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Original Research Article

Is barium esophagram enough? Comparison of esophageal motility found on barium esophagram to high resolution manometry

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ABSTRACT

Background: The aim of the study is to determine if barium esophagram (BE) alone is sufficient to diagnose esophageal dysmotility when compared to the gold standard, high-resolution manometry (HRM).
Methods: This is a retrospective review of patients that underwent laparoscopic fundoplication by two surgeons at a single institution from 10/1/2015-6/29/2019. Patients with large paraesophageal hernias and patients without both BE and HRM were excluded.
Results: Forty-six patients met the inclusion criteria. BE was found to be concordant with HRM for esophageal motility in only 21 patients (46%). Setting HRM as the gold standard, BE had a sensitivity of 14% (95% CI: 5%–35%), specificity of 72% (95% CI: 52%–86%), PPV of 30% (95% CI: 11%–60%), and NPV of 50% (95% CI: 35%–66%). The accuracy was 46%, while a McNemar test showed $p = 0.028$.
Conclusion: Traditional BE should not be used in place of HRM for assessing pre-operative motility in patients undergoing anti-reflux surgery.

Introduction

Gastroesophageal reflux disease (GERD) is the most common benign medical condition of the stomach and esophagus with an estimated 19 million Americans afflicted with the total healthcare burden of disease projected at $9.8 billion.[1] Patients experience a wide variety of symptoms defined as typical heartburn or acid regurgitation, atypical symptoms such as epigastric pain, dyspepsia or bloating or patients can have extra-esophageal symptoms like chronic cough. The diagnosis of GERD is made by a combination of clinical symptoms, response to acid suppression therapy, and objective data such as esophageal pH monitoring and esophagogastroduodenoscopy (EGD).[2] Treatment for GERD usually begins with lifestyle modifications and medical therapy with proton pump inhibitors. Patients who have ongoing, life-limiting reflux symptoms in the face of maximum medical therapy, those who are intolerant to medical therapy, or those with an associated large hiatal hernia, are referred for surgical intervention with fundoplication.[3]

The Esophageal Diagnostic Advisory Panel (EDAP) developed a literature-based consensus statement in 2013 advocating the use of EGD, barium esophagram, pH testing, and high-resolution esophageal manometry for pre-operative evaluation for all patients being evaluated for anti-reflux surgery. Barium esophagram (BE) is a dynamic study that provides anatomical information of the esophagus including length, presence of hiatal hernia and type, and presence of diverticulum or stricture.[4] BE was once thought to be useful in the diagnosis of GERD itself but has since been found to be inaccurate in this regard.[2] High resolution esophageal manometry (HRM) is considered the gold standard in the evaluation of esophageal motility and lower esophageal sphincter function. HRM uses a 32-channel flexible catheter with pressure sensors placed 1 cm apart and swallows are evaluated over time and a pressure curve is created.[3] The advisory panel suggested that manometry can be used to help tailor the type of fundoplication (partial vs full) based on existing pre-operative esophageal dysmotility, though there have been no randomized controlled trials to confirm this.[4–6] Despite the advisory panel recommendation there is still considerable variation amongst general surgeons in the pre-operative evaluation for GERD and operative planning. BE is often used as an initial study in patients with concerns for dysphagia, reflux, or hiatal hernia. Radiologists often comment on dysmotility in the findings on BE, which may lead surgeons to tailor the type of fundoplication to perform without obtaining a pre-operative HRM

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Table 1
Demographic/clinical data.

Variable	Value
Age[a]	57.0 ± 15.7
BMI[a]	28.4 ± 4.4
Sex	
Male	31/46 (66%)
Female	15/46 (33%)
DeMeester Score[b]	37.3 (17.8, 55.8)
Hiatal hernia present	38/46 (83%)

[a] Mean + SD.
[b] Median (25th percentile, 75th percentile).

study. BE does provide valuable anatomic information, especially in the setting of hiatal hernia, but it is unclear whether it is an effective means to evaluate for esophageal dysmotility.

Given the paucity of data in this area, the goal of the study was to compare esophageal motility described on BE to HRM and ascertain if BE can adequately diagnose esophageal dysmotility.

Methods

An IRB approved retrospective review was performed of all patients 18 years of age or older who underwent fundoplication (partial or full) for GERD by two separate surgeons from 10/1/2015-6/29/2019. All patients must have had both HRM and BE performed. Patients who did not have both pre-operative BE and HRM studies were excluded from the study as well as those that underwent emergent or urgent procedures, patients with achalasia or those that had large paraesophageal hernias where HRM was not obtained.

Esophagrams were performed via standard technique. High-density barium is ingested by the patient and multiple radiographs are obtained following transit of contrast through the cervical and thoracic esophagus across the gastroesophageal junction and into the stomach. This is followed by thinned barium, in which the composition is 60% water and 40% high-density barium. Lastly, a barium tablet is given to the patient and repeat radiographs are taken. Images are obtained in a standing anterior/posterior fashion, supine, right lateral oblique and left lateral oblique positions. Radiologists with a focus in GI fluoroscopy read the images and evaluated for esophageal anatomic and functional characteristics.

High resolution manometry was performed by insertion of a transnasal catheter placed into the esophagus and proximal stomach. Pressure bands of the upper esophageal sphincter and lower esophageal sphincter muscles were confirmed. A series of 5 ml wet swallows are evaluated for esophageal motility and bolus transit. HRM reports were blinded and read by two, fellowship trained foregut surgeons that routinely perform and read manometry studies, with an inter-rater reliability of 100%. Dysmotility on HRM was based on the Chicago Classification Criteria.[7] Motility disorders missed on BE but found on HRM included fragmented peristalsis, ineffective esophageal motility, and incomplete bolus clearance.

Primary outcomes included the presence or absence of dysmotility on BE and HRM. Summary statistics were calculated. Sensitivity, specificity, positive predictive and negative predictive values of BE were calculated, along with their 95% confidence intervals (95% CI). The level of disagreement between the two techniques was determined using the McNemar test. Significance was assessed at $p < 0.05$. All analyses were performed using Stata v.15.1 (StataCorp, College Station, TX).

Table 2
Esophageal motility disorders missed by esophagram.

Variable	Value
Ineffective Motility	11/18 (61%)
Fragmented Peristalsis	7/18 (31%)
Impaired Bolus Clearance	17/18 (94%)

Results

There were 94 patients total that underwent fundoplication during the study period. Forty-six of these subjects met the inclusion criteria. Subject demographic and clinical data are shown in Table 1. Most subjects were females, and the average age was 57 years.

BE failed to identify esophageal dysmotility in 18 (39%) patients that were found to have a motility disorder on HRM, these include fragmented peristalsis, ineffective esophageal motility, and incomplete bolus clearance (Table 2). BE falsely identified dysmotility in 7 (15%) patients that had normal motility on HRM. BE was found to be concordant with HRM for normal esophageal motility in 18 patients (39%) while only 3 patients (7%) had dysmotility on both studies. A McNemar test of barium esophagram to high resolution manometry gave a p-value of 0.028, indicating significant disagreement between the two diagnostic studies. Setting HRM as the gold standard, BE was found to have a low sensitivity of 14% (95% CI: 5%–35%) and a specificity of 72% (95% CI: 52%–86%). Positive predictive value and negative predictive value were found to be 30% and 50% respectively and the accuracy of BE relative to HRM was only 46% (Table 3).

Discussion

Laparoscopic Nissen fundoplication traditionally has been the mainstay of anti-reflux surgery however dysphagia and gas bloat are common post-operative symptoms for which the Toupet, or partial, 270-degree fundoplication was developed as means to mitigate these side effects. Initially it was thought that the reduction in these symptoms would come at the cost of higher incidence of post-operative reflux. A 2015 Meta-analysis out of Shanghai reviewed 13 randomized controlled trials that compared Nissen to Toupet fundoplication and found that there were no statistically significant differences in the recurrence of GERD symptoms, requirement for anti-reflux medication or reoperation rates. This study did confirm that the laparoscopic Nissen fundoplication group had statistically significant more post-operative gas-bloat and dysphagia compared to the Toupet fundoplication group.[8]

High resolution manometry is regarded as the gold standard in the evaluation for esophageal dysmotility disorders. The EDAP recommends that all patients who are being evaluated for anti-reflux surgery should be evaluated for underlying esophageal motility disorders and that degree of wrap could be tailored accordingly to try and decrease post-operative symptoms of dysphagia.[4] Barium esophagram can also be a useful study in pre-operative evaluation to help better define anatomy and to rule out esophageal masses, diverticula or presence of a hiatal hernia. Esophageal motility is often commented on the BE as well. In a 2016 study by O'Rourke et al., BE was found to have a low sensitivity and specificity of 59% and 63% respectively, and PPV and NPV of 69% and 52% when compared to HRM in the evaluation for dysmotility. There are a few reasons for the discrepancies in their findings compared to the values in our study. Most disorders missed by BE in our patient population were minor motility disorders, and although ineffective esophageal motility was included in O'Rourke's study,

Table 3
Diagnostic testing data.[c].

Variable	Value with 95% CI
Sensitivity	14% (5%–35%)
Specificity	72% (52%–86%)
Positive predictive value	30% (11%–60%)
Negative predictive value	50% (35%–66%)
Positive Likelihood Ratio	0.5 (0.2–1.7)
Negative Likelihood Ratio	1.2 (0.9–1.6)
Accuracy	46% (32%–60%)

CI: Confidence interval.
[c]High resolution esophageal manometry was set as the gold standard, while barium esophagram was set as the test.

fragmented peristalsis and impaired bolus clearance were not. Furthermore, we excluded patients with achalasia and did not evaluate the rarer nutcracker esophagus, jackhammer esophagus or esophageal spasm patients as in the study by O'Rourke. Lastly, O'Roruke et al. states that a limitation to their study is those reading the BE and HRM were not blinded to patients' diagnoses or clinical histories where the radiologists and those interpreting HRM in our study were blinded which decreases bias.[9] Though some of the values between the two studies are quite different the overall findings between both studies corroborate one another, that when setting HRM as the gold standard, that traditional BE is inaccurate in diagnosing esophageal dysmotility.

Recently, a study by Alicuben et al. developed a new technique of videoesophagram that might be an adequate replacement for esophageal manometry. They compared videoesophagram to esophageal manometry and found it to have a sensitivity of 96.4% and NPV of 99.6% in the evaluation for esophageal dysmotility.[10] The highly protocolized videoesophagram described in their study is significantly different from the standard BE that is typically used in clinical practice and in both O'Rourke's study and our own study, limiting its generalizability though. Furthermore, there study excluded minor motility disorders that we included in our study such as incomplete bolus clearance and fragmented peristalsis.

There are multiple studies that have assessed the relationship between pre-operative dysmotility and post-operative dysphagia and its association with degree of wrap. Amongst those studies was a 2008 study by Booth et al. which failed to find a correlation between pre-operative dysmotility and post-operative dysphagia. Their study had several limitations which include small sample size and all surgeries were performed by a single surgeon. Furthermore, they categorized patients only into effective or ineffective motility without addressing differing degrees or types of dysmotility present.[6] Another study by Broeders et al. also could not find a correlation, however shortcomings included lack of randomization to either partial or full fundoplication and as a result female, elderly and those with poor esophageal motility were more likely to undergo a partial wrap. Furthermore, patients with scleroderma or those with an adynamic esophagus were excluded from the database. These factors introduce significant selection bias and skew the data.[7]

In both these studies, along with the meta-analysis of RCT stated above, one thing remains constant, that there is increasing dysphagia with increasing degree of wrap. For these reasons, the EDAP has continued to recommend that all patients who are being evaluated for anti-reflux surgery be evaluated for any underlying dysmotility, and that degree of wrap should be tailored accordingly. Though motility is often referenced on barium esophagram, traditional BE is inaccurate and an unreliable assessment for dysmotility when compared to the gold standard of HRM-especially in diagnosing minor esophageal motility disorders. Post-operative dysphagia rates in patients with pre-operative minor motility disorders of ineffective motility, fragmented peristalsis, or incomplete bolus clearance following full or partial fundoplication remains to be studied.

Conclusion

Though barium esophagram is a helpful and necessary tool in identifying structural abnormalities of the esophagus and gastroesophageal junction, traditional BE should not be used in place of HRM for assessing pre-operative motility in patient's undergoing anti-reflux surgery.

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