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Elderly Patients Who Develop Pulmonary Insufficiency Following Trauma Admission Have A Mortality Rate Of Almost 20 Percent

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Abstract

Background: Pulmonary insufficiency is common in elderly patients post major trauma and it is associated with major complications including high mortality. The goal of this study was to assess risk factors of in-hospital mortality for patients admitted emergently with trauma and developed pulmonary insufficiency.

Methods: Patients who developed pulmonary insufficiency that were admitted for trauma were analyzed using the National Inpatient Sample (NIS) database, 2005-2014. Data was stratified according to sex and outcomes. The relationship between mortality and different comorbidities, demographics, and possible predictors of pulmonary insufficiency were explored using stratified analysis and multivariable logistic regression analysis.

Results: A total number of 818 elderly patients and 1392 adult patients were included in the study with the diagnosis of PI. 1288 were males and 922 were females.

The mean age for adult males was 43.34 (14.03) years compared to 47.34 (12.93) years in adult females. In the elderly population, the mean age in males was 75.30 (7.18) years compared to 75.61 (7.08) years in females. Mortality rates were similar between males and females in both age groups. In the adult population, the mortality rate was 10.2% and 11.4% for males and females, respectively. In the elderly population, the mortality rate was 19.5% and 18.9% for males and females respectively. In the final regression model, bacterial infections (OR=2.39, p= 0.001), cardiac diseases (OR=3.45, p=0.001), liver diseases (OR=1.93, p=0.002), genitourinary system diseases (OR=1.48, p=0.006), traumas, burns and poisons (OR=1.91, P=0.001), cerebrovascular diseases (OR=1.63, p=0.049), fluid/electrolyte disorders (OR=1.48), neurological disorders (OR=3.16, p=0.001), and surgical operations (OR=1.58, p=0.01) were the main risk factors for mortality whereas hospital length of stay (OR=0.95, p= 0.001) was a protective factor.

Conclusion: Elderly patients admitted for trauma, who developed pulmonary insufficiency are at high risk of mortality. Surgical operations and several comorbidities were the main risk factors, whereas hospital length of stay was a protective factor.

Key Words: Pulmonary Insufficiency, Mortality, Risk factors, comorbidities, admission

Introduction

Pulmonary Insufficiency can be a very life-threatening consequence to trauma or surgery particularly following thoracic injuries.[1-7] Age >65 years, high injury severity score, large volume of transfusion requirement, extra thoracic surgical operations, hypotension on admission, sepsis and late operations as possible risk factors for in-hospital mortality.[1] In moderate or severe pulmonary insufficiency patients, end diastolic volume index was found to strongly correlate with pulmonary insufficiency/regurgitation volume.[6] Cardiac damage is a predictor for poor outcomes after trauma, and has a very poor prognosis and prolonged in person hospitalization.[2] Management of pulmonary insufficiency both in adult an elderly patients following trauma requires multidisciplinary approach, and may require advanced therapeutic intervention from intubation to Venovenous Extracorporeal Membrane Oxygenation (ECMO) in Intractable Pulmonary Insufficiency cases.[8]

The reasons for high mortality after trauma have been addressed by many researchers, however, there is a paucity of data on outcomes on trauma patients who develop pulmonary insufficiency following trauma.[3,4] Variations in patient demographics, clinical presentation and inpatient quality of care can affect patient outcomes and thus requires thorough analysis to increase awareness, adequately stabilize and reduce risk factors for mortality in patients with pulmonary insufficiency. This study aims to investigate the risk factors of in-hospital mortality in patients with pulmonary insufficiency following trauma with a retrospective review using patient information from the National Inpatient sample from 2005-2014 to improve patient outcomes in patients with similar presentations.

Methods

This was a retrospective cohort study using data from the NIS 2005-2014 database to gather information on adult and elderly patients who were admitted emergently with the primary diagnosis of pulmonary insufficiency following trauma or surgery. The ICD-9 code which was used to identify patients with this diagnosis was 518.5. The Healthcare cost and Utilization project was funded by the Agency for Healthcare Research and Quality to form nationwide standardized population-based data leading to the creation of the NIS database. The National (Nationwide) Inpatient Sample (NIS) is the largest publicly available all-payer inpatient care database in the United States, containing data on more than seven million hospital stays. It has been considered ideal for developing national and regional estimates and enables analyses of rare conditions, uncommon treatments, and special populations.[9]

Due to the large sample size of the nationwide data, the information in this database is very generalizable and helps investigators to the associations between demographics, hospital type, treatments, comorbidities, clinical outcomes and mortality. For this study patients were grouped based on race, age, sex, income quartile, insurance type (Private, Medicare, Medicaid, self-pay, no charge and other), hospital location (rural, urban: non-teaching, urban: teaching), and existing comorbidities (immunodeficiencies, alcohol abuse, musculoskeletal disorders, heart diseases, diabetes, fluid/elec-

trolyte disorders, neurological disorders, drug abuse, weight loss and depression). This data was then stratified according to sex and outcome categories.

The NIS database does not specify the duration of the comorbidity before admission and also does not contain all the variables that are needed to calculate the 5-item modified frailty index score.[10] This study used only the variables which were available in the dataset to calculate the facility score. Functional health status as a variable was not included in the dataset so it was estimated based on variables present. For example, if a patient had multiple debilitating comorbidities including renal failure, tumors, paralysis, coagulopathy, weight loss, metastatic cancer, lymphoma, they were assumed to be partially or totally dependent then classified as functionally dependent.[10] If a comorbidity was present then a point was assigned to it and summed up to create the estimated fragility score. The scale ranges from 0-5, 0 being not frail and 5 being the frailest.

Statistical Analysis

The data was described and analyzed using different statistical measures. The mean, standard deviation (SD), confidence interval at 95% (Cl), and p-values were calculated. The p values less than 0.05 were considered significant. Continuous variables were compared using t-test and categorical variables were compared using chi-square tests. The data was initially stratified into adult vs. elderly then male vs. female, deceased vs. survived, and operations vs. no operations. Binary multivariable logistic regression analysis was used to evaluate how the different variables predicted the risks of mortality. This evaluated the most significant factors related to mortality while also controlling for confounding variables such as age, hospital length of stay in days, surgical operation, comorbidities, sex, race, income, health care insurance, hospital location and invasive diagnostic procedure. The analyses were done using SPSS software version 24 (SPSS Inc., Chicago, IL) and R statistical software (Foundation for Statistical Computing, Vienna, Austria).

Results

Sex Differences

The mean age for patients who survived in the adult and elderly populations were 44.62 and 75.00 years, respectively. The mean age for patients who were deceased in the adult and elderly groups were 46.64 and 77.35 years, respectively. In the elderly population, females had the highest percentage of pulmonary insufficiency diagnosis compared to elderly males. Adult and elderly males were more likely to have had a surgical operation. Adult females had a higher mean age and a higher frailty index score. Most of the adult patients were white, funded by private insurance and admitted primarily into urban teaching hospitals. The comorbidities that were found in both male and female in adult and elderly populations are depicted in Table 1.

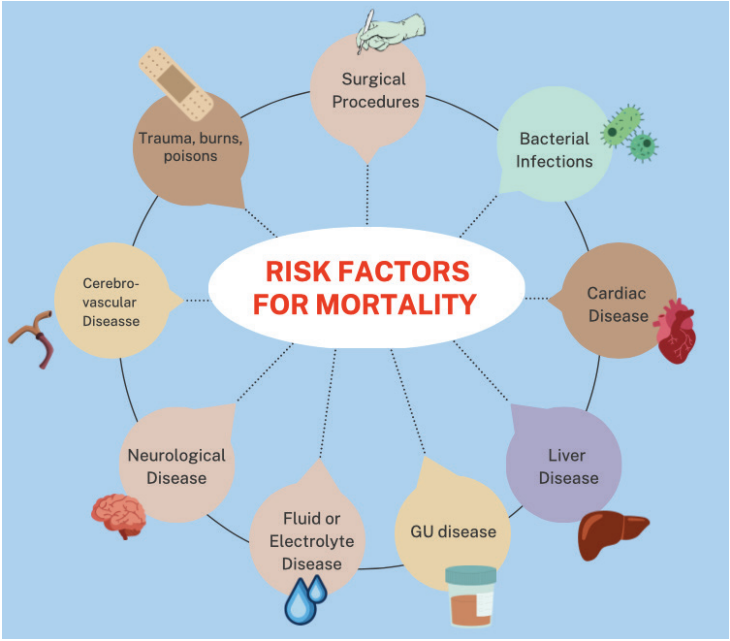
Mortality

In the adult population, the percentage of mortality was 10.6%. On the other hand, the percentage of mortality in the elderly population was 19.3% (Table 2). In all cases of pulmonary insufficiency, the adult population had a higher survival rate than the elderly population. As expected, the mean age of the deceased patients was higher than the mean age of the patients who survived in the elderly population. Income quartile was not found to be a significant predictor of survival. Adult patients with alcohol abuse, chronic pulmonary disease, coagulopathy, hypertension, fluid electrolyte disorders, pulmonary circulatory disorders had a lower survival rate than the total population. Elderly patients with comorbidities such as hypertension, fluid electrolyte disorders, other neurological disorders, obesity, renal failure and unintentional weight loss had a lower survival rate than the total elderly population.

Risk Factors for Mortality

Backwards logistic regression analysis was used to evaluate the associations between mortality and different factors in emergently admitted adult and elderly patients with pulmonary insufficiency (Table 3). When patients received a surgical procedure, it increased the odds of mortality by 58%. An increase in the hospital length of stay by one day decreased the odds of mortality by 5%. A patient contracting bacterial infections other than tuberculosis increased the odds of mortality by a factor of 2.39. Cardiac disease increased the odds of mortality by a factor of 3.45. Liver disease increased the odds of mortality by a factor of 1.93, while the presence of genitourinary infections or fluid and electrolyte disorders both increased the odds of mortality by a factor of 1.48 (Figure 1).

Figure 1. Abstract figure showing the risk factors for mortality in pulmonary insufficiency.



Comorbidities

Table 4 shows a stratified analysis based on comorbidities, lifestyle choices and secondary diagnoses. Some comorbidities such as tuberculosis, hypertension, coagulopathy, cardiac diseases, cerebrovascular diseases, peripheral vascular diseases, liver diseases, diseases of the digestive system other than liver, nutritional/weight disorders, genitourinary system diseases, neurological diseases, bacterial infections other than tuberculosis, fluid and electrolyte disorders, neoplasms, psychiatric diseases, trauma burns and poisoning, alcohol abuse/withdrawal/dependence, tobacco use, long term medications/radiotherapy, sleep disorders were found to be significant. (Table 4, Figure 1). Interestingly, some comorbidities and lifestyle habits appeared in a higher percentage in the population that survived (Table 4). This included patients with hypertension, those who took long term medications or had radiotherapy in both adult and elderly populations.

Table 1. Characteristics of emergency admitted patients with the primary diagnosis of pulmonary insufficiency following trauma and surgery, NIS 2005-2014. Data was stratified according to sex categories.

		Adult, N (%), Total N=1392			Elderly, N (%), Total N=818		
		Male	Female	p	Male	Female	p
All Cases		882 (63.4%)	510 (36.6%)		406 (49.6%)	412 (50.4%)	
Race	White	545 (67.5%)	334 (70.6%)	0.030	310 (83.1%)	314 (82.0%)	0.048
	Black	112 (13.9%)	82 (17.3%)		27 (7.2%)	28 (7.3%)	
	Hispanic	82 (10.1%)	33 (7.0%)		21 (5.6%)	18 (4.7%)	
	Asian/Pacific Islander	17 (2.1%)	8 (1.7%)		1 (0.3%)	13 (3.4%)	
	Native American	20 (2.5%)	4 (0.8%)		1 (0.3%)	1 (0.3%)	
	Other	32 (4.0%)	12 (2.5%)		13 (3.5%)	9 (2.3%)	
Income Quartile	Quartile 1	319 (37.4%)	164 (33.5%)	0.3	116 (29.3%)	111 (27.5%)	0.5
	Quartile 2	239 (28.0%)	133 (27.1%)		117 (29.5%)	107 (26.5%)	
	Quartile 3	182 (21.3%)	125 (25.5%)		88 (22.2%)	102 (25.2%)	
	Quartile 4	113 (13.2%)	68 (13.9%)		75 (18.9%)	84 (20.8%)	
Insurance	Private Insurance	370 (42.1%)	205 (40.3%)	<0.001	50 (12.3%)	39 (9.5%)	0.1
	Medicare	115 (13.1%)	111 (21.8%)		337 (83.0%)	359 (87.6%)	
	Medicaid	160 (18.2%)	108 (21.2%)		1 (0.2%)	4 (1.0%)	
	Self-Pay	148 (16.9%)	45 (8.8%)		3 (0.7%)	1 (0.2%)	
	No Charge	10 (1.1%)	5 (1.0%)		0 (0%)	0 (0%)	
	Other	75 (8.5%)	35 (6.9%)		15 (3.7%)	7 (1.7%)	
Hospital Location	Rural	33 (3.7%)	32 (6.3%)	0.016	39 (9.6%)	30 (7.3%)	0.4
	Urban: Non-Teaching	203 (23.0%)	137 (26.9%)		134 (33.0%)	147 (35.7%)	
	Urban: Teaching	646 (73.2%)	341 (66.9%)		233 (57.4%)	235 (57.0%)	

	AIDS	3 (0.3%)	3 (0.6%)	0.7	1 (0.2%)	0 (0%)	0.5
	Alcohol Abuse	234 (26.5%)	55 (10.8%)	**<0.001**	15 (3.7%)	5 (1.2%)	**0.022**
	Deficiency Anemias	108 (12.2%)	94 (18.4%)	**0.002**	96 (23.6%)	116 (28.2%)	0.1
	Rheumatoid Arthritis	9 (1.0%)	24 (4.7%)	**<0.001**	9 (2.2%)	25 (6.1%)	**0.006**
	Chronic Blood Loss	6 (0.7%)	6 (1.2%)	0.3	7 (1.7%)	6 (1.5%)	0.8
	Congestive Heart Failure	73 (8.3%)	60 (11.8%)	**0.033**	116 (28.6%)	119 (28.9%)	0.9
	Chronic Pulmonary Disease	160 (18.1%)	181 (35.5%)	**<0.001**	141 (34.7%)	176 (42.7%)	**0.019**
	Coagulopathy	88 (10.0%)	41 (8.0%)	0.2	51 (12.6%)	26 (6.3%)	**0.002**
	Depression	77 (8.7%)	95 (18.6%)	**<0.001**	28 (6.9%)	66 (16.0%)	**<0.001**
	Diabetes, Uncomplicated	102 (11.6%)	97 (19.0%)	**<0.001**	130 (32.0%)	111 (26.9%)	0.1
	Diabetes, Chronic Complications	27 (3.1%)	21 (4.1%)	0.3	21 (5.2%)	15 (3.6%)	0.3
	Drug Abuse	111 (12.6%)	40 (7.8%)	**0.006**	1 (0.2%)	4 (1.0%)	0.4
	Hypertension	281 (31.9%)	229 (44.9%)	**<0.001**	261 (64.3%)	280 (68.0%)	0.3
	Hypothyroidism	31 (3.5%)	70 (13.7%)	**<0.001**	29 (7.1%)	100 (24.3%)	**<0.001**
Comorbidities	**Liver Disease**	41 (4.6%)	15 (2.9%)	0.1	13 (3.2%)	9 (2.2%)	0.4
	Lymphoma	9 (1.0%)	2 (0.4%)	0.4	6 (1.5%)	4 (1.0%)	0.5
	Fluid/Electrolyte Disorders	368 (41.7%)	229 (44.9%)	0.3	173 (42.6%)	186 (45.1%)	0.5
	Metastatic Cancer	14 (1.6%)	14 (2.7%)	0.1	14 (3.4%)	15 (3.6%)	0.9
	Other Neurological Disorders	126 (14.3%)	66 (12.9%)	0.5	47 (11.6%)	45 (10.9%)	0.8
	Obesity	143 (16.2%)	164 (32.2%)	**<0.001**	62 (15.3%)	92 (22.3%)	**0.010**
	Paralysis	32 (3.6%)	16 (3.1%)	0.6	9 (2.2%)	12 (2.9%)	0.5
	Peripheral Vascular Disorders	34 (3.9%)	21 (4.1%)	0.8	49 (12.1%)	45 (10.9%)	0.6
	Psychoses	74 (8.4%)	40 (7.8%)	0.7	14 (3.4%)	11 (2.7%)	0.5
	Pulmonary Circulation Disorders	37 (4.2%)	29 (5.7%)	0.2	35 (8.6%)	41 (10.0%)	0.5
	Renal Failure	57 (6.5%)	45 (8.8%)	0.1	95 (23.4%)	64 (15.5%)	**0.004**
	Solid Tumor	17 (1.9%)	21 (4.1%)	**0.016**	30 (7.4%)	27 (6.6%)	0.6
	Peptic Ulcer	0 (0%)	1 (0.2%)	0.4	0 (0%)	0 (0%)	
	Valvular Disease	26 (2.9%)	26 (5.1%)	**0.042**	41 (10.1%)	45 (10.9%)	0.7
	Weight Loss	92 (10.4%)	47 (9.2%)	0.5	55 (13.5%)	57 (13.8%)	0.9
Primary Diagnosis	**Pulmonary Insufficiency**	173 (19.6%)	140 (27.5%)	**0.001**	98 (24.1%)	111 (26.9%)	0.4
	Acute Respiratory Failure	709 (80.4%)	370 (72.5%)		308 (75.9%)	301 (73.1%)	
Invasive Diagnostic Procedure		180 (20.4%)	85 (16.7%)	0.1	70 (17.2%)	69 (16.7%)	0.9
Surgical Operation		182 (20.6%)	82 (16.1%)	**0.037**	71 (17.5%)	57 (13.8%)	0.1
Deceased		90 (10.2%)	58 (11.4%)	0.5	79 (19.5%)	78 (18.9%)	0.8
		Mean (SD)	**Mean (SD)**	**p**	**Mean (SD)**	**Mean (SD)**	**p**
Age, Years		43.34 (14.03)	47.34 (12.93)	**<0.001**	75.30 (7.18)	75.61 (7.08)	0.5
Modified Frailty Index Score		1.00 (1.14)	1.46 (1.24)	**<0.001**	2.15 (1.21)	2.11 (1.18)	0.6
Time to Invasive Diagnostic Procedure, Days		2.85 (4.58)	4.01 (6.60)	0.2	3.11 (5.59)	4.89 (11.01)	0.2
Time to Surgical Operation, Days		5.06 (7.15)	7.09 (8.57)	0.1	3.57 (5.13)	4.98 (6.18)	0.1
Hospital Length of Stay, Days		9.07 (12.42)	8.55 (13.46)	0.3	7.81 (9.35)	8.68 (11.59)	0.2
Total Charges, Dollars		119,608	113,464	0.6	93,632	89,098	0.6

Table 2. Characteristics of emergency admitted patients with the primary diagnosis of pulmonary insufficiency following trauma and surgery, NIS 2005-2014. Data was classified according to outcome categories.

		Adult, N (%), Total N=1390			Elderly, N (%), Total N=818		
		Survived	Deceased	p	Survived	Deceased	p
All Cases		1,242 (89.4%)	148 (10.6%)		660 (80.7%)	158 (19.3%)	
Sex, Female		452 (36.4%)	58 (39.2%)	0.5	334 (50.6%)	78 (49.7%)	0.8
Race	White	791 (69.0%)	87 (64.9%)	0.8	493 (81.4%)	132 (88.0%)	**0.024**
	Black	170 (14.8%)	24 (17.9%)		52 (8.6%)	3 (2.0%)	
	Hispanic	105 (9.2%)	10 (7.5%)		29 (4.8%)	9 (6.0%)	
	Asian/Pacific Islander	21 (1.8%)	4 (3.0%)		13 (2.1%)	1 (0.7%)	
	Native American	21 (1.8%)	3 (2.2%)		1 (0.2%)	1 (0.7%)	
	Other	38 (3.3%)	6 (4.5%)		18 (3.0%)	4 (2.7%)	
Income Quartile	Quartile 1	431 (36.0%)	52 (36.1%)	0.4	189 (29.3%)	38 (24.7%)	0.3
	Quartile 2	328 (27.4%)	44 (30.6%)		182 (28.2%)	43 (27.9%)	
	Quartile 3	271 (22.6%)	35 (24.3%)		156 (24.1%)	34 (22.1%)	
	Quartile 4	167 (14.0%)	13 (9.0%)		119 (18.4%)	39 (25.3%)	
Health Care Insurance	Private Insurance	514 (41.6%)	59 (39.9%)	0.8	66 (10.0%)	23 (14.6%)	0.3
	Medicare	204 (16.5%)	22 (14.9%)		569 (86.5%)	127 (80.4%)	
	Medicaid	239 (19.3%)	29 (19.6%)		4 (0.6%)	1 (0.6%)	
	Self-Pay	169 (13.7%)	24 (16.2%)		3 (0.5%)	1 (0.6%)	
	No Charge	12 (1.0%)	3 (2.0%)		0 (0%)	0 (0%)	
	Other	99 (8.0%)	11 (7.4%)		16 (2.4%)	6 (3.8%)	
Hospital Location	Rural	56 (4.5%)	9 (6.1%)	0.5	56 (8.5%)	13 (8.2%)	0.3
	Urban: Non-Teaching	308 (24.8%)	32 (21.6%)		218 (33.0%)	62 (39.2%)	
	Urban: Teaching	878 (70.7%)	107 (72.3%)		386 (58.5%)	83 (52.5%)	
Comorbidities	AIDS	6 (0.5%)	0 (0%)	1.0	0 (0%)	1 (0.6%)	0.2
	Alcohol Abuse	271 (21.8%)	17 (11.5%)	**0.003**	15 (2.3%)	5 (3.2%)	0.6
	Deficiency Anemias	187 (15.1%)	15 (10.1%)	0.1	170 (25.8%)	42 (26.6%)	0.8
	Rheumatoid Arthritis	30 (2.4%)	3 (2.0%)	1.0	26 (3.9%)	8 (5.1%)	0.5
	Chronic Blood Loss	9 (0.7%)	3 (2.0%)	0.1	12 (1.8%)	1 (0.6%)	0.5
	Congestive Heart Failure	114 (9.2%)	19 (12.8%)	0.2	190 (28.8%)	45 (28.5%)	0.9
	Chronic Pulmonary Disease	316 (25.4%)	24 (16.2%)	**0.014**	265 (40.2%)	52 (32.9%)	0.1
	Coagulopathy	94 (7.6%)	35 (23.6%)	**<0.001**	57 (8.6%)	20 (12.7%)	0.1
	Depression	159 (12.8%)	12 (8.1%)	0.1	82 (12.4%)	12 (7.6%)	0.1
	Diabetes, Uncomplicated	181 (14.6%)	18 (12.2%)	0.4	194 (29.4%)	46 (29.1%)	1.0
	Diabetes, Chronic Complications	45 (3.6%)	3 (2.0%)	0.5	32 (4.8%)	4 (2.5%)	0.3
	Drug Abuse	140 (11.3%)	10 (6.8%)	0.1	4 (0.6%)	1 (0.6%)	1.0
	Hypertension	469 (37.8%)	41 (27.7%)	**0.016**	457 (69.2%)	85 (53.8%)	**<0.001**
	Hypothyroidism	95 (7.6%)	6 (4.1%)	0.1	109 (16.5%)	20 (12.7%)	0.2
	Liver Disease	49 (3.9%)	7 (4.7%)	0.7	18 (2.7%)	4 (2.5%)	1.0
	Lymphoma	8 (0.6%)	3 (2.0%)	0.1	8 (1.2%)	2 (1.3%)	1.0
	Fluid/Electrolyte Disorders	501 (40.3%)	95 (64.2%)	**<0.001**	279 (42.3%)	81 (51.3%)	**0.041**
	Metastatic Cancer	22 (1.8%)	6 (4.1%)	0.1	21 (3.2%)	8 (5.1%)	0.3
	Other Neurological Disorders	166 (13.4%)	26 (17.6%)	0.2	65 (9.8%)	27 (17.1%)	**0.010**

Comorbidities	Obesity	281 (22.6%)	26 (17.6%)	0.2	134 (20.3%)	20 (12.7%)	**0.027**
	Paralysis	40 (3.2%)	8 (5.4%)	0.2	18 (2.7%)	3 (1.9%)	0.8
	Peripheral Vascular Disorders	46 (3.7%)	9 (6.1%)	0.2	69 (10.5%)	25 (15.8%)	0.1
	Psychoses	106 (8.5%)	7 (4.7%)	0.1	18 (2.7%)	7 (4.4%)	0.3
	Pulmonary Circulation Disorders	50 (4.0%)	16 (10.8%)	**<0.001**	64 (9.7%)	12 (7.6%)	0.4
	Renal Failure	97 (7.8%)	5 (3.4%)	0.1	119 (18.0%)	41 (25.9%)	**0.024**
	Solid Tumor	30 (2.4%)	8 (5.4%)	**0.035**	50 (7.6%)	7 (4.4%)	0.2
	Peptic Ulcer	0 (0%)	1 (0.7%)	0.1	0 (0%)	0 (0%)	
	Valvular Disease	45 (3.6%)	7 (4.7%)	0.5	63 (9.5%)	23 (14.6%)	0.1
	Weight Loss	118 (9.5%)	20 (13.5%)	0.1	82 (12.4%)	30 (19.0%)	**0.031**
Primary Diagnosis	Pulmonary Insufficiency	266 (21.4%)	47 (31.8%)	**0.004**	174 (26.4%)	34 (21.5%)	0.2
	Acute Respiratory Failure	976 (78.6%)	101 (68.2%)		486 (73.6%)	124 (78.5%)	
Invasive Diagnostic Procedure		227 (18.3%)	37 (25.0%)	**0.049**	108 (16.4%)	30 (19.0%)	0.4
Surgical Operation		227 (18.3%)	36 (24.3%)	0.1	98 (14.8%)	30 (19.0%)	0.2
		Mean (SD)	Mean (SD)	p	Mean (SD)	Mean (SD)	p
Age, Years		44.62 (13.74)	46.64 (13.79)	0.1	75.00 (7.03)	77.35 (7.28)	**<0.001**
Modified Frailty Index Score		1.17 (1.21)	1.18 (1.17)	1.0	2.15 (1.15)	2.03 (1.35)	0.3
Time to Invasive Diagnostic Procedure, Days		3.05 (5.01)	4.26 (6.92)	0.2	3.26 (5.44)	6.37 (15.00)	0.3
Time to Surgical Operation, Days		5.83 (7.93)	5.06 (6.06)	0.6	4.62 (5.96)	2.68 (4.03)	0.1
Hospital Length of Stay, Days		8.97 (13.13)	8.10 (9.75)	0.4	8.11 (9.18)	8.77 (14.97)	0.5
Total Charges, Dollars		114,311	143,283	0.1	85,844	113,324	**0.044**

Table 3. Backward logistic regression analysis to evaluate the associations between mortality and different factors in emergency admitted patients with the primary diagnosis of pulmonary insufficiency following trauma and surgery (NIS 2005-2014). Mortality was the dependent variable.

Patients' Characteristics	Mortality	
	Total N=2,449	R^2=0.256
	OR (95% CI)	P value
Number of Events	N = 325	
Surgical Procedure	1.58 (1.10, 2.26)	**0.01**
Hospital Length of Stay, Days	0.95 (0.94, 0.96)	**<0.001**
Age, Years	1.00 (0.99, 1.01)	0.1
Sex, Female	1.29 (0.99, 1.69)	0.1
Invasive Procedure	Removed	
Bacterial Infections (Other than Tuberculosis)	2.39 (1.69, 3.38)	**<0.001**
Cardiac Diseases	3.45 (2.52, 4.71)	**<0.001**
Liver Diseases	1.93 (1.26, 2.94)	**0.002**
Genitourinary System Diseases	1.48 (1.12, 1.96)	**0.006**
Fluid and Electrolyte Disorders	1.48 (1.12, 1.95)	**0.006**
Neurological Diseases	3.16 (2.42, 4.14)	**<0.001**
Trauma, Burns, and Poisons	1.91 (1.42, 2.57)	**<0.001**
Cerebrovascular Diseases	1.63 (1.00, 2.63)	**0.049**

Respiratory Diseases	
Coagulopathy	
Peripheral Vascular Diseases	
Neoplasms	
Platelet and White Blood Cell Diseases	Removed
Tuberculosis	
Nonbacterial Infections	
Anemia and/or Hemorrhage	
Digestive Diseases other than Liver	Via
Diabetes	
Drug Abuse/Withdrawal/Dependence	
Alcohol Abuse/Withdrawal/Dependence	
Tobacco Use	Stepwise
Hypertension	
Endocrine Diseases	
Nutritional/Weight Disorders	
Musculoskeletal System and Connective Tissue Diseases	Backward
Psychiatric Diseases	
Skin Diseases	
Long Term Medication Usage	
Diseases of Oral Cavity, Salivary Glands, and Jaw	Elimination
Sleep Disorders	
Lack of Physical Evidence	
Inappropriate Diet and Eating Habits	
High Risk Lifestyle Behaviors	
Social Factors	

Table 4. Comorbidities and secondary diagnoses of patients emergently admitted with a primary diagnosis of pulmonary insufficiency following trauma and surgery (NIS 2011-2014). Data was stratified according to survival status.

	Adult, N (%), Total N=1390			Elderly, N (%), Total N=818		
Comorbidities and Secondary Diagnoses (ICD-9 Codes)	Survived	Deceased	p	Survived	Deceased	p
Observations	1,242 (89)	148 (11)		660 (81)	158 (19)	
Tuberculosis (010.0-018.96)	0 (0)	0 (0)		0 (0)	0 (0)	
Bacterial Infections Other than Tuberculosis (020.0-041.9, 790.7)	123 (10)	41 (28)	**<0.001**	85 (13)	46 (29)	**<0.001**
Nonbacterial Infections (042, 795.71, V08, 045.0-139.8, 790.8, and/or presence of Comorbidity of AIDS)	108 (9)	17 (12)	0.3	43 (7)	13 (8)	0.4
Diabetes (250.0-250.93, V58.67, and/or presence of Comorbidity of Diabetes Uncomplicated or Diabetes Chronic Complications)	228 (18)	21 (14)	0.2	230 (35)	50 (32)	0.5
Hypertension (401.0-405.99, 796.2, and/or presence of Comorbidity of Hypertension)	473 (38)	41 (28)	**0.013**	457 (69)	85 (54)	**<0.001**
Anemia and/or Hemorrhage (280.0-285.9, 784.7, 784.8, and/or presence of Comorbidity of Anemia)	361 (29)	46 (31)	0.6	256 (39)	69 (44)	0.3
Respiratory Diseases (415.0-417.9, 460-519.9, 784.91, 786, and/or presence of Comorbidity of COPD, ILD or Pulmonary Circulation Disease)	807 (65)	97 (66)	0.9	483 (73)	108 (68)	0.2
Coagulopathy (286.0-286.9, 790.92, V58.61, V58.63, and/or presence of Comorbidity of Coagulopathy)	139 (11)	38 (26)	**<0.001**	117 (18)	29 (18)	0.9

	Adult, N (%), Total N=1390			Elderly, N (%), Total N=818		
Comorbidities and Secondary Diagnoses (ICD-9 Codes)	**Survived**	**Deceased**	**p**	**Survived**	**Deceased**	**p**
Observations	1,242 (89)	148 (11)		660 (81)	158 (19)	
Tuberculosis (010.0-018.96)	0 (0)	0 (0)		0 (0)	0 (0)	
Bacterial Infections Other than Tuberculosis (020.0-041.9, 790.7)	123 (10)	41 (28)	**<0.001**	85 (13)	46 (29)	**<0.001**
Nonbacterial Infections (042, 795.71, V08, 045.0-139.8, 790.8, and/or presence of Comorbidity of AIDS)	108 (9)	17 (12)	0.3	43 (7)	13 (8)	0.4
Diabetes (250.0-250.93, V58.67, and/or presence of Comorbidity of Diabetes Uncomplicated or Diabetes Chronic Complications)	228 (18)	21 (14)	0.2	230 (35)	50 (32)	0.5
Cardiac Diseases (391.X, 392.0, 393.398.99, 410.0-414.9, 420.0-429.9, 794.3X, 785.XX, and/or presence of Comorbidity of CHF or Valvular Diseases)	426 (34)	100 (68)	**<0.001**	452 (69)	139 (88)	**<0.001**
Cerebrovascular Diseases (325, 430-438)	32 (3)	15 (10)	**<0.001**	39 (6)	18 (11)	**0.015**
Peripheral Vascular Diseases (440-457.9, and/or presence of Comorbidity of Peripheral Vascular Disorders)	120 (10)	23 (16)	**0.026**	101 (15)	33 (21)	0.1
Liver Diseases (570-573.9, 790.4, 794.8, and/or presence of Comorbidity of Liver Diseases)	77 (6)	28 (19)	**<0.001**	35 (5)	13 (8)	0.2
Diseases of Digestive System other than Liver (530.00-569.9, 574.0-579.9, 787, 001.0-009.3, and/or presence of Comorbidity of Peptic Ulcer)	421 (34)	44 (30)	0.3	321 (49)	62 (39)	**0.034**
Diseases of Oral Cavity, Salivary Glands, and Jaws (520-529)	28 (2)	1 (1)	0.2	6 (1)	1 (1)	0.7
Nutritional/Weight Disorders (260-273.9, 275.XX,277.0-278.8, 783.XX, 799.3-799.4, and/or presence of Comorbidity of Weight Loss)	579 (47)	57 (39)	0.1	416 (63)	85 (54)	**0.032**
Endocrine Diseases (240.0-259.9, 991.0-992.9, and/or presence of Comorbidity of Endocrine Diseases)	323 (26)	33 (22)	0.3	305 (46)	66 (42)	0.3
Genitourinary System Diseases (580.0-629.9, 403.XX, 791.XX, 788.XX, and/or presence of Comorbidity of Renal Diseases)	341 (28)	74 (50)	**<0.001**	316 (48)	107 (68)	**<0.001**
Neurological Diseases (317.0-326, 330.0-337.9, 340-359.9, 392, 780.0-780.09, 780.2-780.4, 317-319, 290.XX, 294.XX, 781.0-782.0, and/or presence of Comorbidity of Paralysis or Other Neurological Disorders or Paralysis)	417 (34)	102 (69)	**<0.001**	207 (31)	92 (58)	**<0.001**
Diseases of the Musculoskeletal System and Connective Tissue (274.XX, 710.0-739, and/or presence of Comorbidity of Rheumatoid Arthritis or Lupus)	299 (24)	26 (18)	0.1	206 (31)	44 (28)	0.4
Fluid and Electrolyte Disorders (275.0-276.9, 458.0-459.9, and/or presence of Comorbidity of Fluid and Electrolyte Disorders)	584 (47)	104 (70)	**<0.001**	313 (47)	92 (58)	**0.015**
Neoplasms (140.0-239.9, V10.XX, and/or presence of Comorbidity of Lymphoma, Metastatic Diseases, or Tumor)	123 (10)	18 (12)	0.4	177 (27)	27 (17)	**0.011**
Platelet and White Blood Cell Diseases (204.0-208.92, 287.0-288.9, 238.71)	165 (13)	24 (16)	0.3	96 (15)	32 (20)	0.1
Psychiatric Diseases (293.XX, 295.0-302.9, 306.0-316, 780.1, V62.8, V15.4, and/or presence of Comorbidity of Psychoses)	385 (31)	30 (20)	**0.007**	147 (22)	25 (16)	0.1
Skin Diseases (680.0-709.9, 782.1-782.9)	92 (7)	6 (4)	0.1	66 (10)	18 (11)	0.6
Trauma, Burns and Poisoning (800-999)	785 (63)	108 (73)	**0.019**	305 (46)	115 (73)	**<0.001**
Drug Abuse/Withdrawal/Dependence (292.0-292.9, 304.0-304.93, 305.2-305.93, and/or presence of Comorbidity of Drug Abuse)	147 (12)	10 (7)	0.1	5 (1)	1 (1)	0.9
Alcohol Abuse/Withdrawal/Dependence (291.0-291.9, 303.0-303.93, 305.0-305.03, and/or presence of Comorbidity of Alcohol Abuse)	271 (22)	17 (12)	**0.003**	15 (2)	5 (3)	0.5
Tobacco Use (305.1)	377 (30)	20 (14)	**<0.001**	201 (31)	34 (22)	**0.026**
Long-Term Medications/Radiotherapy (V58.0-V58-2, V58.62, V58.64-V58.66, V58.68-V58.69)	92 (7)	3 (2)	**0.014**	114 (17)	10 (6)	**<0.001**
Social Factors (V60.0-V62.6, V63.0-V64.3, V15.81)	69 (6)	3 (2)	0.1	19 (3)	2 (1)	0.3
Sleep Disorders (327, 780.5, V69.4, V69.5)	201 (16)	10 (7)	**0.003**	101 (15)	5 (3)	**<0.001**
Lack of Physical Exercise (V69.0)	0 (0)	0 (0)		0 (0)	0 (0)	
Inappropriate Diet and Eating Habits (V69.1)	0 (0)	0 (0)		0 (0)	0 (0)	
High Risk Lifestyle Behaviors (V69.2, V69.3)	0 (0)	0 (0)		0 (0)	0 (0)	

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Diabetes (250.0-250.93, V58.67, and/or presence of Comorbidity of Diabetes Uncomplicated or Diabetes Chronic Complications)	228 (18)	21 (14)	0.2	230 (35)	50 (32)	0.5
Body Mass Index of Less than 18.9 (V85.0)	7 (3)	0 (0)	0.6	8 (8)	3 (20)	0.006
Body Mass Index of 19-24.9 (V85.1)	9 (4)	2 (10)		5 (5)	4 (27)	
Body Mass Index of 25.0-29.9 (V85.21-V85.25)	14 (7)	1 (5)		17 (16)	1 (7)	
Body Mass Index of 30.0 and over (V85.30-V85.45)	179 (86)	17 (85)		75 (71)	7 (47)	

Discussion

The aim of this study was to evaluate the outcomes of patients who developed pulmonary insufficiency post trauma associations between comorbidities, demographics, socioeconomic status, HLOS, surgical operations and mortality in patients admitted emergently after trauma or surgery who developed pulmonary insufficiency. The findings in this study show that in patients with Pulmonary Insufficiency, post trauma or surgery, fluid/electrolyte disorders, neurological disorders, surgical operations and age were risk factors for mortality. Contrary to our multiple findings studying this database,[11-13] where HLOS increased mortality, in this study HLOS was found to decrease the risk of mortality. Our study also found that for every additional day in the hospital the odds of mortality decreased by 5%. Although this study showed decreased risks for mortality with increased HLOS, multiple other studies showed that elongated hospital length of stay could negatively impact the prognosis in patients admitted with pulmonary insufficiency and should be taken into consideration when determining when to discharge a patient. Factors like nosocomial infections, secondary cardiac pathology and higher acuity patients that contribute to this increase in mortality should be addressed through regular quality improvement efforts and further investigations. This is in contrast to results of the above studies, as well as results by Van Vliet et al., who showed a positive correlation between HLOS and elderly hospital hazards like decline in mobility, activities of daily living and mortality. Prolonged HLOS was found to be associated with increased adverse outcomes and hospitalization.[14] Specifically, it was found that a HLOS greater than 7 days increased the risk for mortality due to healthcare associated infections.[15-17] A study by Levy et al. showed that white male patients, non-elderly as well as elderly, who had invasive diagnostic procedures had a high correlation with medical complications not limited to mechanical complications, infections and a higher chance of respiratory or digestive complications leading to surgery and thus a prolonged HLOS.[16]

It is apparent that some hospital systems may manage and prevent postoperative complications more efficiently than others. A study done in England by Almoudaris et al. evaluated differences based on mortality between a high mortality hospital and a low mortality hospital.[17] Both hospitals were similar in terms of units, hospital beds, imaging and number of operating rooms. The patients at the low mortality hospitals were found to have fewer preoperative medical conditions.[18] Another study showed hospitals with lower mortality following complications were found to have higher nurse to patient ratios, better technology, hospital size >200 beds, and teaching hospitals were also associated with lower mortality.[19] Factors like delayed operating room access for emergent surgery have been found to be associated with increased risk of mortality and a longer hospital stay.[20,21] Studies by Guntaka and Latifi et al. showed that patients with comorbidities had an increased HLOS after surgery. [22,23]

A study by Marfil-Garza found that weekend admissions have been associated with an increased risk of prolonged hospital stays and mortality. [24] The cause of the weekend effect is unknown but it is hypothesized to be caused by lower number of staffing and increased transfers from other hospitals. Patients who received surgery

had prolonged hospital stays which are both things that were found to increase mortality risk in PI. The study also showed that factors like gender, hospitalization in shared rooms, admissions through the emergency department, comorbidities and socioeconomic status contributed to prolonged hospital length of stay. Patients with a HLOS of >21 days have increased mortality (OR of 2.41 [CI 95% 2.30–2.51]).[24]

Our study found that having neurological disorders as a comorbidity increased the risks for mortality. In aging populations, neurological disorders like Parkinson are on the rise. Parkinson, stroke and restless leg syndrome are a considerable challenge to the healthcare system and the mortality burden has increased in the past years with cerebrovascular disease having the highest mortality rate.[25] The fastest growing neurological disease in the world is Parkinsons.[26] From 1990 to 2015, the number of people with Parkinson disease doubled to over 6 million and is projected to double again to over 12 million by 2040.[26] Other factors have been identified to increase mortality. The findings of this study showed that the mean age of the deceased patients with pulmonary insufficiency were higher, although age itself was not found to be a risk factor for mortality. Increased mortality with age can be attributed to a higher incidence of cardiovascular and pulmonary complications,[27] timing of the admission (weekend emergency admissions compared to weekday admissions)[28] and many others.

A study by Shah showed that mortality rates for heart diseases was lowest for patients under 45 years of age. Patients 65 and older had the highest mortality for all types of heart disease compared with younger patients.[29] This was also confirmed by another study in patients admitted emergently with gastroparesis where the odds of mortality was found to be 8% in elderly and 4% in adults.[30]

A study by Singh et al. found that age has been shown to significantly influence the prevalence of pulmonary insufficiency.[17] This was confirmed after evaluation of 3589 patients with color doppler echocardiography. Pulmonary regurgitation is usually better tolerated in young individuals but eventually leads to symptoms. A long asymptomatic period can be seen after trauma and it is attributed to chronic right ventricular adaptation facilitated by forward pulmonary flow by the left heart and low resistance pulmonary microcirculation.[20] The progressive regurgitation over the years eventually leads to increase in end diastolic volume dilatation of the RV and RV dysfunction.[20] This finding emphasizes the importance of optimization of care in this patient population.

Strengths and imitations of the study

While the data used in the study was obtained from the National Inpatient Sample and was analyzed using binary multivariable logistic regression analysis, the retrospective nature of the data could be affected by significant biases. There was no access to specific details of the patients' charts and any other comorbidities that may have been overlooked. We have no data on the severity of injuries, associated injuries or primary injuries such as chest, head injuries or soft tissues, and what kind of surgeries they have had. Moreover, we have no data on what kind of treatment was rendered for, such as intubation, or any other forms of ventilatory support that may have been applied.

Conclusion

Patients with pulmonary insufficiency following trauma with bacterial infections, cardiac diseases, liver diseases, genitourinary system diseases, traumas, burns and poisons, cerebrovascular diseases, fluid electrolyte disorders, and neurological disorders had a higher risk for mortality. Hospital length of stay was found to decrease the risk for mortality. Future efforts should be directed at investigating the relationships between the risk factors for mortality and how to attenuate these risk factors.

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