

Intraoperative Measurement of Esophageal Hiatus Normal Area Size in Patients without Hiatus Hernia or Gastroesophageal Reflux Disease

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ABSTRACT

Background: Untreated gastroesophageal reflux disease (GERD) and the associated reflux esophagitis have been negatively impacting the quality of life to a great extent. Data about the normal size of the hiatus opening seems to be prophylactic against the possible anti-reflux surgery postoperative wrap herniation into the thorax that occurs as a result of inadequate crural closure or its disrupted closure. This study aimed at determination of normal size of esophageal hiatus in adults, in an attempt to improve the outcome of anti-reflux surgeries.

Patients and methods: This is a prospective study that was conducted on adult patients consecutively scheduled for abdominal surgery, either open or laparoscopic. Intraoperatively, a calibrated 36-French bougie with a balloon was introduced to the stomach through the mouth. The diameter of the balloon was measured when it was insufflated with the maximum volume that could pass through the hiatus.

Results: Esophageal hiatus area ranged from 2 cm to 6.6 cm² with a mean value of 3.8 cm². No significant difference was found between males and females in the measured parameters ($p > 0.05$). No significant correlation was found between the hiatus surface area and the patient's age, height, weight, BMI, chest circumference, or the esophageal parameters ($p > 0.05$).

Conclusion: This study reported a new mean value of the normal hiatus surface area in order to give a hand in improving the anti-reflux surgery outcome. Further studies on a large cohort are needed to estimate normal variations in regard to age and sex to help in improvement of anti-reflux surgery outcome.

Keywords: Esophageal hiatus, Intraoperative, Normal size.

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INTRODUCTION

Gastroesophageal reflux disease is a common upper gastrointestinal (GIT) disorder affecting persons at any age.¹ Untreated GERD and the associated reflux esophagitis have been assumed to be negatively impacting the quality of life, even more than other diseases such as hypertension and angina pectoris.²

Hiatus hernia (HH) is usually manifested by annoying symptoms, such as dysphagia, nausea, vomiting, and chest pain. It is frequently associated with worsening of the GERD, and may be complicated by gastric volvulus, which is a life-threatening condition.³ Recently, HH is encountering a growing number of patients and representing a main concern of GIT surgical practices.⁴ Laparoscopic surgery, as a choice of HH treatment has been a safe effective method for the majority of patients.⁵ Hence, HH repair by laparoscopic surgery is now a standardized practice.³

The esophageal hiatus is a rather central opening in the diaphragm, through which the esophagus takes its course from the chest to the abdominal cavity. It is formed mainly by the right diaphragmatic crus. Variable contribution is made by the left crus.⁶ These crura are providing anti-reflux mechanism through augmentation of the lower esophageal sphincter.⁷

Availability of data about the normal size of hiatus opening seems to be of great value. This would be prophylactic against the possible anti-reflux surgery postoperative wrap herniation into the thorax that occurs as a result of inadequate crural closure or its disrupted closure.⁸ Moreover, some surgeons adopt modifying the hiatus repair technique according to the size of hiatus opening.⁹

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In view of the lacking knowledge about the normal measures of the hiatus, this study aimed at determination of normal size of esophageal hiatus in adults, in an attempt to improve the outcome of anti-reflux surgeries.

PATIENTS AND METHODS

This is a prospective study that was carried out after the approval of the regional ethical committee. The study was conducted on adult patients consecutively scheduled for abdominal surgery, either open or laparoscopic, at the Surgical Department of Kasr El Ainy Hospital, in the period from October 2018 to May 2020. Patients with a history of GERD, hiatus hernia, or those with previous operations involving the esophagus, the stomach, or the hiatus were excluded from the study. One hundred and six patients were eligible for the

study. A written informed consent was obtained from each patient before starting the procedure.

The included patients underwent detailed history taking, including personal history, history for GERD symptoms, and previous medical therapy, especially anti-reflux medications, e.g., PPI, previous surgeries, and hospital admissions. Proper physical examination as regard height, weight, BMI, and chest circumference was performed.

Routine preoperative workup was conducted. Patients were instructed to fast for at least 6 hours before induction of anesthesia. The surgery team for the study was different from the surgery team for the originally indicated operation.

Operative Technique

The patient was positioned supine on the operating table. After insufflation of the abdomen, esophageal hiatus was inspected for the presence of masses or accidentally discovered hiatus hernia. Based on this, six patients were further excluded due to the incidental detection of HH during the operation. Finally, the study included 100 patients.

A calibrated 36-french bougie with a balloon was introduced to the stomach through the mouth after being fully lubricated. In open surgery, the bougie was palpated in the stomach, while in laparoscopic surgery the bougie was seen while entering the stomach. The balloon was first insufflated near its maximum by about 30 cc of air, it was pulled out through the mouth until it hung at the cardia, and then the length of the whole esophagus was measured from the central incisors till the cardia. After that, the balloon was deflated gradually until it passed through the cardia. The bougie was then pulled till the balloon rehanged at the hiatus. The length from central incisors to the hiatus was measured. The balloon was again gradually deflated until it passed through the hiatus and the maximum volume that can pass through it was observed. Finally, the bougie was extracted out of the mouth after being completely deflated.

The length of the abdominal part of the esophagus was calculated by subtracting the length from central incisures to the hiatus and from that to the cardia.

The diameter of the balloon was measured when it was insufflated with the maximum volume that could pass through the hiatus from the formula: $\text{volume} = 4/3\pi r^3$, where $\pi = 3.14$. Based on this, the hiatus surface area was calculated from the formula: $\text{area} = r^2 \times \pi$.

Study Outcomes

The primary outcome of this study was the estimation of normal values of the hiatus surface area, and the secondary outcome was to assess the possible correlations between the hiatus surface area and the patient's measured parameters.

Statistical Analysis

All collected data were revised and then transferred to the Statistical Package of Social Science Software program (SPSS), version 22 for statistical analysis. Numerical data were presented as range, mean, and standard deviation, while categorical data were presented as frequency and percentage. Independent *t*-test, Chi-square test, or Fisher's exact test were used for comparison as appropriate. Pearson correlation test was used to analyze the association between the hiatus area and the patient's parameters. *p*-values were considered statistically significant if they were less than 0.05.

RESULTS

This study included 100 patients, 60% of them were females. The patient's age ranged between 12 and 68 years with a mean of 40.2 years. They showed mean weight of 100.6 kg, mean height of 166 cm, and mean BMI of 36.7 kg/m². Patients chest circumferences were ranging between 65 and 145 cm with a mean value of 107 cm. Ninety-five percent of the patients had laparoscopic operations and the remainder had open surgeries (Table 1).

The length of the esophagus from central incisors till cardia showed a mean of 35.6 cm, the length of the esophagus from central incisors till the hiatus showed a mean value of 31.4 cm, and the calculated abdominal esophagus showed a mean value of 4.2 cm (Table 2).

The area of the esophageal hiatus was found to be ranged from 2 cm² to 6.6 cm² with a mean value of 3.8 cm².

No significant difference was found between males and females in the measured parameters (*p* > 0.05) (Table 3).

Table 1: Demographic and clinical data of the studied subjects and the received treatment

		All patients (n = 100)
Age (years)		
Range		12.0–68.0
Mean ± SD		40.2 ± 12.4
Gender		
Male		40 (40%)
Female		60 (60%)
Height (cm)		
Range		140.0–185.0
Mean ± SD		166.0 ± 11.0
Weight (kg)		
Range		49–200
Mean ± SD		100.6 ± 25.3
BMI (kg/m ²)		
Range		19.9–67.6
Mean ± SD		36.7 ± 9.4
Chest circumference (cm)		
Range		65–145
Mean ± SD		107 ± 19.3
Type of operation		
Open	Sleeve gastrectomy	25 (25%)
	Cholecystectomy	66 (66%)
	Antral GIST	1 (1%)
	Inguinal hernia	2 (2%)
	Varicolectomy	1 (1%)
Laparoscopic	Cancer colon	3 (3%)
	Incisional hernia	2 (2%)

There was no significant correlation between the measured hiatus surface area and the patient's age, height, weight, BMI, chest circumference, or the esophageal parameters ($p > 0.05$) (Table 4).

Table 2: Esophageal parameters of the studied subjects

All patients (n = 100)	
Length of esophagus till cardia (cm)	
Range	24.0–44.0
Mean ± SD	35.6 ± 4.2
Length of abdominal esophagus (cm)	
Range	2.0–7.0
Mean ± SD	4.2 ± 1.2
Diameter of esophageal hiatus (cm)	
Range	1.6–2.9
Mean ± SD	2.2 ± 0.3

DISCUSSION

The protrusion of abdominal organs into the chest cavity via the widened hiatus opening is called HH. There is still lacking in the data about the normal hiatus size. Determination of the hiatus normal size is important in calibrating to what extent the crura should be closed during the anti-reflux surgery. Knowledge of the normal anatomy of the esophageal hiatus is intimately related to the proper evaluation and management of HH and GERD.

The size of the hiatus in normal subjects is scarcely reported in the literature, no available normal values help to estimate the needed degree of crural closure and hiatus reinforcement. The few available data on the hiatus size were obtained in patients with GERD or HH or obtained from cadavers of normal subjects.^{7,10–13} Such circumstances might render the accuracy suboptimum.

Granderath et al. study documented a method for determining the HSA approximately using surgical measurements and derived the approximate area based on geometric assumptions.¹² Granderath formula was later then used to estimate the approximate HSA

Table 3: Comparison of all parameters regarding sex

	Male	Female	p-value
Age	42.9 ± 11.9	38.4 ± 12.6	0.076
Weight	102.3 ± 33.5	99.5 ± 18.3	0.593
Height	165.9 ± 10.9	166.2 ± 11.1	0.903
BMI	37.1 ± 11.1	36.4 ± 8.2	0.734
Chest circumference	108.1 ± 21.5	106.2 ± 17.7	0.634
Length of esophagus till cardia	35.8 ± 4.4	35.5 ± 4.2	0.738
Length of esophagus till hiatus	31.4 ± 4.2	31.4 ± 4.1	0.945
Abdominal esophagus	4.3 ± 1.2	4.1 ± 1.1	0.379
Diameter of esophageal hiatus in cm	2.2 ± 0.31	2.2 ± 0.28	1
Hiatus surface area in cm ²	3.8 ± 0.075	3.8 ± 0.062	1

Table 4: Correlations between esophageal parameters with each other and with other demographic parameters

		Length of esophagus till cardia	Length of esophagus till hiatus	Abdominal esophagus	Area of the hiatus
Length of esophagus till hiatus	r	0.962			
	p	<0.001			
Abdominal esophagus	r	0.267	0.018		
	p	0.007	0.855		
Diameter of esophageal hiatus in cm	r	0.051	0.042	0.078	
	p	0.612	0.680	0.442	
Age	r	0.008	-0.025	0.104	-0.012
	p	0.936	0.807	0.304	0.906
Weight	r	0.167	0.149	0.106	-0.100
	p	0.097	0.139	0.292	0.321
Height	r	0.786	0.739	0.293	0.119
	p	<0.001	<0.001	0.003	0.240
BMI	r	-0.206	-0.207	-0.003	-0.159
	p	0.040	0.038	0.979	0.114
Chest circumference	r	0.160	0.168	-0.006	-0.030
	p	0.112	0.095	0.954	0.770

in several studies.^{7,8,11,14} In the study of Batirel et al., the authors calculated the HSA from an intraoperative photograph shot.¹⁵ All these studies estimated the HSA in patients during surgeries for GERD or HH surgical repair. Therefore, the hiatal configuration might be distorted during the manipulation of the esophagus and stomach.

We have adopted an alternative manner to measure the surface area of the esophageal hiatus in patients without GERD or HH in an attempt to provide normal mean values of hiatus area. This was achieved via introduction of a calibrated 36-french bougie with balloon to the stomach through the mouth. The diameter of the balloon was calculated based on the maximum volume that could pass through the hiatus. Subsequently the hiatus surface area was calculated.

In our study, the mean value of hiatal surface area was 3.8 cm² ranging from 2 cm² to 6.6 cm². Only two studies examined the values of HSA in patients having no GERD or HH could be reached. Those were the study of Shamiyeh et al.⁷ and the study of Ouyang et al. In the former, fifty cadavers were examined in regard to the esophageal as well as the general physical measures. They reported mean esophageal hiatal surface area of 5.84 cm².⁷ This value is higher than that found in the current study, which may be attributed to that their study on deceased persons was affected by the redundancy of diaphragmatic muscles. In the study of Ouyang et al., the authors assessed the HSA using multiplanar CT and they reported mean HSA of 2.5 cm². This was a simple noninvasive reproducible method for HSA measurement. Nevertheless, in view of the fact that the patient should be in full inspiration to obtain CT images, this induces contractions of the hiatus muscular margin, and makes the HSA in its smallest state.⁹ This could explain their reported less value than that achieved in this study.

The present study showed no significant differences between both sexes concerning either of the measured patient's parameters.

In our study, the secondary outcome was the potential association of the HSA with the patient physical measures. The current study did not demonstrate any statistically significant correlation between the hiatus area and the age, height, weight, BMI, chest circumference, or esophageal measures. Also, no significant difference was noted between males and females in the HH area. In accordance with our findings, Batirel et al. also found no correlation between the hiatus surface area and BMI,¹⁵ Koch et al. found no significant correlation between hiatus area and patients demographic data (age, sex, or BMI),¹⁵ the same findings were reported in their later study.¹⁶ Shamiyeh et al. reported no significant correlation between height, weight, BMI, gender, and the hiatal size. However, they found that the chest circumference was significantly correlated to the hiatus area.⁷

STRENGTH AND LIMITATIONS

The strength of the present work is being a prospective study, adding to the very scarce evidence about the normal HSA in subjects without GERD or HH, and the use of alternative manner to assess the HSA without anatomical distortion of the hiatus opening. This study is however limited by the abdominal CO₂ insufflation that is required for abdominal surgeries and leads to obscuring the respiratory changes in the hiatus region, and the effect of general anesthesia on the diaphragmatic muscles.

CONCLUSION

This study reported a new mean value of the normal hiatus surface area in order to give a hand in improving the anti-reflux surgery

outcome. Further studies on a large cohort are needed to estimate normal variations in regard to age and sex to help in improvement of anti-reflux surgery outcome.

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