 demonstrate how the complexity of cases, as defined by the Cuschieri classification, was distributed between the two operator levels. Our data demonstrate that, in practice, a consultant rather than a trainee invariably performed the more difficult cases. Consultant caseload was 61.3% for Cuschieri grade 1, 27.7% for Cuschieri grade 2 and 11.0% for Cuschieri grade 3 cases. This compared with 73.9% Cuschieri grade 1 for trainees, 23.4% Cuschieri grade 2 and 2.7% Cuschieri grade 3 cases. Based on this information, we analysed our findings, stratified by the difficulty of procedure, to give a more accurate comparison of outcome.

Cuschieri grade 1 cases

Of the 266 completed procedures, 177 (66.5%) were graded as Cuschieri grade 1. Consultant–trainee split of these cases

Table 3 Length of operative time

Cuschieri grade	Time (minutes)				<i>P</i> value (unpaired t-test)
	Mean		95% Confidence interval		
	Consultant	Trainee	Consultant	Trainee	
All	52.5	51.4	49–55.9	48.2–54.6	0.672
1	40.9	45.1	38.7–42.7	42.7–47.5	0.005
2	61.6	65.6	56.7–66.6	59.8–71.4	0.498
3	95	100	84.1–105.9	57–143	0.073

Table 4 Postoperative length of stay

Cuschieri grade	Length of stay (days)						<i>P</i> value (Mann–Whitney test)
	Median		Interquartile range		95% Confidence interval		
	Consultant	Trainee	Consultant	Trainee	Consultant	Trainee	
All procedures	1	1	0–1	0–1	1–1	0–1	0.142
1	1	1	0–1	0–1	0–1	0–1	0.728
2	1	1	1–1	0–1	1–1	0–1	0.038
3	1	1	1–1.5	0–9	1–1	0–9	>0.999

Table 5 Delayed discharge of two or more days post-surgery

Cuschieri grade	Admission		<i>P</i> value (Fisher's exact 2-tail)
	Rate	Range	
All procedures	0.161	25/155	0.1
1	0.126	12/95	0.469
2	0.209	9/43	0.188
3	0.235	4/17	1

was 55.6% vs. 46.4%, respectively. Mean operation time was significantly different in favour of consultants, 40.7 minutes (95% CI 38.7–42.7 minutes, SD 9.75) compared with 45.1 minutes (95% CI 42.7–47.5 minutes, SD 11.00; $P = 0.005$). Length of stay was not significantly different, both with a median length of 1 day ($P = 0.73$). Delayed discharge rates were 12.6% compared with 8.5% ($P = 0.47$). The 30-day all-cause morbidity was not significant for either re-attendance (15.8% vs. 14.6%) or re-admission (2.1% vs. 6.1%) between the groups ($P = 1.00$ and $P = 0.25$, respectively).

Cuschieri grade 2 cases

Some 25.9% of cases were graded as Cuschieri grade 2. 62.3% were completed by a consultant. No statistical difference was noted in the mean operation time, 61.6 minutes (95% CI 56.7–66.6 minutes, SD 16.0) compared with 65.6 minutes for trainees (95% CI 59.8–71.4 minutes, SD 14.3; $P = 0.50$). Delayed discharges were not significant (20.9% vs. 7.7% $P = 0.19$). Median length of stay was statistically different ($P = 0.04$) but with no difference in 30-day morbidity. Re-attendance was 9.3% compared with 19.2% ($P = 0.28$) and re-admission 4.7% compared with 15.4% ($P = 0.19$).

Cuschieri grade 3 cases

A further 7.5% of cases were graded as Cuschieri grade 3, with 85% of cases being consultant-led. No significant difference was noted in mean operation time, 95.0 minutes (95% CI 84.1–105.9 minutes, SD 21.2) compared with 100.0 minutes (95% CI 56.97–145.0 minutes, SD 17.3; $P = 0.07$) or by median length of stay (1 day, $P = 1.00$). Delayed discharges were similar 23.5% vs. 35.3% ($P = 1.00$). There was

no difference in 30-day re-attendance or admission rates, with 5.9% vs. 0% incidence of 30-day morbidity on both criteria ($P = 1.00$ for both).

Discussion

Laparoscopic cholecystectomy has now become the gold standard of care for almost all patients, with gallbladder disease with reduced postoperative pain, shortened hospital stay, faster recuperation and earlier return to normal function compared with open surgery.^{15,14} The need to develop and train the next generation of consultant surgeons must be balanced with maintaining operational efficiency of the hospital. While length of operative time may act as a marker of efficiency in the operating theatre and may subsequently provide cost savings, it should not be considered alone in the factors involved in holistic care of the patient.¹⁵ Recent evidence from Kazuare *et al.*¹⁶ in their evaluation of the American College of Surgery National Surgical Quality Improvement Program database has shown that trainee participation decreases 30-day mortality despite increased operating times. Thus, the efforts of the team that contribute to the care of the patient should not be underestimated.^{15–17}

Laparoscopic cholecystectomy requires many of the attributes that the surgeon in training must develop. The acquisition and assessment of these psychomotor skill sets may be achieved via exposure to training courses and simulators,^{18,19} which enable the acquisition of core principles. However, a trainee surgeon needs to develop and understand the visual cues, visio-perceptive and adaptive skills required to safely perform a laparoscopic cholecystectomy. These must be acquired without compromising patient safety or increasing service running costs and affecting throughput. This fine balance is a constant challenge to any surgical unit involved in training future laparoscopic surgeons. There is no single well-established assessment methodology that satisfies all requirements for confirming competence in operative and cognitive laparoscopic skills.²⁰ The Association of Laparoscopic Surgeons of Great Britain and Ireland has introduced the acquisition of a laparoscopic passport (LapPass) for trainees who are able to demonstrate proficiency in a defined set of five laparoscopic tasks.²¹ This will help trainers to recognise trainees who are suitable for accelerated laparoscopic training but there is no substitute

Table 6 Thirty-day all-cause re-attendance and re-admission rates

Cuschieri grade	Re-attendance rate (range)		<i>P</i> value (Fisher's exact 2-tail)	Re-admission rate (range)		<i>P</i> value (Fisher's exact 2-tail)
	Consultant	Trainee		Consultant	Trainee	
All	0.129 (20/155)	0.153 (17/111)	0.594	0.032 (5/155)	0.081 (9/111)	0.097
1	0.158 (15/95)	0.146 (12/82)	1.000	0.021 (2/95)	0.061 (5/82)	0.252
2	0.093 (4/43)	0.192 (5/26)	0.282	0.047 (2/43)	0.154 (4/26)	0.189
3	0.059 (1/17)	0.000 (0/3)	1.000	0.059 (1/17)	0.000 (0/3)	1.000

Figure 1 Distribution of case complexity based on Cuschieri classification.

for clinical practice under direct supervision for the development of these skills.¹⁹

Our findings compare well with other published data, in which the average delay varied between 5 and 9 minutes per procedure when comparing trainees to consultants.²² In our study, mean all-case operating time was comparable between consultant and trainee, 52.5 minutes compared with 51.4 minutes ($P = 0.67$). On closer examination of the data, when the difficulty of the procedure is considered using the Cuschieri classification, consultant-led operations can be seen to be approximately 5 minutes faster. This was demonstrated across all grades of difficulty. When assessed from a cost versus training perspective, this represents minimal delay and one that is consistent with other centres.²² This difference in timing would be equal to or less than other delays that are experienced in a theatre environment and would be absorbed into the usual daily working routine. One must be careful, however, not to use operative time as a direct marker of competence.²¹ While this can be a good indicator of procedural steps completed during an operation, it does not correlate well with the consequential error rate as shown by the data presented by Tang *et al.*¹⁵

The Intercollegiate Surgical Training Programme sets out the curriculum for all surgical trainees within the UK.²⁵ It defines the essential competencies that a trainee must achieve to complete higher surgical training and be granted a Certificate of Completion of Training. Procedure-based assessments are the principle method by which surgical trainees are assessed in terms of their progression in a specific procedural skill. These represent a continuum of a trainee's progression over a period of time. Unlike in traditional open surgery, in laparoscopic cholecystectomy the only mode of instruction is verbal, which makes training more complicated. Despite this restriction, laparoscopic cholecystectomy has been shown to be a safe procedure in the hands of a trainee in a clearly defined teaching scenario

with standardised operative steps.¹⁹ Our data support this fact, showing no statistical difference in 30-day morbidity between consultant and trainee operations. Furthermore, our subgroup analysis demonstrated that this was achieved with minimal operating time differences. Data show that the frequency of complications, duration of hospital stay and operating time for laparoscopic cholecystectomies are reduced beyond the first 25 cases completed by a trainee.²⁴ After 35 cases, the operating time may significantly decrease for some surgeons but not for others, reflecting variability in the ability to acquire skills.²⁵ There is a reported 40% reduction in operation time for laparoscopic cholecystectomies after 200 operations.²⁶ This highlights the importance of experienced trainers in supervising junior trainees and the need for exposure to a high volume of cases during a surgical training programme to develop the skills and efficiency for independent practice.

A length of hospital stay between 1.1 and 3.5 days has been reported in the literature following cholecystectomy.^{27,28} Our results are consistent, showing no difference in the median length of stay between different groups. Owing to the small sample size, however, a statistical difference was noted in our Cuschieri grade 2 cases ($P = 0.038$). This can be explained by the consultant median length of stay being skewed by a single patient who had a postoperative bleed and had an extended hospital stay of 7 days. The grade of surgeon did not impact on the number of delayed discharges, which was defined in this study as a postoperative length of stay of equal to or greater than 2 days.

The final clinical end point of importance was 30-day morbidity. Of the 155 cases that were consultant-led, 20 patients re-attended (12.9%). In the trainee cohort, 17 of 111 (15.3%) patients re-attended following discharge. This higher rate of re-attendance among cases performed by a trainee was not proven to be statistically significant ($P = 0.59$). Despite the low numbers of higher difficulty cases

performed by trainees, our data would suggest that the rate of postoperative complications and morbidity are not increased when performed by a supervised trainee, consistent with published literature.^{15–17}

It is unsurprising that more complex cases, as defined by the Cuschieri classification, were consultant-led (85% vs. 15%). One might hypothesise that if these cases had been split equally, a significant difference in outcomes between the consultant-led cohort and those performed by trainees might be borne out. However, based on the distribution of cases in our study, it would be inappropriate to draw firm conclusions as to whether or not there is a significant difference between the two groups. The distribution of case allocation by the supervising trainer needs to reflect case difficulty and is reliant on the existing relationship between trainer and trainee to ensure that teaching cases are chosen to reflect the trainee's optimal zone of development, enabling effective teaching while ensuring patient safety.²⁹

While assuming that theatre protocols and staff remained essentially the same, data by Englesbe *et al.*⁵⁰ showed that most of the increase in theatre time when a trainee was lead surgeon occurred between entering the operating room and skin incision and from completion of procedure to the patient leaving the operating room.⁵⁰ Consequently, skin to skin times may be a focus for future studies to provide a more accurate 'operative time'. It would also be useful to compare duration for consultant-supervised operations while there was (1) no trainee present, (2) a consultant training a trainee and (3) a trainee as lead surgeon. This would provide a more detailed breakdown and allow more accurate interpretation of data. Studies relating to surgical times and trainee involvement highlight the fact that it is difficult to measure the extent of involvement in a procedure and subsequent outcomes appropriately.^{14,15,17,50} It may be useful in future studies to collect data regarding the proportion of a procedure completed by a trainee together with total surgical operating time.

Another consideration for the selection of cases and the impact on providing training within service provision lists is the experience of the trainee. This study did not analyse trainees by their level of laparoscopic experience; a senior trainee with more experience would be expected to be more competent and faster. This has been debated, however, in a large study by Teng *et al.*¹⁵ It is not always possible to anticipate the trainee who would be attending a list as such cases cannot be pre-selected based on training grade. Further research would be required to assess the impact of a trainee's experience and how it correlated to operative times, randomising patient selection as well as accounting for individual experience. It would take an experienced surgeon used to weighing up risk in such instances and confident in their teaching abilities to allow 50% of the most complex cases to be performed by a trainee, even when supervised. Direct comparisons between the two groups are therefore challenging. While there is an indisputable value in trainee input with Cuschieri grade 3 or 4 cases, this value may be more useful to those at the latter stages of their training.

Finally, limitations of this study should be noted. By their nature, data were recorded prospectively in respect of

operator, operating time and difficulty of the case, but were not randomised to either consultant or trainee carrying out the procedure. More complex operations tended to be performed by the consultant while the 'simpler' cases were performed by trainees. This implies a selection bias in favour of operative results achieved by trainees. Furthermore, there was no individual differentiation between each trainee's level of surgical experience. It becomes nearly impossible to accurately measure how much participation the trainee actually has in an operation, thus it is not possible to differentiate accurately those that were only partly performed by the trainee, in which the consultant may have performed the critical steps. The problems of non-randomization pertain to any analysis of outcomes, such as the study by Raval *et al.*,⁵¹ which was carried out retrospectively. In their analysis of 607,683 surgical patients, the study found that there was a higher morbidity but equal or even lower mortality in most subgroups of patients when operated by an attending surgeon (consultant grade). This may suggest a potential selection bias where the resident surgeon (trainee grade) tended to operate on 'simpler cases in healthier patients'. The key to employing laparoscopic cholecystectomy as a training experience is fundamentally dependent on optimal patient selection and sufficient supervision by the overseeing consultant to ensure patient safety and maintain progress.

Conclusion

Since the study period, we have started recording operator experience prior to joining our unit. If trainees have little or no experience of laparoscopic cholecystectomy they are encouraged to assist in 20 cases before they embark on performing procedures under close supervision. Our study provides additional evidence that laparoscopic cholecystectomy performed by supervised surgical trainees can be completed without detriment to patient outcomes or the timely completion of an operating list. The greatest task is prudent patient selection. The challenges of maximising training opportunities are well recognised by almost all surgical trainees and the need to demonstrate timely progression is essential. We suggest that trainers should engage with their trainees early on in their placements, making sure to understand their needs with regards laparoscopic surgery. This will help trainers to devise a similar programme for their trainees to progress through their placement and complete all the necessary problem-based assessments for the annual review process. We therefore recommend that, in selected patients, under consultant supervision, laparoscopic cholecystectomy can be performed primarily by surgical trainees.

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