Original Article

Evaluation of Factors Associated with Prolonged Hospital Stay Following Major General Surgical Procedures

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Abstract

Background: Longer length of stay for a major general surgery is linked to high health care costs, slow recovery process, and poor health care efficiency. Recognizing risk factors for prolonged length of stay may help to identify the patients who benefit from more aggressive perioperative care. **Material and Methods:** A prospective observational study was conducted among 320 adult patients undergoing major general surgical procedure. Some demographic, clinical, operative and postoperative parameters were prospectively collected. Longer hospital stay was considered as postoperative hospital stay more than the 75th percentiles (>10 days). Multivariate analyses were performed using multivariable logistic regression and factors associated with prolonged hospitalization were identified. Performance of models was evaluated by receiver operating characteristic (ROC) analysis and calibration test. **Results:** 82 patients had prolonged hospital stay (25.6%). Independent predictors included ICU admission (adjusted odds ratio [aOR] 4.02; 95% CI 2.00–8.09; p<0.001), operative duration >240 minutes (aOR 3.61; 95% CI 1.87–6.97; p<0.001), ASA physical status III–IV (aOR 3.15; 95% CI 1.60–6.21; p=0.001), and hypoalbuminemia (aOR 2.78; 95% CI 1.54–5.02; p<0.001). The prediction model has good discrimination (AUC 0.86, 95% confidence interval 0.81–0.91) and adequate calibration. **Conclusion:** Prolonged hospitalization after major general surgery is strongly associated with preoperative risk factors, operative complexity, and postoperative critical care requirements. Early identification of high-risk patients may support individualized perioperative management and improve surgical outcomes.

Keywords: Prolonged hospital stay; Length of stay; General surgery; Surgical outcomes; Predictive model; Logistic regression; Perioperative risk factors.

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Introduction

Length of hospital stay (LOS) is one generally accepted measure of health care quality, performance of health care resources and outcomes of surgery.[1,2] With the significant improvements of surgical technique, peri-operative management, and improved protocols for enhanced recovery, postoperative hospitalization is now a considerable challenge, especially when related to patients undergoing major general surgery procedures, though it has been significantly reduced. Prolonged hospitalization is also linked to patient care expenses, risk of hospital-acquired infections, loss of functions and limited availability of hospital beds, which pose a significant burden on healthcare systems in all over the world.[3,4]

Major General Surgery (MGS) include heterogeneous procedures such as gastrointestinal, hepatobiliary, colorectal, endocrine and abdominal wall surgeries with different levels of physiological stress and postoperative morbidity.[5,6] A variety of factors, related to the patient, the disease, the surgery and the post-surgical phase, play a role in the number of days someone is hospitalized following these procedures. An elevated ASA physical status, emergency surgery, long surgical time, major blood loss during the surgery and post-operative complications have been consistently shown to be the most influential factors on prolonged LOS.[7-9]

A few surveys have shown that post-operative complications are the single most important factor for long hospital stays. Common late complications after surgery include surgical site infections (SSIs), postoperative ileus, anastomotic leakage, pulmonary complications, UTIs and venous thromboembolism (VTE), which often prolong the recovery and result in higher healthcare costs.[10,11] Moreover, optimization of modifiable risk factors like anemia, diabetes mellitus, hypoalbuminemia, obesity, and smoking before surgery have been reported to have beneficial effects on the outcome of surgery and length of hospital stay.[12-14]

Enhanced Recovery After Surgery (ERAS) protocols have been a success in drastically decreasing surgical stress, early

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mobilization, better pain management and hemoglobin glycosylated level, and allowing introduction of early enteral nutrition. Many randomized trials and meta-analyses have been performed and have shown a positive effect on LOS but no increase in postoperative morbidity or readmissions in different surgical specialties, after implementation of ERAS.[15,16] However, late presentation, poor perioperative resources and heterogenous adherence to standard care pathways persist in causing prolonged hospitalisation in significant numbers of patients especially in L-MICs.[17,18]

To create models that stratify risk in order to optimize perioperative process, manage resources and make targeted intervention to improve recovery, it is essential to know which factors are associated with each other and are associated with prolonged LOS. For the numerous types of surgical procedures there are a number of studies that have considered variables affecting LOS, however, the literature covering the vast range of major general surgery is limited, and especially from the developing healthcare context. Based on this observation, the objective of the present study was to identify and analyse the demographic, clinical, surgical and postoperative parameters contributing to prolonged hospitalisation after major general surgical procedure and thus put forward evidence to aid the development of better surgical management plans and outcomes for each individual patient.

Materials and Methods

Study Design and Participants: A prospective observational study of the Department of General Surgery of a tertiary care teaching hospital was done for 12 months. These patients were selected among adult procedures (aged >17 years) which were performed for major elective and emergency surgery, and involving postoperative hospitalization. If the patients were being treated with minor surgery, day-care surgery, trauma surgery, or were not recorded in the clinical records, patients who had died before they were discharged from the hospital were excluded. The study protocol has been approved by the Institutional Ethics Committee and informed written consent was taken from all the participants.

Data collection: Clinical information included in the protocol was collected using a pre-designed Case Report Form and included the following variables: demographic characteristics (age and sex), lifestyle factors (tobacco use and alcohol consumption), comorbidities (Diabetes Mellitus, hypertension, chronic kidney disease, chronic obstructive pulmonary disease, cardiovascular disease), American Society of Anesthesiologists (ASA) physical status, indication for surgery, surgical procedure, surgical approach (open/laparoscopic), surgical urgency, operative time, estimated blood loss, perioperative blood transfusion, intensive care unit (ICU) admission, and postoperative complications (including surgical site infection, pulmonary complications, urinary tract infection, postoperative ileus, and anastomotic leak).

Outcome Measures: The primary outcome was prolonged hospital stay (postoperative hospital stay > 75th percentile of the study population). Hospital length of stay (LoS) was determined by the number of days from surgery to hospital discharge. Secondary outcomes were the occurrence of surgical morbidity, intensive care unit (ICU) admission, 30-day readmission and in-hospital mortality.

Statistical Analysis: IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA) was used to analyze the data. Continuous variables were reported as mean ± SD or median (interquartile range) and categorical variables were reported as frequencies and percentages. All continuous variables were compared between the groups with independent t-test or Mann–Whitney U test, while categorical variables were compared between the groups with Chi-square or Fisher's exact test. All variables showing $p<0.10$ in univariate analysis and clinically relevant variables were included in a multivariable logistic regression model to identify independent predictors for hospital stay ≥24 hours. The odds ratios (OAs) were adjusted and reported with 95% confidence intervals (CIs). The area under the receiver operating characteristic (ROC) curve was used for the evaluation of model discrimination and the Hosmer–Lemeshow goodness-of-fit test was used for the evaluation of model calibration. A p value of < 0.05 on either side was deemed statistically significant.

Results

In the final analysis, 320 patients undergoing major general surgeries were included. Overall the study aimed to explore factors related to: (1) demographics, (2) clinical data, (3) operative data and, (4) perioperative data that was found to be associated with hospital stay. A total of 82 patients (25.6%) developed prolonged hospitalisation (>10 days) with a shorter postoperative hospitalisation in 238 patients (74.4%).

The distribution of patient-related risk factors, comorbidities, nutritional status and preoperative clinical parameters is summarized in [Table 1] which shows the baseline demographic and clinical data of the study population. The operative and perioperative characteristics summarized in [Table 2] are surgical procedures, operative complexity, intraoperative factors and perioperative management variables. The univariate analysis comparing prolonged hospital stay with no prolonged hospital stay are shown in [Table 3] and possible predictors associated with prolonged hospitalization are identified.

For the multivariable logistic regression testing [Table 4], independent the predictors which were obtained after adjustment of clinically relevant confounding factors. [Table 5] assesses the performance of the predictive model by discrimination, calibration and internal validation parameters; these parameters support the correctness of the model in identifying high-risk patients. [Figure 1] presents the distribution of the length of stay, which had high variability ranging from low to medium length, and also shows that a large number of patients needed more than the normal length of stay. The relative frequencies of complications following surgery are shown in [Figure 2], with the most critical clinical problems identified as a main factor in slow recovery. However, a linear duration of surgery to hospital stay relationship was reflected in [Figure 3]: with longer surgical duration, greater duration in the

hospital.

Table 1: Baseline Demographic and Clinical Characteristics of the Study Population (N = 320)

Variable	Category	n (%) or Mean ± SD
Age (years)	Mean ± SD	49.8 ± 15.6
	<40 years	86 (26.9)
	40–59 years	138 (43.1)
	≥60 years	96 (30.0)
Sex	Male	188 (58.8)
	Female	132 (41.2)
Body Mass Index (kg/m²)	Mean ± SD	25.6 ± 4.3
	Underweight (<18.5)	18 (5.6)
	Normal (18.5–24.9)	124 (38.8)
	Overweight (25.0–29.9)	126 (39.4)
	Obese (≥30.0)	52 (16.2)
Smoking Status	Current smoker	84 (26.3)
	Non-smoker	236 (73.7)
Alcohol Consumption	Yes	68 (21.3)
	No	252 (78.7)
Diabetes Mellitus	Yes	92 (28.8)
	No	228 (71.2)
Hypertension	Yes	108 (33.8)
	No	212 (66.2)
Coronary Artery Disease	Yes	36 (11.3)
	No	284 (88.7)
Chronic Kidney Disease	Yes	18 (5.6)
	No	302 (94.4)
Chronic Obstructive Pulmonary Disease	Yes	28 (8.8)
	No	292 (91.2)
Hemoglobin (g/dL)	Mean ± SD	11.9 ± 1.8
Preoperative Anemia*	Yes	114 (35.6)
	No	206 (64.4)
Serum Albumin (g/dL)	Mean ± SD	3.8 ± 0.6
Hypoalbuminemia†	Yes	74 (23.1)
	No	246 (76.9)
ASA Physical Status	I	54 (16.9)
	II	146 (45.6)
	III	98 (30.6)
	IV	22 (6.9)
Admission Type	Elective	232 (72.5)
	Emergency	88 (27.5)

Table 2: Operative and Perioperative Characteristics of the Study Population (N = 320)

Variable	Category	n (%) or Mean ± SD
Type of Surgical Procedure		
Gastrointestinal surgery		142 (44.4)
Hepatobiliary surgery		54 (16.9)
Colorectal surgery		48 (15.0)
Hernia and abdominal wall surgery		38 (11.9)
Endocrine surgery		22 (6.9)
Other major abdominal procedures		16 (5.0)
Surgical Approach		
Open surgery		218 (68.1)
Laparoscopic surgery		102 (31.9)
Surgical Priority		
Elective procedure		232 (72.5)
Emergency procedure		88 (27.5)
Wound Classification		
Clean		86 (26.9)
Clean-contaminated		146 (45.6)
Contaminated		64 (20.0)
Dirty/Infected		24 (7.5)
Duration of Surgery (minutes)	Mean ± SD	178.4 ± 72.6
	<120 minutes	96 (30.0)
	120–240 minutes	148 (46.3)
	>240 minutes	76 (23.7)
Estimated Blood Loss (mL)	Mean ± SD	286 ± 164
	≤200 mL	122 (38.1)

	201–500 mL	146 (45.6)
	>500 mL	52 (16.3)
Perioperative Blood Transfusion	Yes	62 (19.4)
	No	258 (80.6)
Intraoperative Vasopressor Requirement	Yes	48 (15.0)
	No	272 (85.0)
Intraoperative Complications	Yes	28 (8.8)
	No	292 (91.2)
Postoperative Drain Placement	Yes	186 (58.1)
	No	134 (41.9)
Initial Postoperative Care Location	Surgical ward	258 (80.6)
	Intensive care unit (ICU)	62 (19.4)
ICU Admission Duration (days)	Median (IQR)	3 (2–6)
Enhanced Recovery After Surgery (ERAS) Protocol Applied	Yes	164 (51.3)
	No	156 (48.7)

Table 3: Univariate Analysis of Factors Associated with Prolonged Hospital Stay Following Major General Surgical Procedures (N = 320)

Variable	Normal Hospital Stay (≤10 days) n=238	Prolonged Hospital Stay (>10 days) n=82	p value
Age (years), mean ± SD	47.1 ± 14.8	57.6 ± 15.4	<0.001
Age ≥60 years	54 (22.7)	42 (51.2)	<0.001
Male sex	138 (58.0)	50 (61.0)	0.642
BMI (kg/m²), mean ± SD	25.2 ± 4.1	26.8 ± 4.6	0.006
BMI ≥30 kg/m²	32 (13.4)	20 (24.4)	0.024
Current smoker	54 (22.7)	30 (36.6)	0.014
Alcohol use	44 (18.5)	24 (29.3)	0.038
Diabetes mellitus	58 (24.4)	34 (41.5)	0.003
Hypertension	72 (30.3)	36 (43.9)	0.031
Chronic kidney disease	8 (3.4)	10 (12.2)	0.006
COPD	16 (6.7)	12 (14.6)	0.035
Hemoglobin (g/dL), mean ± SD	12.2 ± 1.7	11.1 ± 1.9	<0.001
Preoperative anemia	70 (29.4)	44 (53.7)	<0.001
Serum albumin (g/dL), mean ± SD	4.0 ± 0.5	3.4 ± 0.6	<0.001
Hypoalbuminemia	38 (16.0)	36 (43.9)	<0.001
ASA physical status III–IV	54 (22.7)	66 (80.5)	<0.001
Emergency surgery	48 (20.2)	40 (48.8)	<0.001
Open surgical approach	146 (61.3)	72 (87.8)	<0.001
Operative duration (minutes), mean ± SD	154.6 ± 58.4	247.8 ± 86.2	<0.001
Operative duration >240 minutes	36 (15.1)	40 (48.8)	<0.001
Estimated blood loss (mL), mean ± SD	242 ± 136	414 ± 196	<0.001
Blood transfusion requirement	32 (13.4)	30 (36.6)	<0.001
ICU admission	26 (10.9)	36 (43.9)	<0.001

Table 4: Multivariable Logistic Regression Analysis Identifying Independent Predictors of Prolonged Hospital Stay Following Major General Surgical Procedures (N = 320)

Independent Predictor	β Coefficient	Standard Error	Adjusted Odds Ratio (aOR)	95% Confidence Interval	p value
Age ≥60 years	0.842	0.321	2.32	1.24–4.34	0.008
BMI ≥30 kg/m²	0.516	0.274	1.68	0.98–2.89	0.058
Diabetes mellitus	0.638	0.289	1.89	1.07–3.35	0.029
Chronic kidney disease	0.774	0.386	2.17	1.02–4.61	0.044
Preoperative anemia	0.691	0.274	1.99	1.16–3.42	0.013
Hypoalbuminemia (<3.5 g/dL)	1.021	0.301	2.78	1.54–5.02	<0.001
ASA physical status III–IV	1.146	0.342	3.15	1.60–6.21	0.001
Emergency surgery	0.918	0.312	2.50	1.36–4.59	0.003
Open surgical approach	0.584	0.297	1.79	1.00–3.22	0.049
Operative duration >240 minutes	1.284	0.335	3.61	1.87–6.97	<0.001
Estimated blood loss >500 mL	0.746	0.329	2.11	1.11–4.02	0.023
Perioperative blood transfusion	0.663	0.318	1.94	1.04–3.63	0.038
ICU admission	1.392	0.356	4.02	2.00–8.09	<0.001

Multivariable Model Summary

Parameter	Value
Number of patients included	320
Patients with prolonged stay	82 (25.6%)
Variables entered into model	13
−2 Log likelihood	238.6
Nagelkerke R^2	0.52

Hosmer–Lemeshow goodness-of-fit test	$\chi^2 = 6.82$, p = 0.614
Area under ROC curve (AUC)	0.86 (95% CI 0.81–0.91)
Overall classification accuracy	82.8%

Table 5: Predictive Performance and Internal Validation of the Multivariable Model for Prolonged Hospital Stay

Model Performance Parameter	Value
Discrimination	
Area under receiver operating characteristic curve (AUC)	0.86
95% Confidence interval for AUC	0.81–0.91
Standard error of AUC	0.026
p value for AUC	<0.001
Classification Performance (Optimal Cut-off Probability = 0.50)	
Sensitivity	78.0%
Specificity	84.5%
Positive predictive value (PPV)	65.7%
Negative predictive value (NPV)	91.1%
Overall accuracy	82.8%
Positive likelihood ratio (LR+)	5.03
Negative likelihood ratio (LR−)	0.26
Model Calibration	
Hosmer–Lemeshow goodness-of-fit test (χ^2)	6.82
Hosmer–Lemeshow p value	0.614
Calibration slope	0.94
Calibration intercept	−0.06
Explained Variance and Information Criteria	
Cox & Snell R^2	0.39
Nagelkerke R^2	0.52
−2 Log likelihood	238.6
Akaike Information Criterion (AIC)	266.6
Internal Validation	
Bootstrap iterations	1000
Optimism-corrected AUC	0.84
Shrinkage factor	0.91

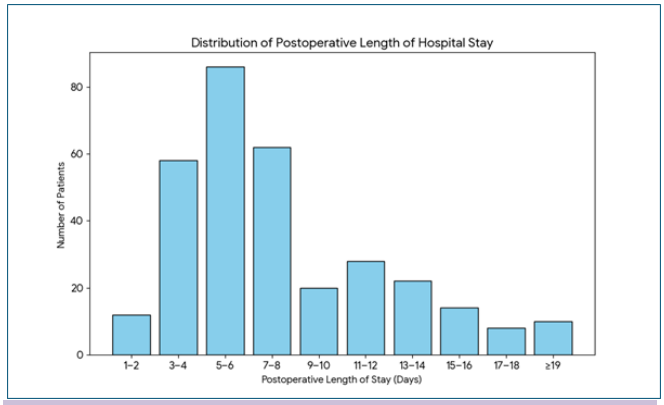

Figure 1: Distribution of Postoperative Length of Hospital Stay

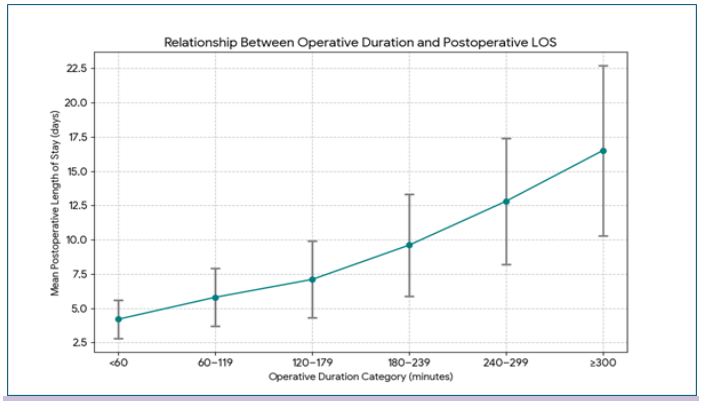

Figure 3: Relationship Between Operative Duration and Postoperative Length of Hospital Stay

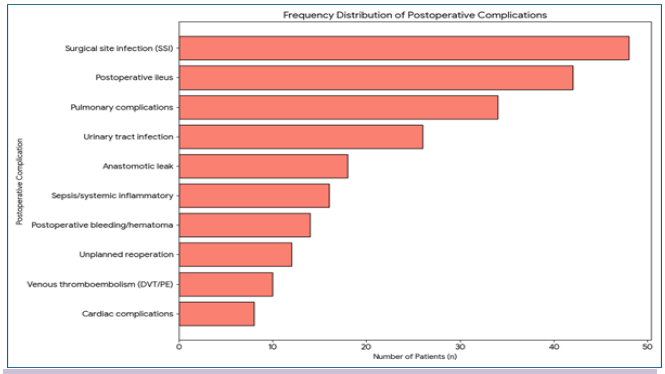

Figure 2: Frequency Distribution of Postoperative Complications Following Major General Surgical Procedures

Discussion

The current study aimed to determine demographic, clinical, operative and peri-operative factors associated with extended hospitalisation after major general surgical procedures. In this group, Advanced Age, ASA physical status, Emergency surgery, Longer operating time, Lower albumin, Blood loss, Admission to the intensive care unit, and Post-operative complications were found to be important factors associated with prolonged hospitalisation (more than 10 days). The multivariable model had good discrimination (AUC 0.86), which suggests that some perioperative factors and vulnerability can help identify patients at higher risk for delayed recovery.

Our study showed that a significant number of patients remain

in hospital for a prolonged period, which is comparable with previous surgical research reporting significant variations in postoperative hospital stay based on patient characteristics, surgery complexity and resources provided. Tefera et al. pointed out prolonged hospital stay in adult surgical patients and showed that age, presence of malaria, emergency admission and postoperative complications significantly predicted prolonged stay in the hospital among the adult surgical patients in Ethiopia.[1] In a large cohort of tertiary care patients, Marfil-Garza et al. found that increased length of stay correlated with medical complexity and disease severity as well as age at admission.[2] The results are consistent with what we observed: preoperative patient vulnerability is a big factor in postoperative recovery.

Age>60 years and ASA III-IV were independent predictors of longer hospital stay in the current study, indicating that, along with increased physiological reserve, increased levels of comorbidities are significant predictive factors of delayed postoperative recovery. This corroborates the findings of Hewitt et al. who put together a systematic review and meta-analysis that, after general surgery, frailty corresponds with a higher prevalence of postoperative complications and extended hospitalization.[10] In a comparable study, Kefie et al. have previously shown that age, co-morbidities, and peri-operative complications had significant impact on the length of post surgery stay in adult surgical patients.[9]

Another important condition was nutritional status as hypoglycaemia and hypoalbuminemia were predictors of longer hospital stay. Low levels of serum albumin are of importance because they denote decreased nutritional reserve, systemic inflammation and diminished stress coping capacity following surgery. Malnutrition and frailty have previously been shown to be key factors in poor surgical outcomes. Hewitt et al. highlighted that following surgery, frailty-related physiological decline is linked to improvements in the outcomes of surgery as well as delayed recovery.[10] These results further emphasize the necessity of performing nutritional evaluation, optimizing an individual's nutrition prior to a major surgical procedure.

In our work, complexity of operation was strongly related to the length of the hospital stay. Patients who underwent procedures that lasted >240 minutes were 3.5 times more likely to be hospitalized for longer periods. Walędziak et al reported many factors influencing the length of stay after appendectomy; operative factors and postoperative morbidity were found to have a significant impact on LLS after laparoscopic appendectomy in a large, multicenter study of over 3,000 patients.[15] In addition, Bath et al. have identified the periodicity of recovery after trauma laparotomy is variable internationally, with variability driven by the complexity of the surgery performed, the state of the patient at surgery and a variety of issues relating to the healthcare system.[16]

Postoperative complications are still the most important factors for discharge delay. With our cohort these were strongly correlated with long hospital stay for the ICP, surgical complications and for infectious events. Thompson et al. has previously shown an association between hospital acquired pneumonia after IAP surgery and increased morbidity, mortality and healthcare cost making the effects of postoperative complications on utilization of healthcare resources a cause of great concern.[3] More recently, Zhang and colleagues described a number of risk factors and phenotypes for surgical site infection in the setting of abdominal surgery, recognizing how well postoperative infection can contribute to an adverse surgical outcome and lengthen recovery.[6] Likewise, Toh et al. reported that the diversity in care process and postoperative complications of an Enhanced Recovery After Surgery (ERAS) pathway can have a significant effect on length of stay after colorectal surgery.[5]

The effects of ERAS pathways in decreasing postoperative hospital stay have been consistently proven. There was no reduced safety outcome after the application of ERAS in minimally invasive colorectal surgery, while the hospital stay was shortened, reported by Li et al.[4] The results of this study re-emphasize the need for standardized peri-operative pathways regarding the early mobilization of the patient, optimizing the management of pain, monitoring of nutritional issues and implementing strategies to prevent complications, especially in patients deemed to be at risk of long term hospital stay.

It seems likely that this multivariable model (AUC 0.86) could be useful in clinical settings and used as an approach to early risk stratification. With the recent development of predictive analytics, there is increasing recognition of the potential of combining multiple peri-operative variables to assist in the prediction of outcome. Wang et al. showed the potential of machine learning methods to improve prediction of postoperative outcomes after gastrointestinal surgery and Elfanagely et al. noted the evolving nature of artificial intelligence-based models in surgical risk prediction.[7,8] Our model was based on logistic regression; however, the model's identified predictors provide a clinically interpretable framework which could facilitate the development of improved prediction tools in the future.

Healthcare-wise, having a plan for them as patients who are high risks for long hospital stays have implications for resource allocation, discharge planning and targeted perioperative interventions. Malaysia and Ethiopia have garnered attention from studies showing that a variety of patient-and system-level factors impacts LOS.[13,14] Thus, predictive models tailored by hospital or institution that feature local surgical practices can offer useful insights to facilitate efficiency and the delivery of patient-centered care.

Limitations: There were several limitations in this study. Firstly, the data from the single-center observational study may not be applicable to other hospitals with distinct surgical populations or resources. Second, multivariable regression was used to control for potential confounders but the possibility of residual confounding cannot be ruled out due to exclusion of other factors like socioeconomic status, surgeon experience and postoperative rehabilitation pathways. Third, prolonged hospital stay was created with a threshold from the population, possibly with different values in different health care systems. Lastly, external validation of the predictive model was not conducted and, thus, future multicenter studies with larger numbers of patients are necessary to ensure the robustness and clinical applicability of the model.

Conclusion

Long post-operative hospital admissions after major general surgery is a multi-factorial outcome dependent upon patient vulnerability, surgical complexity and post-surgical events. In this study, advanced age, ASA physical status, emergency surgery, longer operative time, hypoalbuminemia, higher blood loss and admission to the ICU were singled out as independent parameters associated with longer hospital stay. The constructed multivariable model was well predictive and could potentially help clinicians to identify those patients who are at increased risk during the pre- and post-operative period and may require further optimization. Standardized risk assessment, nutritional optimization, enhanced recovery pathways and proactive strategies to prevent surgical complications may help to mitigate avoidable in-patient stay and optimize the utilization of surgical resources. These results need to be replicated in additional multicenter studies to establish the generalizability of these findings.

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Conflicts of interest

There are no conflicts of interest.

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