Hypothesis: Traditionally, patients with gastroesophageal reflux disease fall into 3 categories based on 24-hour pH testing and the clinical occurrence of their acid exposure. Patients with upright reflux are believed to do worse following surgery compared with supine or bipositional reflux patients. We assessed objective postoperative outcomes for patients with upright, supine, and bipositional reflux following laparoscopic Nissen fundoplication to determine if there is a category of refluxing patient who should be counseled against antireflux surgery.

Design: Retrospective analysis of prospectively collected data.

Setting: Esophageal physiology laboratory at a tertiary care teaching hospital.

Patients: A total of 225 patients (supine, 45; upright, 92; bipositional, 88) with preoperative and postoperative 24-hour pH measurements, manometry results, and standardized symptom assessment forms were included in the study.

Interventions: A Nissen fundoplication was performed based on 24-hour pH and manometry result. Esophageal manometry was performed with a water-perfused system, and 24-hour pH was measured with a digital capture device.

Main Outcome Measures: Preoperative and postoperative symptom correlation, 24-hour pH, and manometric variables.

Results: There was a significant difference in preoperative symptom correlation between groups. Patients with bipositional reflux disease have significantly worst reflux disease (percentage of time with a pH <4, total number of reflux episodes, longest reflux episode, and Johnson-DeMeester score) and the weakest preoperative lower esophageal sphincter pressure. Postoperative symptom correlation was low among all 3 groups. There was no significant difference in postoperative 24-hour pH or manometry among groups. Success following surgery was achieved in 73.3% with supine reflux, 80.4% with upright reflux, and 75.0% with bipositional reflux.

Conclusions: Patients with bipositional reflux have the most severe disease. Supine, upright, and bipositional reflux patients perform equally well following laparoscopic fundoplication as defined by objective outcome criteria.

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of GERD, but these studies traditionally fall into 3 categories based on the pattern of reflux: upright only, supine only, and bipositional reflux. These categorizations are most often considered to echo the progressive worsening of reflux, with upright reflux patterns seen in early disease and bipositional in late, severe disease. Although they have less severe disease, patients with upright reflux disease are believed to do worse following antireflux surgery compared with supine or bipositional reflux patients. This is because patients with upright reflux disease are thought to disproportionately exhibit symptoms related to functional foregut disease or maladaptive behaviors preoperatively, which lead to gas bloat, dyspepsia, and other postfundoplication adverse effects. Because of this, some investigators have suggested that surgery may not be the best option for these patients. Unfortunately, data concerning objective outcomes in these patients are limited. Therefore, our goal was to determine objective postoperative outcomes following laparoscopic Nissen fundoplication for patients with upright, supine, and bipositional reflux to determine if there is a category of refluxing patient who should be counseled against antireflux surgery.

**METHODS**

Our study population consisted of 225 patients evaluated at our regional esophageal physiology laboratory at Legacy Portland Hospital, Portland, Ore, who subsequently underwent antireflux surgery between October 1, 1999, and February 28, 2003. Patients with a Johnson-DeMeester score of 14.7 or higher completed symptom assay forms before and after surgery, and complete preoperative and postoperative 24-hour pH and manometry results were included in the study. Patients with significant hiatal hernias, Collis procedures, and reoperative cases were excluded.

**MANOMETRY**

Esophageal manometry was performed with an 8-channel, water-perfused catheter. The LES was located by the rapid pull-through technique. Overall LES length, abdominal LES length, and LES pressure were analyzed using the stationary pull-through technique. Distal esophageal body contraction amplitudes were determined for a minimum of 10 wet swallows, each consisting of 5 mL of water 30 seconds apart. A commercial software program (Medtronics, Stockholm, Sweden) was used for the interpretation of manometry tracings and data analysis. One person reviewed all manometric tracings (L.L.S.).

**TWENTY-FOUR-HOUR AMBULATORY pH**

Twenty-four-hour pH testing was performed with the patient free of all peptic medications for 5 days. Patients were instructed to maintain a detailed diary of activity, food intake, symptoms experienced, body posture, and sleep-wake cycle. The pH electrode was positioned 5 cm above the upper border of the LES. Data were recorded in a portable digital data logger for a period of 24 hours while the patient was ambulatory and analyzed by calculating the Johnson-DeMeester score using a standard software program (Medtronics/Synectics, Stockholm, Sweden). A Johnson-DeMeester score greater than 14.7 was considered diagnostic of GERD. Parameters recorded included percentage of time pH was less than 4, total number of reflux episodes, number of reflux episodes that lasted longer than 5 minutes, longest reflux episode, and symptom correlation.

**PATTERNS OF REFLUX**

Classification of upright, supine, or bipositional GERD was based on the percentage of time pH was less than 4 and the recorded position (Figure 1A-C). Patients with upright GERD had an acid exposure time greater than 8.4% in the upright position and less than 3.4% in the supine position. Patients with supine GERD had an acid exposure time less than 8.4% in the upright position and greater than 3.4% in the supine position. Patients with bipositional GERD had an acid exposure time greater than 8.4% in the upright position and greater than 3.4% in the supine position. Thirty-six patients had a normal percentage of time pH was less than 4 in both the upright and supine position but had a Johnson-DeMeester score greater than 14.7 based on a high number of refluxes or delayed esophageal clearance of refluxate. These patients were classified according to their dominant position. Thirty-three of these patients were classified as having upright GERD and 3 as having supine GERD.

**OUTCOME MEASURES**

Data on preoperative and postoperative symptoms, symptom correlation, 24-hour pH, and manometric variables were prospectively collected on standardized data sheets and entered into a computerized database. For this study, success following Nissen fundoplication was defined as normalization of the Johnson-DeMeester score.

**STATISTICAL ANALYSIS**

The χ² statistic was used to compare categorical variables. One-way analysis of variance with a post hoc Tukey test, when appropriate, was used to compare continuous variables. P < .05 was considered statistically significant.

**RESULTS**

Patient characteristics are given in Table 1. There were significantly more females in the supine reflux group (P = .02 across groups).

**PREOPERATIVE 24-HOUR pH AND MANOMETRY**

Table 2 and Table 3 give the findings of preoperative ambulatory 24-hour pH testing and manometry. Patients with bipositional GERD had more severe disease when compared with patients with upright or supine GERD. They had a higher percentage of time pH was less than 4 (P < .001), a greater number of total reflux episodes (P < .001), the longest reflux episodes (P < .001), and higher Johnson-DeMeester scores (all P < .001). Patients with bipositional GERD had the highest symptom correlation (P = .008 across all groups) as well. In addition, patients with bipositional GERD had the lowest median LES pressure (P = .006). All these findings suggest that patients with bipositional GERD have the most severe disease.

**POSTOPERATIVE 24-HOUR pH AND MANOMETRY**

The percentage of time pH was less than 4, the total number of reflux episodes, the number of reflux episodes that lasted longer than 5 minutes, the longest reflux episode,
and the Johnson-DeMeester score improved in all groups from preoperative values. There was no statistical difference among groups in these parameters (Table 4). Postoperatively symptom correlation was equally poor among the 3 groups. As would be expected, median LES pressure improved in all 3 groups following laparoscopic fundoplication (Table 5). Success following laparoscopic Nissen fundoplication, as defined by a normalized Johnson-DeMeester score, was achieved in 73.3% of patients with supine GERD, 80.4% of patients with upright GERD, and 75.0% of patients with bipositional GERD (P = .56) (Figure 2).

**COMMENT**

Patients with isolated upright acid reflux have been described as having poorer symptomatic outcomes following antireflux surgery despite the fact that they are often described as having early or mild disease.* Our preoperative results support the early disease theory, because

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*Significant across all groups.

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Table 1. Patient Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Supine (n = 45)</th>
<th>Upright (n = 92)</th>
<th>Bipositional (n = 88)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, median (range), y</td>
<td>55 (41-69)</td>
<td>44 (21-77)</td>
<td>51 (24-73)</td>
</tr>
<tr>
<td>BMI, median (range), kg/m²</td>
<td>28.6 (23.6-49.0)</td>
<td>29.0 (21.7-43.3)</td>
<td>29.0 (18.0-36.6)</td>
</tr>
<tr>
<td>Females, No. (%)</td>
<td>28 (62)</td>
<td>50 (54)</td>
<td>34 (39)</td>
</tr>
<tr>
<td>Follow-up, median (range), mo</td>
<td>10 (3-19)</td>
<td>9 (4-13)</td>
<td>11 (6-26)</td>
</tr>
</tbody>
</table>

Abbreviation: BMI, body mass index.
they show a progressive increase in Johnson-DeMeester score as the pH category moves from upright to supine to bipositional. Poor results in the upright reflux group have been conjectured to be a result of the pathophysiologic characteristics of GERD in these patients. There seems to be a relationship between elective behaviors (such as aerophagia, overeating, and bulimia) and upright reflux disease. Furthermore, many of these patients have some degree of psychological overlay to their symptoms of GERD. Presumably, a surgical repair of their maladaptive behaviors or upsurge in Johnson-DeMeester score by continued gastric distention, vomiting, or overeating. There are data that seem to support this hypothesis. Kamolz et al showed that patients with aerophagia reported a lesser improvement in preoperative symptoms, such as belching, bloating, and flatulence, when compared with patients without aerophagia. As in our study, Kamolz et al showed no significant difference in improvement based on objective testing in patients with or without aerophagia. Winslow et al directly compared symptomatic outcomes after laparoscopic antireflux surgery in patients with upright vs supine reflux. They found no difference in the frequency of typical or atypical symptoms preoperatively between the 2 groups. Postoperatively, patients with upright GERD reported significantly more heartburn, chest pain, odynophagia, and bloating. In addition, they reported less overall satisfaction with operative results. In contrast, Fein et al compared clinical outcomes in patients with upright, supine, and bipositional GERD. They found excellent (asymptomatic) or good (minor symptoms not requiring acid suppression therapy) outcomes in 86% of patients with upright GERD, 90% with supine GERD, and 89% with bipositional GERD.

Our results show no significant difference in objective, postoperative improvement of GERD in patients with upright, supine, or bipositional GERD. All 3 groups showed excellent normalization of their 24-hour pH study. We also show that postoperative symptom correlation is poor among all 3 groups. In this study, however, we did not report on subjective outcomes (persistent symptoms, adverse effects, or patient satisfaction) among the groups. We have previously reported on the limitations of symptoms in assessing postoperative outcomes following fundoplication. Most of the time, postoperative persistent, increased, or new symptoms experienced by patients with upright GERD are not due to actual reflux. If the natural history of early reflux most likely involves progression to bad reflux (esophagitis and hiatal hernia, characterized by

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**Table 2. Preoperative 24-Hour pH Results**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Supine (n = 45)</th>
<th>Upright (n = 92)</th>
<th>Bipositional (n = 88)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time pH &lt;4, %</td>
<td>6.2 (1.6-25.8)</td>
<td>7.5 (0.2-17.2)</td>
<td>20.9 (8.3-68.6)†</td>
</tr>
<tr>
<td>Reflux episodes, No.</td>
<td>96 (36-604)</td>
<td>131 (6-396)</td>
<td>240.5 (79-750)†</td>
</tr>
<tr>
<td>Longest reflux episode, min.</td>
<td>2 (0-18)</td>
<td>3 (0-21)</td>
<td>8 (1-39)</td>
</tr>
<tr>
<td>Symptom correlation, %‡</td>
<td>55.6</td>
<td>63.0</td>
<td>79.5</td>
</tr>
<tr>
<td>Johnson-DeMeester score</td>
<td>33.7 (14.7-129.0)</td>
<td>27.7 (14.7-375.0)</td>
<td>72.7 (27.5-291.2)†</td>
</tr>
</tbody>
</table>

*Data are presented as median (range).
†P < .05 vs all other groups.
‡Significant across all groups.

**Table 3. Preoperative Manometric Characteristics**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Supine (n = 45)</th>
<th>Upright (n = 92)</th>
<th>Bipositional (n = 88)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall LES length, cm</td>
<td>3 (0-5)</td>
<td>2 (0-4)</td>
<td>2 (0-5)</td>
</tr>
<tr>
<td>Abdominal length, cm</td>
<td>1 (0-4)</td>
<td>1 (0-4)</td>
<td>1 (0-3)</td>
</tr>
<tr>
<td>LES pressure, mm Hg</td>
<td>13 (0-47)</td>
<td>15 (2-65)</td>
<td>11 (0-31)</td>
</tr>
<tr>
<td>Distal mean body pressure, mm Hg</td>
<td>79 (20-148)</td>
<td>70 (20-160)</td>
<td>70 (22-150)</td>
</tr>
</tbody>
</table>

Abbreviation: LES, lower esophageal sphincter.
*Data are presented as median (range).
†Significant across groups.

**Table 4. Postoperative 24-Hour pH Results**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Supine (n = 45)</th>
<th>Upright (n = 92)</th>
<th>Bipositional (n = 88)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time pH &lt;4, %</td>
<td>0.5 (0-17)</td>
<td>0.5 (0-23)</td>
<td>1 (0-52)</td>
</tr>
<tr>
<td>Reflux episodes, No.</td>
<td>21 (0-141)</td>
<td>14 (0-213)</td>
<td>24 (0-621)</td>
</tr>
<tr>
<td>Reflux episodes lasting &gt;5 min, No.</td>
<td>0 (0-12)</td>
<td>0 (0-9)</td>
<td>0 (0-32)</td>
</tr>
<tr>
<td>Longest reflux episode, min.</td>
<td>2 (0-56)</td>
<td>2 (0-49)</td>
<td>2 (0-72)</td>
</tr>
<tr>
<td>Symptom correlation, %‡</td>
<td>11.1</td>
<td>10.9</td>
<td>10.2</td>
</tr>
<tr>
<td>Johnson-DeMeester score</td>
<td>3.3 (0-77)</td>
<td>3.1 (0-67)</td>
<td>4.6 (0-205)</td>
</tr>
</tbody>
</table>

*Data are presented as median (range).
supine acid exposure) and from there to even worse disease (strictures, esophageal shortening, and Barrett esophagus, characterized by bipositional reflux), it makes sense to adopt a liberal and aggressive approach to all patients with GERD irrespective of reflux pattern in hopes of interrupting this downward course.

Investigators have sought to explain the poorer symptomatic outcomes in patients with predominant upright GERD. One possible explanation is that patients with upright GERD may have an increased “sensitive” esophagus. Although direct evidence for this view is lacking, there is some suggestion that patients with upright GERD and aerophagia experience symptoms more intensely. A more probable explanation may be the difference in the mechanism of GERD in these patients. It has been shown that patients with upright GERD have a significantly lower crural pressure that offers no mechanical advantage and thus is unable to prevent shortening of the LES after gastric distension. In addition, transient LES relaxation is thought to be an important contributor of upright GERD but is less important in the supine position. With this constellation, Winslow et al hypothesized that a fundoplication, which decreases the frequency of transient LES relaxation when the stomach becomes distended, inhibits the ability of the stomach to vent air in patients with upright GERD. This might result in unhappy patients with a tendency to nausea, dyspepsia, or gas bloat syndrome postoperatively. In this study, we did not specifically assess gas bloat symptoms or other adverse effects. However, we did find equally poor symptom correlation with 24-hour pH testing across all 3 groups postoperatively.

In conclusion, our data show that patients with upright, supine, and bipositional GERD have excellent, equivalent objective outcomes following laparoscopic Nissen fundoplication. This study further confirms our belief that symptom-based outcomes should be used cautiously in determining the failure or success of a fundoplication in the GERD population. Surgical fundoplication can, and perhaps should, be used aggressively in treating all patients with documented acid reflux with the understanding that patients with upright GERD may have more postoperative symptoms and benefit from more preoperative counseling regarding outcomes.

Accepted for publication April 12, 2004.

REFERENCE


DISCUSSION

Blayne A. Standage, MD, Portland, Ore: I admire the work that went into this study but take issue with the authors’ contention that this is the only study that has used objective testing to evaluate postoperative outcomes in upright refluxing patients. Dr Winslow’s paper, which they cite, studied about 40% of their patients, including any upright refluxing patients with persistent symptoms, and found 97% normalization of function. The only outlier had a Toupet fundoplication. In this large, retrospective review, it wasn’t clear what the criteria for postoperative testing were. Were they only the symptomatic ones, leading to a skewed result? All 3 groups did equally well. If the question is can we do a technically successful fundoplication in upright refluxers, the authors have clearly answered that. An unresolved question is, “Do upright refluxers do worse than supine refluxers following fundoplication?”

Although this paper was designed as a report on objective follow-up, I would like to have also seen data on symptom resolution, quality of life, and postoperative side effects. Dr Swanstrom’s group has published on the limitation of using symptoms in assessing postoperative success. Once again, they have demonstrated a very low correlation between symptoms and reflux, around 10% with no intergroup differences. If postoperative symptoms are poor indicators of the technical success of an
Richard J. Finley, MD, Vancouver, British Columbia: I would like to congratulate Dr Swanstrom on educating his patients about the importance of postoperative 24-hour pH and manometry studies. I have 3 questions: (1) What was the incidence of gas bloat syndrome in the upright vs the supine patients? (2) Was there a difference in esophageal motility studies and dysphagia rate in the postoperative period in the upright vs the supine group? (3) What were the anatomic and symptomatic recurrence rates in the upright vs the supine groups?

Carlos A. Pellegrini, MD, Seattle: We do 24-hour pH monitoring in all of our patients preoperatively. We ask everybody to come back after surgery, and about half of our patients do, and we obtain 24-hour pH postoperatively. But if you look at those studies, about half of the postoperative studies are from patients who came back because they had symptoms. Only half are because they came back in answer to our request that they come and be tested. So when we look at postoperative 24-hour pH data, we have to be very careful that that group is heavily laden with patients who have symptoms and thus may not be a true representation of the success rate. Our success rate, measured by 24-hour pH monitoring with the above disclaimer, in about 500 patients is 82% and so it is lower, but it is lower than our symptomatic success rate. The important question though in this group is to determine whether or not the patients have gas bloat after the operation or not. We have a 30% incidence of gas bloat in individuals who are upright refluxers. I continue to operate on them for the same reasons that were given here today.

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Stephen G. Jolley, MD, Anchorage, Alaska: I have a lot of experience with esophageal pH monitoring in children but not so much in adults, although I do understand the adult literature very well. I congratulate the authors on their addressing the issue of using pH monitoring as a standard for success of the operation, not solely because I believe that is absolutely true but because most of the papers identify patients whose symptoms are resolved even though their postoperative pH studies are abnormal as being successes and I think that is intellectually not honest. The controversy exists primarily in patients who have their symptoms resolved after surgery but still have an abnormal pH study. None of us knows really what that means in terms of whether or not those patients are ultimately going to have their operation become completely defective and eventually have symptoms. That is an important part of this study.

The other issue is the patients who have symptoms ongoing and have a normal esophageal pH study postoperatively. I would suggest to the authors that they look at gastric-emptying abnormalities as a potential reason why patients may have ongoing symptoms. I know that that is a situation that we see in children.

Lastly, the thing that I would like to talk about is that in children we have different patterns of reflux we call type I, type II, and type III. The type II pattern is the best pattern in terms of the children outgrowing it by year of age, and that reflux pattern seems to resemble the upright refluxers that you see in the adult population. One of the things I would wonder about is if the adult upright refluxers may be a different type of reflux that is not progressively getting worse in terms of becoming supine only or bipositional but may be going the other direction that we see in children in terms of a neurologic abnormality or a dysautonomia, so to speak, that is getting progressively worse. They never get Barrett esophagus, but they also may never get to a point at which they have their symptoms resolve after antireflux surgery.

Dr Swanstrom: I will try to summarize them a little bit. pH studies are truly a cruel master to task yourself with. It is a highly sensitive test, perhaps too sensitive, and there has always been controversy about its true relation to clinical symptoms. I think everybody’s practice and lab has to pick what
benchmarks they are going to follow for outcomes; we've chosen to define success and failure by 24-hour pH results. Likewise for postoperative symptoms, terms like gas bloat are rather subjective. For example, we have chosen to define gas bloat in our follow-up patients as bloating that requires intervention, namely, those patients who come back to the emergency room and need to have an NG tube placed. Because of this, we record a very low incidence of gas bloat. On the other hand, we do ask about hyperflatulence and belching, and our patients score quite high. I guess it is all in the definition of one's terms. Our upright refluxers postoperatively had about twice the incidence of these kinds of complaints, which we consider to be more side effects than actual complications. So, while gas bloat looks equal between the groups in our database, symptomatic hyperflatulence, belching, and bloating are about twice as frequent in the upright reflux group.

Regarding the theory that upright reflux is an early step in the progression of GERD and bipositional reflux represents end-stage disease, I think you have raised valid questions. There are data to support this theory, but, as Dr Aye mentions, it's theoretically possible that it could be the other way around—bipositional refluxers with a simple anatomic defect and upright refluxers with a more multifunctional and therefore more severe and progressive problem.

Regarding the endoscopic appearance of the antireflux valve, which we also routinely look at, it is my feeling that the structure of the upright reflux group is structurally more normal. We know that their LES pressures and lengths are more normal, and based on those findings and measurements, we chose to call it an earlier form of the disease. But that's obviously subject to debate.

There were quite a few questions about our criteria for preoperative and postoperative testing. We always do 24-hour pH tests preoperatively. In fact, I won't operate on a patient if they refuse to have a 24-hour pH test. It is kind of my “acid test,” if you will, to detect those who will be able to tolerate the side effects of a fundoplication. If they can't or won't put up with a tube in their nose for 24 hours, I don't feel that they will tolerate dysphagia and other symptoms for 2 weeks.

Postoperatively, it has always been our policy to strongly urge all patients to come back for postoperative pH and motility studies and/or endoscopy if they have Barrett esophagus or complicated disease. We are currently about 70% successful in getting our patients back in. I believe our success stems from the fact that we mention postoperative testing from the very first time that we see a patient. In our motility lab, the nurses will say, “Oh, you're so lucky that you are going to get to come back 6 months after your surgery.” We simply define postoperative studies as part of routine follow-up care. We send letters of invitation, if you will, at 6 months. The patients drag their feet somewhat, so the follow-up based on objective testing in this study was 9 months, to answer Carlos' question. Obviously, patients who have symptoms are going to be the ones who are most ready to come back in. So there is a negative bias in our data. If so, our results, when held to a pH standard, are probably much better than our reported 79% success based on the fact that 30% of our patients hide because they are totally asymptomatic. I do think, however, that our pH data are probably fairly accurate, and yet I don't think that I do a bad fundoplication. Dr Peters mentions 90% to 95% success rates after Nissens and our patients, when we look at quality of life and patient satisfaction, are about 95% happy with their results. So I think our results do in fact parallel the literature. My guess is that pH testing is such a highly sensitive test that it detects any flaws in outcomes when you subject your results to it. Whether this is clinically significant is entirely another matter.

Finally, regarding postoperative dysphagia and other postoperative symptoms in this patient group, we have become very leery about following up patients symptomatically. In past studies, when we have compared objective results to the patients' subjective results, we have found, in totally asymptomatic post-Nissen patients with no symptoms of reflux whatsoever, a 9% to 11% incidence of reflux disease by pH testing. Likewise, when we take the not insubstantial 20% or so of patients who have some complaints of residual disease or new reflux and heartburn postoperatively, we find that 65% of those patients are pH negative. They are, in fact, not refluxing at all. For us, symptoms after surgery are simply too random to use for outcomes measurement. We have chosen, then, to do surgery mainly in order to stop patients from having progressive tissue damage. We therefore operate for a normal pH score as opposed to patient satisfaction. Certainly, there is absolutely nothing wrong with operating to make patients happy and to get rid of their initial complaint; we like that. We have just chosen a slightly different tactic for our own outcome determination. Hopefully, that answered all of the questions.