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Original Research Article

Defining risk factors for mortality after emergent hiatal hernia repair in the era of minimally invasive surgery

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ABSTRACT

Background: Risk factors for mortality following emergent hiatal hernia (HH) repair in the era of minimally invasive surgery remain poorly defined.
Methods: Data was obtained from the National Inpatient Sample (NIS), National Readmissions Database, and National Emergency Department Sample for patients undergoing HH repair between 2010 and 2018. Univariate and multivariate logistic regression analyses reported with odds ratio (OR) and 95% confidence intervals (CI) were performed to identify factors associated mortality.
Results: Via the NIS, mortality rate was 2.2% (147 patients). Via the NEDS, the mortality rate was 3.6% (303 patients). On multivariate analysis, predictors of mortality included age (OR 1.05, CI: 1.04,1.07), male sex (OR 1.49, CI: 1.06,2.11), frailty (OR 2.49, CI: 1.65,3.75), open repair (OR 3.59, CI: 2.50,5.17), and congestive heart failure (OR 2.71, CI: 1.81,4.06).
Conclusions: There are multiple risk factors for mortality after hiatal hernia repair. There is merit to a laparoscopic approach even in emergent settings.

1. Introduction

Hiatal hernias (HH) are common, though true incidence is difficult to estimate given their variable symptomatology and presentation. Management of HH disease has in the past decade shifted towards "watchful waiting" for asymptomatic patients or individuals who are high risk for surgery.[1] However, untreated HH is recognized as a risk factor gastric volvulus, obstruction, and necrosis of the intrathoracic stomach, all of which are surgical emergencies requiring immediate operative intervention. Emergent repair is associated with increased morbidity and mortality compared to elective repair, even when controlling for population differences.[2–5]

Minimally invasive repair has been the gold standard for elective HH repairs for at least the past decade, and is widely regarded as a safe, low risk procedure for well-selected patients.[1,6] Open repair remains common in emergent cases, though a growing body of work suggests that minimally invasive repair can be safely performed in this setting and may be preferable.[7,8]

Though surgical approach has evolved, there is a dearth of recent large-scale studies exploring outcomes after emergent repair. As our population ages, recognizing that prevalence of HH disease increases with age, it is necessary to fully understand the risks associated with treatment paradigms to optimize patient outcomes. We seek to better define risk factors for morbidity and mortality following emergent HH repair in the era of minimally invasive surgery.

2. Methods

2.1. Data source and patient selection

Data from the National Inpatient Sample (NIS), National Emergency Department Sample (NEDS), and Nationwide Readmissions Database

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(NRD) were retrospectively analyzed from 2010 to 2018. These large, publicly available datasets are from the Healthcare Cost and Utilization Project (HCUP). The NIS was utilized as the primary dataset for comparison due to the greater depth of available analytical variables. More than 7 million unweighted hospitalizations are documented per year in this database alone. The institutional review board at Thomas Jefferson University Hospital deemed this project exempt.

In order to identify diagnoses and procedures, International Classification of Diseases (ICD)-9 and ICD-10 Clinical Modification and Procedural Medical Billing codes were used. Due to a transition of these codes in the fourth quarter of 2015, relevant ICD-9 codes were converted to equivalent ICD-10 codes for subsequent years. Careful attention was taken to alter relevant ICD codes per year, as appropriate. Furthermore, Current Procedural Terminology (CPT) codes were used and matched to ICD-9 and ICD-10 codes as needed.

Adult patients with a HH diagnosis code who underwent a non-elective or emergent surgical repair from 2010 to 2018 were included in the analysis. Due to the nature of the HCUP databases, emergent in the context of this paper refers to any non-elective repair and includes urgent repairs. To ensure inclusion of only non-elective operations, within the NIS patients were excluded if they were transferred into the hospital or if their procedure was completed after the first day of admission. Patients undergoing concurrent bariatric surgery or those with a congenital diaphragmatic hernia diagnosis were excluded. ICD-9 codes were utilized for years 2010 through quarter three of 2015, and ICD-10 from quarter four of 2015 through 2018. In the NEDS, patients who were admitted through the Emergency Department (ED) and underwent inpatient HH repair were included. Within the NRD, patients undergoing non-elective HH repair were analyzed during the first 11 months of each calendar year to properly identify 30-day readmission rates.

2.2. Primary comparison

The primary comparison groups of this study were between patients who suffered in-hospital mortality and those who did not following emergent HH repair. Secondary outcomes of interest were comorbid conditions and postoperative complications that were associated with increased likelihood of postoperative in-hospital mortality. Based on previous literature analyzing HH repair and perioperative outcomes, complications were classified into cardiorespiratory, infectious, gastrointestinal, renal, and general postoperative categorizations.[9,10] Analyzed complications and their groupings into major and minor categories are detailed in the appendices (Supplemental Table 1). Clavien-Dindo classifications could not be achieved within the HCUP datasets.

2.3. Additional variables

Data were collected on patient characteristics including age, gender, race, insurance status, house income by zip code, primary diagnosis, presence of preoperative gastroesophageal reflux disease (GERD), and frailty. Frailty was defined as the presence of one or more of ten diagnoses using the Johns Hopkins Adjusted Clinical Groups (ACG) frailty defining diagnoses indicator, a previously validated instrument (Supplemental Table 2).[11] Facility level variables included location, teaching status of hospital, and hospital bed size as defined in HCUP databases. Frequency of minimally invasive approach was also collected.

Several comorbidities were defined. These include anemia, congestive heart failure or cardiomyopathy, chronic lung disease, diabetes mellitus, hypertension, chronic kidney disease, liver disease, metastatic cancer, peripheral vascular disease, pulmonary circulation disorder, and valvular heart disease. Additional outcomes analyzed included length of stay, number of procedures completed, and total charges associated with the admission.

A subgroup analysis was completed within the NEDS cohort for patients who underwent emergent HH repair following admission directly from the emergency department (ED).

2.4. Statistical analysis

Analyses followed published HCUP guidelines. Pearson's Chi-squared and Student's t-tests were utilized to compare patient and treatment characteristics between patients which suffered in-hospital mortality to those who did not. Following a univariable logistic regression analysis, a multivariable logistic regression analysis was conducted to identify demographic, comorbidity and treatment factors associated with in-hospital mortality, reported with odds ratio (OR) and a 95% confidence interval (CI). All analyses utilized STATA/SE 15.1 statistical software (StataCorp LLC, College Station, TX). A 2-sided significance level of $p < 0.05$ was used for all statistical testing.

3. Results

From the NIS, 6,604 of 50,536 patients who underwent HH repair were identified as having a non-elective repair. Of those patients, 147 died in-hospital (2.2% in-hospital mortality rate). From the NRD, 24,425 patients were identified as having a non-elective HH repair during their index admission. Of patients readmitted within 30 days, 69 (3.12%) died during their first readmission event. From the NEDS, 8,303 patients were identified as undergoing emergent repair, 303 of whom died during hospitalization (3.6% mortality rate).

3.1. NIS: Patient characteristics

Following emergent repair, patients who died were older (80, [IQR 70–88] vs. 64 [IQR 50–75]; $p < 0.01$), more frequently had Medicare insurance (121 [82.3%] vs. 3353 [52%]; $p < 0.01$), were more likely to be male (64 [43.5%] vs. 2,063 [32%], $p < 0.01$), and more likely to carry a diagnosis of frailty (37 [25.2%] vs. 415 [6.4%] $p < 0.01$). Additionally, there was a difference between patients who died and patients who survived in number of comorbidities (2 [IQR 1–3] vs. 1 [IQR 0–2]) and rate of open repair (100 [68%] vs. 1,848 [28.6%]; $p < 0.01$). Patients who died in hospital were less likely to have a primary diagnosis of HH (70 [47.6%] vs. 3,882 [60.1%]; $p < 0.01$) and less likely to carry a diagnosis of GERD (63 [42.9%] vs. 3,645 [56.5%]; $p < 0.01$). We additionally found that race was correlated with in-hospital mortality, with a higher proportion of white patients dying in hospital after presenting for emergent repair. Though 75% of the total cohort was white, 81% of patients who died in hospital were white ($p = 0.01$) (Table 1).

3.2. NIS: Comorbidities

Comorbidities were seen more frequently among patients who died after emergent HH repair when compared to those who survived (Table 2). Presence of anemia (49 [33.3%] vs. 1,323 [20.5%]; $p < 0.01$), congestive heart failure (41 [27.9%] vs. 423 [6.6%]; $p < 0.01$), chronic kidney disease or peripheral vascular disease (31 [21%] vs. 519 [8%]; $p < 0.01$), or valvular heart disease (12 [8.2%] vs. 210 [3.3%]; $p < 0.01$) were seen at higher rates among patients who died after HH repair.

3.3. NIS: Complications

An analysis of complications after emergency repair was undertaken (Table 3). For the total cohort, 29.2% (1931 patients) suffered a major complication and 36.5% (2410 patients) a minor complication. Patients who died in hospital had a significantly higher rate of experiencing any complication, major or minor, when compared to patients who survived (97.3% vs. 47.3%; $p < 0.01$). This association remained when complications were subdivided into categories of infectious, cardiothoracic, gastrointestinal, renal, and other postoperative. Patients who died had a longer length of stay (9 days [IQR 4–16] vs. 4 days [IQR 2–8]; $p < 0.01$)

Table 1
Demographic data and patient characteristics, NIS.

N		Total	Survived	Died	P-value
		6604	6457	147	
Estimated N		32,869	32,133	736	
Age (yrs), median (IQR[a])		64 (51, 75)	64 (50, 75)	80 (70, 88)	<0.01
Gender	Male	2127 (32.2%)	2063 (32.0%)	64 (43.5%)	<0.01
	Female	4474 (67.8%)	4391 (68.0%)	83 (56.5%)	
Race	White	4766 (75.0%)	4649 (74.8%)	117 (81.2%)	0.01
	Black or Hispanic	1313 (20.7%)	1297 (20.9%)	16 (11.2%)	
	Other	278 (4.4%)	267 (4.3%)	11 (7.6%)	
Calendar year	2010-2011[b]	1391 (21%)	1373 (21.2%)	18 (12.2%)	0.10
	2012	638 (9.7%)	626 (9.7%)	12 (8.2%)	
	2013	692 (10.5%)	677 (10.5%)	15 (10.2%)	
	2014	632 (9.6%)	617 (9.6%)	15 (10.2%)	
	2015	699 (10.6%)	676 (10.5%)	23 (15.6%)	
	2016	861 (13.0%)	844 (13.1%)	17 (11.6%)	
	2017	902 (13.7%)	880 (13.6%)	22 (15.0%)	
	2018	789 (11.9%)	764 (11.8%)	25 (17.0%)	
Insurance	Medicare or Medicaid	4047 (61.4%)	3922 (60.8%)	125 (85.0%)	<0.01
	Private insurance, self-pay, no charge, or other insurance	2545 (38.5%)	2165 (33.6%) 2535 (39.2%)	22 (15%)	
House income by zip	0–25%	1568 (24.3%)	1536 (24.3%)	32 (22.1%)	0.75
	26–50%	1682 (26.0%)	1640 (26.0%)	42 (29.0%)	
	51–75%	1728 (26.8%)	1687 (26.7%)	41 (28.3%)	
	76–100%	1480 (22.9%)	1450 (23.0%)	30 (20.7%)	
Location/teaching status of hospital	Rural	389 (6.1%)	376 (6.0%)	13 (8.9%)	0.33
	Urban nonteaching	2039 (31.8%)	1992 (31.8%)	47 (32.2%)	
	Urban teaching	3985 (62.1%)	3899 (62.2%)	86 (58.9%)	
Bed size of hospital (STRATA)	Small	1031 (16.1%)	1013 (16.2%)	18 (12.3%)	0.25
	Medium	1749 (27.3%)	1713 (27.3%)	36 (24.7%)	
	Large	3633 (56.7%)	3541 (56.5%)	92 (63.0%)	
Primary diagnosis of HH		3952 (59.8%)	3882 (60.1%)	70 (47.6%)	<0.01
GERD		3708 (56.1%)	3645 (56.5%)	63 (42.9%)	<0.01
Frailty		452 (6.8%)	415 (6.4%)	37 (25.2%)	<0.01
Quantity of comorbidities, median (IQR)		1 (0, 2)	1 (0, 2)	2 (1, 3)	<0.01
Approach	Laparoscopic	4656 (70.5%)	4609 (71.4%)	47 (32.0%)	<0.01
	Open	1948 (29.5%)	1848 (28.6%)	100 (68.0%)	

[a] IQR – interquartile range.
[b] Data categories combined to comply with minimum data reporting size as outlined in the HCUP data use agreement

Table 2
Comorbidities associated with mortality after emergent HH repair, NIS.

N	Total	Survived	Died	P-value
	6604	6457	147	
Anemia	1372 (20.8%)	1323 (20.5%)	49 (33.3%)	<0.01
Congestive heart failure/cardiomyopathy	464 (7.0%)	423 (6.6%)	41 (27.9%)	<0.01
Chronic lung disease	1317 (19.9%)	1282 (19.9%)	35 (23.8%)	0.24
Diabetes	1093 (16.6%)	1069 (16.6%)	24 (16.3%)	0.94
Hypertension	3774 (57.1%)	3686 (57.1%)	88 (59.9%)	0.50
Chronic kidney disease or peripheral vascular disease[a]	550 (8.3%)	519 (8.0%)	31 (21.0%)	<0.01
Valvular heart disease	222 (3.4%)	210 (3.3%)	12 (8.2%)	<0.01
Other[b]	508 (7.8%)	492 (7.6%)	16 (10.9%)	0.14

[a] *Chronic kidney disease and peripheral vascular disease are independently associated with mortality with a significance level of $p<0.01$.*
[b] *Other complications include: pulmonary circulation disorder, liver disease, and metastatic cancer. Data categories combined to comply with minimum data reporting size as outlined in the HCUP data use agreement.*

and higher overall costs ($161,770 USD [IQR $92,523-$289,578] vs. $64,929 USD [IQR $38,821 vs. $107,868]; $p < 0.01$).

3.4. NIS: Univariable and multivariable analysis

On univariable analysis (Table 4), age, frailty, open approach, anemia, congestive heart failure, peripheral vascular disease, valvular heart disease, and chronic kidney disease were associated with mortality ($p < 0.001$). Male sex (OR 1.64 [95% CI 1.18, 2.28]; $p = 0.003$) was additionally associated with mortality. Non-white race (OR 0.65 [95% CI 0.44,0.99]; $p = 0.04$) was negatively associated with risk of death.

On multivariable analysis (Table 4), age (OR 1.05 [95% CI 1.03,1.06]; $p < 0.001$), frailty (OR 2.49 [95% CI 1.65,3.75]; $p < 0.001$), open approach (OR 3.59 [95% CI 2.50,5.17]; $p < 0.001$), congestive heart failure (OR 2.71 [95% CI 1.81,4.06]; $p < 0.001$), and male sex (OR 1.49 [95% CI 1.06,2.11]; $p = 0.023$) were significantly associated with mortality after emergent HH repair (Fig. 1).

3.5. NRD: Readmission after Repair

Readmission after emergent HH repair was explored using the NRD (Fig. 2). Over the years analyzed, there were 24,425 non-elective repairs performed, with 2,208 patients readmitted within 30 days of the index procedure (overall readmission rate 9.04%). The readmission rate over time was relatively stable between 8 and 10%, peaking at 9.90% in 2010 with a nadir of 8.29% in 2017.

3.6. NEDS: patient characteristics

A separate analysis of patient characteristics was undertaken using the NEDS (Table 5). Overall mortality was 3.6%, and 54.8% of cases overall were approached laparoscopically. Increased age (79 [IQR 67–86] vs. 67 [IQR 51–79]; $p < 0.001$), Medicare insurance (223

Table 3
Complications associated with mortality after emergent HH repair, NIS.

		Total	Survived	Died	P-value
N		6604	6457	147	
LOS, median (IQR[a])		4 (2, 8)	4 (2, 8)	9 (4, 16)	<0.01
Total charges in USD[b], median (IQR)		65,920 (39,284, 11,0314)	64929.5 (38,821, 10,7868)	161,771 (92,523, 28,9579)	<0.01
Died during hospitalization		147 (2.2%)			
Major complication		1931 (29.2%)	1794 (27.8%)	137 (93.2%)	<0.01
Minor complication		2410 (36.5%)	2288 (35.4%)	122 (83.0%)	<0.01
Any complication		3199 (48.4%)	3056 (47.3%)	143 (97.3%)	<0.01
Complication category					
Infectious	None	6201 (93.9%)	6128 (94.9%)	73 (49.7%)	<0.01
	Infectious, major	403 (6.1%)	329 (5.1%)	74 (50.3%)	
Cardiothoracic	None	5168 (78.3%)	5145 (79.7%)	23 (15.6%)	<0.01
	Cardiothoracic, major OR minor	1145 (17.3%)	1055 (16.3%)	90 (61.2%)	
	Cardiothoracic, major AND minor	291 (4.4%)	257 (4.0%)	34 (23.1%)	
Gastrointestinal	None	4960 (75.1%)	4889 (75.7%)	71 (48.3%)	<0.01
	Gastrointestinal, major	473 (7.2%)	432 (6.7%)	41 (27.9%)	
	Gastrointestinal, minor	1008 (15.3%)	987 (15.3%)	21 (14.3%)	
	Gastrointestinal, major AND minor	163 (2.5%)	149 (2.3%)	14 (9.5%)	
Renal	None	5689 (86.1%)	5623 (87.1%)	66 (44.9%)	<0.01
	Renal, minor	915 (13.9%)	834 (12.9%)	81 (55.1%)	
Other postoperative	None	5226 (79.1%)	5158 (79.9%)	68 (46.3%)	<0.01
	Postoperative, major	808 (12.2%)	757 (11.7%)	51 (34.7%)	
	Postoperative, minor	423 (6.4%)	408 (6.3%)	15 (10.2%)	
	Postoperative, major AND minor	147 (2.2%)	134 (2.1%)	13 (8.8%)	

[a] IQR – interquartile range.
[b] USD – US dollars.

Table 4
Univariable and multivariable analysis of factors associated with mortality after HH repair, NIS.

DIED		Univariable				Multivariable			
		Odds Ratio	P-value	[95% CI]		Odds Ratio	P-value	[95% CI]	
Age		1.07	<0.001	1.06	1.09	1.05	<0.001	1.04	1.07
Gender	Female	1				1			
	Male	1.64	0.003	1.18	2.28	1.49	0.023	1.06	2.11
Race	White	1				1			
	Non-white	0.66	0.044	0.44	0.99	1.09	0.687	0.71	1.67
Frailty		4.90	<0.001	3.33	7.20	2.49	<0.001	1.65	3.75
Approach	MIS[a]	1				1			
	Open	5.31	<0.001	3.74	7.54	3.59	<0.001	2.50	5.17
Anemia		1.94	<0.001	1.37	2.75	0.98	0.926	0.68	1.42
Heart failure or cardiomyopathy		5.52	<0.001	3.80	8.02	2.71	<0.001	1.81	4.06
Chronic kidney disease		2.8	<0.001	1.77	4.42	1.17	0.537	0.72	1.90
Peripheral vascular disease		3.09	0.003	1.48	6.45	1.54	0.277	0.71	3.34
Valvular heart disease		2.64	0.002	1.44	4.85	1.08	0.828	0.56	2.06

[a] MIS – Minimally invasive surgical approach.

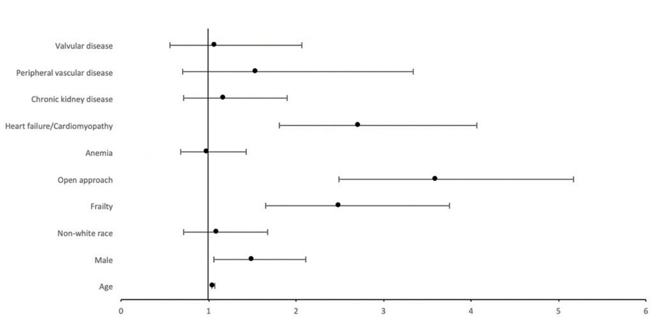

Fig. 1. Forest plot - multivariable analysis of risk factors associated with mortality after emergent HH repair.

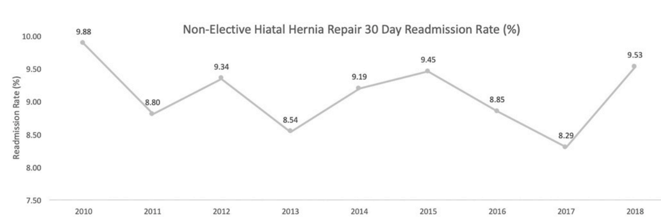

Fig. 2. 30-day readmission rate after emergent HH repair, 2010–2018.

[73.6%] vs. 4517 [56.6%]; p < 0.01), and open approach (219 [72.3%] vs 3524 [44.1%]) were seen more frequently among patients who died following emergent repair, as was a diagnosis of frailty (52 [17.2%] vs. 939 [11.8%]; p = 0.004) and admission to a metropolitan non-teaching hospital (100 [33%] vs. 2308 [28.9%]; p = 0.008). Patients who died were also less likely to have a primary diagnosis of HH (148 [48.8%] vs. 4976 [62.3%]; p < 0.01) or a diagnosis of GERD (75 [24.8%] vs. 3372 [42.2%]; p < 0.001) when compared to those who survived.

Patients who died underwent a higher number of inpatient procedures when compared to patients who survived (7 [IQR 6–9] vs. 4 [IQR 2–6]; p < 0.001) and had higher total charges for inpatient and ED services ($160,178 USD [IQR $105,278-$298,323] vs. $96,597 [IQR $59,435-165,025]; p < 0.001). Length of stay was similar among both

Table 5
Demographics associated with emergent HH repair, NEDS.

Factor		Total	Survived	Died	P-value
N		8303	7990	303	
Estimated N		35,535	34,204	1,287	
Age in years at admission, median (IQR[a])		68 (51, 79)	67 (51, 79)	79 (67, 86)	<0.001
Gender	Male	3243 (39.1%)	3105 (38.9%)	130 (42.9%)	0.16
	Female	5059 (60.9%)	4884 (61.1%)	173 (57.1%)	
Calendar year	2010	503 (6.1%)	479 (6.0%)	24 (7.9%)	0.56
	2011	502 (6.0%)	476 (6.0%)	23 (7.6%)	
	2012	591 (7.1%)	568 (7.1%)	23 (7.6%)	
	2013	639 (7.7%)	617 (7.7%)	22 (7.3%)	
	2014	726 (8.7%)	694 (8.7%)	32 (10.6%)	
	2015	813 (9.8%)	786 (9.8%)	25 (8.3%)	
	2016	1085 (13.1%)	1047 (13.1%)	38 (12.5%)	
	2017	1171 (14.1%)	1135 (14.2%)	35 (11.6%)	
	2018	2273 (27.4%)	2188 (27.4%)	81 (26.7%)	
Household income by zip code	0–25%	2151 (26.5%)	2069 (26.5%)	81 (27.7%)	0.054
	26–50%	2142 (26.4%)	2044 (26.2%)	94 (32.2%)	
	51–75%	2031 (25.0%)	1964 (25.1%)	66 (22.6%)	
	76–100%	1788 (22.0%)	1734 (22.2%)	51 (17.5%)	
Insurance	Medicare or Medicaid	5801 (69.9%)	5552 (69.6%)	243 (80.2%)	<0.001
	Private insurance, self-pay, no charge, or other insurance	2491 (30%)	2427 (30.4%)	60 (19.9%)	
Primary diagnosis of HH		5127 (61.7%)	4976 (62.3%)	148 (48.8%)	<0.001
Frailty		992 (11.9%)	939 (11.8%)	52 (17.2%)	0.004
GERD		3449 (41.5%)	3372 (42.2%)	75 (24.8%)	<0.001
Hospital teaching status	Metro non-teach	2413 (29.1%)	2308 (28.9%)	100 (33.0%)	0.008
	Metro teach	5501 (66.3%)	5316 (66.5%)	180 (59.4%)	
	Non-metro	389 (4.7%)	366 (4.6%)	23 (7.6%)	
Approach	Open	3751 (45.2%)	3524 (44.1%)	219 (72.3%)	<0.001
	Laparoscopic	4552 (54.8%)	4466 (55.9%)	84 (27.7%)	
Number of procedures, median (IQR)		4 (2, 6)	4 (2, 6)	7 (6, 9)	<0.001
Total charge for ED & inpatient services, median USD[b] (IQR)		98,780 (60,183, 169,848)	96,597 (59,435, 165,025)	160,178 (10 5278, 298,323)	<0.001
Length of stay, median days (IQR)		8 (5, 13)	8 (5, 13)	9 (4, 18)	0.094

[a] IQR – interquartile range.
[b] USD – US dollars.

cohorts (9 days [4-18] vs. 8 [IQR 5–13]; p = 0.094).

4. Discussion

This analysis sought to explore risk factors for mortality following emergent hernia repair in the minimally invasive era. Older, frail patients with multiple comorbidities were more likely to have complications and were more likely to die in hospital. Comorbid heart failure specifically was independently associated with risk of in-hospital mortality. Patients undergoing emergent repair were additionally more likely to be readmitted to hospital than patients who underwent elective repair.[12] The mortality rates overall were relatively low at 2.2% for NIS and 3.6% for NEDS. The in-hospital mortality rate from the NIS is comparable to what has been previously reported.[13–15] Though race was correlated with increased rates of in-hospital mortality, given the low numbers of non-white patients who died in hospital this data point is likely underpowered.

Though a greater proportion of patients who died had surgery via an open approach, the majority of patients overall, in both NIS and NEDS databases, received a minimally invasive repair. This likely reflects changing practice patterns, more widespread use of minimally invasive repair, and a recognition of the benefits of laparoscopic repair. Multiple studies have been published in the past decade supporting laparoscopic HH repair, even in emergency settings. Data on robotic HH repair are insufficient at this time to draw conclusions.[2] Mungo et al.[16] found there was a survival benefit for patients undergoing laparoscopic emergent repair, as well as decreased length of stay, when compared to open repair. Klinginsmith et al.[17] came to a similar conclusion and found that patients who received a non-elective laparoscopic repair had lower overall morbidity and mortality when compared to patients who received an open repair. Notably, several studies reported higher rates of minimally invasive repair in emergent settings than what we saw in the NIS and NEDS.[17,18]

Open approach remained an independent predictor of mortality on multivariable analysis. This could be secondary to surgeon perception of a patient's ability to tolerate a laparoscopic repair in the presence of comorbid conditions, reluctance to offer a minimally invasive repair to patients perceived as frail or tenuous, discomfort with performing a minimally invasive repair in an emergent setting, or perceived need for a major organ resection. Alternatively, it is possible that choice of approach is least partially responsible for the association with increased morbidity and mortality. Visualization with a laparoscopic approach is generally superior which may affect surgical outcomes. Among elective, urgent, and emergent repairs, open approach has been independently associated with morbidity, mortality, longer length of stay, and readmission events when compared to a minimally invasive approach.[2,12–14,16,17,19] Augustin et al.[7] in an analysis utilizing the National Surgical Quality Improvement Program (NSQIP) database found that emergent repair was not an independent predictor of 30-day mortality. They did however find that laparoscopic approach was associated with decreased risk of mortality, lending credence to the theory that laparoscopic repair is safer, even in non-elective cases.[7] A recent large database analysis comparing outcomes for patients who received emergent repairs via open, laparoscopic, or robotic approach came to a similar conclusion, finding lower complication rates and increased survival for patients who received a minimally invasive repair.[2] While a prospective study comparing open and minimally invasive repairs in the emergent setting is not feasible, and choice of approach is contingent on surgeon comfort, a growing body of evidence supports the choice of a minimally invasive approach even in an emergency. As new surgeons enter practice with extensive experience in minimally invasive approach to HH repair, it is likely that we will see increased use of laparoscopy in an emergent setting.

4.1. Limitations

There are several limitations to this study, many of them specific to the source data. The NIS, NRD, and NEDS are all representative samples of hospital discharges, readmissions, and ED admissions, respectively. Though they are designed to be used as a generalizable sample of the population, we are limited by the variables captured: it is possible that additional metrics not reflected in the source data played a role in mortality after emergent HH repair. For example, we are unable to stratify data according to what type of HH subtype was repaired. Additionally, we are unable to determine the complexity of the repair, or if additional interventions (such as placement of a gastrostomy tube or creation of a Collis gastroplasty) were required at the time of the procedure. The NRD is provided annually, and patients who received HH repairs in December are excluded from analysis in order to accurately report 30-day outcomes. Additionally, we are only able to calculate in-hospital mortality for patients first readmission event within 30 days of surgery and are unable to define mortality for patients who were readmitted multiple times within 30 days of surgery, or who died on a subsequent readmission.

The NIS was changed in 2012 to a representative sample of the population. It is unfortunately impossible with this dataset from 2012 onward to consider hospital or surgeon volume, both attributes which could impact outcomes. Though we were able to examine some of the most common postoperative complications, we are unable to apply Clavien-Dindo classifications to the HCUP databases. As our source data is representative, we expect it to be generalizable, however prospective studies are needed to corroborate our findings.

5. Conclusions

This study provides an overview of risk factors for mortality associated with emergent hiatal hernia repair. Overall mortality remains relatively low, though as expected higher than for elective hiatal hernia repairs. Differences between patients who died and patients who survived were seen in age at time of operation, frailty, presence of comorbidities, and surgical approach. Multivariable analysis showed that frailty, male sex, presence of pre-existing heart disease, and open approach were all associated with mortality. Current evidence supports the consideration of a minimally invasive approach even in non-elective settings.

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Declaration of competing interest

There are no conflicts of interest in regards to this manuscript from any of the contributing authors.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2023.01.012.

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