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ORIGINAL RESEARCH

Diaphragmatic Hernia in Adults Admitted Emergently to the Hospital: Clinical Characteristics, Risk Stratification and Outcomes *

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Background: Diaphragmatic hernias (DH) are responsible for 1 in every 4,400 hospital admissions annually. While congenital DH has been well-studied, factors affecting hospital length of stay (HLOS) and overall outcomes in adult DH have not been well described. Adult, non-elderly patients were the focus of this study as they have distinct risk factors and comorbidities compared to elderly patients.

Methods: The goal of this study was to identify risk factors associated with mortality in non-elderly adult patients emergently admitted to the hospital with a diagnosis of diaphragmatic hernia. The 2005–2014 NIS databases were retrospectively reviewed for patients with the diagnosis of diaphragmatic hernia (ICD-9 diagnosis code 5533). Data collected included demographics, patient characteristics including hospital length of stay (HLOS), comorbidities, outcomes and social determinants including income status and insurance. Additionally, indications, type of invasive diagnostic procedures and time to such procedures were charted.

Results: A retrospective cohort of 5,909 patients 18-64 years old, in which 61.8% were female were included in this study. The mean (SD) age of female patients was 53.82 (10.09) years, while male patients had a mean age of 50.64 (10.67) years. A total of 3,367 patients (56.9% of cohort) underwent a surgical procedure. A total of 1,559 patients (26.3% of cohort) had a complication of obstruction (1,533, 25.9% of cohort) or

gangrene (26 patients, 0.4% of cohort). In total, 38 patients (0.6% of cohort) died during the study period, including 24 males (1.1% of males) and 16 females (0.4% of females) (p=0.001). Predictors of mortality were assessed utilizing multivariate logistic regression analysis. Female sex appeared to be protective against mortality (OR=0.378, 95% CI: 0.171-0.835, p=0.016). However, the presence of gangrene (OR=10.001, 95% CI: 2.400-41.671, *p*=0.002), undergoing a respiratory invasive diagnostic procedure (OR=4.120, 95% CI: 1.528-11.108, *p*=0.005), and increased HLOS (OR=1.021, 95% CI: 1.005-1.037, *p*<0.010) were all associated with a significantly increased mortality rate. Other factors associated with mortality in operated patients were removed using backwards elimination.

Conclusions: In operated adult patients emergently admitted to the hospital with diaphragmatic hernia, male sex, hernia complicated by gangrene, performance of invasive respiratory diagnostic procedures, and increased HLOS were associated with an increased risk of mortality.

Keywords: Diaphragmatic hernia, in-hospital mortality, gangrene, ICD-9: 5333, hospital length of stay.

1. Introduction

Diaphragmatic hernia (DH) is a common problem in adult patients presenting to the emergency room, and often results in prolonged hospitalization. Diaphragmatic hernias are defined as the herniation of abdominal viscera through the diaphragm into the thorax. According to the National Inpatient Sample (NIS) database from 2005-2014, DH is responsible for around 1 in 4,400 hospital admissions and 1 in 3,300 emergency admissions annually. Congenital diaphragmatic hernias (CDHs), which occur prenatally, are the predominant cause of DHs found in children. Factors affecting CDH, including mortality, HLOS, medical costs, hospital volume, and interhospital variation, have been extensively studied.[1–6] However, comparatively less is known about adult DH. In some cases, congenital hernias such as Bochdalek and Morgnani may be asymptomatic until adulthood.[7–13] However, the majority of adult DH are associated with trauma rather than congenital abnormalities.[14] Adult patients presenting with DH, often have a history of penetrating or blunt trauma, often acute, which occasionally may be missed during initial evaluation after the injury.[15] DH is also associated with damage to other abdominal and thoracic organs, and injury may be subtle and missed by basic imaging. In these cases, thoracic laparoscopy, thoracoscopy or other diagnostic invasive procedures may be indicated to confirm the diagnosis, but may also be associated with poorer outcomes.[16] Laparoscopy, along with open surgical procedures such as thoracotomy and laparotomy are often utilized in corrective surgery.[17–19] However, in general, factors affecting hospital HLOS and overall outcomes in adult DH have not been well described. The aim of this study was to assess risk factors of in-hospital mortality for adult patients admitted with a diagnosis of DH in the NIS database from 2005-2014. This study excluded elderly patients (over 65 years of age), because the etiologies of DH, comorbidities, complications and social determinants of health are unique to that population and different from the non-elderly adult population.

2. Materials and Methods

This was a retrospective cohort study which utilized the NIS database to extract adult patients with a diagnosis of diaphragmatic hernia (ICD-9 diagnosis code 5533). Data collected included race, sex, income quartiles, insurance type, total costs, hospital location and patient characteristics including HLOS, comorbidities, indications and type of invasive diagnostic procedures and time to such procedures. The primary outcome analyzed was HLOS. Secondary outcomes included mortality, need for invasive surgical procedures, and hernia complications including gangrene and obstruction. Data included adults 18-64 years old. Independent data tables were produced and stratified by sex, age range, clinical outcome, administration of invasive diagnostic procedures, surgical correction, hernia complication, and type of corrective surgical procedure. Multiple risk factors for adverse outcomes were further assessed using backward logistic regression analyses.

Statistical Analysis

Descriptive statistical indicators were used to present the findings. Mean, standard deviation (SD), and 95% confidence interval (CI) were calculated for

numerical variables, such as age, HLOS, time to invasive diagnostic procedure, time to surgical procedure, and total hospital charges. P values were calculated for categorical variables via chi-square test and for continuous variables via t-test. P values less than 0.05 were considered significant. Backward logistic regression was performed with mortality as the dependent variable with respect to several risk factors (Tables 8-11).

The coefficient of determination, R^2 was calculated between the factors and mortality. Odds ratio, 95% CI, and p values were calculated for each factor with respect to mortality. Analysis was performed using SPSS software version 24 (SPSS Inc., Chicago, Il) and R statistical software (Foundation for Statistical Computing, Vienna, Austria).

3. Results

3.1 Demographics

In this retrospective cohort of 5,909 patients, 3,653 (61.8%) of patients were female. Male patients had a greater incidence of complications, particularly obstructive complications, increased mortality, need for surgical procedures, HLOS (days), and total charges (Table 1). Patients were predominantly white, and the majority of cases presented to urban hospitals.

Major comorbidities (incidence >10%) included obesity, deficiency anemias, chronic pulmonary disease, depression, uncomplicated diabetes, hypertension, and fluid/electrolyte disorders. Males had a higher incidence of alcohol abuse and renal failure, while females had a higher incidence of deficiency anemias, arthritis, chronic pulmonary disease, depression, hypertension, hypothyroidism, obesity (Table 1).

Table 1. Characteristics of emergency admitted patients with the primary diagnosis of diaphragmatic hernia. Data was stratified according to sex categories, NIS 2005-2014.

		Patients, N (%)		
		Male	Female	p
All Cases		2,256 (38.2%)	3,653 (61.8%)	
Race	White	1,401 (71.6%)	2,268 (71.4%)	<0.001
	Black	208 (10.6%)	447 (14.1%)	
	Hispanic	241 (12.3%)	344 (10.8%)	
	Asian/Pacific Islander	18 (0.9%)	17 (0.5%)	
	Native American	28 (1.4%)	26 (0.8%)	
	Other	60 (3.1%)	74 (2.3%)	
Income Quartile	Quartile 1	671 (30.6%)	1,043 (29.3%)	0.5
	Quartile 2	581 (26.5%)	997 (28.0%)	
	Quartile 3	502 (22.9%)	802 (22.6%)	
	Quartile 4	442 (20.1%)	714 (20.1%)	
Insurance	Private Insurance	1,083 (48.1%)	1,920 (52.7%)	<0.001
	Medicare	384 (17.1%)	662 (18.2%)	
	Medicaid	353 (15.7%)	595 (16.3%)	
	Self-Pay	269 (12.0%)	258 (7.1%)	
	No Charge	30 (1.3%)	42 (1.2%)	
	Other	131 (5.8%)	167 (4.6%)	
Hospital Location	Rural	250 (11.1%)	405 (11.1%)	0.8
	Urban: Non-Teaching	829 (36.7%)	1,371 (37.5%)	
	Urban: Teaching	1,177 (52.2%)	1,877 (51.4%)	
Comorbidities	AIDS	9 (0.4%)	4 (0.1%)	0.040
	Alcohol Abuse	168 (7.4%)	67 (1.8%)	<0.001
	Deficiency Anemias	266 (11.8%)	583 (16.0%)	<0.001
	Rheumatoid Arthritis	24 (1.1%)	149 (4.1%)	<0.001
	Chronic Blood Loss	27 (1.2%)	86 (2.4%)	0.002
	Congestive Heart Failure	53 (2.3%)	103 (2.8%)	0.2
	Chronic Pulmonary Disease	332 (14.7%)	797 (21.8%)	<0.001
	Coagulopathy	70 (3.1%)	54 (1.5%)	<0.001
	Depression	204 (9.0%)	603 (16.5%)	<0.001
	Diabetes, Uncomplicated	235 (10.4%)	402 (11.0%)	0.4
	Diabetes, Chronic Complications	34 (1.5%)	38 (1.0%)	0.1
	Drug Abuse	112 (5.0%)	98 (2.7%)	<0.001
	Hypertension	921 (40.8%)	1,600 (43.8%)	0.025
	Hypothyroidism	92 (4.1%)	483 (13.2%)	<0.001
	Liver Disease	99 (4.4%)	103 (2.8%)	0.001
	Lymphoma	10 (0.4%)	4 (0.1%)	0.013
	Fluid/Electrolyte Disorders	488 (21.6%)	812 (22.2%)	0.6
	Metastatic Cancer	20 (0.9%)	28 (0.8%)	0.6
	Other Neurological Disorders	111 (4.9%)	210 (5.7%)	0.1
	Obesity	249 (11.0%)	707 (19.4%)	<0.001
	Paralysis	68 (3.0%)	53 (1.5%)	<0.001
	Peripheral Vascular Disorders	55 (2.4%)	61 (1.7%)	0.043
	Psychoses	121 (5.4%)	200 (5.5%)	0.8
	Pulmonary Circulation Disorders	21 (0.9%)	34 (0.9%)	0.9
	Renal Failure	74 (3.3%)	74 (2.0%)	0.003
	Solid Tumor	20 (0.9%)	21 (0.6%)	0.2
	Peptic Ulcer	6 (0.3%)	13 (0.4%)	0.6
	Valvular Disease	46 (2.0%)	87 (2.4%)	0.3
	Weight Loss	126 (5.6%)	184 (5.0%)	0.3

		Patients, N (%)		
		Male	Female	p
Complication	No Gangrene or Obstruction	1,524 (67.7%)	2,829 (77.4%)	<0.001
	Gangrene	15 (0.7%)	11 (0.3%)	
	Obstruction	717 (31.8%)	813 (22.3%)	
Invasive Diagnostic Procedure		905 (40.1%)	1,507 (41.3%)	0.3
Surgical Procedure		1,321 (58.6%)	2,041 (55.9%)	0.043
Invasive or Surgical Procedure		1,789 (79.3%)	2,870 (78.6%)	0.5
Deceased		24 (1.1%)	14 (0.4%)	0.001

	Mean (SD)	Mean (SD)	p
Age, Years	49.03 (11.31)	51.66 (10.13)	<0.001
Time to Invasive Diagnostic Procedure, Days	1.96 (2.72)	1.85 (2.57)	0.8
Time to Surgical Procedure, Days	1.59 (2.69)	1.49 (2.44)	0.2
Length of Stay, Days	5.66 (6.95)	5.02 (7.59)	<0.001
Total Charges, Dollars	54,994 (84,082)	44,500 (71,467)	<0.001

3.2 Mortality

In-hospital mortality of this cohort was 0.6% and females represented 36.8% of deceased patients (Table 2). Increased mortality was associated with coagulopathy, fluid/electrolyte disorders, paralysis, neurological disorders and weight loss. Surgical procedures, increased age, increased HLOS, complications and increased charges were also associated with increased mortality. Survivors had significantly fewer complications (Table 2).

Table 2. Characteristics of emergency admitted patients with the primary diagnosis of diaphragmatic hernia. Data was classified according to outcome categories, NIS 2005-2014.

		Patients, N (%)		
		Survived	Deceased	p
All Cases		5,875 (99.4%)	38 (0.6%)	
Sex, Female		3,638 (62.0%)	14 (36.8%)	0.001
Race	White	3,644 (71.5%)	24 (70.6%)	0.023
	Black	653 (12.8%)	2 (5.9%)	
	Hispanic	582 (11.4%)	3 (8.8%)	
	Asian/Pacific Islander	34 (0.7%)	1 (2.9%)	
	Native American	52 (1.0%)	2 (5.9%)	
	Other	132 (2.6%)	2 (5.9%)	
Income Quartile	Quartile 1	1,698 (29.7%)	14 (37.8%)	0.070
	Quartile 2	1,566 (27.4%)	12 (32.4%)	
	Quartile 3	1,296 (22.7%)	10 (27.0%)	
	Quartile 4	1,158 (20.3%)	1 (2.7%)	
Insurance	Private Insurance	2,995 (51.1%)	10 (26.3%)	0.010
	Medicare	1,033 (17.6%)	13 (34.2%)	
	Medicaid	939 (16.0%)	9 (23.7%)	
	Self-Pay	526 (9.0%)	2 (5.3%)	
	No Charge	72 (1.2%)	0 (0%)	
	Other	295 (5.0%)	4 (10.5%)	
Hospital Location	Rural	651 (11.1%)	4 (10.5%)	0.8
	Urban: Non-Teaching	2,189 (37.3%)	16 (42.1%)	
	Urban: Teaching	3,035 (51.7%)	18 (47.4%)	
Comorbidities	AIDS	13 (0.2%)	0 (0%)	0.9
	Alcohol Abuse	234 (4.0%)	1 (2.6%)	0.9
	Deficiency Anemias	843 (14.3%)	6 (15.8%)	0.8
	Rheumatoid Arthritis	173 (2.9%)	0 (0%)	0.6
	Chronic Blood Loss	111 (1.9%)	2 (5.3%)	0.1
	Congestive Heart Failure	155 (2.6%)	1 (2.6%)	0.9
	Chronic Pulmonary Disease	1,118 (19.0%)	11 (28.9%)	0.1
	Coagulopathy	120 (2.0%)	4 (10.5%)	0.008
	Depression	806 (13.7%)	1 (2.6%)	0.054
	Diabetes, Uncomplicated	631 (10.7%)	6 (15.8%)	0.2
	Diabetes, Chronic Complications	72 (1.2%)	0 (0%)	0.9
	Drug Abuse	209 (3.6%)	1 (2.6%)	0.9
	Hypertension	2,505 (42.6%)	15 (39.5%)	0.6
	Hypothyroidism	572 (9.7%)	3 (7.9%)	0.9
	Liver Disease	201 (3.4%)	1 (2.6%)	0.9
	Lymphoma	13 (0.2%)	1 (2.6%)	0.090
	Fluid/Electrolyte Disorders	1,278 (21.8%)	22 (57.9%)	<0.001
	Metastatic Cancer	48 (0.8%)	0 (0%)	0.9
	Other Neurological Disorders	315 (5.4%)	6 (15.8%)	0.015
	Obesity	951 (16.2%)	5 (13.2%)	0.6
	Paralysis	117 (2.0%)	4 (10.5%)	0.007
	Peripheral Vascular Disorders	115 (2.0%)	1 (2.6%)	0.5
	Psychoses	317 (5.4%)	3 (7.9%)	0.4
	Pulmonary Circulation Disorders	54 (0.9%)	1 (2.6%)	0.3
	Renal Failure	146 (2.5%)	2 (5.3%)	0.2
	Solid Tumor	40 (0.7%)	1 (2.6%)	0.2
	Peptic Ulcer	19 (0.3%)	0 (0%)	0.9
	Valvular Disease	131 (2.2%)	2 (5.3%)	0.2
	Weight Loss	302 (5.1%)	8 (21.1%)	<0.001

		Patients, N (%)		
		Survived	Deceased	p
Complication	No Gangrene or Obstruction	4,338 (73.8%)	16 (42.1%)	<0.001
	Gangrene	23 (0.4%)	3 (7.9%)	
	Obstruction	1,514 (25.8%)	19 (50.0%)	
Invasive Diagnostic Procedure		2,395 (40.8%)	17 (44.7%)	0.6
Surgical Procedure		3,337 (56.8%)	29 (76.3%)	0.015
Invasive or Surgical Procedure		4,632 (78.8%)	31 (81.6%)	0.6
		Mean (SD)	Mean (SD)	p
Age, Years		50.64 (10.67)	53.82 (10.09)	0.038
Time to Invasive Diagnostic Procedure, Days		1.87 (2.53)	5.13 (8.41)	0.3
Time to First Surgical Procedure, Days		1.52 (2.52)	2.58 (3.92)	0.090
Length of Stay, Days		5.22 (7.28)	12.34 (13.43)	0.001
Total Charges, Dollars		47,967 (76,105)	134,109 (110,248)	<0.001

3.3. Diagnostic and Surgical Procedures

Patients who were male, white, in income quartiles 2-4, possessing private insurance, and located in urban teaching hospitals were relatively overrepresented in the surgical subgroup (Table 3). Patients requiring surgery had a notably significant increase in gangrene or obstruction, a greater mortality rate, were older, had an increased LOS, and greater total charges (Table 3). Patients undergoing abdominal surgery, respiratory surgery, or an invasive diagnostic procedure of the lung or bronchus exhibited increased mortality (Table 4).

Table 3. Characteristics of emergency admitted patients with the primary diagnosis of diaphragmatic hernia. Data was stratified according to surgery status, NIS 2005-2014.

		Patients, N (%)		
		No Surgery	Surgery	p
All Cases		2,548 (43.1%)	3,367 (56.9%)	
Sex, Female		1,612 (63.3%)	2,041 (60.7%)	0.043
Race	White	1,427 (65.9%)	2,242 (75.5%)	<0.001
	Black	389 (18.0%)	266 (9.0%)	
	Hispanic	252 (11.6%)	333 (11.2%)	
	Asian/Pacific Islander	21 (1.0%)	14 (0.5%)	
	Native American	16 (0.7%)	38 (1.3%)	
	Other	59 (2.7%)	75 (2.5%)	
Income Quartile	Quartile 1	846 (34.2%)	868 (26.4%)	<0.001
	Quartile 2	632 (25.6%)	946 (28.8%)	
	Quartile 3	508 (20.6%)	798 (24.3%)	
	Quartile 4	485 (19.6%)	674 (20.5%)	
Insurance	Private Insurance	1,072 (42.1%)	1,934 (57.7%)	<0.001
	Medicare	526 (20.7%)	520 (15.5%)	
	Medicaid	478 (18.8%)	470 (14.0%)	
	Self-Pay	292 (11.5%)	236 (7.0%)	
	No Charge	39 (1.5%)	33 (1.0%)	
	Other	139 (5.5%)	161 (4.8%)	
Hospital Location	Rural	385 (15.1%)	270 (8.0%)	<0.001
	Urban: Non-Teaching	1,068 (41.9%)	1,137 (33.8%)	
	Urban: Teaching	1,095 (43.0%)	1,960 (58.2%)	
Comorbidities	AIDS	5 (0.2%)	8 (0.2%)	0.7
	Alcohol Abuse	118 (4.6%)	117 (3.5%)	0.024
	Deficiency Anemias	376 (14.8%)	473 (14.0%)	0.4
	Rheumatoid Arthritis	83 (3.3%)	90 (2.7%)	0.1
	Chronic Blood Loss	55 (2.2%)	58 (1.7%)	0.2
	Congestive Heart Failure	86 (3.4%)	70 (2.1%)	0.002
	Chronic Pulmonary Disease	510 (20.0%)	619 (18.4%)	0.1
	Coagulopathy	43 (1.7%)	81 (2.4%)	0.060
	Depression	376 (14.8%)	431 (12.8%)	0.030
	Diabetes, Uncomplicated	336 (13.2%)	301 (8.9%)	<0.001
	Diabetes, Chronic Complications	42 (1.6%)	30 (0.9%)	0.009
	Drug Abuse	124 (4.9%)	86 (2.6%)	<0.001
	Hypertension	1,191 (46.7%)	1,330 (39.5%)	<0.001
	Hypothyroidism	242 (9.5%)	333 (9.9%)	0.6
	Liver Disease	99 (3.9%)	103 (3.1%)	0.080
	Lymphoma	6 (0.2%)	8 (0.2%)	0.9
	Fluid/Electrolyte Disorders	520 (20.4%)	780 (23.2%)	0.011
	Metastatic Cancer	20 (0.8%)	28 (0.8%)	0.8
	Other Neurological Disorders	146 (5.7%)	175 (5.2%)	0.3
	Obesity	408 (16.0%)	548 (16.3%)	0.7
	Paralysis	60 (2.4%)	61 (1.8%)	0.1
	Peripheral Vascular Disorders	65 (2.6%)	51 (1.5%)	0.004
	Psychoses	174 (6.8%)	147 (4.4%)	<0.001
	Pulmonary Circulation Disorders	24 (0.9%)	31 (0.9%)	0.9

		Patients, N (%)		
		No Surgery	Surgery	p
Comorbidities	Renal Failure	95 (3.7%)	53 (1.6%)	<0.001
	Solid Tumor	16 (0.6%)	25 (0.7%)	0.6
	Peptic Ulcer	8 (0.3%)	11 (0.3%)	0.9
	Valvular Disease	83 (3.3%)	50 (1.5%)	<0.001
	Weight Loss	99 (3.9%)	211 (6.3%)	<0.001
Complication	No Gangrene or Obstruction	2,329 (91.4%)	2,027 (60.2%)	<0.001
	Gangrene	1 (0.0%)	25 (0.7%)	
	Obstruction	218 (8.6%)	1,315 (39.1%)	

	Patients, N (%)		
	No Surgery	Surgery	p
Invasive Diagnostic Procedure	1,298 (50.9%)	1,115 (33.1%)	<0.001
Deceased	9 (0.4%)	29 (0.9%)	0.015
	Mean (SD)	Mean (SD)	p
Age, Years	50.28 (10.80)	50.93 (10.57)	0.021
Time to Invasive Diagnostic Procedure, Days	1.82 (1.65)	1.98 (3.45)	<0.001
Length of Stay, Days	2.92 (2.64)	7.04 (9.08)	<0.001
Total Charges, Dollars	19,613 (18,504)	70,433 (94,664)	<0.001

Table 4. Characteristics of emergency admitted patients with the primary diagnosis of diaphragmatic hernia. Data was stratified according to surgical procedure, NIS 2005-2014.

	Adults, N (%)			
Digestive System Surgical Procedure (ICD 9)	Procedures	Survived	Deceased	p
Operations on Esophagus (42.01-42.19, 42.31-42.99)	115 (2.0%)	112 (97.4%)	3 (2.6%)	0.037
Operations on Stomach (43.0-44.03, 44.21-44.99)	2,179 (37.8%)	2,157 (99.0%)	22 (1.0%)	0.007
Operations on Intestine (45.00-45.03, 45.30-46.99)	267 (4.6%)	256 (95.9%)	11 (4.1%)	<0.001
Operations on Appendix (47.01-47.99)	25 (0.4%)	24 (96.0%)	1 (4.0%)	0.1
Operations on Rectum, Rectosigmoid, and Perirectal Tissue (48.0-48.1, 48.31-48.99)	14 (0.2%)	14 (100%)	0 (0%)	0.9
Operations on Anus (49.01-49.12, 49.31-49.99)	2 (0.03%)	2 (100%)	0 (0%)	0.9
Operations on Liver (50.0, 50.21-50.99)	13 (0.2%)	13 (100%)	0 (0%)	0.9
Operations on Gallbladder and Biliary Tract (51.01-51.04, 51.21-51.99)	143 (2.5%)	140 (97.9%)	3 (2.1%)	0.060
Operations on Pancreas (52.01-52.09, 52.21-52.99)	3 (0.05%)	3 (100%)	0 (0%)	0.9
Operations on Hernia (53.00-53.9)	2,435 (42.3%)	2,413 (99.1%)	22 (0.9%)	0.036
Operations on Other Operations on Abdominal Region (54.0-54.19, 54.3-54.99)	564 (9.8%)	553 (98.0%)	11 (2.0%)	<0.001
Digestive System Invasive Diagnostic Procedure (ICD 9), N (%)	**Procedures**	**Survived**	**Deceased**	**p**
Invasive Diagnostic Procedure on Esophagus (42.21-42.29)	44 (1.8%)	44 (100%)	0 (0%)	0.9
Invasive Diagnostic Procedure on Stomach (44.11-44.19)	54 (2.3%)	53 (98.1%)	1 (1.9%)	0.3
Invasive Diagnostic Procedure on Intestine (45.11-45.29)	2,159 (90.0%)	2,149 (99.5%)	10 (0.5%)	0.1
Invasive Diagnostic Procedure on Rectum, Rectosigmoid, and Perirectal Tissue (48.21-48.29)	8 (0.3%)	8 (100%)	0 (0%)	0.9
Invasive Diagnostic Procedure on Liver (50.11-50.19)	32 (1.3%)	31 (96.9%)	1 (3.1%)	0.1
Invasive Diagnostic Procedure on Gallbladder and Biliary Tract (51.10-51.19)	4 (0.2%)	4 (100%)	0 (0%)	0.9
Invasive Diagnostic Procedure on Other Operations on Abdominal Region (54.21-54.29)	98 (4.1%)	95 (96.9%)	3 (3.1%)	0.024
Respiratory System Surgical Procedure (ICD 9)	**Procedures**	**Survived**	**Deceased**	**p**
Operations on Larynx and Trachea (30.01-31.3, 31.5-31.99)	31 (6.9%)	28 (90.3%)	3 (9.7%)	0.001
Operations on Lung and Bronchus (32.01-33.1, 33.31-33.99)	24 (5.4%)	21 (87.5%)	3 (12.5%)	<0.001
Operations on Chest Wall, Pleura, Mediastinum, and Diaphragm (34.01-34.1, 34.3-34.99)	393 (87.7%)	384 (97.7%)	9 (2.3%)	0.001
Respiratory System Invasive Diagnostic Procedure (ICD 9), N (%)	**Procedures**	**Survived**	**Deceased**	**p**
Invasive Diagnostic Procedure on Larynx and Trachea (31.41-31.49)	9 (6.5%)	9 (100%)	0 (0%)	0.9
Invasive Diagnostic Procedure on Lung and Bronchus (33.20-33.29)	117 (84.2%)	111 (94.9%)	6 (5.1%)	<0.001
Invasive Diagnostic Procedure on Chest Wall, Pleura, Mediastinum, and Diaphragm (34.20-34.29)	13 (9.4%)	12 (92.3%)	1 (7.7%)	0.080

3.4. Diaphragmatic Hernia Complications

Female patients were less likely to have gangrene or obstruction (Table 5). Patients with gangrene or obstruction had a significant increase in invasive diagnostic or surgical procedures and a significant increase in digestive system surgical procedures, but a significant decrease in digestive diagnostic procedures (Table 5).

Patients with a complication were associated with increased mortality, longer HLOS, and greater total charges (Table 5).

Table 5. Characteristics of emergency admitted patients with the primary diagnosis of diaphragmatic hernia. Data was stratified according to type of hernia complication, NIS 2005-2014.

		Adult			
		Type of Hernia Complication, N (%)			
		No Comp	Gangrene	Obstruction	p
All Cases		4,356(73.6%)	26 (0.4%)	1,533 (25.9%)	
Sex, Female		2,829(65.0%)	11 (42.3%)	813 (53.1%)	<0.001
Race	White	2,698(71.0%)	13 (65.0%)	958 (73.0%)	0.001
	Black	534 (14.1%)	3 (15.0%)	118 (9.0%)	
	Hispanic	416 (10.9%)	3 (15.0%)	166 (12.7%)	
	Asian/Pacific Islander	24 (0.6%)	0 (0%)	11 (0.8%)	
	Native American	36 (0.9%)	1 (5.0%)	17 (1.3%)	
	Other	92 (2.4%)	0 (0%)	42 (3.2%)	
Income Quartile	Quartile 1	1,316(31.1%)	10 (38.5%)	388 (25.8%)	0.005
	Quartile 2	1,126(26.6%)	8 (30.8%)	444 (29.6%)	
	Quartile 3	936 (22.1%)	3 (11.5%)	367 (24.5%)	
	Quartile 4	852 (20.1%)	5 (19.2%)	302 (20.1%)	
Insurance	Private Insurance	2,148(49.4%)	14 (53.8%)	844 (55.3%)	<0.001
	Medicare	818 (18.8%)	2 (7.7%)	226 (14.8%)	
	Medicaid	740 (17.0%)	3 (11.5%)	205 (13.4%)	
	Self-Pay	360 (8.3%)	5 (19.2%)	163 (10.7%)	
	No Charge	58 (1.3%)	0 (0%)	14 (0.9%)	
	Other	223 (5.1%)	2 (7.7%)	75 (4.9%)	
Hospital Location	Rural	515 (11.8%)	5 (19.2%)	135 (8.8%)	0.014
	Urban: Non-Teaching	1,616(37.1%)	8 (30.8%)	581 (37.9%)	
	Urban: Teaching	2,225(51.1%)	13 (50.0%)	817 (53.3%)	
Comorbidities	AIDS	10 (0.2%)	0 (0%)	3 (0.2%)	0.9
	Alcohol Abuse	163 (3.7%)	2 (7.7%)	70 (4.6%)	0.2
	Deficiency Anemias	619 (14.2%)	6 (23.1%)	224 (14.6%)	0.4
	Rheumatoid Arthritis	137 (3.1%)	0 (0%)	36 (2.3%)	0.1
	Chronic Blood Loss	92 (2.1%)	0 (0%)	21 (1.4%)	0.1
	Congestive Heart Failure	116 (2.7%)	1 (3.8%)	39 (2.5%)	0.9
	Chronic Pulmonary Disease	888 (20.4%)	3 (11.5%)	238 (15.5%)	<0.001
	Coagulopathy	71 (1.6%)	1 (3.8%)	52 (3.4%)	<0.001
	Depression	639 (14.7%)	2 (7.7%)	166 (10.8%)	0.001
	Diabetes, Uncomplicated	496 (11.4%)	3 (11.5%)	138 (9.0%)	0.035
	Diabetes, Chronic Complications	56 (1.3%)	0 (0%)	16 (1.0%)	0.6
	Drug Abuse	152 (3.5%)	0 (0%)	58 (3.8%)	0.5
	Hypertension	1,882(43.2%)	7 (26.9%)	632 (41.2%)	0.1

		Adult			
		Type of Hernia Complication, N (%)			
		No Comp	Gangrene	Obstruction	p
All Cases		4,356(73.6%)	26 (0.4%)	1,533 (25.9%)	
Sex, Female		2,829(65.0%)	11 (42.3%)	813 (53.1%)	<0.001
Comorbidities	Hypothyroidism	444 (10.2%)	3 (11.5%)	128 (8.3%)	0.1
	Liver Disease	155 (3.6%)	0 (0%)	47 (3.1%)	0.4
	Lymphoma	11 (0.3%)	0 (0%)	3 (0.2%)	0.9
	Fluid/Electrolyte Disorders	781 (17.9%)	12 (46.2%)	507 (33.1%)	<0.001
	Metastatic Cancer	33 (0.8%)	0 (0%)	15 (1.0%)	0.6
	Other Neurological Disorders	241 (5.5%)	0 (0%)	80 (5.2%)	0.4
	Obesity	734 (16.9%)	5 (19.2%)	217 (14.2%)	0.044
	Paralysis	91 (2.1%)	0 (0%)	30 (2.0%)	0.7
	Peripheral Vascular Disorders	84 (1.9%)	1 (3.8%)	31 (2.0%)	0.7
	Psychoses	258 (5.9%)	1 (3.8%)	62 (4.0%)	0.019
	Pulmonary Circulation Disorders	36 (0.8%)	1 (3.8%)	18 (1.2%)	0.1
	Renal Failure	119 (2.7%)	1 (3.8%)	28 (1.8%)	0.1
	Solid Tumor	23 (0.5%)	1 (3.8%)	17 (1.1%)	0.009
	Peptic Ulcer	9 (0.2%)	0 (0%)	10 (0.7%)	0.028
	Valvular Disease	111 (2.5%)	0 (0%)	22 (1.4%)	0.030
	Weight Loss	169 (3.9%)	8 (30.8%)	133 (8.7%)	<0.001
Respiratory System Invasive Diagnostic Procedure		57 (1.3%)	4 (15.4%)	73 (4.8%)	<0.001
Respiratory System Surgical Procedure		22 (0.5%)	1 (3.8%)	42 (2.7%)	<0.001
Digestive System Invasive Diagnostic Procedure		1,863(42.8%)	8 (30.8%)	466 (30.4%)	<0.001
Digestive System Surgical Procedure		2,024(46.5%)	25 (96.2%)	1,315 (85.8%)	<0.001
Invasive or Surgical Procedure		3,259(74.8%)	26 (100%)	1,380 (90.0%)	<0.001
Deceased		16 (0.4%)	3 (11.5%)	19 (1.2%)	<0.001

	Mean (SD)	Mean (SD)	Mean (SD)	p
Age, Years	50.48 (10.57)	51.77(11.82)	51.12 (10.93)	0.008
Time to Invasive Diagnostic Procedure, Days	1.90 (2.64)	3.50 (5.53)	1.82 (2.51)	0.080
Time to First Surgical Procedure, Days	1.40 (2.66)	1.21 (1.65)	1.73 (2.34)	<0.001
Length of Stay, Days	4.27 (5.90)	16.08(11.78)	7.91 (9.79)	<0.001
Total Charges, Dollars	38,189 (58,794)	164,497 (190,080)	75,978 (104,937)	<0.001

3.5 Risk Factors of Mortality

Multivariate logistic regression analysis was performed to determine risk factors for mortality within this cohort. Male sex, gangrene, invasive respiratory diagnostic procedures, and increased hospital LOS were associated with increased mortality (Table 6).

4. Discussion

This study utilized a large national database to explore multiple independent risk factors for various outcomes in adults emergently admitted to the hospital with DH. Characteristics and outcome measures on patients presenting with adult diaphragmatic hernia have not been well described.[9,16,20,21] Other studies utilizing the NIS database include only specific subgroups of DH patients. Paul et. al. reported outcome measures between two types of corrective procedures for uncomplicated diaphragmatic hernia without gangrene or obstruction.[17] Gupta et. al studied outcome measures for patients undergoing anti-reflux operations with a primary diagnosis of paraesophageal

hernia, a type of DH, or gastrointestinal reflux disease (GERD).[22] However, this is the first study to comprehensively describe demographics, clinical presentations, complications, and surgical and non-surgical outcomes in DH in adults from the NIS database.

Table 6. Backward logistic regression analysis to evaluate the associations between mortality and different factors in emergency admitted patients with the primary diagnosis of diaphragmatic hernia who underwent an operation. Mortality was the dependent variable. NIS 2005 - 2014.

		Patients with Operation OR (95% CI)	p
Hernia Complication	No Complications [Ref]		0.005
	Gangrene	10.001 (2.400, 41.671)	0.002
	Obstruction	1.134 (0.512, 2.512)	0.7
Respiratory Invasive Diagnostic Procedure		4.120 (1.528, 11.108)	0.005
Hospital Length of Stay, Days		1.021 (1.005, 1.037)	0.010
Sex, Female		0.378 (0.171, 0.835)	0.016

4.1 Sex and Mortality

Female sex was associated with a lower rate of mortality. This includes an odds ratio of 0.438 in all admitted patients, and 0.378 in patients receiving an operation. This was in contrast with the findings of Paul et. al. who found no correlation between sex and mortality in patients undergoing surgical DH repair.[17] There were more female patients diagnosed with diaphragmatic hernia in the NIS sample and as age increased, the female:male ratio also increased across all age groups. Gupta et. al. and Paul et. al. also corroborate the increased prevalence of female sex in their respective subgroups.[17,22,23]

4.2 Complications and Mortality

Patients with complicated DH had increased LOS and total hospitalization costs as well as increased mortality. Gangrenous complications were associated with a 17.7 fold increase in mortality within our sample population. This is consistent with prior studies, such as Degiannis et. al. who found gangrenous perforations to be the most common and aggravating risk factor for mortality in patients with traumatic DH.[26]

4.3 Invasive Procedures and Mortality

Performance of an invasive diagnostic respiratory procedure also resulted in increased mortality. It can be inferred that patients who needed an invasive diagnostic respiratory procedure had a hernia severe enough to cause respiratory compromise and thus likely associated with greater mortality. Gupta et. al. similarly found that pulmonary complications led to postoperative increased mortality for patients with paraesophageal hernia, and also concluded that the pulmonary complications, in part, explained the mortality difference between hernia patients and GERD patients undergoing operations.[22]

4.4 Hospital Length of Stay and Mortality

Increasing HLOS was a predictor for mortality in patients requiring an operation (Table 6). Associations between HLOS and mortality have been observed in several other retrospective studies utilizing the NIS database, including in patients emergently admitted for umbilical hernia, ventral hernia, gastroparesis, tracheostomy, hemorrhoids, duodenal ulcers, rectal malignancy, blunt chest wall trauma, and paralytic ileus.[27-41] However, as the literature surrounding HLOS and mortality in adults with DH is sparse, more research into these particular associations is warranted to potentially identify causative links.

Strengths of the Study

This study uses the National Inpatient Sample, a large administrative database produced by the Agency for Healthcare Research and Quality often utilized for assessing patterns of care and health outcomes. This study analyzes 5,909 non-elderly adult patients who presented to the emergency room with adult-onset diaphragmatic hernia. This represents the largest sample size studied for adult DH. Epidemiological analysis of DH and its associated outcome measures can provide unique insights into standards of care and associated risk factors for these patients. Other studies have either focused on more specific cases of DH, such as patients undergoing surgical correction[17] or subtypes of DH such as paraesophageal hernia[22], or have been limited to small populations and case studies.

Limitations of the Study

This study is a retrospective analysis utilizing the parameters provided by the NIS database, which are extensive but not all-encompassing. For example, the cause of mortality in these patients is not included in the database. Stratification by cause of DH could provide additional insights on outcomes and epidemiological data. Potential

confounding factors such as surgeon's level of training, severity of comorbidities, and reasons for operation (elective vs non-elective) would have also provided additional insights.

Conclusions

The NIS database was utilized to assess epidemiological data and outcomes retrospectively for cases of adult DH, including complications of gangrene and obstruction. Backwards elimination analysis was performed to assess the most powerful factors which explain associations and remove poorer associations. Results of the elimination revealed that in operated patients emergently admitted to the hospital with diaphragmatic hernia, male sex, presence of gangrenous complications, a need for invasive respiratory diagnostic procedures and an increased HLOS was associated with increased mortality. Adult DH has been far less studied than the more common congenital DH, so there is ample opportunity to study these trends prospectively in order to further explain the associations found.

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