Recent experience with laparoscopic appendectomy in a Canadian teaching centre

Abdullah Ali, MD;[*] Michael A.J. Moser; MD, MSc[*†]

Objective: Laparoscopic appendectomy (LA) remains controversial in our city, in part because of results obtained early in the learning curve. In 1995, our centre reported that LA took 30 minutes longer and yet resulted in similar length of hospital stay, compared with open appendectomy (OA). The purpose of the current study is to reexamine LA now that more experience has been gained with the procedure and to document the learning curve at a typical Canadian teaching centre. **Methods:** We undertook a retrospective chart review of patients undergoing nonelective appendectomy between January 2001 and June 2004; this yielded 201 charts that satisfied the inclusion criteria. The 201 cases were divided into 3 groups, each consisting of 67 consecutive cases, to allow for comparison between early, middle and late experience. The main outcomes of interest were operative time, length of stay and the changes over time that occurred in these 2 measures. An intent-to-treat analysis was performed. **Results:** The mean operative time differed by only minutes: 54.9 (standard error of mean [SEM] 1.9) minutes for LA and 48.8 (SEM 1.4) minutes for OA ($p = 0.004$). Length of stay was 1.3 (SEM 0.1) days and 2.9 (SEM 0.2) days for LA and OA groups, respectively ($p < 0.0001$). Analysis of the 3 time periods (early, middle and late) revealed significant improvements in operative time and length of stay for LA in the middle, compared with the early, time periods. **Conclusion:** These data suggest that, with experience, LA operative time approaches that of OA and length of stay decreases. A shortened hospital stay and similar operative time, along with educational advantages, support the use of the LA in teaching centres.

Objectif : L'appendicectomie par laparoscopie (AL) soulève toujours la controverse dans notre ville, en partie à cause des résultats obtenus au début de la courbe d'apprentissage. En 1995, notre centre a signalé que l'AL prenait 30 minutes de plus que l'appendicectomie ouverte (AO) et produisait quand même une hospitalisation d'une durée semblable. L'étude en cours vise à analyser de nouveau l'AL maintenant que l'on a acquis plus d'expérience de l'intervention et à documenter la courbe d'apprentissage à un centre d'enseignement type du Canada. **Méthodes :** Nous avons entrepris une étude rétrospective des dossiers de patients qui ont subi une appendicectomie non élective entre janvier 2001 et juin 2004. L'étude a produit 201 dossiers qui satisfaisaient aux critères d'inclusion. Nous avons réparti les 201 cas en 3 groupes de 67 cas consécutifs afin de comparer l'expérience acquise au début, au milieu et à la fin de la période. La durée de l'intervention, la durée du séjour et les changements survenus dans ces deux mesures ont constitué les principaux résultats d'intérêt. On a analysé l'intention de traiter. **Résultats :** La durée moyenne de l'intervention différait de quelques minutes seulement : 54,9 (erreur-type de la moyenne [ET] 1,9) minutes dans le cas de l'AL et 48,8 (ET 1,4) minutes dans celui de l'AO ($p = 0{,}004$). La durée du séjour s'est établie à 1,3 (ET 0,1) jours et 2,9 (ET 0,2) jours chez les sujets qui ont subi une AL et une AO respectivement ($p < 0{,}0001$). L'analyse des trois périodes (début, milieu et fin) a révélé des réductions importantes de la durée de l'intervention et de la durée du séjour dans le cas de l'AL au cours de la période médiane comparativement au début. **Conclusion :** Ces données indiquent qu'avec l'expérience, la durée de AL se rapproche de celle de l'AO et que la durée du séjour diminue. La durée réduite du séjour à l'hôpital et de l'intervention, ainsi que des avantages sur le plan de l'éducation, appuient l'utilisation de l'AL dans les centres d'enseignement.

In 1995, our centre reported a randomized prospective trial of laparoscopic appendectomy (LA) compared with open appendectomy (OA).[1] In that study, mean operating time was markedly increased (LA 73.8 min v. OA 45.0 min), and there was no benefit in terms of days in the hospital (3.23 v. 3.03, respectively). These results were very early in the learning curve, however. Nonetheless, because of these results and concerns over cost, the procedure was abandoned at our centre for the 5 years that followed.

Since then, several studies and meta-analyses have compared the 2 approaches, with results suggesting

*From the *Department of Surgery, University of Western Ontario, London, Ont., and the †Department of Surgery, University of Saskatchewan, Saskatoon, Sask.*

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Correspondence to: *Dr. Michael A.J. Moser, Division of General Surgery, University of Saskatchewan, 103 Hospital Dr., Saskatoon SK S7N 0W8; drmikemoser@yahoo.com*

a decreased hospital stay and reduced postoperative pain for LA.[2–4] Unfortunately, concerns remain over increased operative time when the LA approach is used,[2,5–8] and it is thought by many that the difference in operative time is further increased in teaching cases.

This study examines the more recent results with LA since the procedure has been reintroduced at our centre and analyzes the learning curve effect at a typical Canadian teaching hospital. We predicted that with experience, the operating time and length of hospital stay (LOS) would improve significantly.

Methods

The study format was a retrospective chart review.

A sample size of 200 was calculated to detect a 1-day reduction in hospital stay with $\alpha = 0.05$ and $\beta = 0.10$. Study inclusion criteria were determined before data were collected.

January 2001 marked the reintroduction of LA to our hospital on a trial basis. A 2.5-year period between Jan. 1, 2001, and June 30, 2004, included 251 patients undergoing appendectomy.

Three surgeons performed both OA and LA during this time, and only their appendectomies form the basis for this study. Two other senior surgeons were nearing retirement and did not perform LA; further, they tended to keep OA patients in hospital longer postoperatively, compared with their other colleagues. This was expected to bias hospital stay in favour of LA, so we excluded the appendectomies done by these 2 surgeons. We also excluded the handful of cases performed by 3 different short-term locums during the study period.

Of the 251 appendectomies, a total of 203 were performed by the 3 surgeons who performed both LA and OA. Two more patients were excluded: in 1 patient, another procedure was performed in addition to appendectomy, and in 1 patient, "interval" appendectomy was performed electively. In the end, 201 patients served as the study population, which represented 80% of the total number of patients undergoing appendectomy during this time.

For comparison over time, we divided the 201 cases into 3 periods, each containing 67 consecutive cases: an early period during which LA was first reintroduced, a middle period during which LA and OA were done in similar numbers and a late period during which most cases were done laparoscopically.

The study protocol was approved by the Ethics Review Board of the London Health Sciences Centre.

Operative technique

Most appendectomies were done by the senior resident; in the middle and late periods, it is estimated that 90% or more were performed by senior residents, as is the case for most standard general surgery procedures taught at our institution. All patients received antibiotics preoperatively and had the procedure performed under general anesthetic. LA in all cases was performed by using a 3-trochar technique (two 10-mm ports and one 5-mm port) that was constant during the study period. A window was dissected between the appendix and its mesentery. Then, an Endo GIA laparoscopic stapler (Ethicon Inc., Cincinnati, Ohio) was fired twice, the first time to divide the appendix and the second time to divide the appendiceal artery. The appendix was then removed through a 10-mm trochar, or if it was too large or friable, it was placed in a bag before being withdrawn through the port site.

Open appendectomy was performed through a standard McBurney's incision. The appendicular artery was tied, and the base of the appendix ligated. The appendix was then amputated and passed from the table. The stump was not inverted.

All resected specimens were submitted for histopathological examination. An appendix was considered normal if the pathology report stated this, regardless of what the operating surgeon dictated in the operative note. Abnormal appendixes were assigned a category according to the operative note (i.e., inflamed, perforated, gangrenous or abscessed). Operating time was measured as the time from first incision to the time of dressing placement.

Patients received postoperative care on a surgical ward and received intravenous fluids until they were tolerating oral fluids well. The decision to discharge a patient was generally made by the operating surgeon or the senior resident on the basis of the patient's clinical progress.

Data analysis

Data collected from the charts were entered into a Microsoft Excel 4.0 database. Intent-to-treat analysis was used. Student's t test was used for parametric data, and χ^2 testing (with Fisher's exact test modification where necessary) was used for non-parametric data. In all cases $p < 0.05$ was considered significant.

Results

A total of 201 patients had emergency surgery for suspected appendicitis; 110 procedures were OA and 91 were LA. Patient characteristics are shown in Table 1. The age of patients was significantly higher in the OA group. There was a trend toward an increased number of patients with previous surgery or comorbidities in the OA group.

The cases were evenly distributed among the 3 attending surgeons. (Table 1) The proportion of LAs increased from 9% in the early phase to 85% in the late phase (Table 2).

Findings at operation are shown in Table 3. Gangrenous, perforated or abscessed (complicated) appendicitis was seen in significantly more patients having OA (38/110, 34.5%), compared with those having LA (15/91, 16.5%) ($p < 0.01$).

Conversion of the laparoscopic approach to an open procedure occurred in 7 (7.7%) of 91 cases. These cases were included in the LA group to allow for intent-to-treat analysis. In 4 of the 7 cases, the reason for conversion was difficulty visualizing the appendix, and in 2 cases, the appendix could not be mobilized. In 1 case, the surgeon was unable to get a stapler around the base of the appendix.

Overall, mean operating time (Table 4) was similar for OA at 48.8 (standard error of mean [SEM] 1.4) minutes, compared with LA at 54.9 (SEM 1.9) minutes, although the 6-minute difference reached statistical significance ($p = 0.004$). In the early period, operating times were significantly longer for LA when compared with OA (68.2 [SEM 4.0] min v. 47.3 [SEM 2.0] min, $p = 0.001$). From the early to the middle phase, LA operating time improved significantly such that, by the middle phase, there was no longer a statistically significant difference between OA and LA.

Mean LOS was almost double after OA, compared with LA (2.9 [SEM 0.2] d v. 1.5 [SEM 0.1] d, $p < 0.001$) (Table 5). Analysis by time period demonstrated consistent improvement in LOS, such that by the late period, LOS averaged 1.3 days for the LA group.

There were 3 wound infections in each group and 1 prolonged ileus after OA. Intra-abdominal abscesses were seen in 2 patients from the OA group and in 1 patient from the LA group (Table 6).

Discussion

Our study shows that operating time for LA approaches that of the open procedure as more experience is gained, even in a teaching centre environment. Also, as confidence with the procedure increased, time to discharge markedly improved over the study period.

The initial experience with LA at our centre was somewhat discouraging. In 1995, Hart and colleagues[1] reported that LA took, on average, 30 minutes longer than OA and that there was no benefit in terms of earlier discharge from hospital. Although separated from the present study by over 5 years during which no LAs were performed, it could be said that the 44 LAs done during the earlier study were nonetheless useful in terms of acquiring experience with the procedure and that they also contributed to the learning curve effect. During Hart's study, LA took on average 74 minutes,

Table 1

Patient demographics: OA v. LA

Characteristic	Group; no. (and %)* OA ($n = 110$)	LA ($n = 91$)	p value
Mean age (and SEM)	38.2 (1.5)	32.8 (1.4)	0.004
Sex (M:F)	53:57	35:56	0.17
Surgeon (A:B:C)	48:28:34	41:27:23	0.64
Patients with previous abdominal surgery	27 (24)	13 (14)	0.13
Patients with comorbidities†	19 (17)	8 (9)	0.08

OA = open appendectomy; LA = laparoscopic appendectomy; SEM = standard error of mean; M = male; F = female.
*Unless otherwise indicated.
†Includes patients recorded as having coronary artery disease, chronic obstructive pulmonary disease or diabetes.

Table 2

Number of OAs and LAs performed during each of the 3 chronological periods

Procedure	Period; no. of cases Early ($n = 67$)	Middle ($n = 67$)	Late ($n = 67$)
OA	61	39	10
LA	6	28	57
Conversion	2	2	3

OA = open appendectomy; LA = laparoscopic appendectomy.

Table 3

Findings at operation*

Finding	Total no. of procedures (and %) OA ($n = 110$)	LA ($n = 91$)	Period; no. of procedures (and %) Early OA ($n = 61$)	LA ($n = 6$)	Middle OA ($n = 39$)	LA ($n = 28$)	Late OA ($n = 10$)	LA ($n = 57$)
Normal	4 (4)	5 (5)	4 (7)	2 (33)	0 (0)	2 (7)	0 (0)	1(2)
Acute	68 (62)	71 (78)	41 (67)	1 (17)	24 (62)	21 (75)	5 (50)	47 (82)
Complicated	38 (35)	15 (16)	16 (26)	3 (50)	15 (39)	5 (18)	5 (50)	9 (16)

OA = open appendectomy; LA = laparoscopic appendectomy.
*An appendix was considered normal if this was reported on the pathology report. Abnormal appendixes were further subdivided on the basis of the operative note. Complicated appendicitis includes perforated, abscessed or gangrenous appendicitis.

whereas in our more recent study, operating times averaged 68, 53 and 55 minutes in each of the successive periods.

Our study is limited by the retrospective nature of the data. A prospective randomized trial would be more useful for comparing operative times and LOS between the 2 groups. The purpose of our study, however, was to look at trends that occurred over time after the reintroduction of LA at our teaching centre. This objective may be well suited to a retrospective review, provided the limitations of LOS as an end point are accepted, as discussed below.

Blinding of LA and OA groups has only rarely been done[5,8] in the dozens of prospective studies done so far. Admittedly, LOS remains a subjective end point that is easily biased, even in prospective trials. Notably, in 2 of the few studies to blind the patient and researcher, there was no difference in postoperative pain or LOS.[5,8]

Thus LOS is often a subjective end point at best, whether the study is randomized or not. Our data nonetheless show significant improvement in LOS and this may instead reflect increased confidence with the procedure, similar to the increase in confidence with laparoscopic cholecystectomies as more of the procedures were done. Indeed, the vast majority of elective laparoscopic cholecystectomies in Canada are now done as day surgery.

It may be difficult to elucidate factors that would cause a surgeon to choose LA over OA in a nonrandomized study. The demographics in Table 1 suggest that age may play a role and that younger patients are favoured to receive LA. Meanwhile, trends are seen toward male patients and patients with previous abdominal surgeries or comorbidities undergoing the open procedure. Other possible factors that arose from a discussion with the participating surgeons include a clinical assessment suggesting a perforated appendix or even the time of night the operation is being performed, in that an OA may be chosen to spare operating room staff from having to set up laparoscopic equipment in the late night and early morning hours. Regardless, the indications for OA obviously became less stringent in the late period where 85% of appendixes were approached laparoscopically, and most (9/14) of the complicated (perforated, gangrenous or abscessed) appendixes were removed with LA.

In the late period, the apparent increase in LOS and operating time for OA probably reflects the fact that, by this time, 50% of the OA cases were for complicated appendicitis.

There is little doubt that the laparoscopic procedure incurs more costs than the open one, as previous studies have shown.[6,9] It seems likely that the cost savings from a reduced hospital stay could offset the excess operating costs, but our study was not designed to examine this question. Certainly, there exist more economical ways than using staplers to perform the procedure. Indeed, one of the authors has begun using mesenteric dissection and the application of an endoloop, again, in a teaching centre. In an informal log of 25 cases, operating time has

Table 4

Operating time for OA v. LA, overall total and total for each phase of the learning curve

Procedure	Total, min; mean (and SEM)	Period, min; mean (and SEM)		
		Early	Middle	Late
OA	48.8 (1.4)	47.3 (2.0)	49.0 (2.5)	57.2 (2.7)
LA	54.9 (1.9)	68.2 (4.0)	52.8 (3.3)*	54.7 (2.5)*
p value	0.004	0.001	0.18	0.34

OA = open appendectomy; LA = laparoscopic appendectomy; SEM = standard error of mean.
*$p < 0.01$ compared with early LA.

Table 5

Postoperative hospital stay for OA v. LA, overall total and for each of the 3 phases of the learning curve

Procedure	Total, d; mean (and SEM)	Period, d; mean (and SEM)		
		Early	Middle	Late
OA	2.9 (0.2)	2.5 (0.2)	3.2 (0.4)	4.3 (0.9)
LA	1.5 (0.1)	3.2 (0.9)	1.6 (0.2)*	1.3 (0.1)*
p value	< 0.001	0.20	0.004	< 0.001

OA = open appendectomy; LA = laparoscopic appendectomy; SEM = standard error of mean.
*$p < 0.01$ compared with early LA.

Table 6

Postoperative complications after OA and LA*

Complication	OA ($n = 110$)	LA ($n = 91$)
Wound infection	3	3
Postoperative ileus	1	0
Intra-abdominal abscess	2	1
Other	2	2
Total (and %)	8 (7)	6 (7)

OA = open appendectomy; LA = laparoscopic appendectomy.
*There were no significant differences between the 2 groups.

averaged 51.2 (SEM 3.3) minutes, with a mean LOS of 1.3 (SEM 0.3) days and no significant complications.

Our reported operating times and LOS are in line with the many previously published works listed in the bibliography, most of which presumably studied appendectomies done in nonteaching hospitals. So many studies have examined the question of OA versus LA that there are currently at least 5 meta-analyses examining the question.[2,3,4,10,11]

The Cochrane Review[2] on the subject, which included 45 studies in adult patients, suggested slightly longer mean operating times for LA (by 12 min, confidence interval [CI] 7–16 min) and LOS reduced by a mean of 1.1 day. Other advantages of LA over OA were noted: decreased wound infection rates, decreased postoperative pain and earlier return to work and activities. Of course, the LOS and postoperative pain results should be interpreted with caution because very few of the studies were blinded.

Our study is unique in that it is the first, to our knowledge, to look at the learning curve in LA and certainly the first to do so in a teaching centre.[12] Our results are in keeping with those seen for laparoscopic cholecystectomy,[13–15] herniorrhaphy[16,17] and splenectomy,[18] in that with experience operating times approach those of the open procedure. In our centre, in about 90% or more of cases, the primary surgeon is a resident supervised by the attending surgeon. Residents rotate through a different service every 3 months, starting on the first day of January, April, July and October. Analyses comparing the start with the end of 3-month blocks showed no difference (data not shown) in any of our parameters. Rather, it seems that operating time depends more on the experience of the teaching surgeon. This seems logical, given observations that a "fast" attending surgeon will be faster than a "slow" one regardless of the trainee doing the procedure.

As more and more general surgical procedures are being performed laparoscopically, it is becoming increasingly important to incorporate advanced laparoscopic procedures into our training programs. This procedure provides an opportunity for residents to hone their laparoscopic skills with a procedure other than laparoscopic cholecystectomy in preparation for the more complex laparoscopic procedures such as colectomy. To teach those surgeons already in practice, it makes sense to have a surgeon experienced in LA to supervise the initial cases. One must be ready to accommodate slightly longer operating times and LOS in the early stages of introducing a procedure. An important point of our study is that a surgeon's LA time should eventually approach that of the OA time, even in a teaching centre.

In conclusion, our results show that with experience the operative times for LA approach those of OA, even in a teaching centre. LOS improves as comfort with the procedure is gained, and mean LOS approaches 1 day without an increase in complications. With an experienced teacher, this procedure does not need to place a strain on emergency operating room time. This, along with the educational advantages, supports the use of LA in teaching hospitals.

Competing interests: None declared.

Contributors: Both authors designed the study. Dr. Ali acquired the data, which both authors analyzed. Both authors wrote and revised the article, and both authors gave final approval for the article to be published.

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