Published in final edited form as:
Liver Int. 2019 August ; 39(8): 1394–1399. doi:10.1111/liv.14156.

In-Hospital Mortality Varies by Procedure Type among Cirrhosis Surgery Admissions

Nadim Mahmud[1], **Zachary Fricker**[1], **Marina Serper**[1,2], **David E. Kaplan**[1,2], **Kenneth D. Rothstein**[1], **David S. Goldberg**[1,3]

[1.]Division of Gastroenterology, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA

[2.]Department of Medicine, Corporal Michael J. Crescenz VA Medical Center, Philadelphia, PA

[3.]Center for Clinical Epidemiology and Biostatistics, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA

Abstract

Background: Patients with cirrhosis have increased peri-operative mortality risk relative to non-cirrhotic patients, however the impact of surgical procedure category on this risk is poorly understood.

Methods: We performed a retrospective cohort study of cirrhosis surgery admissions using the National Inpatient Sample between 2012 and 2014 to estimate the adjusted odds of in-hospital mortality by surgical procedure category.

Results: In-hospital mortality differed by surgical procedure category. Relative to major orthopedic surgeries, major abdominal surgeries had the highest odds of in-hospital mortality (odds ratio [OR] 8.27, 95% confidence interval [CI] 5.96 – 11.49), followed by major cardiovascular surgeries (OR 3.45, 95% CI 2.33 – 5.09). There was also a significant interaction term, whereby elective/non-elective admission status impacted in-hospital mortality risk differently for each surgical procedure category ($p<0.001$).

Conclusion: In-hospital mortality varies substantially by surgical procedure type. Accounting for procedure type in models may improve risk prediction for peri-operative mortality in patients with cirrhosis.

Introduction

The burden of cirrhosis is growing in the United States, largely driven by prevalent hepatitis C infection, consistent rates of alcoholic liver disease, and increasing rates of obesity-related nonalcoholic steatohepatitis.[1] This is occurring despite our ability to cure hepatitis C, as many patients remain untreated or undiagnosed. Furthermore, many individuals cured of hepatitis C already have advanced fibrosis at the time of treatment, and remain at risk of

Corresponding Author: Nadim Mahmud MD MS MPH, 3400 Civic Center Boulevard, 4th Floor, South Pavilion, Philadelphia, PA 19104, Phone: 215-349-8222, Fax: 215-349-5915, nadim.mahmud@uphs.upenn.edu.

Conflict of Interest: The authors have no disclosures or conflicts of interest to report.

cirrhosis-related complications. Indeed, national data suggest that hospitalizations for a primary diagnosis of liver disease have increased by 25% from 2005 to 2014.[2] The majority of these patients are aged 51 – 69, representing the baby boomer generation. Given the aging of this cohort, as well as the ongoing burden of liver disease in the United States, the anticipated need for surgeries in this group is expected to rise.

Patients with cirrhosis have an increased risk of surgical and post-surgical mortality relative to the general population.[3] The degree of this risk is known to increase with severity of cirrhosis, as denoted through decompensation (bleeding esophageal varices, clinical ascites, or hepatic encephalopathy), higher Model for End-Stage Liver Disease (MELD) scores, or Child-Turcotte-Pugh (CTP) B or C classes.[4] Additional peri-operative risk factors include patient age, etiology of liver disease, and the American Society of Anesthesiologists (ASA) physical status score.[5] To date, little is known about the impact of the specific surgical procedure type (e.g., abdominal versus cardiac) or circumstance (elective versus urgent/ emergent) in patients with cirrhosis. Although independent small studies have reported differing mortality rates among patients with cirrhosis undergoing specific surgical procedures,[6, 7] there are currently no large studies that investigate, in detail, associations between categories of surgery and mortality. As such, we sought to examine the impact of surgical procedure category, elective admission status, and the interaction of these two variables on in-hospital mortality using a large national dataset.

Methods

Study Design and Cohort Creation

We performed a retrospective cohort study using the National Inpatient Sample (NIS) between 2012 and 2014. The NIS is the largest payer-independent database of United States hospital discharges, and is maintained by the Agency for Healthcare Research and Quality (AHRQ) as part of the Healthcare Cost Utilization Project (HCUP).[8] Cirrhosis admissions were identified using International Classification of Diseases (ICD)-9 codes (571.2, 571.5). We excluded patients under age 18 and those with prior liver transplantation (ICD-9 codes: V42.7, 996.82). We classified admissions with decompensated cirrhosis using the presence of codes for variceal bleeding (456.0, 456.2), hepatic encephalopathy (572.2), portal hypertension (572.3), hepatorenal syndrome (572.4), or ascites (789.5, 789.59), consistent with prior NIS studies.[9, 10] Etiology of liver disease (hepatitis C, alcoholic liver disease, non-alcoholic fatty liver disease) was ascertained using ICD-9 codes per Peery et al.[2] Demographic data (age, sex, race), primary insurance payer (Medicare, Medicaid, private, self-pay), hospital length of stay, hospital location/teaching status (rural, urban nonteaching, urban teaching), hospital region (Northeast, Midwest, South, West), hospital bed size (small, medium, large), elective versus non-elective admission, and in-hospital death were collected for all admissions. We designated hospitals as experienced liver transplant centers if they performed at least 15 liver transplants annually between 2012 and 2014, based on ICD-9 procedure codes (505.1, 505.9). Finally, we calculated the Elixhauser comorbidity index for each admission, based on prior methods.[11] This is a validated index for hospital-associated mortality that has been shown to outperform other comorbidity indices across a range of applications utilizing large administrative databases.[12]

Surgical Procedure Classification

To inform categorization of surgical procedures, we reviewed the 100 most-frequent primary procedure codes from annual data of all admissions in the cohort. Based on this data, we created five surgery categories: cholecystectomy, hernia repair, major abdominal surgery (total/partial colectomy, nephrectomy, pancreatectomy, splenectomy, gastrectomy), major orthopedic surgery (total/partial knee or hip replacement/revision, major open reduction), and major cardiovascular surgery (coronary artery bypass grafting, open cardiac valve replacement/repair, abdominal aortic aneurysm repair). The ICD-9 procedure codes defining these categories are summarized in Supplemental Table 1. The presence of these procedure codes in any position was sufficient to classify a surgery during a hospital admission.

Statistical Analysis

To estimate the relative odds of in-hospital mortality for each surgical procedure category, we used survey-based logistic regression analysis. We chose this over a time to event analysis given the absence of post-discharge follow-up data in the NIS. Survey-based methods were used to account for the approximate stratified two-stage cluster sampling design of the database, and to incorporate AHRQ-provided discharge weights, as recommended.[13] We first performed univariate (unadjusted) analysis. For continuous covariates we plotted locally weighted scatterplot smoothing curves to test the assumption of linearity. Based on this, we modeled non-linearity in hospital length of stay using with two linear spline functions, with a knot placed at three days. We subsequently constructed several adjusted multivariable models. The *full model* adjusted for age, sex, race, primary insurance payer, Elixhauser comorbidity index, decompensation status, hospital length of stay, elective admission status, hospital region, hospital bed size, hospital location/teaching status, and liver transplant center designation. The *first reduced model* only included variables significant at the alpha = 0.05 threshold after clinician-driven modeling. The *second reduced model* additionally removed decompensation status, as it is possible that decompensations developed as a result of surgery, rather than the codes indicating decompensated cirrhosis upon admission. Finally, the *interaction model* added an interaction term between elective admission status and surgical procedure category. In all models we computed odds ratios (OR) with 95% confidence intervals (CI), coefficient plots, and associated p-values for surgical procedure category.

Exploratory Analysis

As an exploratory analysis, to evaluate heterogeneity within the major abdominal surgery category, we produced an adjusted multivariable logistic regression model to determine the relative odds of in-hospital mortality for subcategories of major abdominal surgery. This model was adjusted for the same covariates as in the *full model* detailed above.

Statistical Notes and Ethical Considerations

Data preparation and analysis were performed using STATA 15.1/IC (College Station, TX). Because data missingness was less than 1% in the regression models, we proceeded with complete case analysis and did not pursue imputation. All methods were performed with adherence to recommended NIS research practices.[14] Finally, as the NIS contains completely deidentified discharge data, this study met University of Pennsylvania Institutional Review Board exemption criteria.

Results

Cohort Characteristics

Admission characteristics of the estimated 72,215 surgical procedures performed in patients with cirrhosis are shown in Table 1. Decompensated cirrhosis was most common among admissions for hernia repairs (60.2%). The Elixhauser comorbidity index was higher among those undergoing major cardiovascular surgeries (median 7 versus median 4-5 in other categories). Major cardiovascular surgery was also more commonly performed at large bed size hospitals (72.5%), and in urban teaching settings (76.3%). Cholecystectomy or hernia repairs took place during elective admissions in fewer than 30% of cases, in contrast to major cardiovascular and major abdominal surgeries which occurred during elective admissions more than 50% of the time. In-hospital death rates were highest among major abdominal surgeries (13.4%) and major cardiovascular surgeries (8.7%), in sharp contrast to major orthopedic surgeries (1.5%). Finally, hospital charges were highest for major cardiovascular surgeries (median $188,800).

In-Hospital Mortality Risk of Surgical Procedures

The average in-hospital mortality rates between 2012 and 2014 by surgical procedure type and elective admission status are shown in Supplemental Table 2. The unadjusted odds of in-hospital mortality were significantly higher for major abdominal surgeries relative to major orthopedic surgery (OR 10.16, 95% CI 7.58 – 13.62; Table 2). This was followed by major cardiovascular surgeries (OR 6.14, 95% CI 4.36 – 8.65) and hernia repairs (OR 2.48, 95% CI 1.79 – 3.45). In all adjusted models (Supplemental Tables 3–6), the effect sizes were somewhat attenuated, but the observed trends in odds of mortality were unchanged (Table 2, Supplemental Figure 1). For example, in the second reduced model, the odds of in-hospital mortality were significantly higher for major abdominal surgeries relative to major orthopedic surgery (OR 8.27, 95% CI 5.96 – 11.49), followed by major cardiovascular surgeries (OR 3.45, 95% CI 2.33 – 5.09) and hernia repairs (OR 2.09, 95% CI 1.47 – 2.98). There was also a significant interaction between elective admission status and surgical procedure category ($p<0.001$; Supplemental Table 7). In particular, with the exception of cholecystectomy, the odds of in-hospital mortality were significantly higher for each surgical procedure for non-elective admissions relative to elective admissions. This effect was most pronounced in major orthopedic and major abdominal procedures (OR 3.59, 95% CI 1.62 – 7.96 and OR 4.52, 95% CI 3.21 – 6.36, respectively). In all models, increasing Elixhauser comorbidity index, increasing age, black race, and increasing hospital size were associated with increased odds of in-hospital mortality. Elective admission status was associated with decreased odds of in-hospital mortality.

Exploratory Analysis of Major Abdominal Surgeries

When expanding the subcategories of major abdominal surgery, there was clear heterogeneity in in-hospital mortality rates between procedures. In particular, total/partial splenectomy or colectomy harbored the highest in-hospital mortality rates, and nephrectomy had among the lowest. In multivariable analysis, the odds of in-hospital mortality were significantly higher for colectomy (OR 3.89, 95% CI 1.93 – 7.83), pancreatectomy (OR 4.56, 95% CI 1.78 – 11.65), and splenectomy (OR 3.04, 95% CI 1.43 – 6.45) relative to gastrectomy (Supplemental Table 8).

Discussion

In this large study of national discharge data, we identified high-volume surgical procedure categories for cirrhosis admissions. We found differences in in-hospital mortality risk by surgical procedure category, in particular an extremely high mortality rate with major abdominal surgery. We also revealed a strong interaction between elective admission status and surgical procedure category, which has clear implications for future efforts to properly model surgical risk in the setting of cirrhosis.

The primary novel finding in this study is that in-hospital mortality risk varies substantially for different surgical procedures among cirrhosis admissions, adjusting for associated risk factors. While this seems intuitive, there is a paucity of published large-database literature on this subject. The Mayo surgical risk score, which is widely used in clinical practice to risk-stratify patients with cirrhosis prior to surgery, does not incorporate different surgical procedures into the risk prediction.[5] Rather, the derivative study pooled together orthopedic, cardiac, and non-cholecystectomy gastrointestinal surgery in order to develop a risk prediction model. Although this score has been externally validated in a Korean cohort, with high discrimination (C-statistic >0.80), the model was noted to significantly overestimate mortality predictions relative to the observed values (for example, 1-year mortality 22.6% predicted versus 8.9% observed, p<0.01).[15] This implies that the model may not be sufficiently calibrated, or that it lacks generalizability.

Several smaller studies have shown that within the context of a given surgical procedure, post-operative mortality increases with worsening severity of liver disease.[16] These data separately corroborate our general findings of high short-term mortality associated with major abdominal and cardiovascular surgery,[17, 18] and lower short-term mortality with orthopedic procedures and cholecystectomy.[19, 20] However, prior to this study, no large-scale studies have directly compared mortality risk *among different surgical procedures*. The finding that major abdominal surgeries have an approximately ~8-fold increased odds of in-hospital mortality relative to major orthopedic surgeries, or that major cardiovascular surgeries have an approximately ~4-fold increased odds of mortality, is highly important. We also found a significant interaction between elective admission status and surgical procedure category. Interestingly, although major orthopedic surgeries had the lowest in-hospital mortality among all procedure categories, these surgeries had among the high increased odds of mortality when performed under urgent or emergent circumstances, second only to major abdominal surgeries. Finally, in an exploratory analysis of the subcategories of major abdominal surgery, we found significant heterogeneity in in-hospital mortality, implying that "major abdominal surgery" itself is an insufficient classifier to adequately delineate surgical risk. Taken together, our findings underscore the substantial knowledge gaps that exist in projecting surgical risk for patients with cirrhosis. Improved risk models are clearly needed to properly risk stratify patients and select appropriate surgical candidates. Such a model would be expected to reduce mortality rates for all procedure categories of interest, in both elective and non-elective settings.

This study has several important limitations. First, as with any administrative database, there is the possibility of misclassification of exposure and outcomes resulting from coding errors. In the aggregate, we would expect these issues to have little impact on the overall trends observed. Second, the NIS dataset does not contain any data on medication history, laboratory data, or relative timing of diagnoses during an admission (i.e. decompensations of liver disease). As such, other parameters of interest such as the MELD score could not be calculated, which would further stratify baseline severity of liver disease. There may also be other unavailable data related to the circumstances of admission that might impact mortality. Similarly, the ASA score, which has previously been shown to be an important predictor of post-operative mortality,[5] was not available to be incorporated into our models. Finally, our outcome of interest, in-hospital mortality, is only a short-term marker of surgical risk and says little about medium or long-term outcomes, which are not recorded in the NIS database.

In conclusion, among cirrhosis surgery admissions we found significant differences in in-hospital mortality as a function of surgical procedure type and urgency. Further studies are needed to confirm these findings, and to elucidate the cause of these differences. However, our findings underscore the substantial knowledge gaps that exist in projecting surgical risk for patients with cirrhosis. Risk scores that incorporate surgical procedure type and urgency are needed to improve patient selection for surgical procedures and identify those better served by non-operative management.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements:

Funding: Nadim Mahmud is supported by a National Institutes of Health grant (2-T32-DK007740-21A1).

Abbreviations:

MELD	Model for End-Stage Liver Disease
CTP	Child-Turcotte-Pugh
ASA	American Society of Anesthesiologists
NIS	National Inpatient Sample
AHRQ	Agency for Healthcare Research and Quality
HCUP	Healthcare Cost Utilization Project
ICD	International Classification of Diseases
OR	odds ratio

CI	confidence interval

References

1. Parikh ND, Marrero WJ, Wang J, et al. Projected increase in obesity and non-alcoholic-steatohepatitis–related liver transplantation waitlist additions in the United States. Hepatology 2017.
2. Peery AF, Crockett SD, Murphy CC, et al. Burden and cost of gastrointestinal, liver, and pancreatic diseases in the United States: update 2018. Gastroenterology 2018.
3. Friedman LS. The risk of surgery in patients with liver disease. Hepatology 1999;29:1617–1623. [PubMed: 10347099]
4. Hoteit MA, Ghazale AH, Bain AJ, et al. Model for end-stage liver disease score versus Child score in predicting the outcome of surgical procedures in patients with cirrhosis. World journal of gastroenterology: WJG 2008;14:1774. [PubMed: 18350609]
5. Teh SH, Nagorney DM, Stevens SR, et al. Risk factors for mortality after surgery in patients with cirrhosis. Gastroenterology 2007;132:1261–1269. [PubMed: 17408652]
6. Perkins L, Jeffries M, Patel T. Utility of preoperative scores for predicting morbidity after cholecystectomy in patients with cirrhosis. Clinical Gastroenterology and Hepatology 2004;2:1123–1128. [PubMed: 15625658]
7. Hayashida N, Shoujima T, Teshima H, et al. Clinical outcome after cardiac operations in patients with cirrhosis. The Annals of thoracic surgery 2004;77:500–505. [PubMed: 14759426]
8. O'leary JG, Reddy KR, Garcia-Tsao G, et al. NACSELD acute-on-chronic liver failure (NACSELD-ACLF) score predicts 30-day survival in hospitalized patients with cirrhosis. Hepatology 2018;67:2367–2374. [PubMed: 29315693]
9. Sam J, Nguyen GC. Protein–calorie malnutrition as a prognostic indicator of mortality among patients hospitalized with cirrhosis and portal hypertension. Liver International 2009;29:1396–1402. [PubMed: 19602136]
10. Csikesz NG, Nguyen LN, Tseng JF, et al. Nationwide volume and mortality after elective surgery in cirrhotic patients. Journal of the American College of Surgeons 2009;208:96–103. [PubMed: 19228510]
11. Stagg V ELIXHAUSER: Stata module to calculate Elixhauser index of comorbidity. 2015.
12. Menendez ME, Neuhaus V, van Dijk CN, et al. The Elixhauser comorbidity method outperforms the Charlson index in predicting inpatient death after orthopaedic surgery. Clinical Orthopaedics and Related Research® 2014;472:2878–2886. [PubMed: 24867450]
13. Houchens R, Ross D, Elixhauser A. Final report on calculating national (nationwide) inpatient sample (NIS) variances for data years 2012 and later: HCUP Methods Series Report# 2015-09 ONLINE. US Agency for Healthcare …, 2015.
14. Khera R, Angraal S, Couch T, et al. Adherence to methodological standards in research using the national inpatient sample. Jama 2017;318:2011–2018. [PubMed: 29183077]
15. Kim SY, Yim HJ, Park SM, et al. Validation of a Mayo post-operative mortality risk prediction model in Korean cirrhotic patients. Liver International 2011;31:222–228. [PubMed: 21134111]
16. Friedman LS. Surgery in the patient with liver disease. Transactions of the American Clinical and Climatological Association 2010;121:192. [PubMed: 20697561]
17. Thielmann M, Mechmet A, Neuhäuser M, et al. Risk prediction and outcomes in patients with liver cirrhosis undergoing open-heart surgery. European Journal of Cardio-Thoracic Surgery 2010;38:592–599. [PubMed: 20413316]
18. Arif R, Seppelt P, Schwill S, et al. Predictive risk factors for patients with cirrhosis undergoing heart surgery. The Annals of thoracic surgery 2012;94:1947–1952. [PubMed: 22921237]
19. de Goede B, Klitsie P, Hagen S, et al. Meta-analysis of laparoscopic versus open cholecystectomy for patients with liver cirrhosis and symptomatic cholecystolithiasis. British Journal of Surgery 2013;100:209–216. [PubMed: 23034741]
20. Tiberi JV, Hansen V, El-Abbadi N, et al. Increased complication rates after hip and knee arthroplasty in patients with cirrhosis of the liver. Clinical Orthopaedics and Related Research® 2014;472:2774–2778. [PubMed: 24993141]

Table 1 –

Cirrhosis Surgery Admissions Characteristics

Variable	Cholecystectomy (N = 22,385)	Hernia Repair (N = 15,190)	Other Major Abdominal (N = 10,845)	Major Orthopedic (N = 18,700)	Major Cardiovascular (N = 5,095)
Age (years; median, IQR)	60 (53 - 69)	58 (52 - 66)	60 (53 - 68)	62 (55 - 71)	64 (57 - 71)
Female (%)	43.0	30.6	40.0	51.1	25.0
Race (%)					
White	65.5	71.6	71.6	78.0	75.3
Black	9.6	8.5	8.7	7.2	8.0
Hispanic	17.2	15.2	13.5	9.6	10.6
Primary Insurance (%)					
Medicare	46.7	42.0	44.7	55.9	53.9
Medicaid	15.9	19.7	15.1	14.3	14.3
Private	25.4	26.6	29.8	22.7	23.4
Self-pay	7.2	6.7	6.3	3.4	4.4
Elixhauser comorbidity index (median, IQR)	4 (3 - 6)	4 (3 - 6)	5 (4 - 7)	5 (4 - 6)	7 (5 - 8)
Etiology of Liver Disease (%)					
Hepatitis C	12.6	14.6	8.8	12.1	11.6
Alcohol	21.0	35.4	26.4	34.4	27.9
Fatty liver	15.0	10.4	20.3	10.2	12.0
Unclassified/missing	51.4	39.5	44.5	43.3	48.6
Decompensated Cirrhosis (%)	29.8	60.2	37.3	22.9	27.0
Length of Stay (days; median, IQR)	5 (3 - 9)	6 (3 - 9)	8 (4 - 15)	4 (3 - 7)	10 (6 - 17)
Elective Admission (%)	26.7	29.2	52.9	43.9	52.9
Region (%)					
Northeast	14.7	17.5	16.3	17.4	17.4
Midwest	17.6	19.7	21.6	20.3	21.6
South	42.6	38.7	40.8	39.8	42.0
West	25.1	24.1	21.3	22.5	20.0
Hospital Bed Size (%)					
Small	13.8	12.4	12.6	15.5	6.6
Medium	25.8	26.3	24.0	27.8	20.9
Large	60.4	61.2	63.4	56.8	72.5
Location/Teaching Status of Hospital (%)					
Rural	9.7	6.6	6.5	8.4	2.5
Urban nonteaching	34.2	28.9	26.6	35.4	21.2
Urban teaching	56.1	64.5	66.9	56.2	76.3
Liver Transplant Center (%)	10.6	13.0	12.0	6.5	14.5

Variable	Cholecystectomy (N = 22,385)	Hernia Repair (N = 15,190)	Other Major Abdominal (N = 10,845)	Major Orthopedic (N = 18,700)	Major Cardiovascular (N = 5,095)
In-Hospital Death (%)	2.9	3.9	13.4	1.5	8.7
Hospital Charges ($; median, IQR)	62,225 (37,008 – 111,196)	56,612 (32,778 – 113,115)	95,232 (52,769 – 182,561)	60,592 (42,085 – 94,825)	188,800 (120,333 – 317,670)

Table 2 –

Multivariable Logistic Regression for In-Hospital Mortality by Surgical Procedure Category

	Model				
	Unadjusted	Full*	Reduced 1†	Reduced 2‡	Interaction§
Procedure Category	**Odds Ratio (95% CI)**	**Odds Ratio (95% CI)**	**Odds Ratio (95% CI)**	**Odds Ratio (95% CI)**	**Odds Ratio (95% CI)**
Major Orthopedic	1 (reference)	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Cholecystectomy	1.75 (1.26 – 2.42)	1.46 (1.03 – 2.07)	1.44 (1.02 – 2.05)	1.47 (1.04 – 2.08)	1.12 (0.76 – 1.64)
Hernia Repair	2.48 (1.79 – 3.45)	1.48 (1.03 – 2.13)	1.48 (1.03 – 2.12)	2.09 (1.47 – 2.98)	1.35 (0.92 – 1.99)
Major Cardiovascular	6.14 (4.36 – 8.65)	3.99 (2.68 – 5.94)	3.95 (2.67 – 5.85)	3.45 (2.33 – 5.09)	3.81 (2.42 – 5.98)
Major Abdominal	10.16 (7.58 – 13.62)	7.86 (5.65 – 10.95)	7.86 (5.66 – 10.92)	8.27 (5.96 – 11.49)	8.73 (6.10 – 12.51)

*Model adjusts for age, sex, race, primary insurance, Elixhauser comorbidity index, decompensation status, hospital length of stay, elective status of admission, hospital region, hospital bed size, hospital location/teaching status, and liver transplant center designation

†Model adjusts for all covariates in the full model minus sex, primary insurance, and hospital location/teaching status, and liver transplant center designation

‡Model adjusts for all covariates in the first reduced model minus decompensation status

§Model adjusts for all covariates in the first reduced model, but adds an interaction term between elective admission status and surgical procedure category