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Original Article

Novel Risk Score for 30-Day Adverse Events Following Colonoscopy in Older Adults

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Background/Aims: Physicians are challenged with balancing benefits and risks of performing colonoscopies in older adults. We identified adverse event risk factors in this population and developed a predictive risk score for colonoscopy-related adverse events.

Methods: From August 2017 to August 2022, 8,154 patients aged ≥60 years who underwent screening or diagnostic colonoscopies were enrolled at Gangnam Severance Hospital. The primary outcome was 30-day adverse events, defined as emergency room visits or unplanned hospitalizations post-colonoscopy. The frailty index calculated via laboratory findings (FI-LAB) was derived from blood test results and vital signs. A risk score was developed and categorized to predict colonoscopy-related adverse events. Data from 9,154 colonoscopies from September 2022 to December 2023 at two tertiary referral hospitals were used for internal and external validation.

Results: The mean age was 67.9 years (range, 60 to 94 years). The 30-day adverse event rate was 1.4%. Adverse events were independently associated with the use of aspirin (adjusted odds ratio [aOR], 2.24), P2Y12 inhibitors (aOR, 1.79), and anticoagulants (aOR, 2.47) and with moderate (aOR, 4.54) and high (aOR, 11.40) FI-LABs. The incidence of adverse events in the low-, moderate-, and high-risk groups were 0.3%, 2.2%, and 10.7%, respectively (p<0.001). The area under the receiver operating characteristic curve for the risk scores were 0.821, 0.856, and 0.757 for the derivation, internal, and external cohorts, respectively.

Conclusions: Colonoscopy-related adverse events in older adults were linked to frailty and medication use and were not dependent on age. This novel risk score supports personalized decision-making when performing colonoscopies in older adults. **(Gut Liver, Published online April 21, 2025)**

Key Words: Aged; Colonoscopy; Frailty; Risk factors

INTRODUCTION

Up to what age are screening and surveillance colonoscopies appropriate? Generally, it is recommended that individuals at average risk should continue colorectal cancer screening regularly until their life expectancy is less than 10 years.[1] According to the current guidelines, colorectal cancer screening is highly recommended in all older individuals until the age of 75 years.[1-7] For people older than 75 years, physicians selectively offer screening for colorectal cancer using an individualized approach, considering the overall health status, prior screening history, and patient's own preference.[7] However, there is no validated tool for determining whether colorectal cancer screening should be performed for people older than 75 years in practice in terms of the risk of colonoscopy-related adverse events and their overall health. In particular, the safety of colonoscopy is a big concern that requires physician discretion and individualized approaches in older adults, considering the rising trend in life expectancy worldwide.[8-11]

Functional status affects life expectancies in older adults. In an epidemiologic study, life expectancy for all

older adult patients who had mobility disabilities was 1 year less than that of older adult patients who were functionally independent.[12] Frailty is an age-related condition that implies a vulnerability status that affects the quality of life and independence of older adults.[13-17] The likelihood of frailty increases with age; however, an individual's frailty does not always correspond to their chronological age, as age-related functional decline occurs at varying rates. The frailty index has been demonstrated as a predictor of poor clinical outcomes associated with various clinical situations in older adult patients.[18-21] However, the association of the frailty index with the risk of colonoscopy-related adverse events has not been fully elucidated yet.

Given the characteristics of colonoscopic procedures, the potential risk associated with unplanned resection of colorectal polyps should be considered before performing screening and diagnostic colonoscopies in older adults.[22] Aging is commonly accompanied by chronic illness and comorbidities.[11,23,24] In addition, polypharmacy is a concern for older adult patients undergoing colonoscopies as they are at a greater risk of adverse events related to medications such as antiplatelet medications and anticoagulants.[25-27] Therefore, a comprehensive risk prediction for colonoscopy-related adverse events is required for individualized decision-making regarding performing colonoscopies in older adults.

This study aimed to determine the risk factors associated with adverse events after colonoscopy and develop a novel risk score for predicting adverse events in older adults who undergo screening and diagnostic colonoscopies.

MATERIALS AND METHODS

1. Patients

Medical records of consecutive patients aged ≥60 years who underwent screening or diagnostic colonoscopies at Gangnam Severance Hospital, a tertiary referral hospital in Seoul, Korea, from August 2017 to August 2022, were retrospectively reviewed. Patient information collected from the medical records included data regarding age, sex, colonoscopic procedures, comorbidities, laboratory findings, vital signs, and prescription of anticoagulant and antiplatelet agents, including aspirin, P2Y12 receptor blockers (clopidogrel, ticlopidine, prasugrel, and ticagrelor), phosphodiesterase inhibitors (cilostazol), heparin, low molecular weight heparin, warfarin, or new oral anticoagulants. The window was extended to include the results of blood tests conducted within 2 months before the colonoscopy to minimize missing values in this retrospective database. To identify adverse events, we collected information about emergency room visits or unplanned hospitalizations within 30 days after colonoscopies. Patients who underwent planned or emergency therapeutic colonoscopies and those with insufficient medical records were excluded. According to current guidelines, patients who were taking anticoagulant or antiplatelet agents were generally recommended to withhold the medication before colonoscopic procedures as follows: aspirin for 7 days, P2Y12 receptor blockers for 5 days, heparin for 6 hours, low molecular weight heparin for 12 to 24 hours, warfarin for 5 days, and new oral anticoagulants for at least 2 days but longer in those with estimated glomerular filtration rates <80 mL/min on dabigatran.[28-30] This study was approved by the Yonsei University College of Medicine Institutional Review Board (IRB number: 3-2022-0329). Requirements for individual informed consent were waived owing to the retrospective design of the study.

2. Procedures

Colonoscopy was performed with a standard colonoscope (CF H260/290AL; Olympus, Tokyo, Japan). In general, 2 L of polyethylene glycol solution was used for bowel preparation. Colorectal polyps detected during the procedures were removed using one of the following methods: cold forceps polypectomy, cold snare polypectomy, and endoscopic mucosal resection. Patients who underwent endoscopic submucosal dissection for endoscopic resection of colorectal polyps were excluded from the study, as these were performed as planned procedures.

3. Definitions of study endpoint and covariates

The primary endpoint was 30-day adverse events, defined as emergency room visits or unplanned hospitalizations within 30 days after colonoscopies. Colonoscopy-related adverse events included not only procedure-related gastrointestinal complications such as bleeding, perforation, and post-polypectomy syndrome, but also sedation or bowel preparation-related adverse events such as aspiration pneumonia.[31] We classified adverse events that may directly cause death related to colonoscopy as major adverse events, including gastrointestinal perforation or bleeding, cardio-pulmonary adverse events such as myocardial infarction, respiratory failure, pneumonia or stroke, and mortality.[31,32] Minor adverse events, which encompassed events other than those classified as major, were also considered, including stable angina, dyspnea, urinary tract infection, and musculoskeletal injury.

The Charlson Comorbidity Index (CCI) was calculated based on age and presence or absence of comorbidities,[33] which included myocardial infarctions, congestive heart

failure, peripheral vascular diseases, cerebrovascular accidents or transient ischemic attacks, dementia, chronic obstructive pulmonary diseases, connective tissue diseases, peptic ulcer diseases, chronic hepatitis or cirrhosis, diabetes mellitus, hemiplegia, chronic kidney diseases, solid tumors, leukemia, lymphoma, and acquired immune deficiency syndrome. To assess the frailty of the patients, we utilized the frailty index calculated via laboratory findings (FI-LAB). This index comprises 31 items, including 13 components from the complete blood count analysis, 13 elements from the comprehensive metabolic profile, and five vital signs (Supplementary Table 1). The FI-LAB score was calculated by dividing the count of abnormal values by 31. FI-LAB scores were categorized into the following groups: high (>0.40), moderate (0.25–0.40), and low (<0.25).[34]

4. Validation analysis

To further validate the risk prediction score developed in this study, both internal and external validation was conducted using additional datasets. Internal validation involved analyzing 3,304 patients aged ≥60 years who underwent screening or diagnostic colonoscopies from September 2022 to December 2023 at Gangnam Severance Hospital, where the original cohort was studied. External validation utilized data from 5,850 patients aged ≥60 years who underwent screening or diagnostic colonoscopies performed over the same period at Severance Hospital, another tertiary referral hospital in Seoul, Korea. Both datasets were utilized to evaluate the predictive performance of the proposed risk score for 30-day colonoscopy-related adverse events.

5. Statistical analysis

Numerical values are expressed as means or numbers (%). Continuous variables were compared using the Student t-test. Categorical variables were compared using the chi-square test, and the linear-by-linear test was used to evaluate the association between variables with ordered categories. Independent risk factors for 30-day adverse events following colonoscopy were analyzed using logistic regression models. Adjusted odds ratios (aORs) and 95% confidence intervals (CIs) were calculated to estimate the effects of the covariates regarding 30-day adverse events in multivariate logistic regression models. A simple point risk prediction score for 30-day adverse events following colonoscopy was developed based on the result of the multivariate logistic regression model. The β coefficients were fitted by multiplying the regression coefficients by 1.25, rounded to one decimal place.[35] The novel older adult colonoscopy risk score of study participants was calculated as the sum of points from each variable. The incidence and risk for 30-day adverse events following colonoscopy were determined according to the novel risk scores. The area under the receiver operating characteristic curve (AUC) was calculated to assess the performance of the model in each derivation and validation cohort. The sensitivity, specificity, accuracy, positive predictive value, and negative predictive value of the risk scores were calculated to predict 30-day colonoscopy-related adverse events using 2×2 tables. All statistical analyses were performed using IBM SPSS Statistics for Windows, version 28.0 (IBM Corp., Armonk, NY, USA) and statistical significance was set at $p<0.05$.

RESULTS

1. Demographics

A total of 12,328 patients aged ≥60 years who underwent colonoscopy at Gangnam Severance Hospital between August 2017 and August 2022 were included in the initial screening. Among them, 4,174 patients (33.8%) were excluded owing to planned therapeutic colonoscopies (572 patients, 4.6%) and insufficient medical records (3,602 patients, 29.2%). Finally, 8,154 patients (66.2%) were included in the study (Fig. 1). The mean age of the participants was 67.9 years (range, 60 to 94 years), and 4,354 (53.4%) were males (Table 1). Among the study popula-

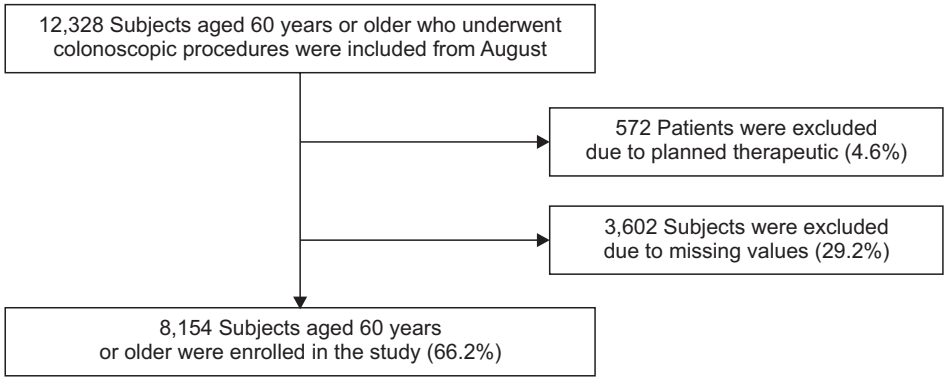

Fig. 1. Study flowchart.

Table 1. Baseline Characteristics of the Study Population

Variable	Total
No. of patients	8,154
Age, mean (range), yr	67.9 (60–94)
Male sex, No. (%)	4,354 (53.4)
Colonoscopic procedures, No. (%)	
Diagnostic colonoscopy	6,828 (83.7)
Colonoscopic polypectomy	1,326 (16.3)
Comorbidities, No. (%)	
Myocardial infarction	170 (2.1)
Congestive heart failure	173 (2.1)
Peripheral vascular diseases	114 (1.4)
CVA/TIA	776 (9.5)
Dementia	226 (2.8)
COPD	226 (2.8)
Connective tissue diseases	210 (2.6)
Peptic ulcer diseases	1,166 (14.3)
Chronic hepatitis or cirrhosis	614 (7.5)
Diabetes mellitus	1,856 (22.8)
Hemiplegia	29 (0.4)
Chronic kidney diseases	243 (3.0)
Solid tumors	461 (5.7)
Lymphoma	71 (0.9)
Charlson Comorbidity Index, mean	3.3
Medication use, No. (%)	
Antiplatelet agents	2,709 (33.2)
Aspirin	2,301 (28.2)
P2Y12 inhibitors	1,228 (15.1)
PDE inhibitor	538 (6.6)
Anticoagulants	748 (9.2)
Heparin/LMWH	377 (4.6)
Warfarin	169 (2.1)
NOAC	367 (4.5)
FI-LAB, mean*	0.17
Low, No. (%)	7,030 (86.2)
Moderate, No. (%)	969 (11.9)
High, No. (%)	155 (1.9)

CVA, cerebrovascular accidents; TIA, transient ischemic attack; COPD, chronic obstructive pulmonary diseases; PDE, phosphodiesterase; LMWH, low molecular weight heparin; NOAC, non-vitamin K antagonist oral anticoagulant; FI-LAB, frailty index calculated via laboratory findings.
*Low, <0.25; moderate, 0.25–0.40; high, >0.40.

tion, 1,326 individuals (16.3%) underwent colonoscopic polypectomies, including cold forceps polypectomies, cold snare polypectomies, or endoscopic mucosal resections. The mean CCI of the study population was 3.3 (range, 2 to 13). The proportions of patients taking antiplatelet and anticoagulants medications were 33.2% (2,709/8,154) and 9.2% (748/8,154), respectively. The mean FI-LAB was 0.17 (range, 0.00 to 0.61), with 7,030 (86.2%), 969 (11.9%), and 155 (1.9%) patients in the low, moderate, and high frailty groups, respectively.

2. Risk factors for colonoscopy-related adverse events

One hundred and fifteen patients (1.4%) experienced adverse events within 30 days following colonoscopy. Older age, male sex, colonoscopic polypectomy, high CCI, antiplatelet medication and anticoagulant use, and a high FI-LAB were significantly associated with 30-day adverse events following colonoscopy (Supplementary Table 2). All comorbidities included in the CCI, except for hemiplegia and neoplasms, were significantly associated with the development of colonoscopy-related adverse events (Supplementary Table 2). The incidence of unplanned emergency room visits or hospitalizations ($p<0.001$) and major ($p=0.005$) and minor adverse events ($p<0.001$) significantly increased with age (Supplementary Table 3). FI-LAB scores were significantly associated with the occurrence of unplanned emergency room visits or hospitalizations, and major and minor adverse events, with a dose-response relationship (all $p<0.001$) (Supplementary Table 3). Independent risk factors for colonoscopy-related adverse events were aspirin (aOR, 2.24; 95% CI, 1.42 to 3.55), P2Y12 inhibitor (aOR, 1.79; 95% CI, 1.14 to 2.79), anticoagulant use (aOR, 2.47; 95% CI, 1.61 to 3.79), and moderate (aOR, 4.54; 95% CI, 2.99 to 6.90) or high (aOR, 11.40; 95% CI, 6.38 to 20.52) FI-LAB scores (Table 2, Fig. 2, Supplementary Table 3). Antiplatelets, including aspirin and P2Y12 inhibitors, did not show a significant association with predicting adverse events following colonoscopy across increasing age limits of the subpopulations, whereas the aORs of FI-LAB for colonoscopy-related adverse events increased with the advancing age limits of the subpopulations (Supplementary Tables 4 and 5).

3. Risk prediction score for colonoscopy-related adverse events

A simple point risk prediction score for 30-day adverse events following colonoscopy was developed using the independent factors in the multivariate logistic regression model (Supplementary Table 6). The novel risk score showed a trend in the incidence of colonoscopy-related adverse events (Supplementary Fig. 1). Based on the risk prediction scores, all patients were categorized into low-risk group (0), moderate-risk group (1–3), and high-risk group (4–6). The incidence of 30-day colonoscopy-related adverse events in the low-, moderate-, and high-risk groups was 0.3%, 2.2%, and 10.7%, respectively ($p<0.001$). Compared to the low-risk group, the moderate-risk group (aOR, 8.38; 95% CI, 4.61 to 15.24) and high-risk group (aOR, 44.90; 95% CI, 23.65 to 85.05) had significantly higher risks of colonoscopy-related adverse events (Table 3). The AUC for the risk scores was 0.821 (Fig. 3). The sen-

Table 2. Risk Factors for 30-Day Adverse Events Following Colonoscopic Procedures

Variable	Number	Adverse events, No. (%)	Univariate analysis		Multivariate analysis	
			OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Age				<0.001		
<75 yr	6,768	72 (1.1)	1 (reference)			
≥75 yr	1,386	43 (3.1)	2.98 (2.03–4.36)			
Sex				0.004		
Female	3,800	38 (1.0)	1 (reference)			
Male	4,354	77 (1.8)	1.78 (1.21–2.64)			
Colonoscopic procedures				<0.001		
Diagnostic colonoscopy	6,828	83 (1.2)	1 (reference)			
Colonoscopic polypectomy	1,326	32 (2.4)	2.01 (1.33–3.04)			
Medication use						
Aspirin	2,301	73 (3.2)	4.53 (3.09–6.65)	<0.001	2.24 (1.42–3.55)	0.001
P2Y12 inhibitors	1,228	48 (3.9)	4.16 (2.86–6.06)	<0.001	1.79 (1.14–2.79)	0.01
PDE inhibitor	538	13 (2.4)	1.82 (1.02–3.27)	0.04		
Anticoagulants	748	44 (5.9)	6.46 (4.40–9.48)	<0.001	2.47 (1.61–3.79)	<0.001
CCI				<0.001		
0–3	5,368	40 (0.7)	1 (reference)			
≥4	2,786	75 (2.7)	3.69 (2.50–5.42)			
FI-LAB				<0.001		<0.001
Low (<0.25)	7,030	53 (0.8)	1 (reference)		1 (reference)	
Moderate (0.25–0.40)	969	44 (4.5)	6.26 (4.17–9.39)		4.54 (2.99–6.90)	
High (>0.40)	155	18 (11.6)	17.30 (9.87–30.30)		11.40 (6.38–20.52)	

OR, odds ratio; CI, confidence interval; PDE, phosphodiesterase; CCI, Charlson Comorbidity Index; FI-LAB, frailty index calculated via laboratory findings.

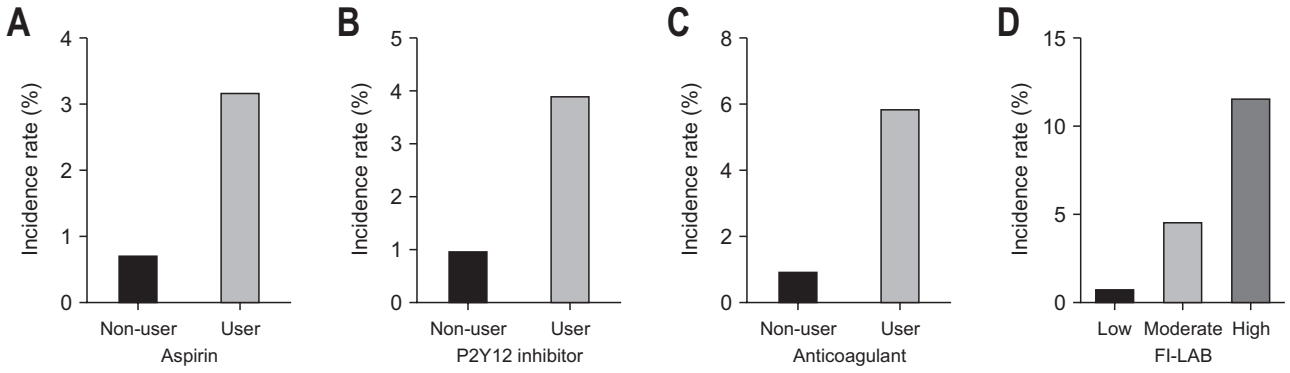

Fig. 2. Difference in the incidence of 30-day adverse events after colonoscopy for (A) aspirin use, (B) P2Y12 inhibitor use, (C) anticoagulant medication, and (D) frailty index calculated via laboratory findings (FI-LAB) score rank.

Table 3. Incidence and Risk of 30-Day Adverse Events Following Colonoscopy Based on Risk Scores

Older adult colonoscopy risk group	Scores	Number	Adverse events, No. (%)	aOR (95% CI)	p-value
Low risk	0	4,877	13 (0.3)	1 (reference)	<0.001
Moderate risk	1–3	2,922	64 (2.2)	8.38 (4.61–15.24)	
High risk	4–6	355	38 (10.7)	44.90 (23.65–85.05)	

aOR, adjusted odds ratio; CI, confidence interval.

sitivity, specificity, accuracy, positive predictive value, and negative predictive value of moderate- or high-risk groups based on the risk scores for predicting colonoscopy-related adverse events were 88.7%, 60.5%, 60.9%, 3.1%, and 99.7%, respectively.

4. Internal and external validation of the risk score

The risk score developed from the derivation cohort was validated using both internal and external datasets (Supplementary Table 7). In the internal validation cohort, the incidence of colonoscopy-related adverse events was

0.1%, 1.8%, and 7.3% for the low-, moderate-, and high-risk groups, respectively (Fig. 4). In the external validation cohort, the corresponding incidence rates were 0.9%, 5.1%, and 10.9%, respectively (Fig. 4). In the pooled validation cohorts, the moderate-risk group (aOR, 6.89; 95% CI, 4.70 to 10.10) and high-risk group (aOR, 17.07; 95% CI, 10.81 to 26.95) had significantly higher risks of 30-day colonoscopy-related adverse events than the low-risk group (Table 4). The AUCs for the risk scores were 0.856, and 0.757 for the internal, and external cohorts, respectively (Fig. 3). Based on the risk scores for predicting colonoscopy-related adverse events in the pooled validation cohorts, the sensitivity, specificity, accuracy, positive predictive value, and negative predictive value of the moderate- or high-risk groups were 81.6%, 65.1%, 65.4%, 4.7%, and 99.4%, respectively.

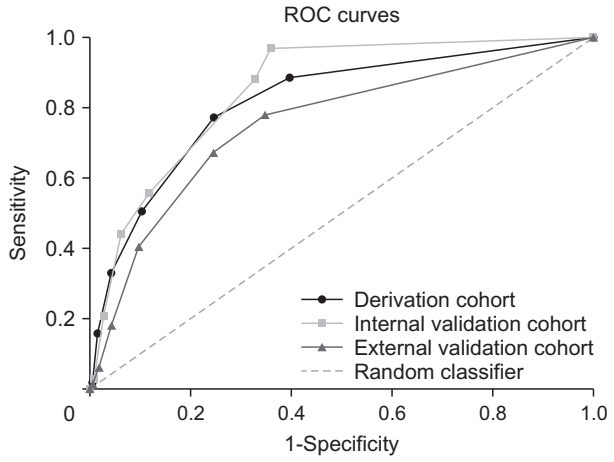

Fig. 3. Performance of the risk score in the derivation cohort and validation cohort. ROC, receiver operating characteristic.

DISCUSSION

In this single-center, retrospective study of individuals 60 years or older who underwent screening and diagnostic colonoscopies, we identified the risk factors for adverse events following colonoscopy and developed a risk prediction score. The incidence of colonoscopy-related adverse events, which was defined as unplanned emergency room visits or hospitalizations within 30 days following colonoscopy, was 1.4%. The incidence of adverse events significantly increased with age, reaching 2.9% in patients aged 75 to 79 years and 3.5% in those aged ≥80 years. Despite the positive association of age with the risk of colonoscopy-related adverse events, medication use (including aspirin, P2Y12 inhibitors, and anticoagulants) and FI-LAB scores were independent risk factors for prediction of adverse events following colonoscopy in the study population. The validation of the simple point-based risk prediction score demonstrated strong performance and highlighted

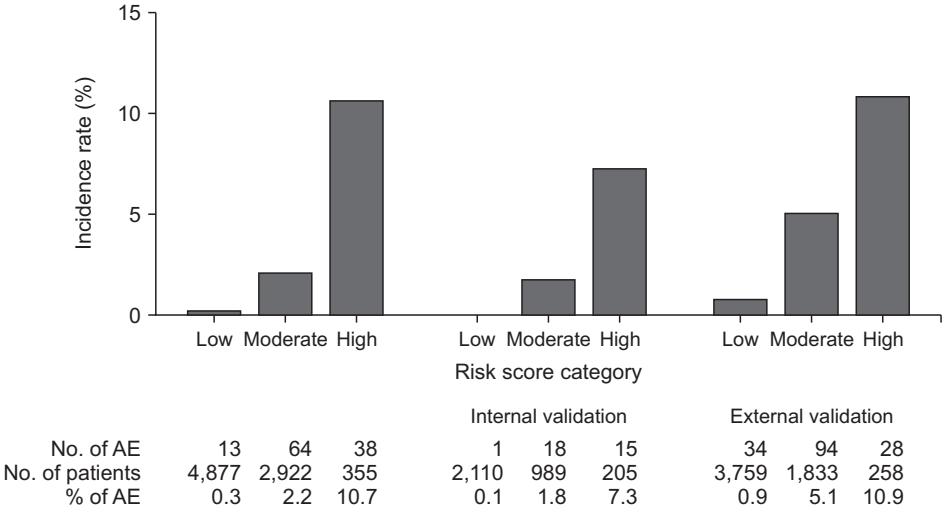

Fig. 4. Incidence of adverse events according to risk score category in the derivation cohort and validation cohort. AE, adverse events.

Table 4. Incidence and Risk of 30-Day Adverse Events Following Colonoscopy in the Full Validation Cohort

Older adult colonoscopy risk group	Scores	Number	Adverse events, No. (%)	aOR (95% CI)	p-value
Low risk	0	5,869	35 (0.6)	1 (reference)	<0.001
Moderate risk	1–3	2,822	112 (4.0)	6.89 (4.70–10.10)	
High risk	4–6	463	43 (9.3)	17.07 (10.81–26.95)	

aOR, adjusted odds ratio; CI, confidence interval.

a consistent trend in the incidence of colonoscopy-related adverse events across risk score categories. The high sensitivity (88.7%) and negative predictive value (99.7%) for predicting colonoscopy-related adverse events in moderate- or high-risk groups supports the potential for clinical application. To the best of our knowledge, this is the first cohort study to develop a novel risk score based on frailty and medication use for predicting adverse events after colonoscopy in older adults. This novel risk prediction score can help physicians make individualized decisions when deciding whether to performing colonoscopies in older adults.

Frailty, but not chronological age, was a significant predictor of colonoscopy-related adverse events. FI-LAB scores were strongly associated with 30-day colonoscopy-related adverse events in older adults, particularly with advancing age. This is consistent with the result of a United States-based prospective cohort study that demonstrated that frailty status, which was assessed using a 20-second upper extremity test, better predicted colonoscopy-related adverse events in adults aged ≥50 years who underwent screening colonoscopies, compared to the use of age and CCI.[20] The FI-LAB is a validated tool based on laboratory values and vital signs that can help assess the frailty status of older adult patients objectively. Ysea-Hill *et al.*[34] reported that higher FI-LAB scores were associated with all-cause in-hospital mortality, intensive care unit admissions, prolonged length of hospital stay, and post-hospitalization all-cause mortality. In addition, the FI-LAB score was more strongly associated with clinical outcomes compared to the Veterans Affairs Frailty Index.[34] These findings suggest that the FI-LAB can accurately assess frailty status in older adults undergoing screening or diagnostic colonoscopies. In the multivariate prediction model, the FI-LAB was more strongly associated with colonoscopy-related adverse events than chronological age or the CCI (a well-validated comorbidity index), suggesting that frailty status is more clinically significant than age or comorbidity status for colonoscopy risk in older adults. This highlights the importance of individualized decision-making based on frailty assessment, rather than universal application of an age cutoff, as a more precise approach for screening or diagnostic colonoscopy in the elderly.

The use of aspirin, P2Y12 inhibitor, or anticoagulant medication was independently associated with an approximately two-fold increased risk of colonoscopy-related adverse events. Similarly, in a Spanish population-based study of 48,730 patients, antiplatelet medication and anticoagulant use were independent risk factors for overall severe complications following diagnostic colonoscopies.[36] In a Japanese nationwide study of 16,812 patients who underwent therapeutic colonoscopies, the use of aspirin, non-aspirin antiplatelet agents, new oral anticoagulants, or warfarin was significantly associated with complicated bleeding, while warfarin use was a risk factor for perforation complications.[37] In the present study, 33.2% were taking at least one antiplatelet agent and 9.2% were using anticoagulants. Given the rising prevalence of advanced colorectal neoplasms and cardiovascular diseases that require antiplatelet agents and anticoagulant use with increased age, medication use has a clinically significant impact on the potential risks of adverse events following colonoscopy.[38,39] Moreover, a retrospective study of 1,050 patients, with 70% aged ≥70 years, found that bleeding risk following colonoscopic polypectomy was significantly, and dose-dependently, related to the number of antiplatelet agents (including aspirin, P2Y12 inhibitors, and cilostazol) being used.[40] Collectively, these studies support the benefits of using the novel risk prediction score in practice, as it provides a quantitative assessment of the collective risk of colonoscopy-related adverse events in older patients who are concurrently using antiplatelet agents and anticoagulants.

There are a few limitations in this study. First, this was a single-center, retrospective study, and the novel risk prediction score needs to be validated in a large-scale, multicenter prospective cohort to ensure its generalizability in clinical practice. Although internal and external validations were conducted, it may remain insufficient to fully evaluate the robustness of the risk scoring model. Additionally, the higher AUC values in internal validation compared to external validation suggest that while the risk score is well-calibrated for the original institution, its predictive accuracy remains acceptable when applied externally. Second, the long-term effects of screening and diagnostic colonoscopy on the clinical outcomes of older adults, such as colorectal cancer-related and overall mortality, were not assessed. This study did not focus on the potential benefit of colonoscopy in older adults, but on its risk of complications. However, the novel risk score may predict the long-term prognosis of older adult patients undergoing colonoscopies because it incorporates medication use and frailty, which are closely related to life expectancy in older adults. Third, data on bowel cleansing agents were not analyzed to determine the risk prediction score for colonoscopy-related adverse events because all subjects uniformly received 2 L-volume polyethylene glycol for bowel preparation during the study period of derivation cohort. Alternative laxatives such as 1 L-volume polyethylene glycol and oral sulfate solution or tablets may increase risk of adverse events related to bowel preparation in older adults at risk of dehydration and electrolyte imbalance. Further studies are required to

determine whether preparation with alternative laxatives is a risk factor of adverse events following colonoscopy in elderly individuals.

In conclusion, colonoscopy-related adverse events were significantly associated with frailty and medication use, but not age, in older adults. The novel risk score, which consists of the frailty index and medication use, may be a promising tool for decision-making when performing screening or diagnostic colonoscopies in older adults.

CONFLICTS OF INTEREST

J.H.C. and J.H.K. are editorial board members of the journal but were not involved in the peer reviewer selection, evaluation, or decision process of this article. No other potential conflicts of interest relevant to this article were reported.

AUTHOR CONTRIBUTIONS

Study concept and design: M.J.K., J.C. Data acquisition: M.J.K., S.C., J.P., S.J.P., J.J.P., J.H.C., T.I.K., Y.K., J.H.K., Y.H.Y., H.P., J.C. Data analysis and interpretation: M.J.K., J.C. Drafting of the manuscript: M.J.K. Critical revision of the manuscript for important intellectual content: J.C. Statistical analysis: M.J.K., J.C. Administrative, technical, or material support; study supervision: J.C. Approval of final manuscript: all authors.

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SUPPLEMENTARY MATERIALS

Supplementary materials can be accessed at https://doi.org/10.5009/gnl250010.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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