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Understanding Health Care Utilization and Mortality After Emergency General Surgery in Patients With Underlying Liver Disease

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Abstract

Background: Mortality and complications are not well defined nationally for emergency general surgery (EGS) patients presenting with underlying all-cause liver disease (LD).

Study design: We analyzed the 2012-2014 National Inpatient Sample for adults (aged ≥ 18 years) with a primary EGS diagnosis. Underlying LD included International Classification of Diseases, Ninth Revision, Clinical Modification codes for alcoholic and viral hepatitis, malignancy, congenital etiologies, and cirrhosis. The primary outcome was mortality; secondary outcomes included complications, operative intervention, and costs.

Results: Of the 6.8 million EGS patients, 358 766 (5.3%) had underlying LD. 59.1% had cirrhosis, 6.7% had portal hypertension, and 13.7% had ascites. Compared with other EGS patients, EGS-LD patients had higher mean costs ($12 847 vs $10 234, $P < .001$). EGS-LD patients were less likely to have surgery (26.1% vs 37.0%, $P < .001$) but for those who did, mortality was higher (4.8% vs 1.8%, $P < .001$). Risk factors for mortality included ascites (adjusted odds ratio [aOR] = 2.68, $P < .001$), dialysis (aOR = 3.44, $P < .001$), sepsis (aOR = 8.97, $P < .001$), and respiratory failure requiring intubation (aOR = 10.40, $P < .001$). Odds of death increased in both surgical (aOR = 4.93, $P < .001$) and non-surgical EGS-LD patients (aOR = 2.56, $P < .001$).

Conclusions: Underlying all-cause LD among EGS patients is associated with increased in-hospital mortality, even in the absence of surgical intervention.

Keywords

emergency general surgery, liver disease, cirrhosis, healthcare utilization, surgical outcomes, liver failure, liver transplantation

Introduction

The burden of all-cause liver disease (LD) is steadily rising worldwide.[1,2] LD is associated with significantly higher surgical morbidity and mortality in both hepatic and nonhepatic operations.[3] The risks have been well defined in elective operations such as hernia repair and cholecystectomy.[4,5] Multiple recommendations exist for optimization and perioperative care of patients with LD with elective surgical problems.[6-9] Nevertheless, there is a generalized reluctance to operate on this patient population, which, in turn, likely increases the chances of requiring emergency surgery.

Twenty percent of all patients admitted to US hospitals carry a diagnosis that requires an emergency operation.[10] Emergency general surgery (EGS) accounts for 50% of all surgical mortality and is associated with a

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disproportionally higher cost compared with elective operations.[10,11] LD has been associated with a high economic burden ($2.5 and 10.6 billion dollars for direct and indirect costs, respectively) and is expected to increase over the next decade as the proportion of patients with hepatitis C cirrhosis will rise.[12] In patients with LD, an EGS diagnosis is associated with increased mortality and is the only independent predictor of length of hospital stay.[10,13-15] Although the Model for End-stage Liver Disease (MELD) and Child-Turcotte-Pugh scores have been used in small cohorts to predict postoperative mortality in patients who undergo elective or emergency surgery, there is little known about mortality and complications in these patients at a national level.[16-19] Similarly, there is no data on the costs-of-care for patients with underlying LD who require emergency surgery (EGS-LD).

In this study, we hypothesized that emergency surgery in all-cause LD is associated with increased morbidity and mortality. We sought to characterize the impact of LD on length of stay (LOS), cost of care, likelihood to pursue operative intervention, and in-hospital mortality for patients who present with acute general surgery problems. Furthermore, we aimed to better define the risk factors associated with mortality in this emergency surgery cohort. Lastly, we hypothesized that even in the absence of surgical intervention patients with LD will have higher mortality compared with the general population.

Methods

We queried the 2012-2014 National Inpatient Sample (NIS) from the Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality (AHRQ). In 2015, the methodology for reporting diagnosis codes changed midyear from International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) to ICD-10-CM codes, which limited the ability to calculate annual total costing as well as maintain consistency with EGS and LD diagnostic coding. The NIS is a nationally representative, all-payer, all-hospital database capturing inpatient hospitalizations and contains data for approximately 35 million weighted discharges from US hospitals annually. Throughout this article, weighted data are presented to provide nationally representative estimates. The database contains demographic and socioeconomic characteristics (eg, age, sex, race, and household income), encounter data (ie, inpatient LOS and discharge destination), hospital characteristics (ie, geographical region, urban vs. rural designation, and hospital bed size) and financial data (ie, inpatient charges).

We captured all adult patients with a primary EGS diagnosis, where ICD-9CM coding was based upon 1 of the 16 American Association for the Surgery of Trauma-defined and graded EGS conditions.[20] We excluded patients under the age of 18 and those with missing cost data. EGS patients with underlying LD were defined as those with all-cause cirrhosis, acute forms of liver failure including hepatitis, congenital LD, malignancy, or alcoholic LD. Non-LD patients were defined as all other adults with a primary diagnosis of EGS.

Our primary outcome of interest was inpatient mortality. Secondary outcomes include medical and liver-related complications, operative intervention, LOS, and costs of care. Cost data were obtained by converting charges to cost using conversion ratios provided by HCUP. Patient demographics, outcome (including mortality), and health care utilization differences between EGS patients with and without underlying LD were analyzed. The NIS codes for race and ethnicity into a single variable. Univariate analyses were performed using the χ^2 tests for categorical variables and Student's independent *t*-tests for continuous variables. We also conducted subanalyses to identify whether differences existed between liver EGS patients who underwent operative intervention compared with those who did not. Furthermore, we analyzed the rates of major complications, which included sepsis, respiratory failure, cardiac event, gastrointestinal complication, and renal complication.[21] Liver-specific sequelae and procedures, including transplantation, hepatic resection, transarterial chemoembolization, portal hypertension, hepatorenal syndrome, and the presence of ascites were analyzed separately. Multiple logistic regression was performed to evaluate predictors of mortality, costs, and LOS. We used a random intercept mixed-effects multivariate linear regression model, with a significance set at $P < .05$. This controlled for potential confounders at both the patient (including demographic and clinical) and hospital level. We tested and verified that the assumptions of the model were satisfied.

All analyses were conducted using Stata SE v14.2 (Stata Corp LLC, College Station, Texas). Use of the NIS follows regulations within the data use agreement as defined by the Agency for Healthcare Research and Quality. The Stanford University Institutional Review Board (IRB) determined this study exempt from IRB review, as it does not meet the definition of human subject research as defined in federal regulations 45 CFR 46.102.

Results

Among the 6.7 million EGS patients analyzed, there were 358 766 (5.3%) patients with underlying LD. Overall, EGS-LD patients were slightly younger (EGS-LD vs other EGS: 55.3 vs 56.9 years, $P < .001$), more often male (55.4% vs 45.5%, $P < .001$), and had a greater mean number of comorbidities (4.1 vs 2.4, $P < .001$) (Table 1).

Table 1. Demographics, Health Care Utilization, and Clinical Outcomes for EGS Patients with Underlying All-Cause LD, 2012-2014 (Weighted Values).

	No LD 6 423 208 (94.71%)	LD (EGS-LD) 358 766 (5.29%)	*P*-value
Patient characteristics			
Age, mean (SE), years	56.9 (0)	55.3 (0)	<.001
Age by category, number (%)			
18-44 years	1 748 393 (27.2)	82 062 (22.9)	<.001
45-64 years	2 298 411 (35.8)	183 113 (51.0)	
65-74 years	1 052 562 (16.4)	55 612 (15.5)	
75-84 years	831 470 (12.9)	29 162 (8.1)	
85 years and above	492 371 (7.7)	9495 (2.6)	
Gender, number (%)			
Male	2 923 031 (45.5)	198 712 (55.4)	<.001
Female	3 500 177 (54.4)	160 055 (44.6)	
Number chronic conditions, mean (SE)	2.4 (0.0)	4.1 (0.0)	
Payer status, number (%)			
Medicare	2 714 146 (42.3)	130 214 (36.3)	<.001
Medicaid	859 276 (13.4)	69 176 (19.3)	
Private	2 018 994 (31.4)	105 799 (29.5)	
Self-pay	55,0696 (8.6)	36 623 (10.2)	
No charge/other	279 417 (4.3)	18 243 (5.1)	
Zip income quartile, number (%)			
0-25th percentile	1 870 468 (29.1)	108 512 (30.2)	<.001
25-50th percentile	1 706 345 (26.6)	94 948 (26.5)	
50-75th percentile	1 528 657 (23.8)	84 775 (23.6)	
75-100th percentile	1 319 094 (20.5)	69 176 (19.3)	
Race/ethnicity			
White	4 614 455 (71.8)	249 577 (69.6)	
Black	741 948 (11.6)	37 301 (10.4)	
Hispanic	727 706 (11.3)	52 221 (14.6)	
Other	337 064 (5.2)	21 702 (6.0)	
Category of LD, number (%)			
All-cause cirrhosis		212 103(59.1)	
Acute hepatitis		5202 (1.5)	
Congenital		5274 (1.5)	
Malignancy		39 249 (10.9)	
Acute alcoholic liver		96 939 (27.0)	
EGS condition, number (%)			
Appendicitis	463 209 (7.2)	5.765 (1.6)	<.001
Breast Infection	40 692 (0.6)	556 (0.2)	
Cholecystitis	610 378 (9.5)	44 083 (12.3)	
Diverticulitis	632 758 (9.9)	21 024 (5.9)	
Esophageal perforation	70 533 (1.1)	12 208 (3.4)	
Hernia	495 762 (7.7)	21 702 (6.0)	
Infectious colitis	302 476 (4.7)	19 668 (5.5)	
Intestinal ischemia	141 743 (2.2)	7460 (2.1)	
Intestinal obstruction	772 467 (12.0)	33 232 (9.3)	
Pancreatitis	679 554 (10.6)	115 294 (32.1)	
Pelvic inflammatory disease	80 705 (1.3)	882 (0.2)	
Perforated ulcer	39 335 (0.6)	2645 (0.7)	
Perirectal abscess	66 463 (1.0)	1695 (0.5)	
Pleural space infection	31 875 (0.5)	2035 (0.6)	
Soft tissue infection	1 590 373 (24.8)	57 647 (16.1)	
Surgical site infection	404 884 (6.3)	12 886 (3.6)	

(Continued)

Table 1. Continued

	No LD 6 423 208 (94.71%)	LD (EGS-LD) 358 766 (5.29%)	*P*-value
Hospital characteristics			
Hospital region, number (%)			
Northeast	1 305 530 (20.3)	63 751 (17.8)	<.001
Midwest	1 407 260 (21.9)	71 889 (20.0)	
South	2 505 939 (39.0)	141 743 (39.5)	
West	1 204 479 (18.8)	81 834 (22.7)	
Hospital teaching location, number (%)			
Rural	823 332 (12.8)	36 623 (10.2)	<.001
Urban nonteaching	2.434,050 (37.9)	135 639 (37.8)	
Urban teaching	3 165 825 (49.3)	186 504 (52.0)	
Hospital ownership, number (%)			
Government	784 674 (12.2)	44 083 (12.3)	<.001
Private	5 638 533 (87.8)	314 684 (87.7)	
90-Day health care utilization			
Major operation	2 378 438 (37.0)	93 591 (26.1)	
Discharge disposition, number (%)			
Home/home health	5 523 918 (86)	300 441 (83.8)	<.001
Rehabilitation/SNF	649 713 (10.1)	32 553 (9.1)	
Died	54 934 (0.9)	9495 (2.6)	
Other	194 371 (3)	16 418 (4.6)	
LOS, mean (SE), days	4.68 (0.01)	5.72 (0.03)	<.001
Mean costs ($)	10 234 (37)	12 847 (97)	<.001

Abbreviations: EGS, emergency general surgery; LOS, length of stay; SNF, skilled nursing faclity; LD, liver disease.

Socioeconomic characteristics were different between groups as well, where EGS-LD patients were more often of nonwhite race/ethnicity (vs other EGS: 30.4% vs 28.2%, $P < .001$), in the bottom 50th percentile of zip code income (vs other EGS: 56.7% vs 55.7%, $P < .001$), and more likely to be insured by Medicaid or self-pay (vs other EGS: 29.5% vs 22.0%, $P < .001$). EGS-LD patients had lower rates of operative intervention (vs other EGS: 26.1% vs 37.0%, $P < .001$) and yet they experienced higher mortality rates (vs other EGS: 2.6% vs 0.9%, $P < .001$). EGS-LD patients also had longer mean LOS (vs other EGS: 5.7 vs 4.7 days, $P < .001$), lower rates of routine discharge home (vs other EGS: 83.8% vs 86%, $P < .001$), and were more likely to be treated at large urban teaching hospitals (vs other EGS: 52.0% vs 49.3%, $P < .001$). Finally, the mean costs of care were higher among EGS-LD patients (vs other EGS: $12 847 vs $10 234, $P < .001$). The total costs of all EGS patients during the study period (2012-2014) was $70.4 billion, where 6.5% ($4.6 billion) of these costs were comprised of EGS patients with underlying all-cause LD.

We next performed a subanalysis on EGS-LD patients to determine whether there were significant differences between those patients who underwent operative intervention (OR) ($n = 93\,566$, 26.1%) versus those who did not ($n = 265\,200$, 73.9%) (Table 2). Mortality was higher for EGS-LD patients that had surgery (LD with OR vs no OR: 4.8% vs 1.9%, $P < .001$) and mean LOS was longer (LD with OR vs no OR: 7.7 vs 5.0 days, $P < .001$). Mean costs were significantly higher for LD patients with OR (vs no OR: $22 214 vs $9,543, $P < .001$). Among all EGS undergoing surgery, patients with underlying LD comprised only 3.8% of the cohort ($n = 93\,591$). Rates of operative intervention were higher among nonliver patients (vs EGS-LD: 37.0% vs 26.1%, $P < .001$). Among nonliver EGS patients, mortality was not impacted by surgical intervention (OR vs no OR: 0.8% vs 0.8%, $P < .001$) although mean LOS was longer in the surgical group (OR vs no OR: 5.6 vs 4.1 days, $P < .001$).

Among EGS-LD patients, the overall liver-related complication rate was 21.5% ($n = 77\,215$). Portal hypertension (6.7% of all EGS-LD patients, $n = 24\,122$) and ascites (13.7% of all EGS-LD patients, $n = 49\,317$) comprised the majority of complications. Among the cirrhosis-only group of EGS-LD patients (59.1% of all EGS-LD patients, $n = 212\,103$), the rate of ascites was correspondingly higher (57.4% of cirrhosis patients, $n = 26\,634$). The overall medical complication rate among EGS-LD patients was 15.5% ($n = 55\,612$), compared with 12.4% ($n = 796\,882$) among all other EGS patients (Figure 1). The most common type

Table 2. Outcomes of EGS Patients with Underlying All-Cause LD, Operative Versus Nonoperative, 2012-2014 (Weighted Values).

	EGS-LD no OR 265 200 (73.92%)	EGS-LD with OR 93 566 (26.08%)	P-value
Patient characteristics			
Age, mean (SE), years	54.8 (0.0)	56.8 (0.0)	<.001
Age by category, number (%)			
18-44 years	62 856 (23.7)	18 871 (20.2)	<.001
45-64 years	137 659 (51.9)	45 456 (48.6)	
65-74 years	38 065 (14.4)	17 472 (18.7)	
75-84 years	19 983 (7.5)	9041 (9.7)	
85 years and above	6637 (2.5)	2727 (2.9)	
Gender, number (%)			
Male	150 000 (56.6)	48 720 (52.1)	<.001
Female	115 200 (43.4)	44 846 (47.9)	
Number chronic conditions, mean (SE)	4.2 (0.0)	3.9 (0.0)	
Payer status, number (%)			
Medicare	94 571 (35.7)	35 338 (37.8)	<.001
Medicaid	54 210 (20.4)	14 745 (15.8)	
Private	74 587 (28.1)	31 105 (33.2)	
Self-pay	28 163 (10.6)	8108 (8.7)	
No charge/other	13 633 (5.1)	4306 (4.6)	
Zip income quartile, number (%)			
0-25th percentile	81 548 (30.7)	27 338 (29.2)	<.001
25-50th percentile	69 852 (26.3)	25 185 (26.9)	
50-75th percentile	62 641 (23.6)	22 710 (24.3)	
75-100th percentile	50 837 (19.2)	18 620 (19.9)	
Race/ethnicity			
White	184 513 (69.6)	63 717 (68.1)	
Black	29 239 (11.0)	7893 (8.4)	
Hispanic	35 984 (13.6)	16 001 (17.1)	
Other	15 463 (5.8)	5991 (6.4)	
Category of LD, number (%)			
All-cause cirrhosis	144 116 (54.3)	68 022 (72.7)	
Acute hepatitis	4054 (1.5)	1148 (1.2)	
Congenital	2224 (0.8)	3050 (3.3)	
Malignancy	30 710 (11.6)	8539 (9.1)	
Acute alcoholic liver	84 413 (31.5)	13 525 (14.5)	
EGS condition, number (%)			
Appendicitis	610 (0.2)	5166 (5.5)	<.001
Breast infection	466 (0.2)	86 (0.1)	
Cholecystitis	9005 (3.4)	34 980 (37.4)	
Diverticulitis	17 544 (6.6)	3157 (3.4)	
Esophageal perforation	11 803 (4.5)	395 (0.4)	
Hernia	4592 (1.7)	17 041 (18.2)	
Infectious colitis	19 481 (7.3)	395 (0.4)	
Intestinal ischemia	5597 (2.1)	2117 (2.3)	
Intestinal obstruction	25 798 (9.7)	7319 (7.8)	
Pancreatitis	105 800 (39.9)	9507 (10.2)	
Pelvic inflammatory disease	610 (0.2)	269 (0.3)	
Perforated ulcer	466 (0.2)	2188 (2.3)	
Perirectal abscess	502 (0.2)	1220 (1.3)	
Pleural space infection	1076 (0.4)	933 (1.0)	
Soft tissue infection	52 523 (19.8)	5166 (5.5)	
Surgical site infection	9328 (3.5)	3624 (3.9)	

(Continued)

Table 2. Continued

	EGS-LD no OR 265 200 (73.92%)	EGS-LD with OR 93 566 (26.08%)	P-value
Hospital characteristics			
Hospital region, number (%)			
Northeast	49 007 (18.5)	14 853 (15.9)	
Midwest	54 102 (20.4)	17 580 (18.8)	
South	103 899 (39.2)	38 029 (40.6)	
West	58 192 (21.9)	23 105 (24.7)	
Hospital teaching location, number (%)			
Rural	28 450 (10.7)	7929 (8.5)	<.001
Urban nonteaching	99 845 (37.6)	36 092 (38.6)	
Urban teaching	136 905 (51.6)	49 581 (53.0)	
Hospital ownership, number (%)			
Government	32 684 (12.3)	11 301 (12.1)	<.001
Private	232 517 (87.7)	82 265 (87.9)	
90-Day health care utilization			
Discharge disposition, number (%)			
Home/home health	223 152 (84.2)	77 098 (82.4)	<.001
Rehabilitation/SNF	22 423 (8.5)	10 440 (11.2)	
Died	4987 (1.9)	4449 (4.8)	
Other	14 598 (5.4)	1614 (1.7)	
LOS, mean (SE), days	5.04 (0.01)	7.65 (0.03)	<.001
Mean costs ($)	9543 (37)	22 214 (97)	<.001

Abbreviations: EGS, emergency general surgery; LOS, length of stay; SNF, silled nursing facility; LD, liver disease.

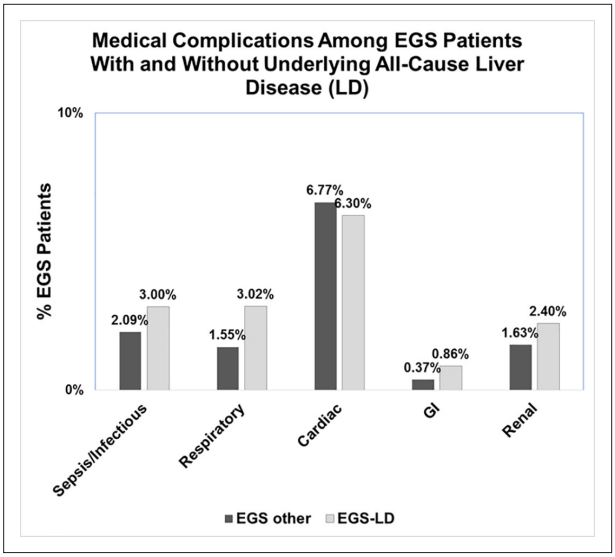

Figure 1. Rates of major complications among EGS-LD patients. Describes the rates of medical complications among EGS patients with underlying LD. EGS, Emergency General Surgery;LD, liver disease; GI, gastrointestinal.

of medical complication was cardiac (EGS-LD vs other EGS: 6.3% vs 6.7%, $P < .001$). Sepsis and renal, gastrointestinal, and respiratory complications were all more common among EGS-LD patients (Figure 1). Among EGS-LD patients with respiratory failure (3.0%, $n = 10\,834$), 30.8% required mechanical ventilation.

Mixed-effect multivariable logistic regression models were performed to examine the impact of LD on EGS mortality, as well as to identify predictors of increased mortality among the EGS-LD cohort (Table 3). Among all EGS patients, a diagnosis of underlying LD was associated with a nearly fivefold increased odds of mortality (adjusted odds ratio [aOR] = 4.5, $P < .001$). Odds of death were increased in both surgical (aOR = 4.93, $P < .001$) and nonsurgical EGS-LD patients (aOR = 2.56, $P < .001$). For EGS-LD patients specifically, there was a stepwise increase in odds of death with increasing age (45-64 years vs 65-74 vs 75-84 vs 85 years and above: aOR = 2.70 vs aOR = 4.39 vs aOR = 6.67 vs aOR = 12.42, $P < .001$ for all). Treatment at a rural hospital (aOR = 1.25, $P < .001$), as well as Black race (aOR = 1.16, $P < .001$) increased the odds of death. Diagnoses of cirrhosis (aOR = 1.29, $P < .001$), ascites (aOR = 2.68, $P < .001$), and hepatic malignancy (aOR = 2.39, $P < .001$) increased the odds of mortality, as did complications including respiratory failure requiring mechanical ventilation (aOR = 10.40, $P < .001$) and sepsis (aOR = 8.97, $P < .001$). Renal failure requiring dialysis was associated with a threefold increase in the odds of death (aOR = 3.44, $P < .001$).

Table 3. Regression to Determine Predictors of Mortality Among Emergency General Surgery Patients with Underlying All-Cause Liver Disease.

				95% CI	
		Odds ratio	*P*-value	Low	High
Female		1.02	.75	0.91	1.14
Age category	18-44 years		1.00	Reference	
	45-64 years	2.69	<.001	2.14	3.41
	65-74 years	4.39	<.001	3.44	5.61
	75-84 years	6.68	<.001	5.17	8.62
	85 and older	12.42	<.001	9.27	16.67
Race category	White		1.00	Reference	
	Black	1.16	.082	0.98	1.39
	Hispanic	0.75	.004	0.63	0.92
	Other	0.82	.108	0.64	1.04
Major operation		1.44	<.001	1.29	1.62
Hospital teaching location	Metropolitan teaching	1.00		Reference	
	Metropolitan nonteaching	0.73	.02	0.59	0.89
	Rural	1.25	.02	0.06	0.37
Liver disease type	Acute hepatitis	1.00		Reference	
	All-cause cirrhosis	1.29	<.001	1.12	1.49
	Hepatic malignancy	2.39	<.001	2.02	2.83
Ascites		2.68	<.001	2.41	2.98
Medical complications	Gastrointestinal	1.00		Reference	
	Sepsis	8.97	<.001	7.94	10.14
	Respiratory requiring mechanical ventilation	10.40	<.001	9.17	11.80
	Cardiac	1.22	.014	1.04	1.43
	Renal failure with dialysis	3.44	<.001	2.87	4.12

We next performed adjusted analyses to determine risk factors for increased LOS and costs. EGS-LD patients spent on average an additional 1.26 days in the hospital ($P < .001$). EGS-LD patients who underwent an operation were admitted on average 2.06 days longer ($P < .001$). Mean LOS was also significantly increased among patients with sepsis (additional 6.74 days, $P < .001$), respiratory failure requiring intubation (additional 6.23 days, $P < .001$), and renal failure requiring dialysis (additional 3.78 days, $P < .001$). A diagnosis of underlying LD increased costs of care for EGS patients by an average of $3607 ($P < .001$). Among EGS-LD patients, having an operation increased costs by an average of $10 502 ($P < .001$). A diagnosis of renal failure necessitating dialysis increased costs of care by a mean of $14 150 ($P < .001$) and respiratory failure requiring mechanical ventilation increased costs by a mean of $24 270 ($P < .001$).

Discussion

Of the 6.4 million patients in the United States who underwent admission for an acute general surgery complaint between 2012 and 2014, 5.3% had underlying LD. Although a seemingly small fraction of the cohort, LD patients have significantly higher in-hospital mortality, increased length of hospital stay, and greater costs of care. Our primary outcome of interest was inpatient mortality. LD confers a nearly a fivefold increase in odds of in-hospital mortality (aOR = 4.5, $P < .001$). This is consistent with previous studies of cirrhotic patients who undergo trauma laparotomy and found to have a higher risk of serious complications and death even with minor traumatic injuries (hazard ratio 7.6).[13] The reported in-hospital mortality in the literature in cirrhotic patients who undergo emergency surgery can be as high as 47%.[14] This is in contrast with our results that reveal inpatient mortality of 3%, likely a reflection of the large National Inpatient Sample dataset that allows for a broad capture of a variety of all-cause LD and severity, as well as EGS conditions.[14] Furthermore, the NIS captures in-hospital mortality only and likely underestimates mortality at 30 or 90 days for this high-risk group.

Overall, EGS-LD were less likely to undergo operative intervention compared with other EGS patients. Not

surprisingly, EGS-LD patients who underwent operation had higher mortality compared with those who did not (4.8% vs 1.9%, $P < .001$). By contrast, the mortality of non-LD patients was not impacted by the decision to pursue an operation. The reasons for this cannot be fully elucidated from the NIS database, but do underscore an important decision-tree branch point that may impact outcomes. These findings suggest that emergency surgery in LD patients requires a thoughtful assessment of risks and benefits, appreciating that even *without* surgery this patient population is at increased risk of mortality (aOR = 2.56). As underlying LD is associated with a higher in-hospital mortality overall and emergency surgery increases the risk even further, operative intervention should be a deliberate decision in discussion with the patient, family, and other medical teams involved. The patient factors associated with increased odds of death and that can be taken into consideration in the care of these patients are increased age, Black race, the presence of hepatic malignancy, renal failure and dialysis, and the presence of sepsis. Notably, respiratory failure requiring mechanical ventilation is the most significant contributor to increased odds of death (OR = 10.4) in comparison to gastrointestinal complications. Previous literature suggests that respiratory failure requiring mechanical ventilation in patients with cirrhosis is associated with 89% mortality at 1 year.[22] Although optimization of patients with LD has been studied in elective surgeries, the same principles can be applied to EGS. Intraoperatively, choosing minimally invasive techniques when possible, the use of topical hemostatics, advanced energy devices, and mechanical staplers may mitigate some of the surgical risks.[6,7] Cautious preoperative care with judicious fluid and product resuscitation, postoperative diuresis, avoidance of nephrotoxic and hepatotoxic medications, nutrition, as well as pharmacologic adjuncts to correct coagulopathy is important in these patients.[8,9]

Lastly, even though rural hospitals were less likely to treat patients with EGS-LD or perform operative interventions, treatment in these centers was a predictor of mortality. This is consistent with previous research showing increased mortality of patients managed in rural institutions as well as a shortage of physicians trained to provide a higher level of care to these complex patients.[23,24] Indeed, management by hepatologists or gastroenterologists as well as care coordination in specialty centers for cirrhosis has been associated with improved outcomes, including reducing mortality and decreasing readmission rates.[25-27] Although the majority of patients with chronic liver failure do not undergo a liver transplant, proximity to such a center has been associated with decreased mortality, presumably due to access to specialized care.[28] We can infer from the literature and the results of this study that patients with EGS-LD are best served at specialty centers that have access to higher-level care through a multidisciplinary approach.

Secondary outcomes of this study were LOS and costs of care, neither of which have been previously documented this high-risk population. Compared with non-LD patients, EGS-LD patients spent 1 additional day on average in the hospital, or 2 additional days if they underwent an operation. Moreover, they were less likely to be routinely discharged home. These findings underline critical considerations for both in-hospital as well as postdischarge resource utilization and needs. While quality improvement efforts are underway to reduce readmission rates for patients with cirrhosis, the postdischarge trajectory of these patients is not well characterized and warrants further research.[29] Consistent with prior studies, the economic burden of acute care surgery in our study is significant, at over $70 billion annually. More importantly, although EGS-LD patients account for only 5.3% of all EGS admission, the costs associated with this group are disproportionately high, representing 6.5% of the total cost ($4.6 billion). Indeed, the cost of admission for the EGS-LD population was significantly higher than for the EGS patients ($12 847 vs $10 234, $P < .001$). We suspect that increased rates of interventions and complications, longer LOS, and complexity of surgical intervention are all drivers of increased cost in the EGS-LD cohort. LD patients who underwent operative intervention accounted for more than double the cost compared with those who did not ($22 214 vs $9543, $P < 0.001$). Additionally, EGS-LD patients are more likely to be treated at urban teaching hospitals, likely due to the complexity of the underlying disease, comorbidities, and requirements for higher-level specialization.

Although recent research suggests that teaching and nonteaching hospitals may have equivalent costs, urban institutions have historically been more expensive than rural counterparts. Given that the EGS-LD population is more likely to be insured by Medicaid or self-pay and in the bottom 50th percentile of zip income, the increased costs of care are noteworthy and should serve as an incentive to medically optimize patients for potential elective surgery to minimize the need for emergency interventions.

The current study offers a first-time insight into the mortality, morbidity, and costs of care of a large national dataset of patients with all-cause LD and EGS presentations. As the prevalence of LD is expected to increase, surgeons will be faced with difficult decisions regarding the operative management of patients with all-cause LD and acute care surgery presentations. Our data is consistent with other studies in patients with end-stage renal disease or hemodialysis who were found to have significantly higher mortality, morbidity, and LOS from either elective or EGS.[30,31] While prior smaller studies have

documented an increased risk of death in patients with cirrhosis undergoing emergency surgery, there are no previous in-depth analyses of all-cause LD and its impact upon EGS procedures. Although patients with all-cause LD represent a small fraction of all EGS admissions, they pose unique challenges for the acute care surgeon. Despite the urgency of the presentation, the decision to operate must be thoughtful and deliberate, with a clear understanding of the risks associated with both surgical and nonsurgical intervention. The increased health care costs associated with caring for EGS-LD patients provide an additional incentive to optimize medical care and, wherever medically feasible, avoid the need for emergency surgery.

There are several limitations to our study. This is a retrospective study, with inherent limitations in determining the causal effects of mortality among EGS-LD patients. The NIS is a nationally representative administrative database meant to provide valuable demographic, cost, and health care utilization data. However, it does not include granular clinical data such as liver-specific laboratory values that would enable us to calculate MELD score or detailed information regarding candidacy for transplantation. Furthermore, rates of liver resection, transplantation, and other procedures such as transarterial chemoembolization were difficult to capture and are likely underrepresented due to limitations in ICD-9CM coding for transplant-related procedures.[32] Finally, the NIS uniquely captures data associated with inpatient hospitalizations. Consequently, we were not able to extrapolate upon the outcomes of EGS patients discharged, the rate of return visits to the ED or readmission to hospital, nor the out-of-hospital mortality rate (ie, for patients who later died after discharge from the ED or the inpatient setting).

Conclusion

EGS in patients with underlying all-cause LD is associated with a fivefold increase in mortality, longer LOS, increased complication rates, and greater cost of care. Although EGS-LD patients are less likely to undergo surgery, mortality and complication rates are significantly higher in those who have an operation compared with those who do not. The findings of this large-scale national sample study suggest that despite the urgency of the presentation, a thoughtful decision-making process must be utilized in patients with underlying LD and acute surgical presentations. Multidisciplinary care for this vulnerable patient population should include early referral to specialized care and close follow-up to reduce the need for emergent surgical intervention wherever possible.

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