Transition From Open to Laparoscopic Fundoplication

The Learning Curve

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Background: Two of us (B.C.S. and C.W.D.) began performing laparoscopic fundoplication in 1992. We have always designated the resident as the operating surgeon.

Objective: To determine the time necessary for both experienced surgeons and residents to become proficient in laparoscopic fundoplication.

Design: The medical records of 241 consecutive patients undergoing laparoscopic fundoplication were reviewed. This period started with the implementation of the procedure in January 1992 and ended in March 1998. For 3 consecutive years, residents were given a questionnaire regarding their confidence in performing laparoscopic fundoplication.

Results: Laparoscopic fundoplication was attempted in 241 patients and completed in 203 patients (84%). Comparing the first 25 attempted laparoscopic fundoplications with the second 25, there were 14 conversions (56%) vs 4 conversions (16%) (P<.01). Average operative times decreased from 236 to 199 minutes (P<.05), and the intraoperative complication rates were 5 (20%) and 1 (4%), respectively. Subsequently, the conversion rate stabilized at 2%. The operative time continued to decline to an average of 99 minutes for the last 25 laparoscopies. Senior residents and recent graduates returning the questionnaire performed an average of 112 laparoscopic procedures, including 15.7 laparoscopic fundoplications. They felt comfortable with the procedure after performing an average of 10.6 operations.

Conclusions: The learning curve is very steep for the first 25 laparoscopic fundoplications for experienced surgeons. However, improvements, as judged by decreases in operative time, conversion rate, and intraoperative complications, continue to occur after 100 cases. Under supervision, residents can become comfortable with this procedure after about 10 to 15 procedures.

PATIENTS AND METHODS

The medical records of 241 patients who had an antireflux procedure initiated laparoscopically at the Oregon Health Sciences University (Portland) and the Portland Veterans Administration Medical Center were reviewed. Patients with achalasia were excluded from the review. The operations were performed with at least 1 staff surgeon present (B.C.S. or C.W.D.), but with the surgical resident as the operating surgeon.

Indications for antireflux surgery did not change during the study and consisted of symptoms refractory to medical management, complicated gastroesophageal reflux disease, and willingness of patients to discontinue medical therapy and undergo surgical treatment. Twenty patients had undergone previous antireflux procedure. A 360° fundoplication was performed on all patients, with 2 exceptions. A partial wrap was performed on 1 patient with scleroderma and in 1 with severe hypomotility of the esophagus. Twenty-eight percent of the patients were obese, 10% had chronic obstructive pulmonary disease, and 8.4% had cardiac disease as comorbid conditions.

A questionnaire was sent to the residents and recent graduates. They were asked which parts of the operation they found difficult and if they could perform the operation alone. We separated the operation into 3 steps on the questionnaire: (1) dissection of the right and left crus and the retroesophageal window, (2) division of the short gastric vessels and mobilization of the fundus, and (3) performing the wrap.

Patient information, presenting symptoms, preoperative studies, and operative records were collected prospectively and entered into an electronic database from which they could subsequently be analyzed. Statistical analysis was performed using the χ² test or analysis of variance and confirmed with the Scheffé test when appropriate.

We assessed the learning curve for the operation by examining conversion rate, intraoperative complications, and operative times in sequential groups of 25 patients.

RESULTS

Laparoscopic fundoplication was attempted in 241 patients and completed in 203 patients (84%), 154 men and 87 women. The mean (±SD) age of the patients was 47 ± 14 years. Mean body mass index (BMI or Quetelet index): calculated as weight in kilograms divided by the square of the height in meters: weight [kg]/[height (m)]² was 29 kg/m² (range, 16-47).

There was no mortality in this series and the long-term outcomes for gastroesophageal reflux disease were similar to those of 114 patients who had had an open fundoplication performed at our institution by 2 surgeons (B.C.S. and C.W.D.) between 1989 and 1992.10

CONVERSION RATE

Conversion rates declined progressively, with the sharpest drop between the first and second 25 cases. The conversion rate leveled off at 2% for the last 75 cases (Figure 1).

Initially, most cases were converted to open fundoplications because of difficulty in dissecting posterior to the esophagus and in identifying the left diaphragmatic crus and seeing the gastric fundus. Later in the series, a hemorrhage obscuring the view of structures was the major reason for conversion.

INTRAOPERATIVE COMPLICATIONS

In the first 50 cases, there were 4 potentially life-threatening intraoperative complications, 3 perforations of abdominal viscus, and 1 episode of hemorrhage requiring splenectomy. Subsequently, the intraoperative complications have been less serious (ie, pneumothorax or hemorrhage requiring conversion to open fundoplication). Intraoperative complications have decreased to 3% in the last 100 cases. The intraoperative complications are listed in the Table. Although many of the

Figure 1. Conversions to open fundoplication per 25 attempts at laparoscopic fundoplication, given as percentages. Numbers in parentheses are the corresponding actual number of conversions. There was a significant decrease in conversion from the first to the second set of 25 cases (P<.01).
intraoperative complications caused conversion to open fundoplication, none resulted in serious morbidity or death.

**OPERATIVE TIME**

Operative time is also a measure of the expertise of the operating surgeon. Operative times per 25 patients are shown in Figure 2. There was a gradual decrease in operative times in the first 100 cases. Our operative times reached a plateau of 90 to 110 minutes by the end of the study. The resident performing the operation seemed to be the major factor affecting operative times. As shown in Figure 2, the operative time for laparoscopic fundoplication was shorter than for open fundoplication at the end of the study. Our experience with the open fundoplication consisted of 114 cases, also performed by the same 2 staff surgeons (B.C.S. and C.W.D) between 1989 and 1992.

**TECHNICAL ASPECTS OF OPERATION**

For the open fundoplications, the rates of ligation of the short gastric vessels and closure of diaphragmatic crura were 79% and 34%, respectively. As we performed more laparoscopic fundoplications, we found that fundal mobilization and division of the short gastric vessels greatly facilitated making a loose wrap and that closure of the diaphragm was important in preventing herniation of the wrap into the mediastinum. We now close the crura and divide the short gastric vessels on virtually all patients (Figure 3).

A questionnaire was sent out to all residents and returned by 8 of 20 senior and chief residents and 9 practicing surgeons. They each performed an average of 112 laparoscopic procedures and 15.7 laparoscopic fundoplications, and felt comfortable performing a laparoscopic fundoplication alone after being supervised in 10.6 cases. Thirteen of the respondents felt they would be competent with the laparoscopic fundoplication after completion of residency. Retroesophageal dissection of the left crus was considered difficult by 76% of the respondents. Ligation of the short gastric vessels was considered difficult by 59% of the respondents. Wrap development was considered difficult by 35% of the respondents. Seven of 9 former residents performing general surgery who were trained between 1993 and 1998 now perform laparoscopic fundoplication in their practices.

**COMMENT**

Enthusiasm for fundoplication as treatment of gastroesophageal reflux disease has increased markedly with the advent of minimally invasive techniques. The introduction and refinement of laparoscopic fundoplication has occurred in the past 6 years. Our center, with 2 surgeons who were able to serve as their own controls during the transition from open to laparoscopic fundoplications, provided a unique opportunity to evaluate this process and compare results. Our experience, which was similar to many other studies, shows that the number of fundoplications is increasing. Laparoscopic fundoplication represents most of this increase and has become the operation of choice for gastroesophageal reflux disease. Laparoscopic fundoplication requires the ability to perform an operation in multiple planes within a 2-dimensional environment. The acquisition of this skill, along with the need to acquire facility with new instruments, suturing techniques, and new technological devices are challenges in performing safe and effective operations. A learning curve of 20 procedures per surgeon and 50 procedures per institution has been previously established for laparoscopic fundoplication, although it is recognized that individuals may progress at different rates.

Important indicators on the learning curve for laparoscopic surgery are the conversion rate and operative complications. In our experience, the greatest decline in conversion rate was between the first and second 25 cases. Most conversions during this period were for technical reasons; eg, our ability to adequately dissect the posterior "window" behind the esophagus required learning...
techniques of retraction and new anatomical landmarks or surgical planes. Only a small percentage of all conversions were for potentially life-threatening complications such as esophageal or gastric perforation or hemorrhage. Our conversion rates in the first 25 cases were similar to rates reported by others. Other technical challenges were the division of the short gastric vessels and fundal mobilization, closure of the diaphragmatic crura, and suture of the fundoplication. Once these steps were learned, conversion rates remained extremely low (2%-5%). Although the largest decrease in intraoperative complications, conversion rates, and operating times occurred between the first and second set of 25 patients, these factors continued to decrease after 100 cases.

During the second and third set of 25 cases, the harmonic scissors and the endostitch were introduced. These technical devices aided in division of the short gastric vessels and suturing the wrap and must have also contributed to decreased operative times, but we are unable to quantify this effect. Our overall mean operative time of 140 minutes for the laparoscopic fundoplications compares with operative times for open fundoplications and is well within the range of the large laparoscopic series of fundoplications. The last 50 laparoscopic fundoplications were performed more quickly than open fundoplications (99 vs 142 minutes, P<.05).

Initially, we experienced some potentially serious complications. There were 2 esophageal perforations and 1 gastric perforation. All perforations occurred posteriorly and emphasized the potential for problems in the retroesophageal dissection with identification of the left diaphragmatic crus and creation of the window. However, we did not experience this complication after 50 cases. These perforations were recognized, handled properly, and did not result in any long-term morbidity. We also experienced 1 splenic injury requiring splenectomy in the second 25 cases, but none afterward. Our experience compares favorably to other reported series. Certainly, splenic injury occurs much less frequently after laparoscopic fundoplication compared with open fundoplication.

After the first 25 cases, there were no major intraoperative complications and, although there were some episodes of hemorrhage requiring conversion to open fundoplication, they did not require transfusion or splenectomy and were converted because the amount of bleeding obscured the laparoscopic field.

It seems that the bulk of learning occurred during the first 25 cases, since we experienced large decreases in conversion rate and intraoperative complications during this time period. However, in a supervised setting, the residents seem to become proficient in about 12 cases.

The most difficult part of this procedure for both staff and residents was the retroesophageal dissection and identification of the left crus, and this is where most supervision is necessary. Residents are able to learn this procedure during their residency and subsequently perform it in their practices.

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REFERENCES

This article is an excellent overview of the results of the introduction of laparoscopic fundoplication to university and Veterans Affairs academic programs. It is always encouraging to see advanced procedures practiced, taught, and evaluated in these settings. This introduction contrasts sharply with the introduction of laparoscopic cholecystectomy, which was mainly championed by community-based surgical pioneers, while academics were slow to recognize its potential dramatic effect on the practice of surgery. The authors must be commended for their heroic efforts to establish resident proficiency in performing this procedure. Unfortunately, this level of commitment and implementation has not been observed universally.

The article provided answers about the authors’ experience as the result of their approach to introducing laparoscopic antireflux procedures into their institution. But the review raises more questions than answers about the learning curve they encountered. First of all, whose learning curve is being assessed, that of the residents or that of the attending surgeons? The article does not provide enough detailed information about the experience of individual participants to make a valid conclusion about the learning curve. This is in sharp contrast to the work of Waston et al,1,2 as referenced by the authors. In addition, the sample size of responses to the questionnaires was small; therefore, the authors’ conclusions may be incorrect.

Previous experience was shown by the authors in open fundoplication, but was not documented by the attending surgeons in laparoscopic fundoplication. No mention is made of the use of proctors during the initial procedures. There is no information given on cognitive instruction, suturing and advanced skill development, or laboratory experience with live animals prior to embarking on initial cases. If the attending surgeons proceeded with only their initial open experience as a guide and allowed the resident to be first surgeon on all of the cases, I am not surprised at the early results. A conversion rate of 56% and a major complication rate of 16% to 20% suggest that the aforementioned preparatory instructional way stations were not established. I take issue with the authors’ suggestion that these numbers are within the norm for the initial (first 25) experiences with these procedures. Many references demonstrate better initial results and the 2 references cited may be the result of the same training deficiencies. However, I must note that after the first 100 cases, results similar to those of other series were documented. This experience reinforces suggestions that have been made by others concerning the establishment of advanced, minimally invasive procedures. Optimally, initial cases are accompanied by maximal skill development and cognitive preparation along with experienced proctoring to achieve early success and patient safety.

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The left recurrent laryngeal nerve loops around the aorta at the level of the ligamentum arteriosum and then extends up posterior to the inferior thyroid artery. The right recurrent laryngeal nerve branches off the vagus, loops around the right subclavian artery, and courses posterior to the inferior thyroid artery.