Extended Transmediastinal Dissection

An Alternative to Gastroplasty for Short Esophagus

Robert W. O’Rourke, MD; Yashodhan S. Khajanchee, MBBS; David R. Urbach, MD; Nicole N. Lee, BA; Barbara Lockhart, RN; Paul D. Hansen, MD; Lee L. Swanstrom, MD

Hypothesis: The significance of short esophagus and its impact on failure after laparoscopic Nissen fundoplication are unknown. Although patients with severe esophageal shortening that requires Collis gastroplasty comprise a small percentage of patients undergoing fundoplication, we hypothesize that patients with moderate esophageal shortening requiring extended mediastinal dissection make up a larger subgroup and that extended laparoscopic mediastinal dissection is a good treatment strategy for such patients.

Design and Setting: Retrospective comparative analysis in an academic and private practice-based tertiary referral center.

Patients: A total of 205 patients underwent laparoscopic Nissen fundoplication for gastroesophageal reflux disease or paraesophageal hernias over 4 years. Outcomes in patients requiring either a type I (<5 cm) or type II (>5 cm) mediastinal dissection were compared.

Interventions: Laparoscopic Nissen fundoplication with or without extended mediastinal dissection and esophageal physiology testing.

Main Outcome Measures: Symptom assessments, operative reports, and outcomes were prospectively recorded on standardized data sheets. Postoperative symptom assessment and esophageal physiology testing were performed.

Results: A total of 133 (65%) of the 205 patients underwent type I dissection, and 72 (35%) of the 205 patients underwent type II dissection. Failure occurred in 15 (11%) of 133 patients and 6 (10%) of 72 patients, respectively. The presence of a large hiatal or paraesophageal hernia predicted the need for type II dissection.

Conclusions: No difference was seen in failure rates between patients who required a type II dissection and those who did not. This finding suggests that aggressive application of laparoscopic transmediastinal dissection to obtain adequate esophageal length may reduce fundoplication failure in patients with esophageal shortening and provide a success rate similar to that of patients with normal esophageal length. More liberal application of Collis gastroplasty in these patients is not warranted.

Arch Surg. 2003;138:735-740

LAPAROSCOPIC NINESS FUNDOPICATION (LN) has revolutionized the treatment of patients with gastroesophageal reflux disease (GERD) and paraesophageal hernias (PEHs) and is currently associated with success rates of approximately 90% to 95%. These good results and the high prevalence of GERD in the general population have resulted in a rapid increase in the number of antireflux operations performed. Identifying and preventing causes of LN failure would therefore lead to significant savings in patient morbidity, mortality, and health care costs. A reported cause of LN failure is the presence of preoperative esophageal shortening, which is thought to be either the result of proximal displacement due to an enlarging hiatal hernia or intrinsic shortening due to fibrosis and scarring of the distal esophagus secondary to reflux-induced inflammation. Unrecognized esophageal shortening might lead to the creation of a wrap under tension and subsequent failure from herniation, “slippage,” or disruption.

The incidence and impact of the short esophagus (SE) on outcomes after LN are controversial in part because the definition of SE is debated. Several investigators have attempted to identify preoperative predictors of esophageal shortening. Although some studies have identified preoperative predictors as defined by the need for Collis gastroplasty, such as a hiatal hernia larger than 5 cm or the presence of Barrett esophagus or stricture, in general such criteria have not consistently and accurately predicted SE. Thus,
the diagnosis of SE must be made, by definition, intraoperatively. The need for a lengthening procedure, such as a Collis gastroplasty, certainly defines a patient population with severe esophageal shortening. However, the percentage of patients who require Collis gastroplasty is small in most series, generally approximately 1% to 4%. As originally described by Collis, there is a larger subset of patients who have only moderate esophageal shortening (MES), which can be corrected by an extended mediastinal dissection. This subgroup of patients, which makes up a significant percentage of the total population of patients undergoing LN, has not been well studied with regard to potential impact on surgical outcome. We performed the current study to document the incidence of MES in GERD and PEH patients and to determine whether an extended type II mediastinal dissection performed laparoscopically is an adequate lengthening procedure in patients with MES. Recurrence in patients undergoing a type II dissection might suggest the presence of worse disease severity, predisposing to recurrent reflux, or the presence of extensive esophageal fibrosis, predisposing to mechanical wrap failure. Such a finding would argue for the more liberal use of Collis gastroplasty for these patients. Alternatively, a failure rate similar to patients requiring only type I dissection would support high mediastinal dissection in patients with MES to achieve a tension-free fundoplication and optimal results.

METHODS

STUDY PATIENTS

A retrospective review of prospectively gathered data of all patients who underwent LN for GERD or PEHs at Legacy Health System, Portland, Ore, from January 1, 1997, through December 31, 2000, was performed. During this time, an intraoperative data form was used to document the extent of mediastinal dissection required for esophageal mobilization. All patients are requested to return for postoperative pH and motility testing at 6 to 12 months. A total of 487 patients were identified who underwent fundoplication during this period; of these patients, 21 underwent Collis gastroplasty and 32 underwent partial fundoplication and were excluded from analysis. Another 51 patients underwent reoperative fundoplication for failure of a primary procedure and were excluded from analysis. Of the remaining 383 patients, 205 underwent LN and had completed data sheets or adequate medical records for analysis. All procedures were performed by 1 of 2 surgeons: 191 (93%) by the senior author (L.L.S.), and the remaining 14 (7%) by an attending surgeon. The LAPARASCOPE instrumentation at Legacy Health System, Portland, Ore, from January 1, 1997, through December 31, 2000, was performed. During this time, an intraoperative data form was used to document the extent of mediastinal dissection required for esophageal mobilization. All patients are requested to return for postoperative pH and motility testing at 6 to 12 months. A total of 487 patients were identified who underwent fundoplication during this period; of these patients, 21 underwent Collis gastroplasty and 32 underwent partial fundoplication and were excluded from analysis. Another 51 patients underwent reoperative fundoplication for failure of a primary procedure and were excluded from analysis. Of the remaining 383 patients, 205 underwent LN and had completed data sheets or adequate medical records for analysis. All procedures were performed by 1 of 2 surgeons: 191 (93%) by the senior author (L.L.S.), and the remaining 14 (7%) by another experienced surgeon (P.D.H.). Completed data sheets and operative reports were used to determine the extent of mediastinal dissection. The definitions of type I, II, and III dissections were determined before 1997 and were used consistently throughout this period. Preoperative endoscopy allowing determination of the presence or absence of stricture, Barrett’s esophagus, and esophagitis was performed on 127 of the 133 patients undergoing type I dissection and 67 of the 72 patients undergoing type II dissection. Preoperative manometry and measurements of both lower esophageal sphincter (LES) and upper esophageal sphincter locations were identified in 109 of 133 patients undergoing type I dissection and 48 of 72 patients undergoing type II dissection. Incomplete monometric studies, lacking either an upper esophageal sphincter or LES measurement, were available in 43 patients, and 5 patients had no monometry before surgery.

SURGICAL PROCEDURE

Our technique of LN includes standard laparoscopic access, mobilization of the fundus including division of the proximal short gastric vessels, a crural closure that incorporates 2 posterior gastroscopy sutures, sutures that fix the medial aspect of the fundus on each side to the esophageal wall laterally, and 3 anterior fundal Nissen sutures. Pledged sutures are used for the crural repair if it is believed to be under tension. The gastroesophageal junction, as identified by the angle of His, oblique sling muscle fibers, and phrenoesophageal membrane attachment, was brought into the abdomen for a minimum of 2.5 cm. An esophageal dissection greater than or equal to 5 cm into the mediastinum defined a type II dissection. A dissection less than 5 cm into the mediastinum defined a type I dissection. The extent of dissection was measured intraoperatively using marked instruments of known length. The type II mediastinal dissection technique involves dissection circumferentially around the intrathoracic esophagus using a combination of blunt and harmonic scalpel dissection, with visualization provided by navigation of the laparoscope through the hiatus and into the mediastinum along with the dissecting instruments, using the laparoscope to provide ventral retraction. Posterior, anterior, and lateral attachments are divided, with careful preservation of the main branches of the intrathoracic vagus nerves, but with division of accessory branches to allow for full esophageal mobilization. On average, a type II dissection is carried up between 7 and 10 cm into the mediastinum. In cases in which type II dissection fails to release 2.5 cm of tension-free distal esophagus into the abdomen, a thoracoscopic-assisted Collis gastroplasty was performed, as previously described. These patients were excluded from this analysis.

DIAGNOSTIC STUDIES

Twenty-four-hour ambulatory pH testing was performed when patients were no longer taking any antacid medications and by positioning the pH electrode 3 cm above the upper border of the LES. The data were recorded in a portable digital data logger for 24 hours while the patient is ambulatory and were analyzed by calculating the Johnson-DeMeester score using a standard software program (Medtronico, Stockholm, Sweden).

Esophageal manometry was performed with an 8-channel per茚us catheter. The LES was located using the stationary pull-through technique and the resting LES pressure was determined. Relaxation of the LES and the upper and lower esophageal body contractility was determined for a total of 10 wet swallows. A commercial software program (Medtronic, Stockholm, Sweden) was used for the interpretation of the manometry tracings and data analysis.

All patients underwent preoperative EGD. In 12 patients, preoperative EGD reports from other institutions were not available for analysis. All patients underwent preoperative pH testing except in the case of a large PEH with no GERD symptoms; these patients underwent preoperative manometry only. A standardized symptom assessment form was used to quantify GERD symptoms in all patients both preoperatively and postoperatively. Symptomatic assessment included grading of reflux, heartburn, and dysphagia on a 4-point scale, with symptoms occurring less than once per month, less than once per week, daily, or continuously representing grades 1 through 4.
respectively. A total of 73% of patients also underwent postoperative pH and/or manometry testing, including those being operated on for non–reflux-related disease (eg, PEHs). All patients in whom surgery failed returned for postoperative pH and manometry testing. Postoperative upper endoscopy was reserved for patients with Barrett esophagus or symptoms after surgery. Failure was defined as a Johnson-DeMeester score greater than 14.7 on 24-hour pH testing postoperatively, objective evidence of wrap disruption on upper gastrointestinal series or EGD, or the need for an additional operation.

STATISTICAL METHODS

Means of continuous variables were compared using 2-tailed t tests, and proportions were compared using χ² tests. The association between predictor variables and the use of type II mediastinal dissection was assessed using logistic regression models. For these models, type II dissection was the outcome variable. Risks were expressed as odds ratios and 95% confidence intervals. Associations were considered to be statistically significant if the 95% confidence intervals excluded the value of 1.0.

RESULTS

Patient characteristics and results of preoperative workup are given in Table 1 and Table 2. Mean age of the type II group was greater than that of the type I group. There were no significant differences in sex distribution between the 2 groups, and length of follow-up was similar between the 2 groups. There were significantly more PEHs among patients who required type II dissection.

Outcomes after surgery were as follows. There were 15 (11%) of 133 type I patients who were counted as failures. There were 7 (10%) of 72 type II patients who were determined to be surgical failures. Of the 133 patients in the type I group, 2 had recurrent heartburn or reflux symptoms, 13 had abnormal postoperative Johnson-DeMeester score, and 1 had a mechanical wrap disruption. Of the 72 patients in the type II group, 2 had recurrent heartburn or reflux symptoms, 6 had abnormal postoperative Johnson-DeMeester score, and 1 had a mechanical wrap disruption. Of the 13 patients (11%) in the type I group in whom surgery failed, 6 patients had no symptoms and borderline abnormal postoperative Johnson-DeMeester scores (<2.0). Of the 7 patients (10%) in the type II group in whom surgery failed, 1 patient had no symptoms and a borderline abnormal postoperative Johnson-DeMeester score (17). One patient in the type I group had a normal postoperative Johnson-DeMeester score (12.7) but a low LES resting pressure (8 mm Hg) on postoperative manometry and an endoscopy that showed herniation of the wrap into the mediastinum. In the type II group, one patient had a normal postoperativ

<table>
<thead>
<tr>
<th>Table 1. Patient Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissection</td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td>Type I</td>
</tr>
<tr>
<td>Type II</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Abbreviations: LOFU, length of follow-up; PEH, paraesophageal hernia.

<table>
<thead>
<tr>
<th>Table 2. Patient Preoperative Studies*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>Sample size</td>
</tr>
<tr>
<td>Mean preoperative DeMeester score</td>
</tr>
<tr>
<td>Esophagitis grade</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>Barrett esophagus</td>
</tr>
<tr>
<td>Stricture</td>
</tr>
<tr>
<td>Hiatal hernia &gt;5 cm</td>
</tr>
<tr>
<td>Manometric length, mean, cm</td>
</tr>
</tbody>
</table>

*Data are presented as number (percentage) of patients unless otherwise indicated.
†Comparison is based on 111 patients undergoing type I dissection and 45 patients undergoing type II dissection for whom these data were available.
‡Comparison is based on 108 patients undergoing type I dissection and 50 patients undergoing type II dissection for whom these data were available.

Axial shortening of the esophagus results from chronic acid injury, leading to loss of elasticity, scarring, and fibrosis of esophageal tissues, or from gastroesophageal displacement from a large hiatus hernia. Esophageal shortening has been implicated in LN failure. Fundoplication is optimally performed around the distal intra-abdominal esophagus, and it should be created without radial or axial tension. Frequently, these goals cannot be
achieved without specific surgical maneuvers designed to increase intra-abdominal esophageal length. We rely on extended mediastinal dissection in such patients, reserving gastroplasty for the rare patient with severe shortening refractory to mediastinal dissection. Others have advocated a more liberal application of Collis gastroplasty, arguing that the need for a type II dissection places patients at an inherent increased risk for failure after fundoplication.12,13 The actual prevalence of SE in patients undergoing LN is unknown, in part because of the variability and subjectivity of the definition of SE in the literature. Some investigators have attempted to define preoperative predictive criteria, including the presence of Barrett esophagus, stricture, severe esophagitis, hiatal hernia, or manometric length to predict SE, with limited success.4 Others, however, have shown that preoperative criteria cannot accurately predict SE. Most investigators conclude that intraoperative assessment and the need for an esophageal lengthening procedure remain the gold standard for defining SE.5 In his original manuscripts on this subject,10 Collis stressed the utility of extended thoracic mediastinal mobilization as a tool for achieving adequate esophageal length in most cases of SE.10 When the need for Collis gastroplasty to achieve adequate esophageal length for fundoplication is used to define SE, the incidence in large series of LN patients is only 2% to 4%.7,9 Although some investigators have reported outcomes in patients requiring Collis gastroplasty7-9 and others have stratified patients using preoperative predictors of SE,1,14 few studies have examined outcomes in patients with SE treated by mediastinal mobilization as opposed to gastroplasty. The prevalence of such patients and their outcomes after fundoplication is unknown.

We believe that it is necessary to develop an operative strategy for patients with esophageal shortening that is not severe enough to require gastroplasty but that is certainly abnormal. Worse outcomes in this patient group might be expected because of either severe or complicated reflux disease or tension on the repair created by inadequate esophageal mobilization leading to subsequent failure. To minimize failure in patients with MES, some investigators have advocated for more liberal application of Collis gastroplasty15 or, alternatively, open transthoracic dissection, which is argued by some to provide greater esophageal length than a standard laparoscopic approach.3 We propose a third alternative, namely laparoscopic extended transmediastinal (type II) dissection, as a means to achieve adequate esophageal length for fundoplication, avoid an open procedure, and minimize the need for a Collis gastroplasty. This study documents the ability to achieve adequate esophageal length laparoscopically and shows that the outcomes are similar to those seen in patients with normal esophageal length.

We believe that more liberal use of the Collis lengthening procedure is not the optimal solution for patients with SE. There are disadvantages to Collis gastroplasty. Early reports suggested worse outcomes in patients undergoing Collis gastroplasty compared with patients not requiring gastroplasty.15 More recent studies,3,8 however, report good symptomatic outcomes in patients undergoing Collis gastroplasty, similar to that seen in patients with normal esophageal length. It has, however, been shown that there is a high incidence of abnormal 24-hour pH study results following open or laparoscopic gastroplasty.9,16 Therefore, although Collis gastroplasty may afford excellent symptomatic relief in patients with GERD, the translocation of gastric mucosa into the neoesophagus that characterizes this operation leads to nonphysiologic results, including ectopic acid secretion, hypomotility, and esophageal dilation in a significant number of patients.17 It has become our goal to limit the use of Collis gastroplasty to patients with severe esophageal shortening refractory to mediastinal dissection.

There have been a few previous attempts to document outcomes of patients with MES in whom fundoplication is accomplished without gastroplasty but with extended mediastinal dissection. Yau et al14 studied a group of 484 patients with a median follow-up of 2 years who underwent LN and attempted to correlate preoperative manometric esophageal length with the need for subsequent operation. They found that although esophageal...
length did not influence the requirement for subsequent surgical intervention, postoperative paraesophageal herniation was more likely in patients with short manometric esophagi. The incidence of this complication was low, however, and these investigators therefore argued that patients should not undergo routine gastroplasty lengthening procedures based only on preoperative manometric esophageal length. Gastal et al. studied 65 patients (28% of the study population) suspected of having short esophagus based on preoperative studies who underwent transthoracic dissection. In 37 patients, a Collis gastroplasty was performed. The remaining 28 patients required only extensive transthoracic esophageal mobilization to the level of the aortic arch. These patients were compared with 171 patients who were not suspected of having SE preoperatively and who therefore underwent standard laparoscopic dissection. No difference in outcomes was seen between patient groups, with excellent or good outcomes in approximately 90% of all patients. These investigators suggested that complete transthoracic mobilization allows for good outcome in patients with SE as defined by manometry. Our study shows that a laparoscopic approach with aggressive mediastinal dissection can provide outcomes in patients with shortened esophagi similar to those seen with the transthoracic approach in the series by Gastal et al. while avoiding an open procedure and minimizing the need for a nonphysiologic gastroplasty.

One weakness of these studies is the use of preoperative indicators to define patients with SE whether undergoing a laparoscopic or transthoracic approach. The role of preoperative criteria in predicting the presence of SE is unclear. Some investigators have defined predictors of the need for gastroplasty, whereas others have not shown any correlation. Although the combination of EGD, upper gastrointestinal series, and manometry has been shown to be associated with a high positive predictive value for SE, sensitivity and negative predictive value for the combination of these tests are low, and no single criterion has been shown to be associated with a high specificity or predictive value. Furthermore, no study has examined the role of preoperative criteria in differentiating between MES that would necessitate a type II mediastinal dissection and severe shortening treatable only with a gastroplasty. This study examined esophagitis grade, manometric esophageal length, and the presence of Barrett esophagus, stricture, or hiatal hernia larger than 5 cm in this series and found that, using multivariate analysis, only the presence of a PEH or a type I hiatal hernia larger than 5 cm predicted the need for a type II dissection. Thus, with the exception of these 2 factors, preoperative diagnostic criteria do not accurately predict MES that required type II dissection in this group of patients. However, the presence of a large type I hiatal hernia or a type III PEH identified in the preoperative setting should alert surgeons to the possible need for either an extended transmediastinal type II dissection or gastroplasty.

Given the limitations of preoperative criteria to reliably predict the presence of MES, it is probable that the studies by Yau et al. and Gastal et al. were contaminated with patients without significant esophageal shortening, since both studies included a significant number of patients who did not need more extensive procedures to obtain a tension-free repair. A previous small series by our group addresses this problem by defining outcomes in patients with MES as defined intraoperatively by the need for a type II dissection. We studied 34 patients in whom the gastroesophageal junction was more than 5 cm above the hiatus based on preoperative studies. Of these patients, a type I dissection was performed in 30%, a type II dissection was required in 30%, and a type II dissection did not provide adequate esophageal length for fundoplication and gastroplasty or gastropexy was required in 20%. Although a higher rate of persistent postoperative esophageal acid exposure (0% vs 6%) and recurrent hiatal hernia (10% vs 20%) was seen in patients who required a type II dissection when compared with those who required only a type I dissection, patient numbers were small, and these differences were not statistically significant. These patients also represent an earlier phase in the development of our technique for LN.

Since this study, incorporation of sutures that fix the medial aspect of the fundal wrap to the lateral walls of the esophagus, along with subtle modifications of dissection technique, may make comparison to this more recent series inappropriate. The present study defines outcomes in a larger group of patients with MES, as defined by the need for a type II mediastinal dissection. We show that such patients have similar outcomes after LN when compared with patients with normal esophageal length. This operative approach thus minimizes the use of gastroplasty and yet does not expose the patient to increased risk of failure, at least during the intermediate follow-up. We suggest that in all patients in whom standard laparoscopic dissection does not provide adequate intra-abdominal esophageal length for fundoplication, an extended type II mediastinal dissection be performed. Only if type II dissection does not provide adequate esophageal length should gastroplasty be performed. In such cases, we recommend a thoracoscopic-assisted Collis gastroplasty, which we have described previously. Our results with such a technique have been good, with symptomatic relief achieved in 86% of patients at long-term follow-up. However, 50% of these patients did not have normal postoperative pH study results. This fact, combined with the good results we demonstrate with type II dissection, suggests that more liberal use of Collis gastroplasty is not indicated. Furthermore, establishing guidelines with respect to operative strategy in this large subgroup of patients is important, since our results show that patients with MES comprise a large minority of all patients undergoing LN (33% in this series). Finally, we found no correlation between esophagitis grade, Barrett esophagus, stricture, or manometric length and the need for type II dissection, suggesting that these variables are not reliable predictors of MES. Only the presence of a type III PEH or a type I hiatal hernia larger than 5 cm were predictors of MES, which makes intuitive sense. Nevertheless, in only 1 patient with a PEH did surgery fail, suggesting that application of a type II dissection to a PEH can provide good results, similar to those seen in patients with GERD.

One potential criticism of this study is that the determination of esophageal shortening is subjective and therefore inexact. Our definition of a type II dissection
is strict, however, as is our technique for measuring the length of distal esophagus delivered into the abdomen without tension to perform fundoplication.\textsuperscript{17} Furthermore, both surgeons in this study perform LN using an identical technique, and 93\% of these operations were performed by the senior author (L.L.S.). All these factors act to limit variability in definition of MES and type II dissection and standardize the operation.

These data are limited by a relatively short duration of follow-up. Median follow-up was 8 months, with a range of 2 to 48 months. Data suggest, however, that most failures occur within the first 2 years after fundoplication.\textsuperscript{12,18} Therefore, although longer follow-up will be necessary to ascertain true long-term failure rates, failure rates in the first 1 to 2 years may at least provide a reasonably accurate estimate of long-term outcomes.

We noted no significant complications in patients undergoing type II dissection. Specifically, there were no cases of hemorrhage, esophageal perforation, or vagus nerve transection. One concern associated with type II dissection is the potential for occult injury to the vagus nerve resulting from extensive dissection. Such injuries can be difficult to diagnose, although some investigators have attempted to develop objective testing for vagal nerve integrity.\textsuperscript{19} Pending the refinement and widespread application of accurate diagnostic testing to verify such injury, however, it is difficult to determine the frequency of this complication. We noted no significant difference in the frequency of symptoms, such as dumping, early satiety, or chronic nausea, in patients undergoing type II dissection compared with those undergoing type I dissection. Nevertheless, the potential for vagus nerve injury remains a theoretic concern with type II dissection.

This study examines the role of extended laparoscopic transmediastinal dissection in patients with MES. We show that such patients comprise a large percentage of all patients undergoing LN (35\% in this series). Furthermore, the presence of a PEH or hiatal hernia larger than 5 cm predicts the need for a type II dissection and thus can forewarn surgeons regarding the possibility of a more complicated procedure. Finally, application of type II dissection in these patients provides success rates after fundoplication similar to those in patients with normal esophageal length. These findings support the application of aggressive mediastinal dissection and esophageal mobilization in patients with MES and suggest that such a laparoscopic dissection leads to outcomes similar to those seen in patients with normal esophageal length not requiring extensive mobilization procedures. More liberal use of Collis gastroplasty is therefore not indicated in these patients if an adequate type II dissection is performed.

Accepted for publication December 22, 2002.

A portion of these data was presented as a poster abstract at the Society of American Gastrointestinal and Endoscopic Surgeons meeting, New York, NY, March 13, 2002.

Corresponding author and reprints: Lee L. Swanstrom, MD, 501 N Graham St, Suite 120, Portland, OR 97227 (e-mail: lswanstrom@aol.com).

REFERENCES