

〈Regular Article〉

Utility of Geriatric Focused Preoperative Assessment in Predicting Postoperative Complications and Outcomes

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ABSTRACT Background: With Japan's rapidly aging population, the number of older adults undergoing surgery continues to rise. The American Society of Anesthesiologists Physical Status (ASA-PS) classification, widely used for preoperative evaluation, does not fully capture the heterogeneity and complexity of this population. Several studies have suggested that ASA-PS is not strongly correlated with postoperative complications or long-term outcomes in older adults. In contrast, Comprehensive Geriatric Assessment (CGA) has gained attention as a tool to better evaluate this population, particularly as preoperative physical function decline is associated with poor outcomes. We developed a novel Geriatric Perioperative Risk Assessment (GPRA) tool that combines CGA elements with physical function measures and examined its association with postoperative complications and outcomes.

Methods: We retrospectively analyzed 101 consecutive patients aged 70 years or older who underwent elective surgery at our hospital between April 2022 and September 2024 (59 for gastrointestinal diseases, 42 for cardiovascular diseases). The assessment included the key CGA components of the Mini-Mental State Examination and the 15-item Geriatric Depression Scale – Short Form, along with physical function measured by the Five-Times Sit-to-Stand Test. Outcomes included the length of hospital stay, the incidence of postoperative delirium (POD) and other complications, discharge disposition (to home or transfer to another facility), and one-year postoperative mortality. Associations between outcomes and our GPRA system were compared with those of ASA-PS.

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Results: The mean age of participants was 78.4 ± 5.8 years; 56% were male, and the mean BMI was 22.0 ± 3.5 kg/m². POD occurred in 9 cases. Complications classified as Clavien–Dindo grade II or higher occurred in 47% of patients. Among the 101 patients, 84 were discharged to their home and 17 were transferred to another facility. Five patients died within one year of their surgeries. The GPRA tool was significantly associated with POD ($p < 0.01$) and discharge outcome ($p < 0.05$). In contrast, ASA-PS was associated with prolonged hospitalization ($p < 0.05$) and non-delirium complications ($p < 0.05$).

Conclusion: Geriatric Perioperative Risk Assessment incorporating cognitive, psychological, and physical function measures may help predict postoperative delirium and discharge outcomes in older adults. Integrating CGA components into routine preoperative evaluations may support the development of preventive strategies and improve perioperative recovery in older patients.

doi:10.11482/KMJ-E202551187 (Accepted on October 17, 2025)

Key words : Geriatric Assessment, Postoperative delirium, Geriatric surgery, Risk stratification, ASA-PS, Preoperative assessment

INTRODUCTION

Japan is currently facing a super-aged society. Advances in medical care have improved the safety of surgical procedures in older adults, leading to a growing number of surgeries in this population. However, compared to younger individuals, older patients are at increased risk of postoperative complications such as delirium and falls, which can significantly affect long-term survival¹⁾. These complications are closely linked to the multidimensional diversity of older adults, encompassing physical, cognitive, psychological, and social factors. Therefore, there is an urgent need to develop predictive models for postoperative complications that account for this heterogeneity, along with preventive strategies based on such models.

The American Society of Anesthesiologists Physical Status classification (ASA-PS) has long been used for preoperative risk assessment in anesthesiology^{2, 3)}. However, this system primarily evaluates organ-based comorbidities and does not fully capture the complex and varied characteristics of older adults. Consequently, its ability to predict postoperative complications and outcomes has been reported to be limited^{4, 5)}. While some prognostic

models incorporate elements such as nutritional status and comorbid conditions, they still fall short in addressing the full complexity of aging.

Recently, geriatric assessment, and especially Comprehensive Geriatric Assessment (CGA), has gained attention as a means of evaluating the multidimensional characteristics of older patients⁶⁾. CGA assesses a range of domains, including physical function, cognitive ability, nutritional status, and psychological well-being, and has been shown to be associated with the incidence of postoperative delirium (POD), other complications, and short-term outcomes^{7, 8)}.

In gastrointestinal surgery, studies have identified cognitive decline and depressive symptoms as risk factors for POD⁹⁾, and CGA has demonstrated stronger prognostic value than age or performance status⁶⁾. Nishizawa *et al.* reported in their study on laparoscopic surgery for older colon cancer patients that a classification system combining MMSE, GDS, and lower limb muscle strength was associated with POD risk¹⁰⁾. In the field of cardiovascular surgery, it has been reported that depressive symptoms in older adults significantly increase the risk of both all-cause mortality and cardiovascular mortality¹¹⁾. However, CGA is not yet widely adopted as a

standardized tool for preoperative assessment.

Additionally, The stand-up test reflects lower-body muscle strength and is a practical method for measuring muscle strength¹²⁾. Preoperative lower limb muscle weakness has been reported as an independent predictor of postoperative mortality in older patients with gastrointestinal cancer¹³⁾. In cardiac surgery, lower limb weakness has also been significantly associated with prolonged ICU stays and a higher risk of pulmonary complications¹⁴⁾.

Conversely, commonly used preoperative risk models in cardiovascular surgery, such as the JapanSCORE¹⁵⁾ and EuroSCORE II¹⁶⁾, primarily focus on organ dysfunction and do not incorporate assessments of lower limb muscle strength or geriatric frailty. Research applying CGA in the context of cardiovascular surgery remains limited, and its relationship to postoperative complications and prognosis is not well understood.

In this study, we aimed to evaluate the preoperative utility of CGA and physical function assessment in older patients undergoing gastrointestinal (GID) or cardiovascular (CVD) surgery at our institution. We also developed a Geriatric Perioperative Risk Assessment (GPRA) tool and investigated its association with postoperative complications and patient outcomes.

METHODS

Participants

This study included 101 consecutive patients aged 70 years or older who were admitted to the Department of General Surgery at Kawasaki Medical School General Medical Center in Okayama, Japan for elective gastrointestinal or cardiovascular surgery between April 1, 2022, and September 19, 2024.

Patients were excluded if they were unable to walk independently; had a history of stroke with severe hemiparesis; were diagnosed with Parkinson's disease or a parkinsonian syndrome; had implanted

pacemakers; had severe visual impairment that precluded assessment; had cognitive impairment that interfered with communication; underwent emergency surgery; refused to participate or had missing essential data.

Assessment Items

Prior to surgery, a Comprehensive Geriatric Assessment (CGA) was conducted to evaluate the multidimensional functions of the patients. The CGA was comprised of 7 assessments, which included basic activities of daily living measured by the Barthel Index and the Lawton Instrumental Activities of Daily Living scale; cognitive and psychological function assessed using the Mini-Mental State Examination (MMSE), Vitality Index, Geriatric Depression Scale - Short Form (GDS-15), and Apathy Scale; and nutritional status evaluated using the Mini Nutritional Assessment - Short Form.

In addition to the CGA, physical function was assessed in five different ways: body composition (measured by bioelectrical impedance analysis), calf circumference, grip strength, the Five-Times Sit-to-Stand Test, and a one-leg standing test with eyes open.

Preoperative risk was also evaluated using the American Society of Anesthesiologists Physical Status (ASA-PS) classification. ASA I indicates a normal healthy patient; ASA II, a patient with mild systemic disease; ASA III, a patient with severe systemic disease; ASA IV, a patient with a severe systemic disease that is a constant threat to life; ASA V, a moribund patient not expected to survive without an operation; and ASA VI, a brain-dead patient whose organs are being removed for donation.

Postoperative Outcomes

Postoperative outcomes included the incidence of POD and other complications (defined as a Clavien-Dindo grade II or higher)¹⁷⁾. Additional outcomes

included the length of intensive care unit stay, total hospital stay (from admission to discharge), and discharge disposition (discharged to home versus transferred to another facility/one-year postoperative mortality). Regarding discharge disposition, when analyzing transfers to other facilities and one-year mortality separately, no mortality cases were observed for CVD. Therefore, to enhance statistical power and perform a more reliable analysis, transfers and mortality were combined and treated as a single outcome.

Risk Classification and Sub-analysis

Based on the results of the CGA and physical function assessments and other previous reports, we developed a novel Geriatric Perioperative Risk Assessment tool. Patients are categorized as low, moderate, or high risk based on the results of three assessments: cognitive function measured by the MMSE, depressive symptoms assessed by the GDS-15, and lower limb function evaluated by the Five-Times Sit-to-Stand Test.

Patients with acceptable results in all three assessments were defined as low risk; those who failed one or two of the evaluations were classified as moderate risk; and those with poor results in all three were classified as high risk.

To perform GID versus CVD specific analyses, we corrected some imbalances in the number of ASA-PS and GPRA cases. For GID surgery cases, since there were few ASA-PS IV cases, we limited the analysis to ASA-PS I–III. For CVD surgery cases, since there were few ASA-PS I cases, the analysis was limited to ASA-PS II–IV. Furthermore, in both disease areas, since there were few cases in the high-risk GPRA risk category, the GPRA risk categories were reclassified into two groups: low risk and medium risk.

Ethical Considerations

This study was approved by the Ethics Committee

of Kawasaki Medical School (approval no. 5261-01) and was conducted in accordance with the Declaration of Helsinki and its subsequent revisions. Informed consent was obtained from all participants.

Statistical Analysis

We analyzed the relationships between the GPRA risk classification and the ASA-PS level with postoperative outcomes, including delirium, complications other than delirium, length of hospital stay, and discharge status.

To compare differences between groups, appropriate statistical methods were applied. Categorical variables were analyzed using the chi-square test. For continuous variables, Student's t-test was used when data were normally distributed, while the Mann–Whitney U test was employed for non-normally distributed variables. To evaluate linear trends across the ordered risk categories, the Cochran–Armitage trend test was used. This test assesses the presence of a significant linear trend across a $2 \times k$ contingency table, where k represents the number of ordered risk groups.

All statistical analyses were performed using JMP Pro 15 software (SAS Institute Inc., Cary, NC, USA). A two-tailed p-value of less than 0.05 was considered statistically significant.

In the univariate analysis, we assessed associations between operative time, blood loss, surgical approach (open or laparoscopic), and prognostic factors to identify significant variables. Subsequently, multivariate logistic regression analyses (outcomes: POD, postoperative complications) and multivariate linear regression analysis (outcome: length of hospital stay) were performed, adjusting for age, sex, and the procedure-related factors (operative time or blood loss) that were significant in the univariate analysis.

RESULTS

A total of 101 patients aged 70 years or older who

Table 1. Patient characteristics

	GID (n = 59)	CVD (n = 42)	Total (N = 101)	p-value
Age (years)	78.9 ± 6.3	77.6 ± 4.9	78.4 ± 5.8	0.2532
Male, n (%)	34 (57.6%)	24 (57.1%)	58 (57.4%)	0.9613
BMI (kg/m ²)	21.5 ± 3.5	23.1 ± 3.0	22.2 ± 3.4	0.0178
Diabetes, n (%)	8 (13.6%)	11 (26.2%)	19 (18.8%)	0.1094
Smoking within 1 month, n (%)	4 (6.8%)	4 (9.5%)	8 (7.9%)	0.6327
Grip strength (kg)	24.9 ± 7.9	26.1 ± 8.7	25.4 ± 8.2	0.4654
Five-Times Sit-to-Stand Test (sec)	10.0 ± 2.9	10.6 ± 4.0	10.3 ± 3.4	0.4442
Barthel Index	97.8 ± 5.3	98.5 ± 3.4	98.1 ± 4.6	0.4810
Lawton IADL scale	6.6 ± 1.5	7.0 ± 1.4	6.8 ± 1.5	0.1778
Vitality Index	9.6 ± 0.7	9.9 ± 0.4	9.7 ± 0.6	0.0651
Mini-Mental State Examination	25.8 ± 3.5	25.8 ± 3.5	25.8 ± 3.5	0.9419
GDS-15	4.4 ± 2.7	3.5 ± 2.4	4.0 ± 2.6	0.0900
Apathy Scale	13.4 ± 6.8	10.8 ± 5.7	12.3 ± 6.5	0.0479
Mini Nutritional Assessment	9.1 ± 3.1	11.0 ± 2.2	9.9 ± 2.9	0.0013

Baseline characteristics of patients (mean ± SD or number [%]) in GID and CVD surgery groups.

Abbreviations: GID, gastrointestinal disease; CVD, cardiovascular disease; Lawton IADL scale, Lawton Instrumental Activities of Daily Living scale; GDS-15, Geriatric Depression Scale-Short Form.

underwent elective gastrointestinal or cardiovascular surgery were included in the analysis. The mean age was 78.4 ± 5.8 years, and 56% were male. The surgeries were for 59 cases of gastrointestinal disease and 42 cases of cardiovascular disease. The mean BMI was 22.0 ± 3.5 kg/m². Nineteen patients (18.8%) had comorbid diabetes mellitus (Table 1). Although BMI tended to be higher in the cardiovascular disease surgery group, no significant differences were observed in other physical function or assessment measures.

Among the 59 patients who underwent gastrointestinal surgery, the most common preoperative diagnosis was colon cancer (n = 28, 47%), followed by gastric cancer (n = 14, 24%). Other diagnoses included esophageal cancer (n = 8, 14%), pancreatic cancer (n = 7, 12%), and hepatocellular carcinoma (n = 2, 3%).

Among the 42 patients who underwent cardiovascular and thoracic surgery, the most frequent preoperative diagnosis was valvular disease (n = 24, 57%), followed by coronary artery disease (n = 8, 19%) and aortic disease (n = 7, 17%). Combined valvular and coronary disease was present in 2 patients (5%), and 1 patient (2%) had a

left atrial appendage thrombus.

Postoperative complications were graded according to the Clavien-Dindo classification system. Forty-nine patients (49%) experienced no complications (grade 0). Minor grade I adverse events occurred in 5 patients (5%), and moderate grade II complications in 33 patients (33%). Eight patients (8%) had moderately severe grade IIIa complications, with more severe grade IIIb adverse events in 3 patients (3%), and severe grade IVa complications in 3 patients (3%).

Postoperative delirium occurred in 9 patients (8.9%). As for discharge outcomes, 84 patients (83.2%) were discharged to their home, 17 (16.8%) were transferred to other hospitals. Five patients (5.0%) died within one year postoperatively, all due to the progression of their underlying disease. The mean length of hospital stay was 24.1 ± 14.5 days.

According to our newly developed GPRA tool, 49 patients (48.5%) were categorized as low risk, 49 patients (48.5%) as moderate risk, and 3 patients (3.0%) as high risk. According to the ASA-PS, 10 patients (9.9%) were classified as ASA I, 47 (46.5%) as ASA II, 39 (38.6%) as ASA III, and 5 (5.0%) as ASA IV. No patients were classified as

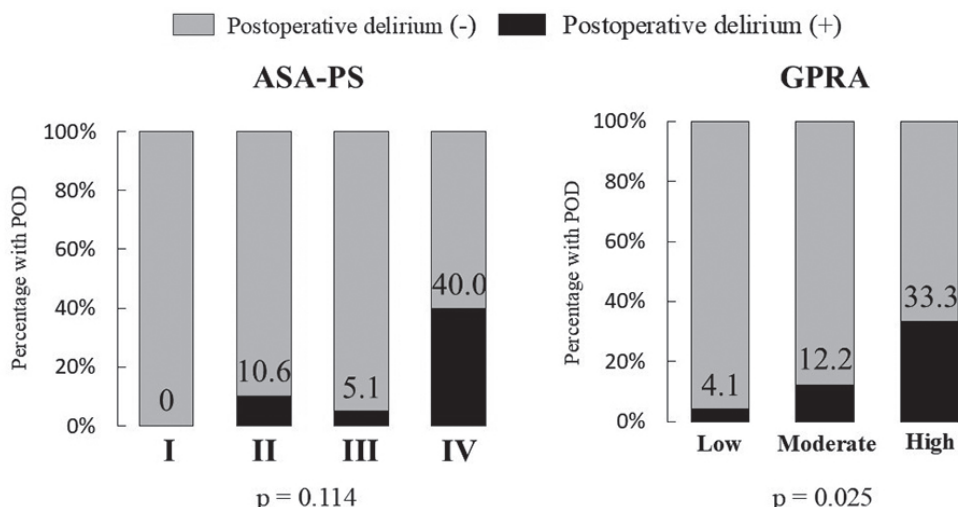


Fig. 1. The association between the incidence of postoperative delirium and the ASA-PS or GPRA score
A Cochran-Armitage trend test was used to examine the trends in the incidence of postoperative delirium in each risk assessment level.

Abbreviations: POD; postoperative delirium, ASA-PS; American Society of Anesthesiologists Physical Status, GPRA; Geriatric Perioperative Risk Assessment

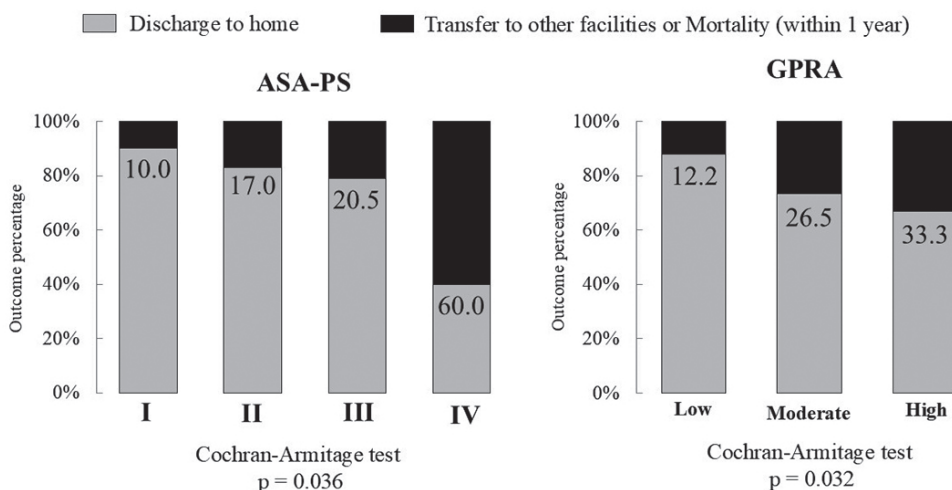


Fig. 2. The association between outcomes and the ASA-PS or GPRA score
A Cochran-Armitage trend test was used to examine outcome incidence trends in each risk assessment level.

ASA V or ASA VI.

Comparative analysis revealed that higher GPRA classification was significantly associated with an increased incidence of POD and a decreased likelihood of discharge to home ($p < 0.05$; Fig. 1 and 2). In contrast, higher ASA-PS scores were significantly associated with longer hospital

stays and a higher incidence of postoperative complications ($p < 0.05$; Fig. 3 and 4).

In univariate analysis, we examined the relationship between outcomes and the type of surgery, operating time, and blood loss (Table 2 a), b)). Based on these findings, multivariate analyses were conducted for each disease category, adjusting

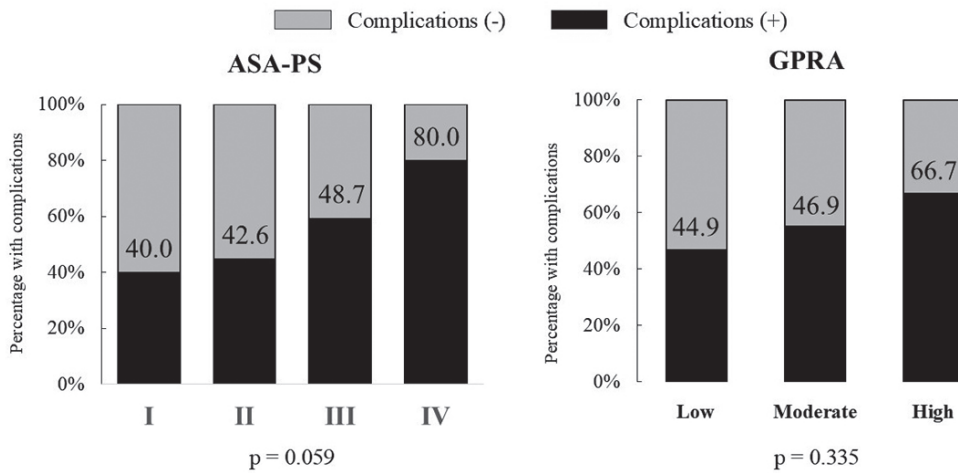


Fig. 3. The association between the incidence of postoperative complications and the ASA-PS or GPRA score
A Cochran-Armitage trend test was used to examine postoperative complication incidence trends in each risk assessment level.

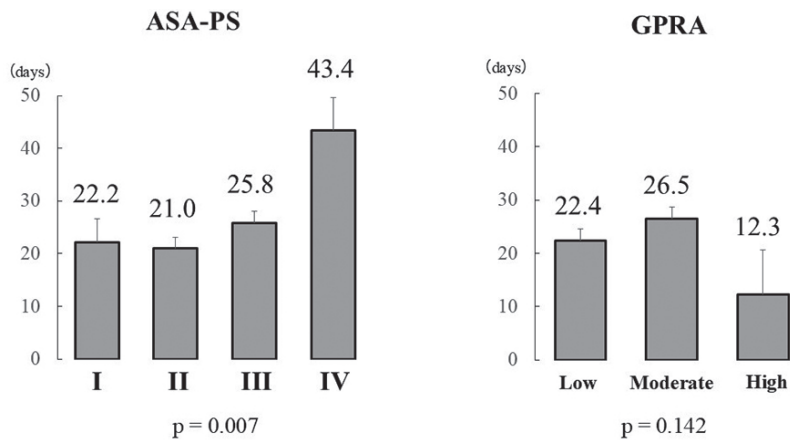


Fig. 4. Length of hospital stay for patients in each risk assessment level
Length of hospital stay between ASA-PS and GPRA groups was compared using one-way analysis of variance (ANOVA).

for age, sex, invasiveness factors, and preoperative assessment (ASA-PS or GPRA).

We next examined the relationship between preoperative assessments (ASA-PS, GPRA) and prognostic factors by disease category (Supplemental Fig.1-8).

In GID, neither ASA-PS nor GPRA emerged as independent risk factors for POD in multivariate logistic regression (ASA-PS: $\chi^2 = 4.59$, $p = 0.10$;

GPRA: $\chi^2 = 0.43$, $p = 0.51$). Instead, operative time was a significant independent risk factor (ASA-PS: $\chi^2 = 4.60$, $p = 0.03$; GPRA: $\chi^2 = 6.32$, $p = 0.01$). Similarly, ASA-PS and GPRA were not independent predictors of outcomes (ASA-PS: $\chi^2 = 2.67$, $p = 0.26$; GPRA: $\chi^2 = 1.10$, $p = 0.30$), whereas age was significantly associated as an independent factor (ASA-PS: $\chi^2 = 5.43$, $p = 0.02$; GPRA: $\chi^2 = 5.16$, $p = 0.02$).

Table 2.

a) Association between gastrointestinal disease operation factors and outcomes

GID (n = 59)	POD		Complications		Hospital stay days	Discharge status	
	–	+	–	+		Home	Transfer/ Mortality
Operation time (min)	297.0 ± 134.3	435.0 ± 193.6	318.9 ± 152.2	350.1 ± 174.9	$R^2 = 0.281$ $p < 0.0001$	334.0 ± 145.8	324.0 ± 226.5
	$p = 0.003$		$p = 0.468$			$p = 0.856$	
Blood loss (mL)	249.8 ± 403.6	252.7 ± 241.3	253.7 ± 406.1	246.2 ± 314.5	$R^2 = 0.053$ $p = 0.078$	263.2 ± 378.5	195.3 ± 322.9
	$p = 0.979$		$p = 0.939$			$p = 0.585$	
Laparoscopic n (%)	26 (5)	9 (40)	22 (65)	13 (35)	17.3 ± 1.94	29 (60)	6 (40)
Open n (%)	18 (60)	6 (40)	12 (52)	12 (48)	29.0 ± 23	19 (55)	5 (45)
	$p = 0.906$		$p = 0.326$		$p < 0.0002$	$p = 0.721$	

Results of a univariate analysis of GID patient outcomes versus invasiveness factors.

b) Association between cardiovascular disease operation factors and outcomes

CVD (n = 37)	POD		Complications		Hospital stay days	Discharge status	
	–	+	–	+		Home	Transfer/ Mortality
Operation time (min)	310.5 ± 85.8	313.4 ± 70.2	291.4 ± 79.7	332.1 ± 50.0	$R^2 = 0.003$ $p = 0.288$	311.1 ± 82.0	311.8 ± 85.4
	$p = 0.952$		$p = 0.131$			$p = 0.984$	
Blood loss (mL)	301.3 ± 331.7	695.6 ± 523.9	327.4 ± 336.8	471.0 ± 484.6	$R^2 = 0.249$ $p = 0.001$	378.1 ± 425.7	449.5 ± 392.4
	$p = 0.011$		$p = 0.300$			$p = 0.742$	
Thoracoscopic n (%)	3 (60)	2 (40)	2 (40)	3 (60)	20.4 ± 15.3	5 (100)	0 (0)
Open n (%)	25 (78)	7 (22)	17 (53)	15 (47)	25.4 ± 12.7	26 (81)	6 (19)
	$p = 0.380$		$p = 0.5850$		$p = 0.378$	$p = 0.290$	

Results of a univariate analysis of CVD patient outcomes versus invasiveness factors.

In CVD, neither ASA-PS nor GPRA were independent predictors of POD (ASA-PS: $\chi^2 = 0.69$, $p = 0.71$; GPRA: $\chi^2 = 0.31$, $p = 0.58$). In contrast, blood loss was a significant independent risk factor (ASA-PS: $\chi^2 = 6.06$, $p = 0.01$; GPRA: $\chi^2 = 6.36$, $p = 0.01$).

Finally, multivariate linear regression showed that ASA-PS and GPRA were not independent predictors of length of hospital stay (ASA-PS: $\beta = -1.2$, 95% CI: -9.49 to 2.46, $p = 0.24$; GPRA: $\beta = -1.50$, 95% CI: -6.99 to 1.06, $p = 0.143$). By contrast, blood loss volume was a significant independent factor (ASA-PS: $\beta = 3.57$, 95% CI: 0.007-0.03, $p = 0.0012$; GPRA: $\beta = 3.13$, 95% CI: 0.005-0.02, $p = 0.004$).

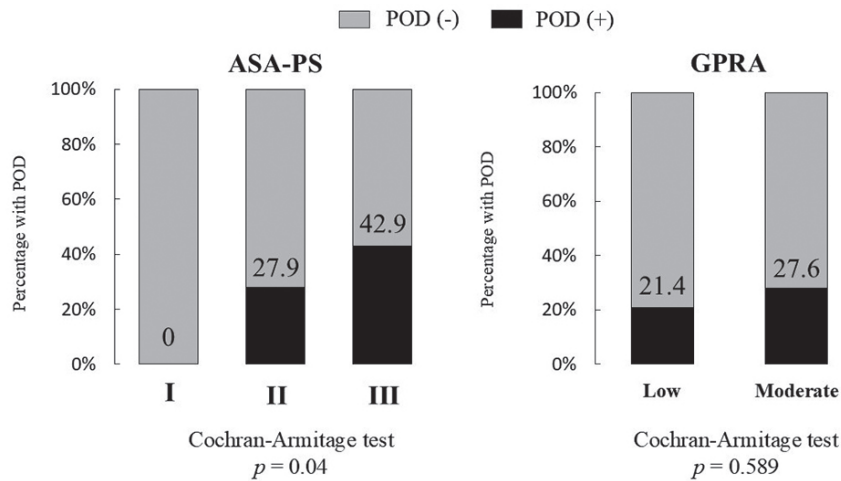
DISCUSSION

While the usefulness of CGA in surgical fields has been increasingly reported, its application in

cardiovascular surgery remains limited. In Japan, the rapid aging of the population has led to a growing number of older patients undergoing surgery. Alongside this, accumulating evidence on frailty and patient heterogeneity underscores the importance of incorporating physical function assessments into preoperative evaluations for older adults⁷⁻¹⁴.

In this study, we evaluated older patients undergoing gastrointestinal or cardiovascular surgery using both CGA and physical function assessments, including muscle strength. Our original GPRA classification was significantly associated with the development of POD and discharge outcomes.

In particular, patients classified into moderate- and high-risk categories based on cognitive function (MMSE), depressive symptoms (GDS-15), and lower limb function (Five-Times Sit-to-Stand Test)

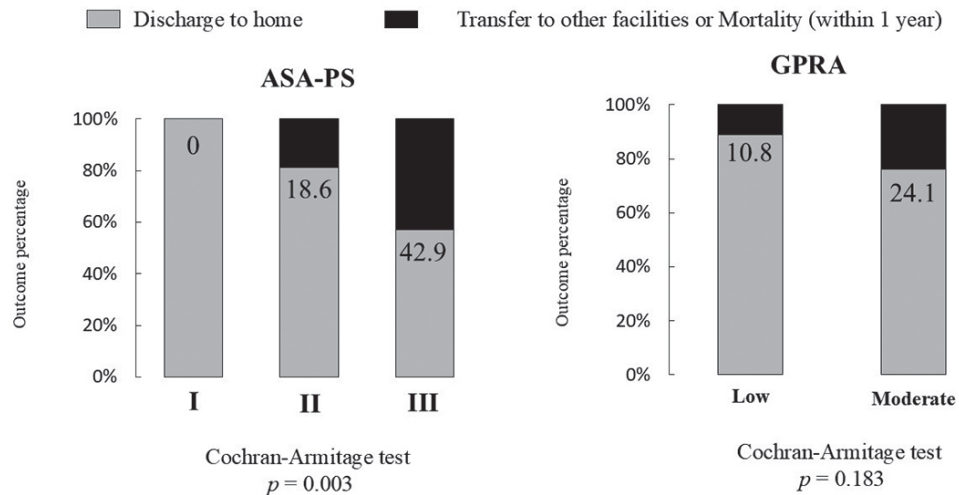


Supplemental Fig. 1. (GID)

The association between the incidence of postoperative delirium in GID and the ASA-PS or GPRA score

A Cochran-Armitage trend test was used to examine the trends in the incidence of postoperative delirium in each risk assessment level.

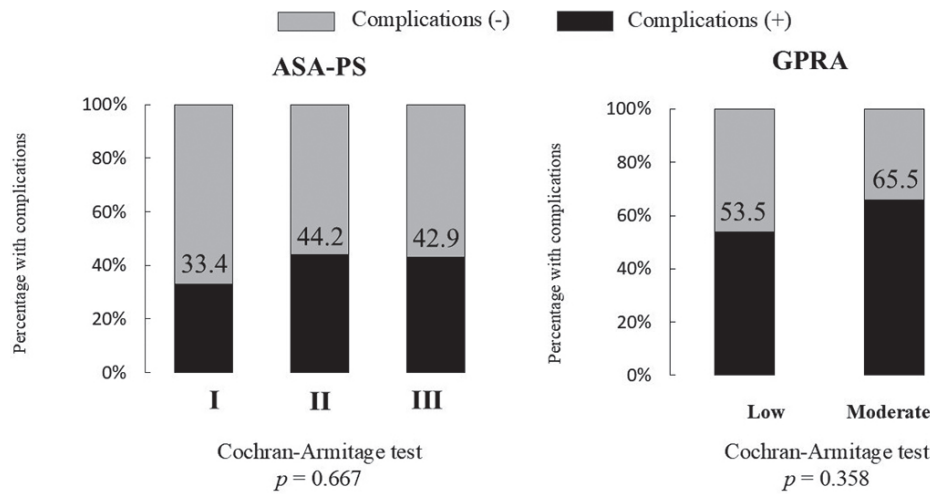
Abbreviations: GID; gastrointestinal disease, POD; postoperative delirium, ASA-PS; American Society of Anesthesiologists Physical Status, GPRA; Geriatric Perioperative Risk Assessment



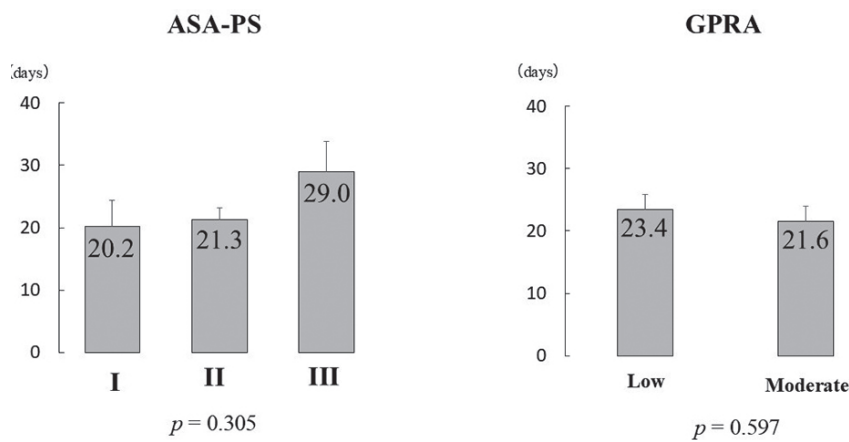
Supplemental Fig. 2. (GID)

The association between outcomes in GID and the ASA-PS or GPRA score

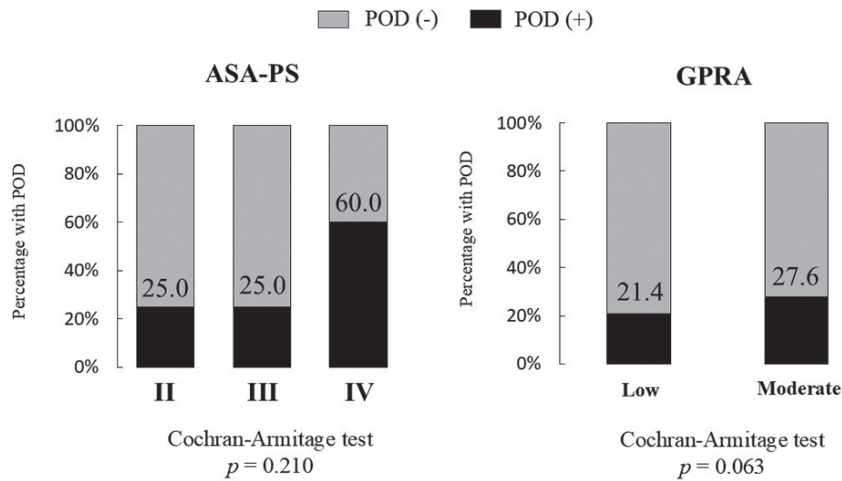
A Cochran-Armitage trend test was used to examine the trends in the incidence of outcomes in each risk assessment level.



Supplemental Fig. 3. (GID)
The association between the incidence of postoperative complications in GID and the ASA-PS or GPRA score
A Cochran-Armitage trend test was used to examine the trends in the incidence of postoperative complications in each risk assessment level.



Supplemental Fig. 4. (GID)
Length of hospital stay for patients in each risk assessment level in GID
The comparison of hospital stay between ASA-PS and GPRA was analyzed using one-way analysis of variance (ANOVA).

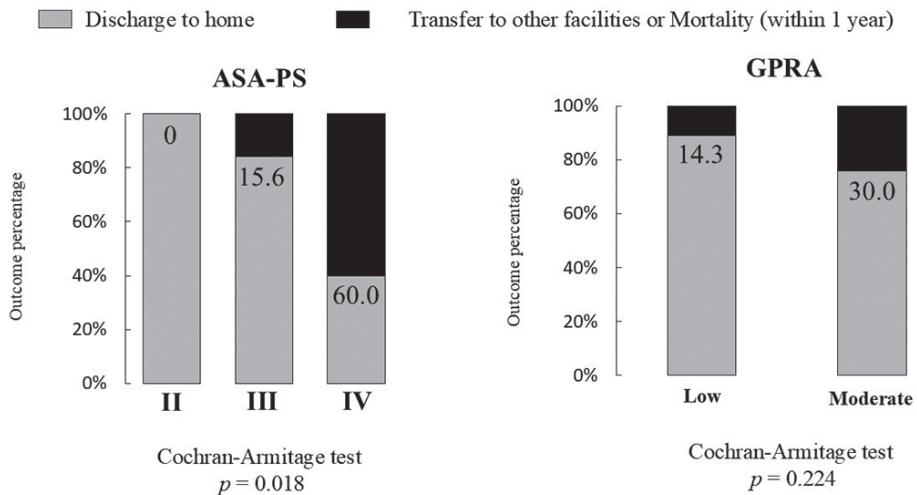


Supplemental Fig. 5. (CVD)

The association between the incidence of postoperative delirium in CVD and the ASA-PS or GPRA score

A Cochran-Armitage trend test was used to examine the trends in the incidence of postoperative delirium in each risk assessment level.

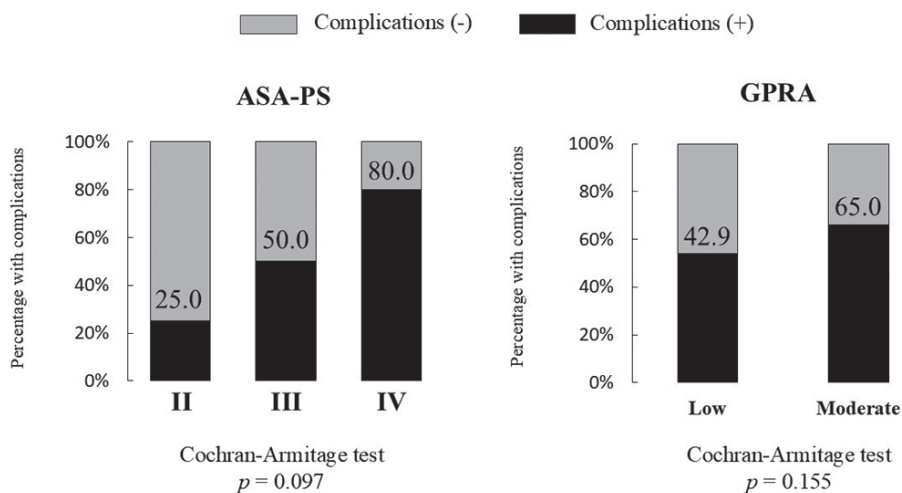
Abbreviations: CVD; cardiovascular disease, POD; postoperative delirium, ASA-PS; American Society of Anesthesiologists Physical Status, GPRA; Geriatric Perioperative Risk Assessment



Supplemental Fig. 6. (CVD)

The association between outcomes in CVD and the ASA-PS or GPRA score

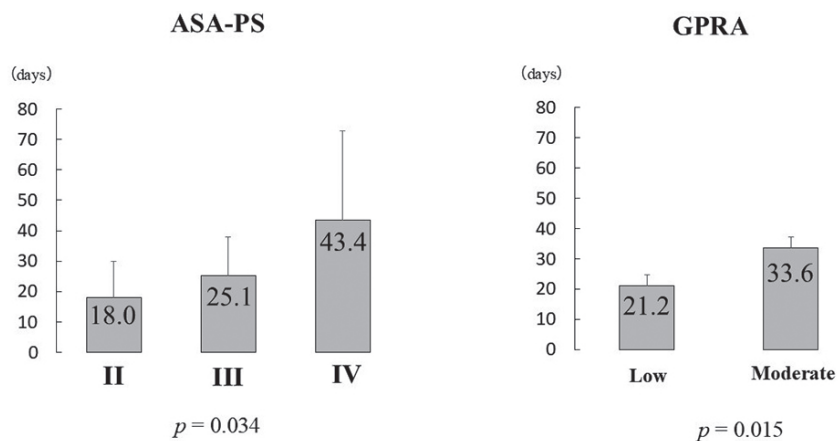
A Cochran-Armitage trend test was used to examine the trends in the incidence of outcomes in each risk assessment level.



Supplemental Fig. 7. (CVD)

The association between the incidence of postoperative complications in CVD and the ASA-PS or GPRA score

A Cochran-Armitage trend test was used to examine the trends in the incidence of postoperative complications in each risk assessment level.



Supplemental Fig. 8. (CVD)

Length of hospital stay for patients in each risk assessment level in CVD

The comparison of hospital stay between ASA-PS and GPRA was analyzed using one-way analysis of variance (ANOVA).

were more likely to develop POD and less likely to be discharged home. This suggests that our CGA-based risk classification system offers clinical utility through its stronger predictive value for POD than the conventional ASA-PS.

On the other hand, a significant association was found between ASA-PS and the length of hospital stay. This was primarily influenced by the markedly prolonged hospitalizations seen in ASA IV patients, with minimal differences observed among those of ASA I, II, and III patients. In the cardiovascular surgery group, elevated biomarkers of organ dysfunction (e.g., creatinine, urea nitrogen, BNP) likely contributed to a classification of ASA IV, which may in turn have led to longer hospital stays. Additionally, prolonged hospitalization may also be a function of patient or family preferences or delays in transfer to other rehabilitation facilities.

A similar pattern was observed for postoperative complications, with substantially higher incidences in the ASA IV patients, and no clear trend among ASA I, II, and III patients. This suggests that ASA-PS has utility for identifying high-risk patients but may be less effective in stratifying those at low to moderate risk. Moreover, ASA-PS is subject to inter-rater variability and does not account for geriatric-specific factors such as frailty and cognitive decline. These findings reinforce the importance of developing geriatric-centered evaluations.

As shown in Fig. 1 and 2, the GPRA, which is based on CGA and physical function assessments, demonstrated the potential for a more accurate stratification within the low- to moderate-risk groups compared to the conventional ASA-PS classification.

We further analyzed the results by dividing the cohort into those with gastrointestinal disease and those with cardiac disease. For GID, ASA-PS was significantly associated with POD and discharge status. For CVD, ASA-PS was significantly associated with POD, postoperative complications,

and the length of hospital stay, while GPRA was significantly associated with postoperative complications and the length of hospital stay. However, neither ASA-PS nor GPRA showed clearly superior predictive power in either disease group.

Multivariate analysis adjusted for age, sex, invasiveness factors, and preoperative assessment (ASA-PS or GPRA) by disease showed that postoperative outcomes are influenced not only by preoperative status but also by surgical invasiveness. However, because invasiveness factors such as operative time and blood loss are difficult to predict preoperatively, tools like ASA-PS and GPRA remain essential for risk assessment.

It should be noted that the two groups, gastrointestinal and cardiac diseases, are quite broad categorizations. The gastrointestinal group included not only gastrointestinal cancers but also hepatic and pancreatic malignancies, while the cardiac group included valvular heart disease, coronary artery disease, and aortic disease. Thus, the many potential differences in both surgical procedures and disease characteristics were not fully considered. Future studies are needed to conduct more granular analyses stratified by specific procedures and disease types to further clarify which assessment tools are most useful in each perioperative context.

Although some studies have explored CGA in cardiovascular surgery, most have focused on transcatheter aortic valve implantation¹⁸⁾. To our knowledge, there are currently no reports incorporating CGA into preoperative assessments for open-heart surgery. This study may be the first to apply CGA and physical function assessment in this setting and carries important clinical implications.

In gastrointestinal surgery, risk assessment tools such as POSSUM¹⁹⁾ and E-PASS²⁰⁾ are commonly used. In cardiovascular surgery, the JapanSCORE¹⁵⁾, EuroSCORE II¹⁶⁾, and STS score²¹⁾ are standard tools for evaluating acute-phase risk, particularly

organ dysfunction and perioperative mortality. However, given the high prevalence of older patients in modern surgical practice, it is essential to assess POD and neuropsychiatric symptoms, which influence not only short-term outcomes but also long-term prognosis.

Preoperative implementation of CGA and physical function assessments can enhance prognostic accuracy and inform risk mitigation strategies. For example, when muscle weakness or malnutrition is identified, preoperative nutritional and rehabilitative interventions can be initiated. For patients with cognitive decline or depressive symptoms, early involvement of family and multidisciplinary teams may support delirium prevention strategies, including psychiatric consultation and pharmacologic management. Such interventions can help prevent postoperative falls and help maintain quality of life.

LIMITATIONS

This study has several limitations. First, it was conducted at a single institution, which may limit the generalizability of the findings. Second, a longer follow-up period is needed to assess the impact on long-term outcomes.

Additionally, cardiovascular surgery is highly invasive and may be associated with POD due to factors such as fluid overload or prolonged cardiopulmonary bypass time^{22, 23}. Therefore, relying solely on cognitive and physical function assessments may be insufficient for comprehensive risk evaluation in such cases.

CGA and detailed physical function assessments are time-consuming and may not be feasible for all patients, particularly in emergency settings. This represents a practical limitation to their universal application.

Future studies should aim to longitudinally assess changes in cognitive function and depressive symptoms from the preoperative to postoperative

periods, and to examine how improvements or prevention of these conditions influence the incidence of delirium and long-term prognoses.

CONCLUSION

Comprehensive Geriatric Assessment was found to be useful in predicting postoperative delirium and discharge outcomes in older surgical patients. Importantly, CGA-based evaluation allowed for a more accurate risk stratification even among patients classified as low risk by long established tools such as the ASA-PS.

Preoperative implementation of CGA and physical function assessments enables targeted interventions aimed at preventing postoperative complications and improving the post-discharge quality of life. Our findings suggest that CGA and physical function assessment could serve as valuable tools for risk stratification and care planning in older patients undergoing surgery and may play an important role in the future standard of perioperative assessment in geriatric surgical care.

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