A Retrospective Analysis of the Effects of Hiatal Hernia Repair on Pulmonary Function Tests

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Introduction

Hiatal hernias manifest clinically as the herniation of abdominal components into the thoracic cavity through the esophageal hiatus. There are four described pathologies: the sliding of the gastroesophageal (GE) junction superior to the diaphragm (type I), herniation of the gastric fundus alongside the esophagus passing superior to the diaphragm with the GE junction placement intact (type II), a combination characterized by displacement of both the GE junction and gastric fundus (type III), and lastly the herniation of additional abdominal organs through the diaphragmatic hiatus (type IV).[1] Surgical intervention is indicated in symptomatic paraesophageal hernias (type II-IV).

Patients present clinically with a spectrum of symptoms that include dyspepsia, dysphagia, chest pain and cough, but also include diagnoses such as gastroesophageal reflux disease (GERD), gastric volvulus, and asthma.[2] The pathophysiology behind the respiratory symptoms in hiatal hernia patients are considered to be multifactorial. The effect of hiatal hernias and their impact on pulmonary function tests has been studied in the past with mixed results. Pulmonary function tests (PFTs) include both functional measurements, such as forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC), and also on volume-based measurements, such as total lung capacity (TLC), vital capacity (VC), residual volume (RV), and diffusion capacity of the lung for carbon monoxide (DLCO). Utilization of PFTs to assess respiratory status following operative repair of hiatal hernias has been controversial.[3–5] In the post-operative period, there is overall improvement in FEV_1, FVC, TLC, and VC associated with patients presenting with a greater percentage of intrathoracic stomach (%ITS).[3,5–7] The RV and DLCO remained unchanged, regardless of % ITS stratification.[3,5,6] However, objective improvement in PFTs have not aligned with improvement in subjective measures, such as dyspnea, dyspepsia, chest pain, regurgitation, cough, wheeze.[4,8] The goal of this retrospective study was to assess the alteration in respiratory status, both objectively and subjectively, following operative hiatal hernia repair and ascertain the relationship with the characteristics such as size and type of hiatal hernia.

Methods & Procedures

Search Criteria, Inclusion & Exclusion Criteria

A retrospective chart review of our institutions electronic medical record system was conducted after obtaining approval from institutional review board (IRB). All patients who had undergone hiatal hernia repair between January 1, 2005-December 31, 2019 were included in the study. All patients under the age of 19 and over the age of 80 were excluded from the study. Fitting this search criteria, a total of 547 patients underwent hiatal hernia repair during this time frame. Patients were included if they had pre- and post-operative PFTs. A total of 11 subjects had pre- and post-operative PFTs. Patients were excluded if their medical record did not provide the size of hernia, the type of hernia, or was missing either pre- or post-operative data. A total of 177 subjects were excluded: 48 lacked a hernia size, 88 lacked a type of hernia, and 41 did not have post-operative follow-up charted.

Outcome Measures

Patient demographic (i.e. age, sex, reported race) and comorbid conditions data was collected. Pulmonary function test (PFT) outcomes included forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), total lung capacity (TLC), residual volume (RV), expiratory reserve volume (ERV), and diffusion capacity of the lung for carbon monoxide (DLCO). The type of hernia was based upon the results of computerized tomography (CT) scans, endoscopy, and intraoperative assessment by the surgeon. The size of hiatal hernia was assessed via CT scan, barium swallow, and intraoperative assessment. Lastly, dyspnea status was collected for each patient for both the pre- and post-operative period.

Analysis

Analysis of demographic variables occurred via a Mann-Whitney test to assess differences in age, and a Fisher's exact test for assessment of demographic variations in sex, race, type and size of hernia, and smoking status. Patients were stratified by the size and type of hiatal hernia. Dyspnea status was assessed as either no change/worsened or improved/resolved. Comparison of pre- versus post-operative dyspnea was conducted utilizing a McNemar's paired test ($\alpha = 0.05$). For the 11 patients with both pre- and post-operative pulmonary function tests, analysis was conducted on the overall group and also stratified by sex, age, size of hernia, type of hernia, and dyspnea status. A two-tailed, paired t-test ($\alpha = 0.05$) was used.

Further, comorbid conditions underwent binary logistic regression analysis to assess the role each comorbid condition plays in the continued dyspnea in the post-operative period. The odds ratio and 95% confidence interval (CI) were calculated.

Results

Demographics

Of 370 patients included in the study, 277 (74.86%) were females and the median age was 61 years old; there is no significant difference in age between patients with and without persistent dyspnea in the post-operative period (p = .4973), nor sex (p = .6438). There were 9 African American (2.43%), 8 Hispanic (2.16%), and 353 Caucasian (95.41%) patients. Neither pre- nor post-operative dyspnea differed significantly between the reported race (p = 1.000). Of the 11 patients with both pre- and post-operative PFTs, 10 (90.91%) were females, 10 (90.91%) were Caucasian and 1 (9.09%) was an African American, and the median age was 56 years old. Smoking status was ascertained, 163 (44.05%) patients are either current or former smokers. Smoking status was non-significantly associated with dyspnea status (p = .6983). Common comorbid conditions among this group included GERD (95.68%), Obesity defined as > 30 BMI (45.14%), asthma (16.76%), OSA (16.22%), diabetes (15.41%), coronary artery disease (14.59%), COPD (11.35%), chronic heart failure (7.03%), and restrictive lung disease (2.16%).

Dyspnea Status

Seen in Table 1. In the pre-operative period, 25.14% of patients undergoing surgical repair of their hiatal hernia presented with a complaint of dyspnea; this was significantly reduced to 12.70% in the post-operative period (p <.001). Pre-operative dyspnea becomes more prevalent as the hernia becomes larger and more severe: type I (11.46%), type II (16.22%), type III (30.05%), and type IV (44.12%). Surgical repair of hiatal hernias results in significant improvement in dyspnea in the post-operative period for type II hiatal hernias overall group (p = .044), type III overall (p < .001) and stratified into the moderate (p = .044) and large (p < .001) categories, and type IV overall (p = .003) with all categorized as large hiatal hernias.

Comorbid Conditions and Dyspnea Status

Patients were divided into four groups depending upon dyspnea status before and after surgery. Table 2 presents the breakdown of patients based upon their dyspnea category along with the percentage of patients falling into that category. Conducting a binary logistic regression analysis which controls for the pre-operative dyspnea status, significantly associated comorbidities with post-operative dyspnea include COPD (OR 3.34; 95% CI 1.56-12.195; p = .0050) and coronary artery disease (OR 2.79; 95% CI 1.11-6.99; p = .0290). Other comorbidities such as GERD, asthma, and diabetes did not show any significance with post-operative dyspnea while accounting for pre-operative dyspnea. These are seen in Table 3 below.

Pulmonary Function Tests

Seen in Table 4, a total of eleven patients had undergone pre- and post-operative PFTs. On average, the pre- and post-operative PFTs were obtained 354 days prior to and 339 days following the operation, respectively. Significantly increased ERV function was observed in patients less than 60 years old with an increase of 75.11% (p = .042). Additionally, for those reporting improved dyspnea status, there was significantly increased RV (p = .044).

Discussion

Demographics

Similar studies have identified similar demographic variables as this study. On average, hiatal hernia repairs occurred in older patients with a majority for female patients.[3,5–7] The presence of GERD, COPD, history of smoking, asthma, sleep apnea, cardiac disease and diabetes are common comorbid conditions effecting the patient population that presents for hiatal hernia repair.[3]

Dyspnea Status

Poor respiratory function has been noted by patients who have a concurrent hiatal hernia, but as noted above, the pre-operative complaints of dyspnea increase in a direct correlation with both the type and size of hiatal hernia with the moderate-large hernias presenting with a higher prevalence. Fortunately, dyspnea status has improved for patients that have undergone surgical repair of their hernias. However, the degree to which operative interventions provide relief is dependent upon the initial size and type of hernia, with more drastic improvement for patients presenting with type III or IV hiatal hernias that are moderate-large in size. Because of this, when providing guidance to patients regarding relief of their dyspnea it is important to consider the type, and subsequent size, of their hiatal hernia in addition to their comorbid cardiopulmonary conditions.

Comorbid Conditions and Dyspnea Status

The ability of a surgeon to accurately assess whether symptomatic relief will predictably be obtained following an operation influences the decision by both the surgeon and the patient whether to pursue with a particular treatment. Given that hiatal hernia repair is often pursued with the presence of dyspeptic symptoms, it was unsurprising that the rate of GERD among the population was elevated. However, the lower rates of GERD among patients without dyspnea relief is likely due to the higher rates of larger hernias among this group leading to other indications for surgery (i.e., incarceration and dyspnea). Based upon our comorbidity analysis, the presence of dyspnea and whether relief can be obtained is negatively influenced COPD and CAD. Having comorbid COPD puts a patient at 4.367 higher odds of having dyspnea in the post-operative period compared to counterparts without COPD. Similarly, being afflicted with CAD results in a 2.793 times higher odds of having dyspnea in the post-operative period compared to counterparts that are without coronary arterial disease. Of note, while asthma was insignificant in our data set, asthma is a common comorbidity among the hiatal hernia population. With odds between 0.942-5.000, asthma may be of clinical significance when assessing patients on an individual basis.

Table 3

	Odds Ratio	95% Confidence Interval			p
		Lower Limit	-	Upper Limit	
GERD	0.528	0.135	-	2.066	0.3586
COPD	4.367	1.560	-	12.195	0.0050
Asthma	2.174	0.942	-	5.000	0.0689
CAD	2.793	1.111	-	6.993	0.0290
Diabetes	1.119	0.460	-	2.725	0.8041

Pulmonary Function Tests

Literature suggests that following surgical repair of a hiatal hernia, notably the moderate-large size, results in improved FEV1, FVC, TLC, and VC.[3,5–7] No changes are seen in RV or DLCO.[3,5–7] However, there is no reported associated alteration in FEV_1, FVC, TLC, RV, or DLCO that is significantly associated with dyspnea improvement.[4] Our data supported this conclusion regarding the PFT values collected and seen in Table 3; however, a significant increase in the residual volume (RV) was observed among the two patients that showed improvement in their dyspnea status. This suggests that through removal of the intrathoracic abdominal contents provides a non-functional benefit, improving the RV while leaving the other volumes unchanged. While insignificant, there was slight decrease in the FVC, FEV1, FEV1/FVC ratio, DLCO, TLC, and ERV in the patients with dyspnea or worsening dyspnea following surgical repair. This suggests that the presence of dyspnea, or worsening dyspnea, will present with progressively worsening respiratory function, observed through the PFTs.

Limitations

Notable limitations of this study are the small sample size due to lack of post-operative PFTs. Additionally, there was no standardized dyspnea questionnaire used to assess in the pre- and post-operative period.

Conclusion

Surgical repair of a HH results in improvement in dyspnea. The factors that suggest clinical improvement in dyspnea include a moderate-large and a Type III or IV HH. However, our results showed that improvement in dyspnea status is not directly related to changes in PFTs. The patients with improvement also show increases in the RV. In patient selection, dyspnea status is more commonly improved in patients that do not currently nor have a history of chronic obstructive pulmonary disease or coronary arterial disease. Clinically assessing for dyspnea relief in the perioperative period necessitates accounting for the type and size of hiatal hernia, the degree of pre-operative dyspnea, and the presence of comorbid conditions, notably COPD and CAD.

Table 1

	Sample Size (n) (%ntotal)	Pre-Op Dyspnea (n) (%)	Post-Op Dyspnea (n) (%)	Dyspnea Improvement (% Δ)	p
Total	370 (100.00%)	93 (25.14%)	47 (12.70%)	- 49.46%	<.001 *
Type I Hiatal Hernia	95 (25.68%)	11 (11.46%)	8 (8.33%)	- 27.27%	.083
Small	86 (23.24%)	9 (10.47%)	7 (8.14%)	- 22.22%	.159
Moderate	9 (2.43%)	2 (22.22%)	1 (11.11%)	- 50.00%	.347
Large	0 (0.00%)	0 (0.00%)	0 (0.00%)	N/A	
Type II Hiatal Hernia	37 (10.00%)	6 (16.22%)	2 (5.41%)	- 66.67%	.044 *
Small	9 (2.43%)	2 (22.22%)	2 (22.22%)	0.00%	> .05
Moderate	23 (6.22%)	3 (13.04%)	0 (0.00%)	- 100.00%	.083
Large	5 (1.35%)	1 (20.00%)	0 (0.00%)	- 100.00%	.374
Type III Hiatal Hernia	204 (55.14%)	61 (30.05%)	30 (14.78%)	- 50.81%	<.001 *
Small	0 (0.00%)	0 (0.00%)	0 (0.00%)	N/A	
Moderate	47 (12.70%)	8 (17.02%)	4 (8.51%)	- 50.00%	.044 *
Large	157 (42.43%)	53 (33.76%)	26 (16.56%)	- 50.94%	<.001 *
Type IV Hiatal Hernia	34 (9.19%)	15 (44.12%)	7 (20.59%)	- 53.33%	.003 *
Small	0 (0.00%)	0 (0.00%)	0 (0.00%)	N/A	
Moderate	0 (0.00%)	0 (0.00%)	0 (0.00%)	N/A	
Large	34 (9.19%)	15 (44.12%)	7 (20.59%)	- 53.33%	.003 *

Table 2

	Sample Size (n) (%ntotal)	GERD	Obesity (>30 BMI)	Smoking Status	Asthma	OSA	Diabetes	CAD	COPD	CHF	Restrictive Lung Disease
Total	370 (100.00%)	354 (95.68%)	167 (45.14%)	163 (44.05%)	62 (16.76%)	60 (16.22%)	57 (15.41%)	54 (14.59%)	42 (11.35%)	26 (7.03%)	8 (2.16%)
Dyspnea Status											
A *Negative Initial & Negative Follow-up −/−*	271 (73.24%)	263 (97.05%)	112 (41.33%)	117 (43.17%)	36 (13.28%)	37 (13.65%)	35 (12.92%)	31 (11.44%)	17 (6.27%)	10 (3.69%)	2 (0.74%)
B *Negative Initial & Positive Follow-up −/+*	6 (1.62%)	6 (100.00%)	3 (50.00%)	2 (33.33%)	1 (16.67%)	1 (16.67%)	0 (0.00%)	1 (16.67%)	2 (33.33%)	1 (16.67%)	0 (0.00%)
C *Positive Initial & Negative Follow-up +/−*	52 (14.05%)	49 (94.23%)	34 (65.38%)	18 (34.62%)	10 (19.23%)	12 (23.08%)	11 (21.15%)	7 (13.46%)	7 (13.46%)	8 (15.38%)	1 (1.92%)
D *Positive Initial & Positive Follow-up +/+*	41 (11.08%)	36 (87.80%)	18 (43.90%)	26 (63.41%)	15 (36.59%)	10 (24.39%)	11 (26.83%)	15 (36.59%)	16 (39.02%)	7 (17.07%)	5 (12.20%)

Table 4

	n	FVC (% Δ)	p	FEV_1 (% Δ)	p	FEV_1/FVC (% Δ)	p	$FEF_{25-75\%}$ (% Δ)	p	DLCO (% Δ)	p	TLC (% Δ)	p	RV (% Δ)	p	ERV (% Δ)	p
Overall	11	+ 0.25%	.825	- 2.57%	.590	- 1.60%	.330	-3.02%	.376	+ 3.80%	.765	- 1.02%	.753	- 3.97%	.447	+ 36.07%	.115
Female	10	+ 0.61%	.780	- 1.74%	.742	- 1.00%	.543	+ 0.63%	.792	+ 6.18%	.615	+ 2.61%	.778	+ 0.33%	.972	+ 34.71%	.225
Male	1	- 3.31%	N/A	- 10.89%	N/A	- 7.58%	N/A	- 35.87%	N/A	- 10.48%	N/A	- 22.82%	N/A	- 29.77%	N/A	+ 42.86%	N/A
Age (y) < 60	6	+ 1.88%	.621	- 4.23%	.720	- 3.26%	.232	- 12.46%	.536	- 5.22%	.499	- 4.34%	.658	- 7.02%	.533	+ 75.11%	.042*
> 60	5	- 1.70%	.605	- 0.59%	.720	+ 0.39%	.954	+ 6.42%	.583	+ 10.57%	.399	+ 1.47%	.951	- 1.69%	.701	- 2.98%	.865
Small	4	+ 9.08%	.052	+ 2.89%	.750	- 1.04%	.710	- 0.32%	.983	+ 7.71%	N/A	- 6.42%	N/A	- 25.40%	N/A	+ 77.92%	N/A
Moderate	1	+ 12.84%	N/A	+ 7.35%	N/A	- 4.94%	N/A	- 7.81%	N/A	- 12.65%	N/A	+ 11.93%	N/A	+ 8.85%	N/A	+ 57.451%	N/A
Large	6	- 7.73%	.280	- 7.87%	.340	- 1.42%	.565	- 3.90%	.389	+ 6.31%	.541	- 2.53%	.692	- 2.25%	.624	+ 20.27%	.473
Type I	4	+ 9.08%	.052	+ 2.89%	.750	- 1.04%	.710	- 0.32%	.983	+ 7.71%	N/A	- 6.42%	N/A	- 25.40%	N/A	+ 77.92%	N/A
Type II	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Type III	7	- 4.79%	.499	- 5.69%	.440	- 1.92%	.398	- 4.46%	.326	+ 3.15%	.906	- 0.12%	.865	- 0.40%	.738	+ 27.70%	.252
No Dyspnea	3	+ 7.09%	.249	+ 9.98%	.250	+ 2.09%	.748	+ 35.87%	.231	+33.40%	N/A	+ 4.53%	N/A	+ 6.35%	N/A	N/A	N/A
Improved	2	+ 4.57%	.603	+ 2.93%	.560	- 1.76%	.656	+ 6.22%	.914	+ 5.35%	.988	+ 22.45%	.247	+ 8.67%	.044*	+ 19.78%	.602
Dyspnea	6	- 4.61%	.750	- 10.68%	.270	- 3.40%	.219	- 19.07%	.222	- 4.37%	.502	- 14.14%	.055	- 12.87%	.212	+ 44.21%	.197

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