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Examining the learning curve of laparoscopic fundoplications at an urban community hospital

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Abstract

Background: Laparoscopic fundoplication for gastroesophageal reflux disease is a procedure associated with specific complications, especially in a surgeon's early experience. The learning curve of this procedure was examined at a tertiary community institution.
Methods: A retrospective review of the first 100 cases performed at Royal Columbian Hospital was conducted. Two surgeons performed the majority of cases and routinely assisted each other. Patients were grouped chronologically with the first 50 cases defined as early institutional experience and a surgeon's first 20 cases defined as early personal experience.
Results: Operative time was longer in both the early institutional (117.8 versus 91.3 minutes, $P < .001$) and personal experience (126.8 versus 89.7 minutes, $P < .001$). The rate of dysphagia requiring intervention was higher during the early institutional (22% versus 4%, $P = .017$) but not personal experience (19% versus 8%, $P =$ not significant). The conversion rate was 0%, reoperation rate was 1%, mean length of stay was 2.5 ± 1.4 days, and the readmission rate was 5%; these outcomes were unaffected by the learning curve.
Conclusions: There is a definable learning curve in laparoscopic fundoplication in terms of operative time. However, an acceleration of the personal learning curve in terms of dysphagia was observed with a two-surgeon collaborative approach. With careful patient selection conversion, reoperation, readmission, and complication rates equivalent to experienced centers can be achieved in the community setting early in the personal and institutional experience. © 2005 Excerpta Medica Inc. All rights reserved.

Keywords: Laparoscopic fundoplication; Learning curve

Laparoscopic Nissen fundoplication was first described by Dallemagne et al [1] in 1991. Long-term follow-up studies of this procedure show good patient satisfaction and relief of symptoms [2–4]. Studies showing decreased cost [5], reduced in hospital stay [5,6], and earlier return to work [5,6] compared with open fundoplications have further fueled the popularity of this procedure.

The advantages of the laparoscopic Nissen fundoplication are achieved at a risk of procedure-specific complications. These include perforated viscus, pneumothorax, transhiatal migration of the stomach into the chest, and dysphagia requiring dilation [7–9]. The complication rate has been shown to decrease with surgeon experience [7,10,11].

Operative time, conversion rates, reoperative rates, and hospital stay all follow the same learning curve and improve with surgeon experience [7,10–13]. The learning curve has been observed to plateau at 20 cases for an individual surgeon [7,10] and at 50 for an institution [8,11,13]. This phenomenon has been shown both at teaching centers and nonteaching centers [7]. The objective of our study is to examine the learning curve of laparoscopic fundoplication at our institution in terms of operative time, conversions, reoperations, readmissions, length of hospital stay, and complications.

Methods

A retrospective chart review was conducted on the first 100 laparoscopic fundoplications performed at Royal Columbian Hospital, an urban tertiary care hospital in

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New Westminster, British Columbia, affiliated with the general surgery training program at the University of British Columbia. This review covered a period from January 1995 to April 2002.

One surgeon learned how to do the procedure by taking an advanced laparoscopic course in San Francisco, CA. The other took sabbatical leave to learn the procedure in England. All procedures were performed by these two surgeons except two that were performed by a surgical locum. One surgeon performed 74, and the other performed 24 during the study period. In all but 10 cases, 1 surgeon assisted the other. In the other 10, the first assistant was another surgeon. The second assistant was a surgical resident, intern, or general practitioner.

The patients were placed in modified lithotomy position. Five trocars sites were used with a stationary flexible liver retractor. Dissection was performed with the high-frequency ultrasound scalpel. The short gastric vessels were divided in 68 cases. A 360° wrap was performed in 88 cases and a partial Toupet wrap in 12 cases. The length of the wrap was kept between 1.25 and 2.0 cm. Silk sutures were used in all but one case, in which Ethibond (Ethicon Surgical, Somerville, NJ) was used, and sutures were placed using the Endostitch device (US Surgical, Norwalk, CT). At least one stitch of the wrap included a bite of the anterior wall of the esophagus in all cases with care not to incorporate the anterior vagus nerve. Size 50 to 60 French Bougie esophageal dilators were placed by the anesthetist to gauge the wrap in 90 cases. In 10 cases, the Bougie was not used because of excessive resistance met in placing the Bougie. The crura were approximated posteriorly in all but one case in which the hiatal opening was very small. The wrap was anchored to the crura in 72 cases. Concomitant procedures were performed in five cases (four cholecystectomies and one vasectomy). The patients were all started on clear fluids on the first postoperative day. Two patients were discharged on the first postoperative day. Seventy-five were discharged on the second postoperative day. The overall mean length of stay was 2.5 days (range 1–9).

The data were grouped to compare the first 50 cases (n = 50) performed at the hospital to the remainder (n = 50) cases and the first 20 by each surgeon (n = 42) to the remainder performed by each surgeon (n = 58). Statistical significance was evaluated at the $\alpha = 0.05$ level. We applied the chi-square statistic with Yates' correction or Fisher exact test, when appropriate, to categorical variables. We applied the two-tailed Student t test, with the equal or unequal variances formula when applicable, to compare continuous variables. Statistics were reviewed by a statistical analyst.

The majority of patients presented with typical reflux symptoms. Two patients presented with cough, two with hoarseness, one with "belching", one with "choking," and two presented with symptomatic paraesophageal hiatal herniae. Ninety-six patients had preoperative endoscopy, 74 had barium esophagograms, 91 had esophageal motility studies, and 82 had 24-hour ambulatory pH monitoring. Fifty-nine patients had all four preoperative investigations. The mean DeMeester score, recorded in 29 cases, was 53.8 (range 11.6–182.5). Only one value was less than 15 in a patient who did not discontinue omeprazole before the pH probe test. Forty-five patients were women, and 55 were men. The mean age was 46.7 years (range 20–85 years). Thirty-seven patients were American Society of Anesthesiologists class I, 59 were class II, and 4 class III. The mean body mass index was 27.7 (range 18.3–34.2).

Results

The institutional learning curve comparison is summarized in Table 1. The patient characteristics and preoperative workup were comparable in each group. The mean operative time was significantly longer in the early group compared with the late group. Surgeons in the early group anchored the fundoplication to the crura less often and used a smaller-caliber Bougie.

There were no mortalities and no conversions. There were two intraoperative complications in the late group: one pneumothorax shown on a chest x-ray after subcutaneous emphysema was noted intraoperatively that resolved with-

Table 1
Comparing the first 50 institutional cases with the second 50

	Cases 1–50	Cases 51–100
Operative technique		
Operative time (min)	117.86 ± 34.70 (108.00–127.72)	91.3 ± 20.1* (86.69–98.79)
Concomitant procedure	2	3
Division of short gastric vessels	39	29
Toupet partial fundoplication	6	6
Anchor stitch to crura	26	46†
Bougie esophageal dilator	47	43
Bougie size (French)	56.06 ± 5.27 (47) (54.52–57.61)	59.30 ± 2.22 (43)* (58.62–59.99)
Outcomes		
Mortality	0	0
Conversions	0	0
Intraoperative complications	0	2
Postoperative complication	20	9*
Dysphagia requiring invervention	11	2*
Recurrence of symptoms	3	1
Gas bloat	0	1
Other	6	5
Length of stay (d)	2.34 ± 1.10 (2.03–2.65)	2.74 ± 1.59 (2.29–3.19)
Early readmission (<30 d)	5	0
Early reoperation (<30 d)	0	1

Data are reported as frequency of occurrence or mean ± SD with (n analyzed) and 95% confidence interval.

* $P < .05$.

Table 2
Comparing surgeons' first 20 personal cases with subsequent cases

	First 20 (n = 42)	21+ (n = 58)
Operative technique		
Operative time (min)	126.79 ± 32.98 (116.51–137.06)	89.74 ± 18.24* (84.95–94.54)*
Concomitant procedure	5	0*
Division of short gastric vessels	26	42
Toupet partial fundoplication	7	5
Anchor stitch to crura	18	54*
Bougie esophageal dilator	38	52
Bougie size (French)	55.08 ± 5.48 (38) (55.28–56.88)	59.46 ± 1.90 (52)* (58.93–59.99)
Outcomes		
Mortality	0	0
Conversions	0	0
Intraoperative complications	1	1
Postoperative complications	14	14
Dysphagia requiring invervention	8	5
Recurrence of symptoms	1	3
Gas bloat	0	1
Other	5	6
Length of stay (d)	2.55 ± 1.23 (2.16–2.93)	2.53 ± 1.48 (2.15–2.92)
Early readmission (<30 d)	4	1
Early reoperation (<30 d)	0	1

Data are reported as frequency of occurrence or mean ± SD with (n analyzed) and 95% confidence interval.
* $P < .05$.

out a chest tube and a malfunction of the suture device resulting in the loss of a small 3-mm needle fragment. Neither of these patients suffered an adverse outcome. There were more postoperative complications in the early group, comprised mostly of dysphagia requiring intervention. Two cases required reoperation several months after the initial operation, and 11 required endoscopy and dilation on 1 or more occasions. One patient in each group required multiple dilations for chronic dysphagia lasting more than a year from operation. There was one early reoperation in the late group: an acute paraesophageal hernia on the first postoperative day in a patient who underwent a Toupet partial fundoplication. Despite the crural approximation and anchoring of the wrap to the crura, 75% of the stomach had herniated into the chest and perforated. The patient presented with a tension hydrothorax, and bilious fluid was drained with a chest tube. The patient was brought back to the operating theater for laparotomy, the hernia was reduced, the perforation repaired, and a tube gastrostomy created. The patient recovered without any other problems.

The length of stay was comparable in each group as was the early readmission rate. The very first patient was readmitted with dysphagia, two were readmitted with chest pain attributed to anxiety after negative investigations, one patient was admitted with abdominal pain and sepsis that resolved with intravenous antibiotics after a negative contrast study, and one patient was admitted for pneumonia.

The personal learning curve comparison is summarized in Table 2. The cases grouped in the early group comprised of the first 20 cases performed by each of the surgeons plus the 2 performed by the surgical locum. As shown in the institutional comparison, the patient characteristics and preoperative workup were comparable and the operative time was significantly longer in the early group. Surgeons in the early group anchored the fundoplication to the crura less often, used a smaller-caliber Bougie esophageal dilator, and performed more concomitant procedures.

There were no significant differences in complications in the personal learning curve. The lengths of stay were similar, and the readmission and reoperation rates were also similar. Four cases required reoperation. One was early, three delayed, and all were open procedures. Of the delayed reoperations, two were revisions of the fundoplication for persistent dysphagia and one was for a recurrence of a hiatal hernia in a patient with cerebral palsy in whom the stomach could not be reduced because of dense adhesions and thus a gastrostomy was created to function as a gastropexy.

Comments

The outcomes of our series, summarized in Table 3, are comparable to those published in a recent review article of 10,735 cases of primary minimally invasive antireflux procedures performed both during and after the learning curve period [14]. The conversion rate specifically during the learning curve in the literature ranges from 1% to 22% and improves with experience [7,10,11,13]. In this series, the conversion rate was 0%, which is better than the average rate of 3.7% [14]. Common reasons for conversions include surgeon comfort, poor exposure, suspected perforation,

Table 3
Comparison of overall results to literature

	This study (n = 100)	Carlson et al14 (n = 10,735)
Conversion (%)	0	3.7
Reoperation (%)	4	3.78
Operating time (min)	105.3	137
Mortality (%)	0	0.08
Dysphagia (%)	13	0.3–20
Pneumonia (%)	1	0.57
Atelectasis (%)	2	0.15
Wrap herniation (%)	1*	1.3
Pneumothorax (%)	1	1.0
Perforated viscus (%)	1*	0.78
Gas bloat (%)	1	0–45
Persistent reflux (%)	3	3.47
Length of stay (days)	2.5	2.8

* One case of acute paraesophageal herniation resulted in a gastric perforation.

bleeding, obesity, large hiatal hernia, adhesions, paraesophagitis, and technical difficulties [7,9,11–13]. Of these, the most important is surgeon comfort [14]. Having a second surgeon as an assistant early in the personal learning curve has been shown to decrease conversions and need for early reoperation [7]. The higher level of skill and expertise in an assistant would minimize many of the factors influencing conversion. The low conversion rate in our series may be partially explained by having a second surgeon in all cases. Patient selection may also play a role because the mean body mass index was 27.7 and none of the patients had large hiatal herniae. Technical difficulties did not affect the conversion rate because our center was very experienced with laparoscopic cholecystectomy at the time when fundoplications were first performed.

The early (<30 days) reoperation rate ranges from 0% to 13% and improves with experience [7,11,13]. Early reoperations are caused by wrap herniation, dysphagia, perforated viscus, or gas bloat [7,9,14]. In this series, the single early reoperation was for acute paraesophageal herniation and occurred late in the series. Voitk et al [7] describe a low threshold for reoperation for dysphagia and gas bloat in the early learning curve. The anticipation of transient dysphagia and higher threshold for reoperation may explain the low reoperation rate in our series. All patients with severe postoperative dysphagia in our series were investigated with contrast studies. If these were normal, the patient was reassured or underwent dilations rather than reoperation.

The overall reoperation rate, including three delayed cases, was 4%. This compares with the published rate of 3.78% [14]. One of the two patients reoperated on for persistent dysphagia developed an aperistaltic esophagus after chemoradiation therapy to the chest for lung cancer, which was found on a chest x-ray postoperatively. This is a described complication of radiation therapy and is poorly responsive to medical therapy [15], as was observed in this patient. He did not respond to dilations and required a gastrostomy tube for feeding. He had an open revision 4 years after the original surgery. His outcome, although unfortunate, cannot be attributed to the learning curve or operative technique but simply bad luck. We now consider past or potential radiotherapy to the chest a relative contraindication to fundoplication.

Paraesophageal herniation is a known complication, and most studies support routine approximation of the posterior crura [16], although good results have been achieved without routine approximation [17]. However, the topic of incorporation of the esophagus into the wrap and anchorage of the wrap to the diaphragm is controversial [14]. The surgeons consistently incorporated the esophagus into the wrap and closed the posterior hiatus throughout the series. Early in the institutional and personal learning curve, surgeons did not anchor the wrap to the crura consistently but did so routinely late in the learning curve. This reflects the experience of an acute paraesophageal herniation in the 53rd case, the only early reoperation in the series. In this case, the crura were approximated, the esophagus incorporated (it was a Toupet), and the wrap was anchored to the right crus. However, after experiencing this complication, the importance of the anchoring stitch was perhaps exaggerated and thus was used more consistently in the later cases.

Longer operative time early in the learning curve has been shown in multiple studies [10–13]. We reproduced this trend in both the institutional and personal learning curves. The five cases in which there was a concomitant procedure, which increased the operative time, were all in the early phase of the personal learning curve. However, when these cases were excluded from the analysis, the operative time was still significantly longer in the early phase.

The rate of dysphagia ranges from 0.3% to 20% [14]. The overall rate of dysphagia requiring intervention was 13% in this series. Dysphagia has been shown to be unaffected by division of the short gastric vessels [18,19] or selective use of esophageal manometry and pH studies [20]. Routine use of an esophageal Bougie has been shown to decrease the incidence of dysphagia [21]. We found no relationship of dysphagia to these factors. However, it was not our objective to examine these relationships because it is difficult in a retrospective nonrandomized study. Interestingly, dysphagia was significantly higher early in the institutional learning curve but not the personal learning curve. This could be explained by the fact that 1 surgeon performed his first 20 procedures early in the institutional experience and the other surgeon performed his first 20 spread out over the whole period of this study. Because one surgeon assisted the other in most cases, the surgeon who performed fewer cases benefited from the institutional learning curve so that his outcomes, although still early in his personal learning curve, became similar to those late in the institutional learning curve. This reproduces the experience of the study by Voitk et al [7], in which dysphagia was related more to inexperience rather than operative technique. In this series, the one patient who had a reoperation for dysphagia after 3 months had preoperative motility and pH studies, division of the short gastric vessels, and a 52-French esophageal Bougie intraoperatively.

The expansion of laparoscopic surgery in the early 1990s has been described by Alfred Cuschieri as “the biggest unaudited free-for-all in the history of surgery” because the initial forays were conducted in peripheral rather than teaching centers [22]. We have shown that operative times are longer and dysphagia rates are higher early in the learning curve. However, outcomes equivalent to experienced centers as far as conversions, reoperations, readmissions, and complications can be achieved in the community setting early in the learning curve. With a collaborative approach with two surgeons, personal experience can be doubled and the institutional learning curve becomes more influential than the personal. Moreover, this approach generates excellent outcomes despite the learning curve as we have shown.

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Discussion

Mark Ludvigson, M.D. (Tacoma, WA): The premise of this paper is to characterize the learning curve for laparoscopic fundoplication in a community hospital setting. The authors' results stimulate reflection for all of us performing this operation. My partners and I in Tacoma share with the authors a remarkably similar experience with this surgery. Three surgeons in my group performed laparoscopic fundoplication in the same time period. My two senior partners probably did 20 cases before me. We have some departures from the technique presented in this paper: we do not secure the wrap to the crura (except in a Toupet procedure) and we always secure the wrap to the esophagus. We used an endoscopic stapling device to take down the short gastric vessels in the first year and then used the harmonic scalpel. We did not always help one another after the first 20 cases.

In my first 50 laparoscopic fundoplications: one patient was converted to open case for uncontrollable hemorrhage at the short gastric vessels and required splenectomy, two cases were stopped without completion (one had an irreducible hiatal hernia and foreshortened esophagus and the other was markedly obese and partially slid off the table), five patients (to my knowledge) required postoperative endoscopic dilatation for dysphagia, and three patients (to my knowledge) had postoperative symptoms of reflux. There were no reoperations. With regard to my failed laparoscopic cases, bleeding, poor exposure, obesity, large hiatal hernia, and, especially, surgeon discomfort were the reasons for failure. Needless to say, I am impressed with our authors zero conversion rate.