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.

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 (Medtronic, Stockholm, Sweden) was used for the interpretation of manometry tracings and data analysis. One person reviewed all manometric tracings (L.L.S.).

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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### 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.

*Significant across all groups.

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Figure 1. Twenty-four-hour pH tracing characteristic of an upright reflux pattern (A), a supine reflux pattern (B), and a bipositional reflux pattern (C). PostPr indicates postprandial; PrePra, preprandial.
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

| Table 2. Preoperative 24-Hour pH Results* |
|-----------------|-----------------|-----------------|
| Variable        | Supine (n = 45) | Upright (n = 92) | Bipositional (n = 88) |
| Time pH <4, %   | 6.2 (1.6-25.8)  | 7.5 (0.2-17.2)  | 20.9 (8.3-68.6)† |
| Reflux episodes, No. | 96 (36-604) | 131 (6-396) | 240.5 (79-750)‡ |
| Longest reflux episode, min. | 2 (0-18) | 3 (0-21) | 8 (1-39) |
| Symptom correlation, %  | 55.6 | 63.0 | 79.5 |
| Johnson-DeMeester score | 33.7 (14.7-129.0) | 27.7 (14.7-375.0) | 72.7 (27.5-291.2)‡ |

*Data are presented as median (range).
†P < .05 vs all other groups.
‡Significant across all groups.
investigators have hypothesized that a fun-
dication, which decreases the frequency of transient
LES relaxation when the stomach becomes distended, in-
hibits the ability of the stomach to vent air in patients
with upright GERD. This might result in unhappy pa-
tients with a tendency to nausea, dyspepsia, or gas bloat
syndrome postoperatively. In this study, we did not spe-
cifically assess gas bloat symptoms or other adverse ef-
fects. However, we did find equally poor symptom cor-
relation 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 fun-
doplication can, and perhaps should, be used aggres-
sively in treating all patients with documented acid re-
flux with the understanding that patients with upright
GERD may have more postoperative symptoms and
benefit from more preoperative counseling regarding
outcomes.

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sion. The discussions that follow this article are based on
the originally submitted manuscript and not the revised
manuscript.

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83-91.

Blayne A. Standage, MD, Portland, Ore: I admire the work
that went into this study but take issue with the authors’ con-
tention that this is the only study that has used objective test-
ing to evaluate postoperative outcomes in upright refluxing pa-
tients. Dr Winslow’s paper, which they cited, studied about 40%
of their patients, including any upright refluxing patients with
persistent symptoms, and found 97% normalization of func-
tion. The only outlier had a Toupet fundoplication. In this large,
retrospective review, it wasn’t clear what the criteria for post-
operative 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 reso-
lution, quality of life, and postoperative side effects. Dr Swan-
strom’s group has published on the limitation of using symp-
toms in assessing postoperative success. Once again, they have
demonstrated a very low correlation between symptoms and re-
flux, around 10% with no intergroup differences. If postopera-
tive symptoms are poor indicators of the technical success of an

Figure 2. Success following laparoscopic Nissen fundoplication (P>.05).
supine acid exposure) and from there to even worse dis-
ease (strictures, esophageal shortening, and Barrett esopha-
gus, 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 in-
terrupting this downward course.

Investigators have sought to explain the poorer symp-
tomatic outcomes in patients with predominant upright
GERD. One possible explanation is that patients with up-
right GERD may have an increased “sensitive” esopha-
gus. Although direct evidence for this view is lacking, there
is some suggestion that patients with upright GERD and
aerophagia experience symptoms more intensively.6 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 gas-
tric distension.10 In addition, transient LES relaxation is
thought to be an important contributor of upright GERD
but is less important in the supine position.11 With this
constellation, Winslow et al7 hypothesized that a fundo-
plication, which decreases the frequency of transient
LES relaxation when the stomach becomes distended, in-
hibits the ability of the stomach to vent air in patients
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tients with a tendency to nausea, dyspepsia, or gas bloat
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operation and not due to reflux, what is going on? The literature is divided on the wisdom of operating on upright refluxers. The choice or performance of the operation probably isn’t the reason, but less stringent inclusion criteria may be important. Generally, a pH less than four more than eight percent of the upright times or greater than three percent supine is abnormal. The Winslow paper concluded that upright refluxers had less satisfactory outcomes. They included patients with a pH less than four more than four percent total time and six percent upright or two percent supine. By using less stringent criteria they may have included people with a lower pain threshold or possibly other, potentially confusing GI problems. Including more marginal patients might lead to less patient satisfaction. Dr Fein’s paper from USC using the previously mentioned criteria concluded the opposite, that isolated upright reflux is not a contraindication to surgery. Although Dr Hong’s paper used the USC criteria, patient selection may be a problem. When they sorted their 225 patients, 16 percent fell out. These patients had a DeMeester score of more than 14.7 but didn’t exceed inclusion times in either of the two positions. They then sorted by their “dominant mode of reflux,” and 33 of the 36 were judged to be upright refluxers. Are these real GERD patients or are we stretching the envelope a little, potentially leading to a perfect technical operation with a bad clinical outcome?

Upright reflux has been thought of as early GERD, usually not associated with esophagitis but more prone to postoperative bloating. They are more likely to have a normal LES but perhaps increased transient LES relaxations. Supine and borial refluxers, generally speaking, have more hiatal hernias, esophageal damage, and lower LES pressures.

Is upright reflux a fundamentally different form of the disease or should we expect progression to supine and borial reflux? Interrupting the natural history early might be worthwhile or to eliminate dependence on PPIs and dietary and positional restrictions. But if our indication for operating on these patients is symptom relief, should we be satisfied with the knowledge that we can objectively normalize minor manometric or pH abnormalities in the lower esophagus if the patient continues to have symptoms or suffers side effects? Can the authors comment on whether it is possible to identify a group of patients who should be managed nonoperatively or at least undergo intensive preoperative counseling to lower unrealistic expectations?

Jeffrey H. Peters, MD, Los Angeles, Calif: Dr Swanstrom, this is a great paper. It really speaks to the aphorism that we heard a moment ago that resonated in my mind, because it applies to this population of patients more than many, and that is that you need to understand the patient with the disease as much as you need to understand the disease the patient has. This is very true in this population of patients. The thing that strikes me about your data, Dr Swanstrom, is that the 75 percent to 80 percent outcome was not what most of us feel it is or should be in a population of patients with reflux disease who have had lapa-

We have seen anecdotally a dramatic change in the anatomic appearance of the gastroesophageal valve endoscopically in supine vs upright positions. In some upright refluxers, the valve looks fairly normal in the supine position but essentially disappears in the upright position. That would suggest that in at least some upright refluxers this is not a mild form of the disease but is truly an anatomic breakdown. I wonder if you have had any experience looking at the valve in these patients.

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 three questions: (1) What was the incidence of gas bloating 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 pa-

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 effective and eventually have symp-

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 symp-

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studies and/or endoscopy if they have Barrett esophagus or com-
monly subject to debate. For example, we have chosen to define gas bloating 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 bloating. 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 reflexes 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 bloating 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.