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ORIGINAL ARTICLE

Analysis of a structured training programme in laparoscopic cholecystectomy

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Abstract
Background Laparoscopic cholecystectomy is an established treatment for almost all gallbladder diseases with bile duct injury rates similar to open cholecystectomy. These laparoscopic skills must be passed on to junior surgeons without compromising patient safety.
Materials and methods We analysed our structured training programme over 6years (May 2000 to May 2006) by following three trainee surgeons during their training and beyond. During this period, 1,000 laparoscopic cholecystectomies were carried out with five consultant surgeons supervising and three new trainees who completed their accreditation in laparoscopic cholecystectomy.
Results There were 694 patients operated on by consultant surgeons (Group 1), 202 by trainee surgeons (Group 2) and 104 by newly trained surgeons (Group 3). There were no differences between the groups in terms of age and gender. However, there was a significant difference in gallbladder disease among the three groups; Group 2 had more gallstone pancreatitis patients ($P < 0.019$). There were no differences among the three groups in conversion rates, bile duct injury rates, general complication rates or length of stay. However, the duration of operation in Group 2 was significantly longer compared to the other two groups ($P < 0.0001$).
Conclusion This programme is effective in training junior surgeons and does not compromise patient safety.

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Introduction

The introduction of laparoscopic cholecystectomy in the early 1980s saw the coming of a new era in general surgery [1]. It is now one of the most common operations performed in both specialised and general surgical units [2]. Decrease in the number of bile duct injuries came when the initial steep learning curve was overcome.

However, it is now important for this knowledge and surgical technique to be passed on to the junior surgeons. This must be done without compromising patient safety.

The European Association of Endoscopic Surgery [3] and the Society of American Gastrointestinal Endoscopic Surgeons [4–6] have both published training recommendations but do not specify numerical requirements for laparoscopic cholecystectomy or any other laparoscopic procedures. In some states, e.g. New York, [7] some specific recommendations have been suggested: inexperienced surgeons should assist in five to ten laparoscopic procedures and subsequently perform five to ten laparoscopic procedures under supervision. Similarly, the training programme in Pennsylvania requires surgeons to assist in a minimum of five procedures and be supervised for a minimum of three subsequent procedures. [8] These numbers were chosen arbitrarily.

Our general surgical unit instituted a structured training programme in the early 1990s as part of our advanced surgical training in order to provide adequate and proficient training in laparoscopic cholecystectomy. In this study, we review this structured programme in terms of patient safety and the performance of our trainee surgeon during their training and beyond.

Materials and methods

The study period extended from May 2000 to May 2000. During this period, there were five consultant surgeons who were the supervisors and three new trainees who joined our unit for our advanced surgical training. During this period, the three trainee surgeons completed their accreditation process in laparoscopic cholecystectomy surgery.

The three trainee surgeons had completed their 3-year course of basic surgical training and had spent at least a year in general surgery. They had passed one of the examinations conducted by the Royal Colleges of UK. During their basic training, they would have assisted in laparoscopic surgery, specifically laparoscopic cholecystectomy, and they would have held the laparoscope or retracted the fundus of the gallbladder. Moreover, they would have assisted and partially done some open cholecystectomy. During this period, they would also have attended a minimum of two courses on basic laparoscopic surgery. The first course was conducted by the Royal Colleges and one conducted by our unit. Here, they were taught basic laparoscopic technique and were introduced to the instruments. They were then encouraged to practice their laparoscopic skills on both simulators and animals. They were tested on these by the consultant surgeons and given certificates of attendance.

They subsequently joined the advanced surgical programmes offered by our hospital's general surgical unit.

In order for them to attain accreditation in laparoscopic cholecystectomy, they must meet certain criteria as described below.

Phase one

1. Trainees undergo supervised training in three laparoscopic appendicectomies and, if found to be proficient in them, trainees are allowed to be independent in this surgical procedure.
2. They then perform a minimum of five laparoscopic appendicectomies unsupervised. These cases are videotaped and this is reviewed by the supervisors.
3. At the same time, they must be supervised for at least five open cholecystectomies. During this open surgical operation, the trainee is tested on the surgical anatomy of the biliary tree as well as the different variations of the anatomy. Only after the trainee shows extensive knowledge of the anatomy and shows proficiency in laparoscopic appendicectomy are they allowed to proceed to the next phase.

Phase two

1. They are supervised in 15 laparoscopic cholecystectomies. These cases are videotaped. The trainee then presents these cases to the unit and is assessed by all supervisors on safety and proficiency. The edited videotapes of all 15 laparoscopic cholecystectomies are viewed by all supervisors in the department. If the trainee is found wanting, he will be required to undergo further supervised training in an unspecified number of cases. Once he has satisfied his supervisor, he will again present his cases to the unit for re-evaluation.
2. Once they are found to be safe, they are then allowed to perform laparoscopic cholecystectomy unsupervised. At the weekly surgical morbidity rounds, they present the cases they are going to perform. If the case is complicated and has significant risks, the case would be passed on to the supervisor. They also present all cases of laparoscopic cholecystectomy that they have done in the previous weeks. Their supervisors are always on hand to intervene or assist if required or called upon.
3. Once they have completed another 35 laparoscopic cholecystectomies, they present all 50 cases (initial 15 and subsequent 35 cases) to a review board. This board consists not only of all supervisory consultant surgeons but a consultant surgeon from an external unit. This board meeting reviews all cases of laparoscopic appendicectomy and open cholecystectomy performed by the trainee. If need be, the external consultant surgeon may view the trainee surgeon performing a laparoscopic cholecystectomy. If the trainee passes the review board, he or she will be accredited to perform laparoscopic cholecystectomy. If the trainee is found wanting, he or she will be required to perform another 15 laparoscopic cholecystectomies under supervision.

Throughout the training period, the trainee surgeons are required to practice their laparoscopic skills on a simulator as well as animals. This process is not enforced but is encouraged by the unit. The trainees record the number of hours of training and this is presented to the review board. At the same time, the trainees meet regularly with their supervisors with an edited videotape of their laparoscopic cholecystectomy and, during this meeting, a critique is given to the trainee surgeons.

On the other hand, the consultant surgeon supervisors are experienced surgeons who have performed more than 200–300 laparoscopic cholecystectomies. They are also accredited by their peers yearly and are required to submit a yearly return of a minimum of 20 laparoscopic cholecys-

tectomies and five laparoscopic appendicectomies to the review board. The whole unit's performance on laparoscopic cholecystectomy is submitted monthly to the Department of Health, Singapore.

For our surgical technique, we use an open insertion of our laparoscope port, which is placed infraumbilically unless there is a history of previous lower abdominal surgery and in such a situation we place it supraumbilically. The other three ports are placed under direct vision. We use a 10-mm port at the epigastrium and two 5-mm ports; one port is placed at the midclavicular line about three finger breadths below the costal margin and another port is placed at the midaxillary line five finger breadths below the costal margin. The Calot's triangle is dissected with a "hook" diathermy at low voltage. No clipping is done until all anatomical structures are identified. We do not perform routine intra-operative cholangiograms. The specimen is routinely delivered in a bag through the laparoscope port. Drains are not routinely placed.

Intravenous antibiotics are given only for acute cholecystitis and only when there is inadvertent perforation of the gallbladder during the dissection.

Statistical analysis

All values are expressed as mean ± standard deviation. The Wilcoxon rank sum test with Bonferroni's correction was used to compare mean operating time. The Kruskal–Wallis test was used for other continuous variables. For categorical data, the chi-squared test or Fischer's exact test was used. A *P*-value of <0.05 was considered to be significant. The analyses were done using SPSS computer software (SPSS version 13 for Windows, SPSS Inc., Chicago, IL, USA).

Results

A total of 1,000 laparoscopic cholecystectomies were performed in our unit from May 1998 to May 2004. During this period, there were five consultant surgeon supervisors (Group 1) and three trainee surgeons (Group 2). The three trainee surgeons subsequently finished their training and became newly trained surgeons (Group 3) in laparoscopic cholecystectomy. There were 694 cases performed by consultant surgeons (Group 1), 202 cases performed by trainee surgeons (Group 2) and 104 cases performed by newly trained surgeons (Group 3) during this period. All data were recorded prospectively but analysed retrospectively.

Demographics

There were 623 female and 377 male patients with a mean age of 50.08 ± 14.73years. The mean age of patients operated on by consultant surgeons (Group 1) was 50.2 ± 14.0years, by trainee surgeons (Group 2) 48.8 ± 14.5years and by newly trained surgeons (Group 3) 51.5 ± 14.3years. There were no significant differences between the groups. The gender distribution among the groups of patients is shown in Table 1.

Diagnosis

There were 643 patients with colic due to gallstones, 201 patients with acute cholecystitis (these included cases with complications of acute cholecystitis such as gangrene and empyema of the gallbladder), 97 patients with cholangitis (these included patients with common bile duct stones secondary to gallstones with or without cholangitis), 54 patients with gallstone pancreatitis and five other patients with gallbladder polyps who underwent laparoscopic cholecystectomy. In Group 1, there were 454 patients (69%) with gallstone colic, 141 patients (20%) with acute cholecystitis, 65 patients (9%) with cholangitis, 29 patients (4%) with gallstone pancreatitis and five patients (0.72%) with symptomatic gallbladder polyps. In Group 2, there were 123 patients (60%) with gallstone colic, 36 patients (17%) with acute cholecystitis, 21 patients with cholangitis (10%) and 22 patients (10%) with gallstone pancreatitis. In Group 3, there were 66 patients (63%) with gallstone colic, 24 patients (23%) with acute cholecystitis, 11 patients (5%) with cholangitis and three patients (2%) with gallstone pancreatitis. The distribution was significantly different ($P < 0.019$) among the three groups. In Group 2, there were more patients with gallstone pancreatitis.

Length of stay

The mean length of stay was 2.47 ± 1.87days for the whole study group. The mean length of stay was 2.43 ± 1.78days in Group 1, 2.47 ± 1.91days in Group 2 and 2.80 ± 2.31days in Group 3. There was no significant difference between the three groups of patients ($P = 0.289$).

Duration of operation

The mean length of operations was 46 ± 22min in Group 1, 118 ± 23min in Group 2 and 45 ± 16min in Group 3. There was a statistically significant difference among the three

Table 1 Patients' characteristics and outcome

Parameters	Group 1 (n=694)	Group 2 (n=202)	Group 3 (n=104)	P-value
Age (years)	50.2±14.0	48.8±14.5	51.5±14.3	0.364
Sex				
Male (n)	272	63	42	0.099
Female (n)	422	139	62	
Diagnosis				
Gallstone colic (n, %)	454 (69)	123(60)	66 (63)	0.019
Acute cholecystitis (n, %)[a]	141 (20)	36 (17)	24 (23)	
Cholangitis (n, %)[b]	65 (9)	21 (10)	11 (5)	
Gallstone pancreatitis (n, %)	29 (4)	22 (10)	3 (2)	
Gallstone polyps (n, %)	5 (0.72)	0	0	
Length of stay (days)	2.43±1.78	2.47±1.91	2.80±2.31	0.289
Operating time (min)	**46±22**	**118±23**	**45±16**	**0.0001**
Bile duct injury (n)	3	1	0	0.143
Other complications (n)	47	9	5	0.406

Significant values are highlighted in bold.
[a] These include cases of acute cholecystitis with or without complications such as gangrene and empyema.
[b] These include cases of common bile duct stones with or without cholangitis.

groups ($P < 0.0001$) with the Group 2 patients having the longest duration of operation.

Conversion to open cholecystectomy

There were 103 patients (10.3%) who required open conversion in the study group, 62 patients (8.9%) in Group 1, 25 patients (12.3%) in Group 2 and 16 patients (15.3%) in Group 3. There was no statistically significant difference between the three groups ($P = 0.072$).

Bile duct injuries

There were a total of four patients (0.4%) who had bile duct injuries. There were two bile leaks from the cystic duct stump requiring re-laparoscopic control and one transected bile duct discovered during surgery which was repaired with a Roux-en-Y hepatico-jejunostomies. The fourth patient had injury to the bile duct during an attempted intra-operative cholangiogram and this was repaired over a T-tube. All are well to date.

Of these four patients, three (0.38%) were operated on by consultant surgeons (Group 1) and one patient (0.5%) was operated on by a trainee surgeon (Group 2). No patients in Group 3 suffered any bile duct injuries. The bile duct injury rate was no different between the three groups of surgeons ($P = 0.143$).

Other complications

There were 61 patients (6.1%) who suffered various forms of complications other than bile duct injury. The complications are listed in Table 2. Among the 61 patients, 47 patients came from Group 1, nine patients came from Group 2 and five patients came from Group 3. There was no significant difference in terms of general complications among the three groups (P=0.406).

There was no 30-day surgical mortality in the whole series.

Discussion

Laparoscopic cholecystectomy has become the gold standard for almost all gallbladder diseases. [9, 10] The bile duct injury rates are also now similar to open cholecystectomy after surgeons were able to conquer the initial learning curve, which in laparoscopic cholecystectomy required more time than expected [11].

The question now is how do we impart the skills and knowledge of this operation to junior surgeons without

Table 2 Complications other than bile duct injury

Complications	No. of patients
Wound infection	25
Infraumbilical incisional hernia	10
Ileus	5
Pneumonia	5
Adhesion colic	5
Thrombophlebitis	5
Deep vein thrombosis	2
Acute retention of urine	3
Acute myocardial infarction	1
Total	61

compromising patient safety. Unlike open surgical operations, the only mode of instruction in laparoscopic surgery is verbal and this makes training in laparoscopic cholecystectomy that much harder [12]. A trainee surgeon has to be trained in the visual cues, visio-perceptive and psychomotor skills required in laparoscopic cholecystectomy. This must be passed on without compromising costs or safety. This fine balance is a constant challenge to any surgical unit involved in training future laparoscopic surgeons.

There are plenty of excellent laboratory aids and simulators which have been shown to improve the skills in laparoscopic surgery [13, 14]. However, these skills need to be used in the operating theatre and be duplicated repeatedly and safely.

In a survey in 2003, 82% of Canadian surgical residents considered their training in minimally invasive surgery inadequate [15] and similarly 65% of their American counterparts also found it wanting [16]. Our centre started this programme in the late 1990s in order to address the issue of training our junior surgeons. Since its inception, more than ten trainee surgeons have successfully completed the training programme. However, the method that was laid down above has been arbitrary and not examined objectively. With this in mind, we examined our early experience with three trainee surgeons in this study to provide evidence that our training programme is safe and effective.

In this study, we found that there were no differences in terms of bile duct injury among the three groups of patients. This attests to the safety of our training programme as the cases operated on by junior surgeons (whether independently or under supervision) did not have a higher rate of bile duct injury.

Similarly, when we analysed the occurrence of other complications beside bile duct injury, there were no differences among the three groups of patients. This offers objective evidence that our training programme does not lead to increased morbidity to our patients.

Although conversion is not looked upon as a failure by the surgeon, it is viewed by the patient as a failure. As such, we included it as an index of outcome in this study.

In terms of conversion rates, there was no difference between the three groups but there was a slightly higher rate among our newly trained surgeons (15.3% versus 8.9%). However, this could be due to significantly more patients with acute cholecystitis in this group and acute cholecystitis has been found to be a risk factor for conversion [17].

The length of stay was similar among the three groups but the operating time was significantly higher in the trainee surgeon group. This is not surprising as these surgeons are on the learning curve. However, this longer operating time did not lead to any ill effects in the patients.

Dagash et al. [18], in a review of the literature, found that there is a learning curve in laparoscopic surgery and subsequent to it the learning curve plateaus. He and his co-authors discovered that there is a wide variation in the number of laparoscopic cholecystectomies that are required before proficiency is reached. However, they felt that all the reports were unreliable as none of the series were able to show a plateauing of the results subsequent to accreditation. In this series, where we followed three trainee surgeons in laparoscopic cholecystectomy, we were able to show this plateau. This is evident when these newly trained surgeons were able to show similar conversion rates, operation time and length of stay to the more experienced supervisor surgeons. The mean number of cases in this series before they were accredited and subsequently became newly trained laparoscopic surgeons was about 67. In the group of trainee surgeons, the conversion rate was also similar to the rest of the surgeons. This is mainly because they were informed that if a conversion was required by their surgical judgement, they should call on their supervisors before making the decision. As such, input from these experienced surgeons may help in decreasing the conversion rate in this group.

One of the main criticisms levelled at this training programme is the subjective assessment of the trainees at each stage. This has been found to be very variable and unreliable [19, 20]. In order to decrease this, the programme includes viewing of the laparoscopic cholecystectomy procedures on video and this is viewed by all supervisors as well as an external consultant surgeon in the hope of adding more objectivity.

In this training programme, we included open cholecystectomy and laparoscopic appendicectomy in order to give breadth and depth to the training. Open cholecystectomy is important as it is what most surgeons rely upon if laparoscopic cholecystectomy fails or is unsafe. However, in a review, Shoemaker [2] found that, in America, there was a decrease in the number of open cholecystectomies performed in general surgical units and a concomitant increase in laparoscopic cholecystectomy and as such the experience on such open surgery may be lost. In this training programme, the whole unit participates in the training and all open cholecystectomies are shared. If a consultant surgeon decides to convert a case, he would immediately allow the trainee surgeon to perform this under his supervision. If the trainee surgeon that is with him has sufficient numbers, he would call upon his fellow trainee surgeons to perform the operation. This “sharing” of cases, which is encouraged among our trainee surgeons, helps in ensuring that there is equal distribution of cases among the trainees. The inclusion of laparoscopic appendicectomy as part of the programme is to allow our trainee surgeons to be comfortable in basic laparoscopic surgery. It is during these surgical procedures that the trainee gains insight into any weakness so that he or she can improve on it in the

laboratory. It is also during this initial training on basic laparoscopic surgery that the trainee learns to troubleshoot problems he or she may face during laparoscopic surgery.

Conclusion

This structured and stepwise training programme does not lead to increased morbidity in the patients but was efficacious in producing safe and competent surgeons in laparoscopic cholecystectomy.

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