Predicting Functional Decline in Geriatric Abdominal Surgery Patients: Unveiling Incidence, Risk Factors, and Innovative Predictive Models in Thailand

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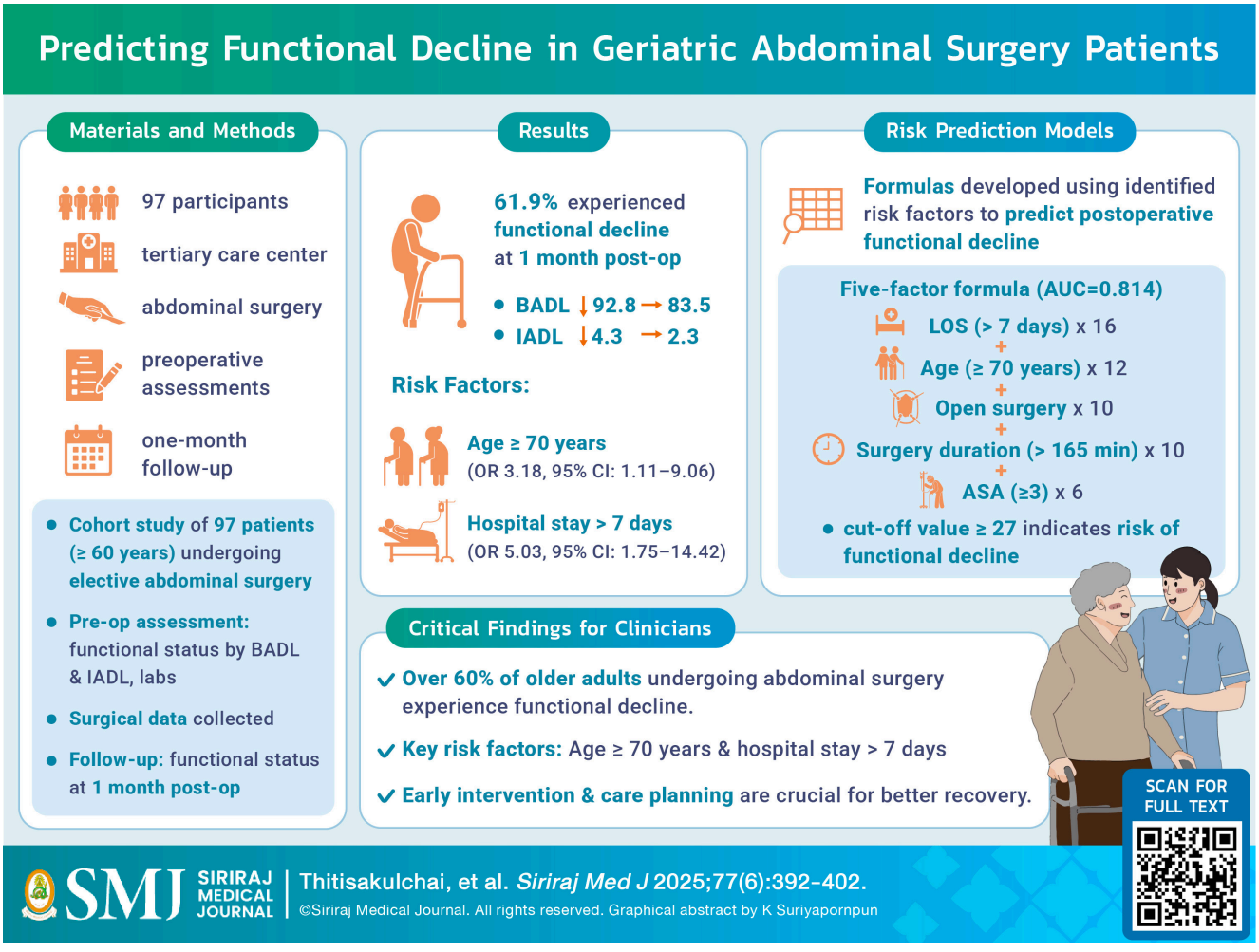

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ABSTRACT

Objective: Surgery poses significant challenges for older adults, potentially leading to functional decline. This study investigated the incidence and risk factors associated with postoperative functional decline in older adults and developed formulas to predict its occurrence.

Materials and Methods: This cohort study analyzed patients aged 60 and over who underwent elective abdominal surgery at a tertiary care center in Thailand. The baseline characteristics including Basic Activities of Daily Living [BADL] and Instrumental Activities of Daily Living [IADL] scores, preoperative laboratory testing and surgery-related data were recorded. Functional status was reassessed one month post-surgery.

Results: The study involved 97 participants. One month post-surgery, the incidence of functional decline was 61.9%. The mean BADL and IADL scores in the functional decline group decreased from 92.8 ± 11.3 to 83.5 ± 17.8 and from 4.3 ± 1.3 to 2.3 ± 1.3, respectively ($p<0.001$). Multivariable logistic regression analysis identified age ≥ 70 years (adjusted OR 3.18, 95% CI 1.11–9.06, $p=0.031$) and a length of stay > 7 days (adjusted OR 5.03, 95% CI 1.75–14.42, $p=0.003$) as factors most strongly associated with functional decline. Formulas created using five factors related to decline from univariable analyses effectively predicted its occurrence, with AUCs ranging from 0.766 to 0.814.

Conclusion: Over 60% of older adults who underwent abdominal surgery experienced functional decline one month after surgery. The developed formulas can be used to identify patients at risk and help prevent functional decline in this population.

Keywords: Activities of daily living; functional status; geriatrics; risk factors; surgery (Siriraj Med J 2025; 77: 392-402)

INTRODUCTION

The aging of the global population has become a growing concern in recent years. One of the most prevalent issues among older adults is functional decline,[1] which is characterized by a decreased ability to perform activities of daily living. This condition poses significant challenges, adversely impacting their independence, social interactions, overall life satisfaction, and quality of life.[2]

In addition, older individuals often battle diverse illnesses, including some that may require surgical intervention. For those in advanced age, undergoing major surgery represents a critical event that can expose them to various complications. It can result in both short-term and sustained functional decline, which can shorten their survival, increase healthcare utilization, or even lead to institutionalization after surgery.[3-5]

Several studies have sought to identify risk factors associated with postoperative functional decline and poorer surgical outcomes in older individuals across various circumstances.[4–14] Researchers have also attempted to predict this decline using predictive indices that encompass a range of parameters and screening tools with varying degrees of accuracy.[15-18] However, for elective abdominal surgery, which accounts for approximately 40% of all surgical procedures performed on older patients in our institution, the frequency and determinants of postoperative functional decline remain unclear. Furthermore, a simple and effective method to predict and identify at-risk individuals has yet to be established.

Against this background, our research aims to identify the incidence rate and risk factors of functional decline following elective abdominal surgery in older adults. Additionally, we aim to utilize these factors to formulate simple equations that predict its occurrence. We believe these findings will offer valuable insights into patient care by aiding in the identification of individuals at risk, enabling healthcare providers to implement appropriate interventions, and potentially improving patient outcomes and recovery trajectories.

MATERIALS AND METHODS

Study design

This prospective cohort study was conducted at a tertiary care center in Thailand between August 2019 and March 2021. Corresponding to the statutory retirement age in Thailand, the inclusion criteria comprised individuals aged 60 years and older who were undergoing elective abdominal surgery. The exclusion criteria included patients scheduled solely for gastrostomy or jejunostomy, as well as those already in a state of dependence (Barthel Index < 10).

Measurements

The ASA Physical status serves as a classification system for assessing the preoperative health status of

individuals. The scale comprises five classes, ranging from ASA 1 to ASA 5. Notably, an ASA status of 3 or higher is reported to be related to poorer postoperative outcomes.[13-15]

Physical condition was assessed using the Medical Research Council sum score and a 30-second chair stand test. The sum score comprises the combined scores from 6 muscle groups in the upper and lower extremities on both sides.[19] The score ranges from 0 to 60, and is typically used to evaluate global peripheral muscle strength. The 30-second chair stand test involves recording the total number of completed chair stands executed in 30 seconds. The test assesses lower body strength and endurance in older adults.[20]

Functional status was measured by evaluating Basic Activities of Daily Living (BADLs) and Instrumental Activities of Daily Living (IADLs) using the Barthel Index and the Lawton IADL scale, respectively. The Barthel Index evaluates a patient's functionality across 10 BADL items (feeding, grooming, transfer, toilet use, mobility, dressing, stairs, bathing, and bowel and bladder control) with a final score ranging from 0 to 100,while the Lawton IADL scale was used to assess 5 IADL items (ability to use telephone, shopping, transportation, managing medications, and managing finances), with an overall score ranging from 0 to 5. [21,22,23] For both indices, scores are assigned based on the ability to perform each task independently, and lower scores indicate a higher level of dependency.

Cognitive function was evaluated using the Thai Mental State Examination (TMSE). With the maximum score of 30, a higher score represents better cognitive function. A cutoff score of < 24 is used to signify the presence of cognitive impairment.[24]

Nutritional status was evaluated by the Mini Nutritional Assessment short-form (MNA-SF), a validated tool designed to assess nutritional status in older adults. The score can range from 0 to 14, with higher scores indicating better nutrition. Patients with a score of 7 or lower were considered malnourished.[25]

Depression was evaluated through the Patient Health Questionnaire-9 (PHQ-9), which comprises 9 items assessing the frequency of depressive symptoms experienced by patients. Each item is scored on a scale from 0 to 3, resulting in an overall score ranging from 0 to 27. A cutoff score of ≥ 9 is applied to identify the presence of depression.[26]

Quality of life was assessed using the EQ-5D-5L questionnaire, which covers 5 dimensions with 5 items each. Responses were converted into an index value, known as the utility score, utilizing standard values specific to Thailand. The maximum utility score is 1, with a higher value indicating a better health state. Additionally, participants were asked to rate their self-perceived current health status using the EQ Visual Analogue Scale (EQ-VAS), which ranges from 0 (worst) to 100 (best health).

Data collection

Before surgery, a research assistant, uninvolved in any therapeutic procedures, collected data on patient demographics, physical condition, functional status, cognitive function, depressive symptoms, nutritional status, and quality of life. Preoperative laboratory tests were conducted to measure hemoglobin, albumin, and vitamin D levels. After discharge, another research assistant retrospectively reviewed medical records to collect perioperative details, including the type of surgery (upper abdominal, lower abdominal, or urological), surgical technique (open or laparoscopic), surgery duration, estimated blood loss (EBL), and length of stay (LOS). Postoperative complications, such as infectious, surgical, cardiovascular, respiratory, renal, and neurological issues, were documented according to established criteria from previous studies.[13,27] One month after surgery, the initial research assistant conducted a telephone follow-up to reassess each patient's functional status, depressive symptoms, and quality of life. Of all participants, only one remained hospitalized and was reassessed directly in the ward. The participants were then divided into 2 groups (functionally stable and functionally declined) based on changes in their functional capacity between baseline and follow-up. In line with a preceding study, functional decline was defined as a decrease of ≥ 10 points in BADLs on the Barthel Index or ≥ 2 points in IADLs on the Lawton IADL scale between the 2 assessments.[12]

Statistical analyses

Continuous variables with normal distributions are presented as means ± standard deviations, while non-normally distributed variables are shown as medians (IQR). Categorical data are expressed as numbers and percentages. As cut-off points for continuous variables, such as LOS, EBL, and surgery duration, are typically determined based on clinical context or operation category, we employed Receiver Operating Characteristic (ROC) analyses to define optimal thresholds. These cut-off values were selected to achieve the best balance between sensitivity and specificity, as determined by the Youden index.[28] The corresponding area under the ROC curve (AUC) values for the selected thresholds are as follows: LOS > 7 days (0.725), EBL > 550 ml (0.586), and surgery

duration > 165 minutes (0.598). Associations between variables and outcomes in the univariable analysis were assessed using independent t-tests, chi-square tests, or Mann–Whitney U tests, as appropriate. Comparisons of BADLs and IADLs within groups were analyzed using paired t-tests, while comparisons between groups were analyzed using independent t-tests. A p-value of less than 0.05 was considered significant for all analyses. Factors showing statistical significance in the univariable analysis were introduced into a multivariable logistic regression model to control for potential confounding factors. These significant factors were also used to formulate predictive equations for postoperative functional decline. Model discrimination was assessed by the AUC of each equation. All analyses were conducted using PASW Statistics for Windows, version 18.0 (SPSS Inc, Chicago, IL, USA).

RESULTS

A total of 190 patients scheduled for elective abdominal surgery and meeting the inclusion criteria were approached. Of these, 100 provided informed consent to participate in the study. However, 2 were not operated on due to unstable medical conditions, and 1 died after surgery. Consequently, these 3 were excluded from the final study cohort (Fig 1). The remaining 97 participants had a mean age of 70.2 ± 6.6 years, with 64.9% being male. 37.1% had an ASA classification of 3, while the rest had a classification of 2. The mean TMSE score was 25.1 ± 3.9, while the mean BADL and IADL scores were 92.8 ± 11.1 and 4.1 ± 1.5, respectively. The mean MNA-SF score, blood albumin, and vitamin D levels were within normal ranges and no statistical significance was observed between the groups (Table 1).

Regarding the operation, 71.1% were open surgeries, while 28.9% were performed laparoscopically. 69.1% of the surgical procedures exceeded a duration of 165 minutes. The median LOS was 7 days (IQR 5–10), with 44.3% of participants staying more than 7 days (Table 2). Nearly one-third of participants (28.9%) had 1 or more postoperative complications during admission. The most common complications were infectious, surgical, cardiovascular, renal, neurological, and respiratory (10.3%, 7.2%, 6.2%, 6.2%, 5.2%, and 4.1%) respectively.

At the one month follow-up, the incidence of functional decline, as defined previously, was 61.9%. Within the decline group, 31.7% showed a decrease in BADLs only, 46.7% in IADLs only, and 21.7% in both BADLs and IADLs. The BADL items significantly impacted were mobility, stair climbing, bathing, toilet use, and bladder control, while all aspects of IADL except telephone usage were affected. No statistically significant improvement in EQ-5D-5L utility score was observed for both the functionally stable and the functionally declining group. However, the stable group reported a significantly higher EQ-VAS (self-perceived health) score post operation than the declining group (77.6 ± 12.3 vs.

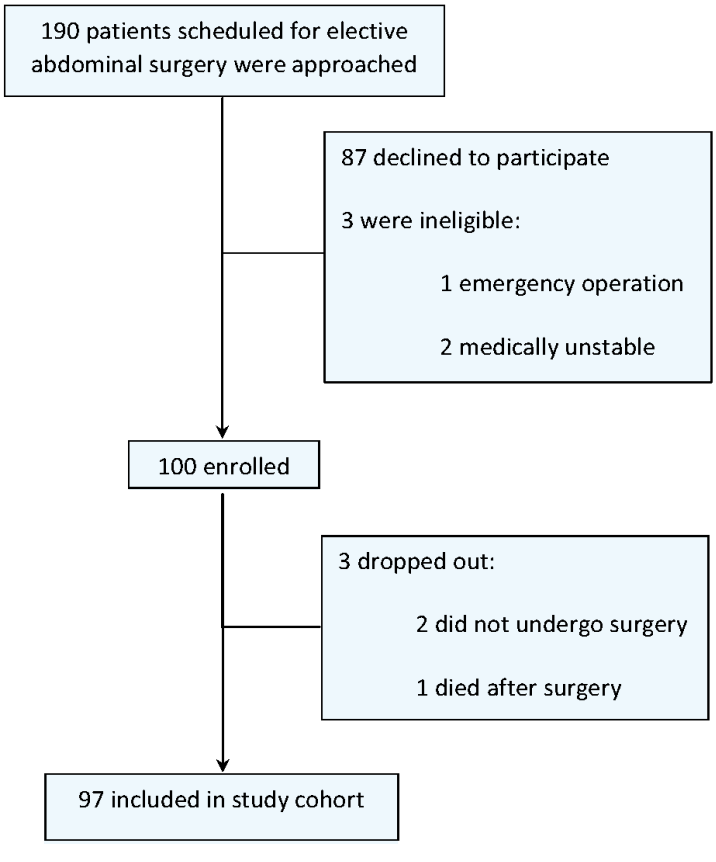

Fig 1. Flow diagram of the study.

TABLE 1. Baseline characteristics of patients and preoperative laboratory findings.

Variables	Total n = 97	Stable n = 37	Functional decline n = 60	p-value
Age (years), M (SD)	70.2 (6.6)	69.0 (6.6)	70.9 (6.6)	0.175
60–69, n (%)	51 (52.6)	26 (70.3)	25 (41.7)	0.006*
≥ 70, n (%)	46 (47.4)	11 (29.7)	35 (58.3)	
Sex, n (%)				
Male	63 (64.9)	25 (67.6)	38 (63.3)	0.671
Female	34 (35.1)	12 (32.4)	22 (36.7)	
BMI (kg/m^2), M (SD)	23.7 (3.8)	24.0 (3.9)	23.6 (3.8)	0.601
Education, n (%)				
≤ 12 years	71 (73.2)	28 (75.7)	43 (71.7)	0.665
> 12 years	26 (26.8)	9 (24.3)	17 (28.3)	
Comorbidities, n (%)				
Diabetes mellitus	29 (29.9)	10 (27.0)	19 (31.7)	0.628
Hypertension	64 (66.0)	21 (56.8)	43 (71.7)	0.132
Dyslipidemia	35 (36.1)	11 (29.7)	24 (40.0)	0.306
Chronic kidney disease	3 (3.1)	0 (0)	3 (5.0)	0.285
Musculoskeletal problems	36 (37.1)	10 (27.0)	26 (43.3)	0.106
ASA physical status, n (%)				
ASA 3	36 (37.1)	9 (24.3)	27 (45.0)	0.041*
ASA 2	61 (62.9)	28 (75.7)	33 (55.0)	
Ambulatory status, n (%)				
Walking	94 (96.9)	35 (94.6)	59 (98.3)	0.556
Chair-bound	3 (3.1)	2 (5.4)	1 (1.7)	
Walking assistance, n (%)				
With gait aid	11 (11.3)	4 (10.8)	7 (11.7)	1.00
Without gait aid	86 (88.7)	33 (89.2)	53 (88.3)	
BADL score, M (SD)	92.8 (11.1)	93.0 (10.8)	92.8 (11.3)	0.924
IADL score, M (SD)	4.1 (1.5)	3.7 (1.7)	4.3 (1.3)	0.084
Hemoglobin (g/dl), M (SD)	11.9 (2.1)	12.2 (2.1)	11.6 (2.0)	0.167
Albumin (g/dl), M (SD)	4.0 (0.5)	3.9 (0.4)	4.0 (0.6)	0.812
Vitamin D (ng/ml), M (SD)	25.4 (9.2)	25.8 (8.7)	25.2 (9.6)	0.727
MRC sum score, M (SD)	58.4 (3.3)	58.1 (3.7)	58.5 (3.1)	0.538
30 sec chair stand (times), M (SD)	10.9 (4.1)	11.2 (4.4)	10.7 (4.0)	0.575
MNA-SF score, M (SD)	11.0 (2.7)	11.0 (2.5)	10.9 (2.8)	0.846
TMSE score, M (SD)	25.1 (3.9)	25.1 (4.4)	25.1 (3.6)	0.949

Continuous data were analyzed using independent t-tests, and categorical data were analyzed using chi-square tests.

* Significant at p-value < 0.05

Abbreviations: ASA, American Society of Anesthesiologists; BADL, Basic Activities of Daily Living; BMI, Body Mass Index; IADL, Instrumental Activities of Daily Living; M, mean; MNA-SF, Mini Nutritional Assessment short-form; MRC, Medical Research Council; SD, standard deviation; TMSE, Thai Mental State Examination

TABLE 2. Surgery-related variables

Variables	Total n = 97	Stable n = 37	Functional decline n = 60	p-value
Type of surgery, n (%)				
Upper abdominal	33 (34.0)	16 (43.2)	17 (28.3)	0.132
Lower abdominal	29 (29.9)	12 (32.4)	17 (28.3)	0.668
Urological procedures	35 (36.1)	9 (24.3)	26 (43.3)	0.058
Method of surgery, n (%)				
Open surgery	69 (71.1)	21 (56.8)	48 (80.0)	0.014*
Laparoscopic surgery	28 (28.9)	16 (43.2)	12 (20.0)	
Surgery duration, median (IQR)	205 (155,285)	185 (150,260)	207.5 (170,322.5)	0.106
> 165 minutes, n (%)	67 (69.1)	21 (56.8)	46 (76.7)	0.039*
EBL, median (IQR)	150 (400,1100)	300 (100,700)	490 (150,1280)	0.158
> 550 ml, n (%)	37 (38.1)	10 (27.0)	27 (45.0)	0.077
≥ 1 complication, n (%)	28 (28.9)	7 (18.9)	21 (35.0)	0.090
LOS (days), median (IQR)	7 (5,10)	6 (4,7)	8 (6,12.5)	< 0.001*
> 7 days, n (%)	43 (44.3)	7 (18.9)	36 (60.0)	< 0.001*

Categorical data were analyzed using chi-square tests. Non-normally distributed data are presented as median (IQR) and analyzed using Mann–Whitney U tests.

* Significant at p-value < 0.05

Abbreviations: IQR, interquartile range; LOS, length of stay; EBL, estimated blood loss; ml, milliliter; M, mean; SD, standard deviation

72.8 ± 14.9, p=0.023). The stable group also presented a lower postoperative PHQ-9 score (fewer depressive symptoms) than the declining group (2.8 ± 3.2 vs. 3.9 ± 3.7, p=0.051; Table 3).

Factors found to be associated with functional decline from the univariable analysis were age ≥ 70, ASA ≥ 3, open surgery technique, surgery duration > 165 minutes, and LOS > 7 days. After a multivariable analysis adjusting for other variables in the model, the factors significantly associated with postoperative functional decline were age ≥ 70 (adjusted odds ratio [OR] 3.18, 95% confidence interval [CI] 1.11–9.06) and LOS > 7 days (adjusted OR 5.04, 95% CI 1.75–14.42; Table 4). Other variables, including laboratory testing, physical condition, and nutritional status, showed no significant association with functional changes after surgery.

The five factors showing statistical significance from the univariable analysis were used to develop four predictive equations. These equations incorporated either two, three, four, or all five factors in order of their significance. To predict the risk of functional decline, each factor present in a patient was assigned a value of 1, and its absence a value of 0. This value was then multiplied by a coefficient derived from the β coefficient of each factor, representing its association with decline. If the resulting value from each equation met or exceeded the cut-off, it indicated a risk of postoperative functional decline. The predictive accuracy increased with the number of factors used, yielding AUCs of 0.766, 0.788, 0.805, and 0.814 for the two-, three-, four-, and five-factor formulas, respectively. The five-factor formula showed the best performance, with an accuracy of 74.2%, a positive predictive value of 83.0%, a negative predictive value of 63.6%, a sensitivity of 73.3%, and a specificity of 75.7% (p<0.001) (Table 5).

DISCUSSION

This study examined the incidence rate and risk factors associated with postoperative functional decline following elective abdominal surgery in older patients. Our findings revealed that nearly two-thirds of the patients experienced a decline in function one month after surgery. Age ≥ 70 and LOS > 7 days were identified as the factors

TABLE 3. Comparison of pre- and postoperative outcome scores.

Variables	Stable n = 37			Functional decline n = 60			
	Preop	Postop	Post–Pre	Preop	Postop	Post–Pre	p-value
BADL score, M (SD)	93.0 (10.8)	94.5 (10.7)	1.5 (3.5)	92.8 (11.3)	83.5 (17.8)	-9.3 (11.6)	< 0.001*
Feeding	10.0 (0)	10.0 (0)	0	9.8 (0.9)	9.6 (1.7)	-0.3 (1.7)	0.260
Transfer	14.2 (2.8)	14.3 (2.7)	0.1 (0.8)	14.8 (0.9)	14.6 (1.7)	-0.3 (1.7)	0.202
Grooming	5.0 (0)	5.0 (0)	0	4.9 (0.6)	4.8 (0.9)	-0.1 (0.6)	0.435
Toilet use	9.9 (0.8)	9.7 (1.6)	-0.1 (0.8)	9.8 (0.9)	8.9 (2.8)	-0.9 (2.3)	0.021*
Bathing	4.7 (1.1)	4.7 (1.1)	0	4.8 (1.1)	4.1 (2.0)	-0.7 (1.9)	0.010*
Mobility	14.1 (2.8)	14.3 (2.7)	0.3 (1.1)	14.5 (2.0)	13.5 (3.9)	-1.0 (3.0)	0.004*
Stairs	9.1 (2.8)	9.3 (2.4)	0.3 (1.1)	9.4 (2.3)	6.6 (4.7)	-2.8 (4.6)	< 0.001*
Dressing	9.9 (0.8)	9.9 (0.8)	0	9.8 (1.1)	9.5 (1.5)	-0.3 (1.1)	0.083
Bowels	8.8 (3.0)	8.5 (3.3)	-0.3 (2.0)	7.5 (4.0)	7.1 (4.3)	-0.4 (3.5)	0.817
Bladder	7.4 (4.2)	8.7 (3.0)	1.2 (3.2)	7.3 (4.0)	4.8 (4.9)	-2.5 (4.5)	< 0.001*
IADL score, M (SD)	3.7 (1.7)	3.6 (1.8)	-0.1 (0.7)	4.3 (1.3)	2.3 (1.3)	-1.9 (1.3)	< 0.001*
Telephone	0.9 (0.3)	0.9 (0.3)	0 (0.2)	1.0 (0.2)	0.9 (0.3)	-0.1 (0.3)	0.266
Shopping	0.6 (0.5)	0.6 (0.5)	0 (0.4)	0.9 (0.4)	0.2 (0.4)	-0.7 (0.5)	< 0.001*
Transportation	0.7 (0.5)	0.6 (0.5)	-0.1 (0.3)	0.7 (0.5)	0.3 (0.5)	-0.4 (0.5)	0.001*
Managing medications	0.8 (0.4)	0.8 (0.4)	0 (0.4)	0.9 (0.3)	0.8 (0.4)	-0.2 (0.4)	0.015*
Managing finances	0.7 (0.5)	0.7 (0.5)	-0.1 (0.4)	0.8 (0.4)	0.2 (0.4)	-0.6 (0.5)	< 0.001*
EQ-5D-5L, M (SD)	0.87 (0.17)	0.93 (0.15)	0.05 (0.20)	0.87 (0.14)	0.87 (0.19)	0 (0.20)	0.209
EQ-VAS, M (SD)	68.5 (16.2)	77.6 (12.3)	9.1 (16.1)	72.5 (16.3)	72.8 (14.9)	0.3 (19.2)	0.023*
PHQ-9, M (SD)	4.0 (4.2)	2.8 (3.2)	-1.2 (3.9)	3.3 (3.1)	3.9 (3.7)	0.6 (4.3)	0.051

* Significant at p-value < 0.05

Abbreviations: BADL, Basic Activities of Daily Living; IADL, Instrumental Activities of Daily Living; M, mean; PHQ-9, Patient Health Questionnaire-9; SD, standard deviation

most closely associated with the decline, while other factors, such as ASA ≥ 3, surgery duration > 165 minutes, and the use of open surgery techniques, showed a lower level of association. These findings emphasize the need for evaluations that address not only surgical risk but also strategies to mitigate postoperative functional decline, while highlighting the importance of incorporating geriatric considerations into surgical care to optimize patient-centered outcomes. By combining these factors, we developed a predictive model that integrates commonly available clinical variables to estimate the likelihood of functional decline following surgery. This approach underscores the potential for individualized patient management and proactive planning, ultimately aiming to reduce the burden of postoperative morbidity in older populations.

TABLE 4. Results of multivariable logistic regression analysis to determine predictive factors for postoperative functional decline.

Variables	β coefficients	Crude odds ratio (95% CI)	p-value	Adjusted odds ratio (95% CI)	p-value
Age ≥ 70 years	1.155	3.30 (1.38–7.91)	0.006	3.18 (1.11–9.06)	0.031*
ASA ≥ 3	0.621	2.55 (1.03–6.31)	0.041	1.86 (0.62–5.59)	0.268
Open surgery	1.088	3.05 (1.23–7.55)	0.014	2.97 (0.98–8.99)	0.054
Surgery duration > 165 min	0.982	2.50 (1.04-6.06)	0.039	2.67 (0.93-7.68)	0.069
LOS > 7 days	1.614	6.43 (2.43-16.98)	< 0.001	5.03 (1.75–14.42)	0.003*

* Significant at p-value < 0.05

Abbreviations: ASA, American Society of Anesthesiologists; LOS, length of stay. Each variable was adjusted for other variables included in the model.

TABLE 5. Receiver operating characteristics of the predictive formulas.

Formula characteristics	Two-factor formula	Three-factor formula	Four-factor formula	Five-factor formula
AUC	0.766	0.788	0.805	0.814
p-value	<0.001	<0.001	<0.001	<0.001
Accuracy (95%CI)	74.2% (64.3-82.6)	75.3% (65.5-83.5)	73.2% (63.2-81.7)	74.2% (64.3-82.6)
PPV (95%CI)	76.9% (68.9-83.3)	82.1% (72.7-88.8)	85.4% (74.6-92.1)	83.0% (73.1-89.8)
NPV (95%CI)	68.8% (54.1-80.4)	65.9% (53.9-76.1)	61.2% (51.3-70.3)	63.6% (52.5-73.4)
Sensitivity (95%CI)	83.3% (71.5-91.7)	76.7% (64.0-86.6)	68.3% (55.0-79.7)	73.3% (60.3-83.9)
Specificity (95%CI)	59.5% (42.1-75.2)	73.0% (55.9-86.2)	81.1% (64.8-92.0)	75.7% (58.8-88.2)

Abbreviations: AUC, area under the receiver operating characteristic curve; PPV, positive predictive value; NPV, negative predictive value; LOS, length of stay

Two-factor formula: LOS (> 7 days) x 18 + Age (≥ 70 years) x 11, cut-off value ≥ 11

Three-factor formula: LOS (> 7 days) x 16 + Age (≥ 70 years) x 13 + Open surgery x 10, cut-off value ≥ 15

Four-factor formula: LOS (> 7 days) x 16 + Age (≥ 70 years) x 13 + Open surgery x 10 + Surgery duration (> 165 min) x 10, cut-off value ≥ 28

Five-factor formula: LOS (> 7 days) x 16 + Age (≥ 70 years) x 12 + Open surgery x 10 + Surgery duration (> 165 min) x 10 + ASA (≥3) x 6, cut-off value ≥ 27

The presence or absence of each factor is assigned a value of 1 or 0, respectively.

Age has consistently been identified by numerous studies as a predictor of worse surgical outcomes,[5-7, 13-17] with some research also reporting a significant association between longer LOS and functional decline after surgery.[7,15] Conversely, while higher ASA classification, longer operation time, and the distinction between major and minor operations have been recognized by certain studies as factors linked to functional decline or undesirable surgical results,[13,14] other studies have found no such association.[29,30] For instance, a study by Yamaguchi et al. on postoperative functional decline identified higher ASA score and major surgery as contributing factors but found no significant relation between longer operation time and this outcome.[15] In contrast, a study by Zattoni et al. reported no significant association between major operations or higher ASA scores and functional decline.[17]

Nonetheless, a combination of these factors can effectively predict functional decline. Patients of advanced age, particularly those with multiple comorbidities or scheduled for open surgery, should be thoroughly prepared for the physiological stress of surgery. Moreover, patients undergoing prolonged surgeries or extended hospital stays require close monitoring for functional changes to ensure timely interventions and mitigate potential decline. Employing our developed predictive equations can further aid in the early identification of at-risk individuals, enabling the implementation of preventive strategies.

Examining the specific ADLs affected can provide valuable insights for delivering effective strategies to prevent such declines. In the decline group, several BADLs showed significant deterioration, particularly in stair climbing, mobility, bathing, toilet use, and bladder control (Table 3). While surgeries involving the urological system may impact bladder function, the broader decline in other areas indicates challenges related to overall physical mobility. Therefore, implementing strategies to maintain patients' physical capabilities, such as early mobilization, is crucial. Early mobilization is also a core component of the ERAS pathways and has been shown to offer numerous postoperative benefits, including improved physical function, reduced risk of complications, and shorter hospital stays.[31-36]

In terms of IADLs, all aspects except telephone usage were negatively impacted. While this too could partly be attributed to the aforementioned difficulties in mobility, which is reported to be one of the significant predictors of IADLs function,[37] postoperative delirium (POD) might be other aspect to be considered. POD is reported to be one of the factors associated with decreased IADL functionality after surgery.[38-40] However, in our study, through the reviews of medical records we identified only 4 cases (4.1%) of POD, with no statistically significant differences between the functional stable and the decline groups. Future studies with larger sample sizes and standardized POD identification protocols are needed to clarify the relationship between POD and IADL functionality and to establish effective preventive strategies.

As for predicting postoperative functional decline, several strategies have been proposed across different surgical scenarios. Yamaguchi et al. used total psoas muscle volume measured by CT scans to predict decline following emergency abdominal surgery, achieving a good predictive value (AUC = 0.802 from ROC analyses).[15] Another study by Fukuda et al. utilized multiple routine medical data to create complex predictive equations for decline after hip fracture surgery.[16] Two other studies by Zattoni and Hoogerduijn employed screening tools—the Flemish version of the Triage Risk Screening Tool (fTRST) and the Identification of Seniors at Risk-Hospitalized Patients (ISAR-HP)—to predict decline in emergency and cardiac surgery, with AUCs of 0.72 and 0.73, respectively.[17,18]

Nevertheless, to the best of our knowledge, no published study has specifically addressed the prediction of decline following elective abdominal surgery. Based on the risk factors for postoperative functional decline identified in this population, our predictive equations can effectively forecast its occurrence without requiring additional investigations or complex calculations. Given the limited resources, these formulas are valuable tools for healthcare providers. By identifying patients at higher risk of postoperative functional decline, clinicians can prioritize resources for those who are most likely to benefit. This targeted approach could help optimize patient outcomes and enhance overall care quality and efficiency for patients undergoing elective abdominal surgery.

However, our study has several limitations. First, postoperative complications were identified exclusively through medical record reviews, which may limit the completeness of the data. Additionally, participants were reassessed only one month after surgery. Extending the follow-up period could provide valuable insights into the long-term trajectory of patients' functional capacities post-surgery. Third, the data for this study were collected prior to the full implementation of the ERAS pathway at our institution. Future research conducted after its full adoption could provide a clearer picture of how these strategies impact both the incidence and prognosis of functional decline. Lastly, while the developed formulas demonstrated good performance within the studied sample, further validation is necessary to confirm their

broader applicability.

CONCLUSION

More than 60% of Thai older adults undergoing elective abdominal surgery are likely to experience functional decline one month after the procedure. Age ≥ 70 and LOS > 7 days were found to be the factors most strongly associated with this decline. The predictive formulas developed using these factors could be useful for early postoperative risk stratification and guiding timely interventions. These findings highlight the need for proactive measures to mitigate this deterioration and emphasize the importance of tailored strategies to preserve functionality in this population.

Data Availability Statement

The data supporting the findings of this study are not publicly available but can be obtained from the corresponding author upon reasonable request.

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DECLARATIONS

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Conflict of Interest

The researchers claim no conflicts of interest.

Ethics approval

Ethics approval was obtained from the Medical Ethics Committee of the Human research protection unit of the hospital (COA no. 202/2018). All participants gave their written consent to participate.

Author Contributions

Conceptualization: PT, PD; Data curation: PT, SJ, NS; Funding acquisition: PT; Methodology: PT, PD, AS; Project administration: PT; Supervision: PD; Writing – original draft: PT; Writing – review & editing: PT, PD. All authors have read and agreed to the final version of the manuscript.

Use of Artificial Intelligence

ChatGPT-4o was used to check for grammatical errors and improve the readability of this manuscript. The content was subsequently reviewed and edited as needed. The authors take full responsibility for the final version of this publication.

REFERENCES

1. Abdulaziz K, Perry JJ, Taljaard M, Emond M, Lee JS, Wilding L, et al. National Survey of Geriatricians to Define Functional Decline in Elderly People with Minor Trauma. Can Geriatr J. 2016;19:2-8.
2. Asakawa T, Koyano W, Ando T, Shibata H. Effects of functional decline on quality of life among the Japanese elderly. Int J Aging Hum Dev. 2000;50:319-28.
3. Suwanabol PA, Li Y, Abrahamse P, De Roo AC, Vu JV, Silveira MJ, et al. Functional and Cognitive Decline Among Older Adults After High-risk Surgery. Ann Surg. 2022;275:e132-e139.
4. Lawrence VA, Hazuda HP, Cornell JE, Pederson T, Bradshaw PT, Mulrow CD, et al. Functional independence after major abdominal surgery in the elderly. J Am Coll Surg. 2004;199:762-72.
5. Robinson TN, Wallace JI, Wu DS, Wiktor A, Pointer LF, Pfister SM, et al. Accumulated frailty characteristics predict postoperative discharge institutionalization in the geriatric patient. J Am Coll Surg. 2011;213:37-42; discussion 42-4.
6. Finlayson E, Zhao S, Boscardin WJ, Fries BE, Landefeld CS, Dudley RA. Functional status after colon cancer surgery in elderly nursing home residents. J Am Geriatr Soc. 2012;60:967-73.
7. Zhang LM, Hornor MA, Robinson T, Rosenthal RA, Ko CY, Russell MM. Evaluation of Postoperative Functional Health Status Decline Among Older Adults. JAMA Surg. 2020;155:950-8.
8. Iglar PJ, Hogan KJ. Vitamin D status and surgical outcomes: a systematic review. Patient Saf Surg. 2015;9:14.
9. Hsu HY, Hwang LC, Lin CH, Lin CJ, Tjung JJ. Impact of serum albumin on functional status and hospital outcome in oldest-old inpatients. Int J Gerontol. 2015;9:220-2.
10. van Stijn MF, Korkic-Halilovic I, Bakker MS, van der Ploeg T, van Leeuwen PA, Houdijk AP. Preoperative nutrition status and postoperative outcome in elderly general surgery patients: a systematic review. JPEN J Parenter Enteral Nutr. 2013;37:37-43.
11. Kotlarczyk MP, Perera S, Ferchak MA, Nace DA, Resnick NM, Greenspan SL. Vitamin D deficiency is associated with functional decline and falls in frail elderly women despite supplementation. Osteoporos Int. 2017;28:1347-53.
12. Arnau A, Espaulella J, Serrarols M, Canudas J, Formiga F, Ferrer M. Risk factors for functional decline in a population aged 75 years and older without total dependence: A one-year follow-up. Arch Gerontol Geriatr. 2016;65:239-47.
13. Simões CM, Carmona MJC, Hajjar LA, Vincent JL, Landoni G, Belletti A, et al. Predictors of major complications after elective abdominal surgery in cancer patients. BMC Anesthesiol. 2018;18:49.
14. Hacim NA, Akbas A, Ulgen Y, Aktokmakyan TV, Meric S,

Tokocin M, et al. Association of Preoperative Risk Factors and Mortality in Older Patients following Emergency Abdominal Surgery: A Retrospective Cohort Study. Ann Geriatr Med Res. 2021;25:252-9.
15. Yamaguchi K, Matsumoto S, Abe T, Nakajima K, Senoo S, Shimizu M, et al. Predictive value of total psoas muscle index for postoperative physical functional decline in older patients undergoing emergency abdominal surgery. BMC Surg. 2023;23:171.
16. Fukuda T, Imai S, Maruo K, Horiguchi H. A formula for predicting postoperative functional decline using routine medical data in elderly patients after hip fracture surgery. Curr Orthop Pract. 2023;34:208-14.
17. Zattoni D, Montroni I, Saur NM, Garutti A, Bacchi Reggiani ML, Ghignone F, et al. Prediction of functional loss in emergency surgery is possible with a simple frailty screening tool. World J Emerg Surg. 2021;16:12.
18. Hoogerduijn JG, de Rooij SE, Grobbee DE, Schuurmans MJ. Predicting functional decline in older patients undergoing cardiac surgery. Age Ageing. 2014;43:218-21.
19. Kleyweg RP, van der Meche FG, Schmitz PI. Interobserver agreement in the assessment of muscle strength and functional abilities in Guillain-Barre syndrome. Muscle Nerve. 1991;14: 1103-9.
20. Jones CJ, Rikli RE, Beam WC. A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. Res Q Exerc Sport. 1999;70:113-9.
21. Mahoney FI, Barthel DW. Functional Evaluation: The Barthel Index. Md State Med J. 1965;14:61-5.
22. Laohaprasitiporn P, Jarusriwanna A, Unnanuntana A. Validity and Reliability of the Thai Version of the Barthel Index for Elderly Patients with Femoral Neck Fracture. J Med Assoc Thai. 2017;100:539.
23. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist. 1969;9:179-86.
24. Train the Brain Forum Committee. Thai mental state examination (TMSE). Siriraj Hosp Gaz. 1993;45:661-74.
25. Kaiser MJ, Bauer JM, Ramsch C, Uter W, Guigoz Y, Cederholm T, et al. Validation of the Mini Nutritional Assessment short-form (MNA-SF): a practical tool for identification of nutritional status. J Nutr Health Aging. 2009;13:782-8.
26. Lotrakul M, Sumrithe S, Saipanish R. Reliability and validity of the Thai version of the PHQ-9. BMC Psychiatry. 2008;8:46.
27. Jakobson T, Karjagin J, Vipp L, Padar M, Parik AH, Starkopf L, et al. Postoperative complications and mortality after major gastrointestinal surgery. Medicina (Kaunas). 2014;50:111-7.
28. Nahm FS. Receiver operating characteristic curve: overview and practical use for clinicians. Korean J Anesthesiol. 2022;75: 25-36.
29. Tan HL, Chia STX, Nadkarni NV, Ang SY, Seow DCC, Wong TH. Frailty and functional decline after emergency abdominal surgery in the elderly: a prospective cohort study. World J Emerg Surg. 2019;14:62.
30. Honda Y, Takahashi K, Sasanuma N, Itani Y, Nagase M, Uchiyama Y, et al. Predictors of Functional Decline in Activities of Daily Living at Discharge in Patients After Cardiovascular Surgery. Circ J. 2021;85:1020-6.
31. Kanejima Y, Shimogai T, Kitamura M, Ishihara K, Izawa KP. Effect of Early Mobilization on Physical Function in Patients after Cardiac Surgery: A Systematic Review and Meta-Analysis. Int J Environ Res Public Health. 2020;17(19):7091.
32. Tazreean R, Nelson G, Twomey R. Early mobilization in enhanced recovery after surgery pathways: current evidence and recent advancements. J Comp Eff Res. 2022;11:121-9.
33. Epstein NE. A review article on the benefits of early mobilization following spinal surgery and other medical/surgical procedures. Surg Neurol Int. 2014;5:S66-73.
34. Hu Y, McArthur A, Yu Z. Early postoperative mobilization in patients undergoing abdominal surgery: a best practice implementation project. JBI Database System Rev Implement Rep. 2019;17:2591-611.
35. Heng G, Lohsiriwat V, Tan K-Y. Suitability of Enhanced Recovery after Surgery (ERAS) Protocols for Elderly Colorectal Cancer Patients. Siriraj Med J. 2020;72:18-23.
36. Somnuke P, Pongraweewan O, Siriussawakul A. Optimizing Perioperative Care for Elderly Surgical Patients: A Review of Strategies and Evidence-Based Practices. Siriraj Med J. 2024;76: 465-72.
37. Bruderer-Hofstetter M, Gorus E, Cornelis E, Meichtry A, De Vriendt P. Influencing factors on instrumental activities of daily living functioning in people with mild cognitive disorder - a secondary investigation of cross-sectional data. BMC Geriatr. 2022;22:791.
38. Rudolph JL, Inouye SK, Jones RN, Yang FM, Fong TG, Levkoff SE, et al. Delirium: an independent predictor of functional decline after cardiac surgery. J Am Geriatr Soc. 2010;58:643-9.
39. Liang CK, Chu CL, Chou MY, Lin YT, Lu T, Hsu CJ, et al. Interrelationship of postoperative delirium and cognitive impairment and their impact on the functional status in older patients undergoing orthopaedic surgery: a prospective cohort study. PLoS One. 2014;9:e110339.
40. Suraarunsumrit P, Pathonsmith C, Srinonprasert V, Sangarunakul N, Jiraphorncharas C, Siriussawakul A. Postoperative cognitive dysfunction in older surgical patients associated with increased healthcare utilization: a prospective study from an upper-middle-income country. BMC Geriatr. 2022;22:213.