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ORIGINAL RESEARCH

Association of Preoperative Frailty and Post-Induction Hypotension in Elderly Patients Undergoing Major Non-Cardiac Surgery: A Prospective Observational Cohort Study

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Purpose: Post-induction hypotension (PIH) is one of the most common complications during general anesthesia, especially in elderly patients. Frailty, which describes age-related decrease of physiological capacity with increased susceptibility to stress, may be associated with PIH, when stress is brought by anesthetics. This study aimed to explore the association between preoperative frailty and PIH as well as postoperative complications.

Patients and Methods: This study was a prospective observational cohort study. Elderly patients scheduled for elective non-cardiac surgery under general anesthesia were recruited from December 2019 to April 2022 in Peking Union Medical College Hospital. Preoperative frailty was assessed by FRAIL scale. The primary outcome was post-induction hypotension. Secondary outcome included postoperative complications, functional recovery, length of stay and hospital cost.

Results: A total of 147 patients were included in the final analysis, of which 25 (17.0%) were considered frail. Frailty patients were generally older and suffered more from anemia, hypoalbuminemia, weakness, and orthostatic hypotension. The incidence of PIH was significantly higher in frail patients than non-frail elderly (80.0% vs 37.7%). Multivariable analysis revealed that frailty was associated with higher risk of PIH (aRR 1.72, 95% CI 1.20–2.47, P=0.003) after adjusting for baseline characteristics, surgical type and intraoperative medications. Comprehensive complication index within 30 days after surgery was significantly higher in frail patients.

Conclusion: Frailty is associated with post-induction hypotension during general anesthesia in elderly patients undergoing non-cardiac surgery. Preoperative frailty assessment may help identify high-risk patients for better anesthesia plan.

Keywords: frailty, post-induction hypotension, orthostatic hypotension, autonomic dysfunction

Introduction

Despite great efforts made to avoid hemodynamic instability, intraoperative hypotension is still one of the most common complications during general anesthesia, especially in elderly patients.[1,2] Among all intraoperative hypotension, post-induction hypotension (PIH) is of particular concern to anesthesiologists, as it is influenced by the patient's condition and the anesthesia technique rather than surgical factors. PIH is generally considered as hypotension between anesthesia induction and surgical incision.[2] Although the timeframe is relatively short and PIH might be considered as a transient phenomenon, previous studies have shown that PIH is associated with higher risk of organ hypo-perfusion damage including acute kidney injury,[3] as well as longer intensive care and ventilation requirement,[4] substantiating its clinical importance. Understanding the mechanism behind post-induction hypotension may aid in providing individualized anesthesia management for elderly patients.

Risk factors for PIH included elder age, higher American Society of Anesthesiologists (ASA) physical status classification, history of diabetes mellitus, lower baseline blood pressure and emergency surgery.[1,2,5] Elderly patients are the most susceptible population to PIH, however, previously identified risk factors failed to predict PIH effectively in

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this group of high-risk patients during clinical practice. As post-induction hypotension is closely related to patients' cardiovascular regulatory function[6,7] and reflects decreased functional reserve to adapt to the instant and drastic hemodynamic changes brought by general anesthetics,[8] we hypothesize that frailty is a risk factor for PIH. Frailty describes the condition of age-related decrease of physical capacity with increased susceptibility to stress.[9] Frail patients are at higher risk of orthostatic hypotension,[10] cardiovascular diseases[11,12] and even cardiovascular mortality,[13] indicating impairment of functional cardiovascular reserve.

Previous studies have found that frailty is associated with higher risk of severe postoperative complications,[14] postoperative delirium,[15] higher medical cost,[16] 30-day surgical readmission,[17] and poorer survival.[18] While frailty assessment has been increasingly recommended for pre-anesthesia evaluation, its association with intraoperative hypotension especially PIH has not been fully studied.

Therefore, we conducted a prospective cohort study aimed to explore the association between preoperative frailty and post-induction hypotension as well as postoperative prognosis.

Material and Methods

This study was a single-center prospective observational cohort study. Patients were recruited from December 2019 to April 2022 in Peking Union Medical College Hospital. The study protocol was approved by the local Research Ethics Committee on August 20th 2019 (reference number: ZS-2079) and prospectively registered at clinicaltrials.gov (NCT04120012). Written informed consents were obtained from all participants. This study complied with the Declaration of Helsinki and adheres to the applicable STROBE guidelines.

Participants

Patients who met all the following inclusion criteria were considered for recruitment: 1) age ≥ 65 years; 2) scheduled for elective major non-cardiac surgery; 3) scheduled for general anesthesia; 4) ASA physical status classification I–III; 5) study protocol fully understood by the patients, written consent obtained. Patients who met any of the following exclusion criteria would be excluded: 1) emergency surgery; 2) in active state of infection or inflammation; 3) chronic kidney disease (CKD) stage 5; 4) have conditions that would interfere accurate measurement of upper extremity blood pressure (eg, subclavian artery stenosis); 5) having conditions that would interfere with frailty assessment (eg, mental disorder, severe hearing disorder); 6) study protocol not fully understood, no written consent obtained.

Preoperative Assessment

Patients were visited the day before surgery for informed consent and preoperative assessment. The condition of frailty was assessed by FRAIL scale,[19] a simple 5-question scale for frailty assessment: fatigue, resistance, ambulation, comorbidities and loss of weight. Each question scores 0 to 1 point, and the total score ranges from 0 to 5. Patient with a total score ≥3 was considered as frail. Patients' body weight index (BMI), grip strength, gait speed, mean upper arm circumference, waist circumference, thigh circumference, baseline blood pressure and orthostatic blood pressure were also measured for physical evaluation. Other preoperative assessments included comprehensive medical history, ASA physical status classification, revised cardiac risk index (RCRI),[20] Mini Nutritional Assessment – Short Form (MNA-SF),[21] and baseline 15-item Quality of recovery score (QoR-15).[22] Preoperative laboratory tests and examinations were also recorded from the hospital information system.

Intraoperative Management

Each patient received standard intraoperative monitoring including electrocardiogram, non-invasive cuff blood pressure, pulse oximetry and other monitoring in accordance with ASA guidelines. Patients were induced with propofol, fentanyl, and rocuronium in a titration manner, and maintained with sevoflurane, as this was the routine practice for general anesthesia in our institute. The attending anesthesiologists were allowed to individualize the anesthesia plan according to patients' condition. Intraoperative management including blood pressure intervention was not standardized; however, dosages of anesthetic agents and vasoactive drugs were recorded. The attending anesthesiologists in charge of each

patient were blinded to the study hypothesis and study's preoperative assessment results. Post-induction blood pressure was measured noninvasively every two minutes. Intraoperative blood pressure was measured every three minutes.

Postoperative Follow-up

Postoperative follow-up was achieved by ward visit on postoperative day (POD) 1–3 and every three days after if the patient was in hospital. On POD7 and POD30, patients received telephone follow-up. Patients' electronic medical records were also reviewed as auxiliary information. Postoperative complications, QoR-15 score and other postoperative recovery information were collected. Postoperative complications were classified according to the Clavien-Dindo classification,[23] and comprehensive complication index (CCI)[24] was calculated for early postoperative complications (within POD30).

Outcomes

The primary outcome for this study was post-induction hypotension. The timeframe was defined as within 20 minutes after anesthesia induction or before surgical incision, whichever came first.[2] Hypotension was defined as non-invasive mean arterial pressure <65 mmHg or 30% decrease from baseline. Baseline blood pressure was recorded during preoperative visit in ward one day before surgery. Secondary outcome included early intraoperative hypotension (eIOH), postoperative complications, postoperative recovery, length of stay and hospital cost. Early intraoperative hypotension was defined as hypotension during the first 30 minutes of surgery when no complex surgical factors were introduced.

Statistical Analysis

Baseline information was described using mean and standard deviation (SD), median and quartiles or number and percentage as appropriate. Comparison of variables between frail and non-frail patients were performed using Student *t* test and Chi-square test according to variable type. Multivariable modified Poisson regression was performed to compare incidence of PIH and early intraoperative hypotension in frail and non-frail patients after adjusting for age, sex, ASA physical status classification, previous history of hypertension, coronary artery disease, cerebral infarction, diabetes, and medication history including usage of angiotensin-converting enzyme inhibitors (ACEI), angiotensin receptor blockers (ARB), beta-blockers, calcium channel blockers (CCB), surgical type, and induction dosage of propofol. Multivariable linear regression was performed to compare postoperative comprehensive complication index between frail and non-frail patients. Repeated measure analysis of variance was used for QoR-15 before and after surgery. The associations were reported as rate ratio (RR) or mean difference (MD) with 95% confidence intervals (CI). A two-sided P-value <0.05 was considered statistically significant. All analyses were performed using SPSS Statistics 22.0 (SPSS, Inc, IBM Company, Chicago, IL).

Sample Size Estimation

The incidence of post-induction hypotension observed in our preliminary trial was 42% in non-frail patients and 75% in frail patients, number of non-frail vs frail patients was 3:1. Assuming two-sided probabilities of 5% and 10% for type I and type II errors, 120 patients were required. Considering a dropout rate of 10%, we planned to recruit 134 patients in total.

Results

A total of 166 patients were recruited between December 2019 and April 2022. One hundred and sixty-three patients completed the preoperative assessment and intraoperative monitoring, 16 patients were excluded from final analysis because of deviation in anesthesia management or prophylactic vasoactive medication usage during anesthesia induction. One hundred and forty-seven patients were analyzed in the study, of which 25 patients (17.0%) were considered frail according to FRAIL scale definition (Figure 1).

The baseline characteristics of patients are shown in Table 1. Around 90% of the patients in our cohort received laparoscopic surgery for gastrointestinal and colorectal neoplasm, as these were the major indications for surgery in

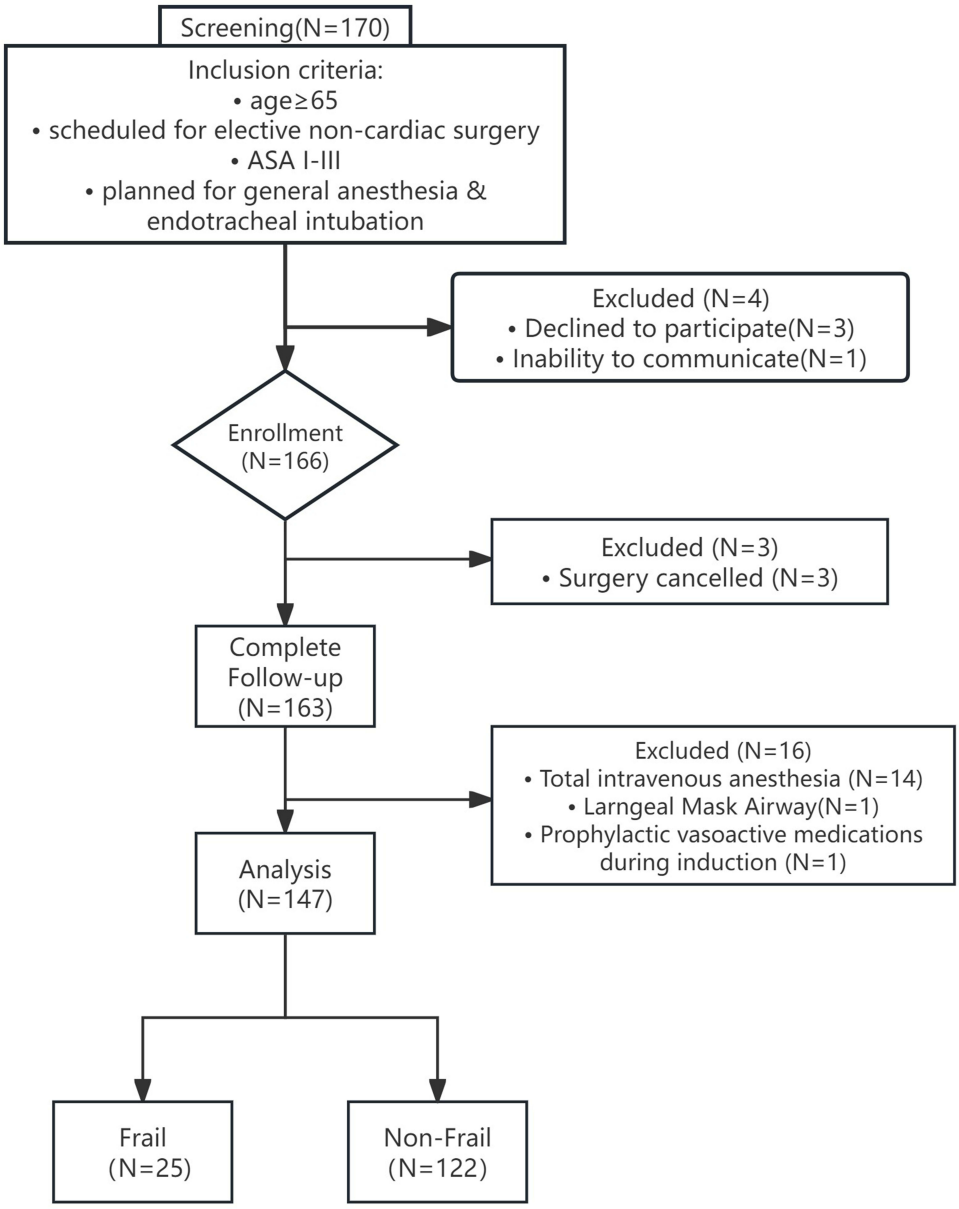

Figure 1 Study flowchart diagram.

elderly patients in our institution. The average age of this cohort was 73.2 ± 5.3 years, and frail patients were generally older than non-frail patients. More female patients were frail in this cohort. Frail patients were more likely to suffer from anemia (44.0% vs 17.2%) and hypo-albuminemia (60.0% vs 23.0%). Grip strength was significantly lower in frail patients (19.0 ± 7.9 vs 27.1 ± 8.5 kg), as well as gait speed (0.98 ± 0.29 vs 1.36 ± 0.33 m/s). The mean upper arm circumferences and thigh circumferences were also smaller for frail patients. Nutritional status assessed by MNA-SF was poorer in frail patients. Incidence of orthostatic hypotension was also significantly higher in frail patients (48.0% vs 19.7%). The ASA classification, previous medical history, long-term medication and RCRI score did not differ significantly between frail and non-frail patients in this cohort.

The intraoperative information is shown in Table 2. For anesthesia induction, average dosage of propofol was 1.67 ± 0.52mg/kg, and there was no significant difference between frail and non-frail patients. About 15.6% patients received reduced amount of propofol but additional etomidate for anesthesia induction, 24.0% frail patients received this combined an anesthetic induction protocol, higher than that in non-frail group (13.9%); however, the difference was

Table 1 Patients' Baseline Characteristics

	All (N=147)	Non-Frail (N=122)	Frail (N=25)	P Value
Age (year)	73.2 ± 5.3	72.7 ± 5.3	75.7 ± 4.7	0.009
Surgery type (N, %)				0.031
Lap. cholecystectomy	6 (4.1%)	6 (4.9%)	0 (0.0%)	
Lap. resection of colorectal cancer	101 (68.7%)	78 (63.9%)	23 (92.0%)	
Lap. resection of gastric cancer	33 (22.4%)	31 (25.4%)	2 (8.0%)	
Lap. resection of prostate cancer	4 (2.7%)	4 (3.3%)	0 (0.0%)	
Lap. resection of renal cancer	3 (2.0%)	3 (2.5%)	0 (0.0%)	
Sex (N, %)				0.017
Male	90(61.2%)	80(65.6%)	10(40.0%)	
Female	57(38.8%)	42(34.4%)	15(60.0%)	
BMI (kg/m^2)	24.46 ± 3.31	24.68 ± 3.25	23.38 ± 3.44	0.074
ASA classification (N, %)				0.059
II	100(68.0%)	87(71.3%)	13(52.0%)	
III	47(32.0%)	35(28.7%)	12(48.0%)	
Previous medical history				
Hypertension	78(53.1%)	62(50.8%)	16(64.0%)	0.229
CAD	32(21.8%)	24(19.7%)	8(32.0%)	0.174
Diabetes	42(28.6%)	33(27.0%)	9(36.0%)	0.367
COPD	16(10.9%)	14(11.5%)	2(8.0%)	1.000
Cerebral infarction	21(14.3%)	17(13.9%)	4(16.0%)	0.758
Malignancy	20(13.6%)	16(13.1%)	4(16.0%)	0.749
Previous medication				
ACEI/ARB	35(23.8%)	29(23.8%)	6(24.0%)	0.980
β-blocker	22(15.0%)	16(13.1%)	6(24.0%)	0.215
CCB	52(35.4%)	44(36.1%)	8(32.0%)	0.699
RCRI				0.718
1	99(67.3%)	84(68.9%)	15(60.0%)	
2	38(25.9%)	31(25.4%)	7(28.0%)	
3	7(4.8%)	5(4.1%)	2(8.0%)	
4	3(2.0%)	2(1.6%)	1(4.0%)	
Preoperative anemia (N, %)	32 (21.8%)	21 (17.2%)	11 (44.0%)	0.003
Preoperative hypo-albuminemia (N, %)	43 (29.3%)	28 (23.0%)	15 (60.0%)	<0.001
Grip strength(kg)	25.7±8.9	27.1±8.5	19.0±7.9	<0.001
Gait speed (m/s)	1.30±0.35	1.36±0.33	0.98±0.29	<0.001
MNA-SF (N, %)				<0.001
Normal	76 (51.7%)	72 (59.0%)	4 (16.0%)	
At risk of malnutrition	55 (37.4%)	41 (33.6%)	14 (56.0%)	
Malnourished	16 (10.9%)	9 (7.4%)	7 (28.0%)	
Orthostatic hypotension (N, %)	36(24.5%)	24(19.7%)	12(48.0%)	0.003

Abbreviations: Lap., Laparoscopic; BMI, Body mass index; ASA, American Society of Anesthesiologists; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; ACEI, angiotensin converting enzyme inhibitors; ARB, angiotensin receptor blockers; CCB, calcium channel blockers; RCRI, revised cardiac risk index; MNA-SF, mini nutritional assessment short form.

Table 2 Intraoperative Information

	All (N=147)	Non-Frail (N=122)	Frail (N=25)	P Value
Induction Medication				
Propofol (mg/kg)	1.67 ± 0.52	1.68 ± 0.49	1.58 ± 0.67	0.389
Additional etomidate (N, %)	23 (15.6%)	17 (13.9%)	6 (24.0%)	0.229
Fentanyl (ug/kg)	1.67 ± 0.69	1.66 ± 0.70	1.69 ± 0.63	0.862
Rocuronium (mg/kg)	0.73 ± 0.13	0.72 ± 0.13	0.76 ± 0.13	0.218

(*Continued*)

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Table 2 (Continued).

	All (N=147)	Non-Frail (N=122)	Frail (N=25)	P Value
Post-induction hypotension (N, %)	66 (44.9%)	46 (37.7%)	20 (80.0%)	<0.001
Early intraoperative hypotension (N, %)	17 (11.6%)	11 (9.0%)	6 (24.0%)	0.044
Ephedrine bolus after induction (N, %)	103 (70.1%)	87 (71.3%)	16 (64.0%)	0.467
Continuous phenylephrine administration after induction (N, %)	116 (78.9%)	95 (77.9%)	21 (84.0%)	0.494
Surgical time (hour)	2.27 ± 1.17	2.27 ± 1.25	2.25 ± 0.68	0.946
Intraoperative blood transfusion (N, %)	14 (9.5%)	7 (5.7%)	7 (28.0%)	0.003

not significant. More frail patients received packed red blood cell intraoperatively to treat anemia than that in non-frail patients. A majority of patients received ephedrine bolus after induction. For the primary outcome, 44.9% patients in our cohort experienced post-induction. Incidence of PIH and early intraoperative hypotension were both significantly higher in frail patients than non-frail patients. After adjusting for age, gender, ASA classification, comorbidities, medication, surgical types and induction dosage of propofol, multivariable analysis revealed that frailty was associated with higher risk of PIH (aRR 1.72, 95% CI 1.20–2.47, P=0.003) and eIOH (aRR 2.88, 95% CI 1.02–8.08, P=0.045) (Table 3).

Considering that preoperative hypovolemia may be a risk factor for PIH, we also performed passive leg raising (PLR) test in patients without contraindications for the test preoperatively. A total of 101 patients finished the PLR test, of which 32 patients (31.7%) were tested positive. However, hypovolemia was not significantly associated with PIH (aRR 0.87, 95% CI 0.55–1.38, P=0.562). Multivariable analysis showed that preoperative frailty remained a risk factor for PIH (aRR 1.57, 95% CI 1.07–2.29, P=0.020) after adjusting for hypovolemia and baseline characteristics (Table 4).

In terms of postoperative complications (Table 5), comprehensive complication index within 30 days after surgery was significantly higher in frail patients than non-frail patients (22.1 ± 14.1 vs 13.3 ± 15.2, P = 0.008). After adjusting for age, sex and ASA physical status classification, multivariable analysis still showed higher postoperative CCI in frail patients than non-frail patients (aMD 7.98, 95% CI 1.08–14.87, P=0.024) (Table 3). More patients with frailty

Table 3 Univariate and Multivariable Analyses of Preoperative Frailty and Outcomes

	Post-Induction Hypotension							
	Univariate Analysis				Multivariable Analysis[a]			
	RR	95% CI		P value	aRR	95% CI		P value
Frailty	2.12	1.57	2.87	<0.001	1.72	1.20	2.47	0.003
	Early Intraoperative Hypotension							
	Univariate Analysis				Multivariable Analysis[b]			
	RR	95% CI		P value	aRR	95% CI		P value
Frailty	2.66	1.09	6.53	0.032	2.88	1.02	8.08	0.045
	Postoperative Comprehensive Complication Index							
	Univariate Analysis				Multivariable Analysis[c]			
	MD	95% CI		P value	aMD	95% CI		P value
Frailty	8.80	2.29	15.30	0.008	7.98	1.08	14.87	0.024

Notes: [a,b]Adjusted for age, sex, ASA physical status classification, history of hypertension, coronary artery disease, diabetes, cerebral infarction, COPD, history of cancer, long-term usage of ACEI/ARB, β-blocker, calcium channel blockers, surgical type and induction dosage of propofol. [c]Adjusted for age, sex, ASA physical status classification.

Table 4 Multivariable Analysis of Preoperative Hypovolemia and PIH

	RR	95% CI		P Value
Preoperative hypovolemia*	0.87	0.55	1.38	0.562
Frail	1.57	1.07	2.29	0.020
Age	1.05	1.01	1.08	0.017
Sex (female vs male)	1.76	1.19	2.62	0.005
ASA classification≥3	0.74	0.47	1.16	0.190
Long-term use of ACEI/ARB	0.95	0.54	1.66	0.848
Surgery type (gastrointestinal surg. vs others)	3.11	0.78	12.39	0.108
Induction dosage of propofol	1.21	0.79	1.85	0.388

Notes: *Preoperative hypovolemia was assessed by passive leg raising test. A positive result was considered as an indication for hypovolemia in this cohort.

Table 5 Postoperative Complications and Recovery

	All (N=147)	Non-Frail (N=122)	Frail (N=25)	P Value
Comprehensive complication index	14.8 ± 15.3	13.3 ± 15.2	22.1 ± 14.1	0.008
Clavien-Dindo classification				<0.001
0	45 (30.6%)	43 (35.2%)	2 (8.0%)	
1	44 (29.9%)	36 (29.5%)	8 (32.0%)	
2	45 (30.6%)	36 (29.5%)	9 (36.0%)	
3a	8 (5.4%)	2 (1.6%)	6 (24.0%)	
3b	3 (2.0%)	3 (2.5%)	0 (0.0%)	
4a	1 (0.7%)	1 (0.8%)	0 (0.0%)	
5	1 (0.7%)	1 (0.8%)	0 (0.0%)	
Day of defecation	3.3 ± 1.5	3.3 ± 1.5	3.0 ± 1.6	0.406
Day of urination	3.8 ± 3.4	3.8 ± 3.6	3.8 ± 2.5	0.918
Day of oral intake	3.8 ± 2.5	3.6 ± 2.5	4.4 ± 2.4	0.150
Day of off-bed activity	1.5 ± 1.0	1.4 ± 1.1	1.6 ± 0.8	0.507
Postoperative ICU admission (N, %)	29 (19.7%)	22 (18.0%)	7 (28.0%)	0.274
Length of stay	11.0 ± 4.7	10.9 ± 4.9	11.2 ± 3.8	0.791
In-hospital cost (kRMB)	49.9 ± 23.0	49.2 ± 23.2	53.3 ± 22.1	0.414

experienced relatively severer postoperative complications of Clavien-Dindo classification ≥3. However, other post-operative recovery index including day of defecation, day of urination, day of oral intake and length of stay were not significantly different between each group. Although the cost was higher in frail patients, the differences were not significant (Table 5).

Discussion

This study was the first study focusing on the influence of frailty on post-induction hypotension. As a comprehensive concept of decreased functional reserve, frailty is being increasingly recognized by perioperative physicians and is found to be highly prevalent among the elderly surgical population. We found that preoperative frailty was associated with increased risk of PIH and early intraoperative hypotension in elderly surgical patients.

Hypotension after administration of general anesthetics is rather common in clinical observations, as most anesthetics may induce a vasodilation and negative inotropic and chronotropic effect, which cause reduction in peripheral vascular resistance as well as cardiac output. In younger patients with normal physical condition, autoregulation will restore hemodynamic stability instantly; however, this process might be difficult when it comes to elderly patients with reduced cardiovascular reserve or disability in autonomic tone, inducing drastic hemodynamic change after general anesthesia. Previous studies have identified several risk factors for post-induction hypotension, including senior age, ASA classification III to IV, type II diabetes mellitus, preoperative usage of ACEI or ARB medications, hypotension before induction,

and large dosage of propofol.[1,25,26] However, these factors were not significantly associated with PIH in this cohort, in which overall incidence of PIH was 44.9%, higher than previous studies. This indicates that other than traditional predictors, preoperative frailty assessment might be more informative for prediction of PIH in high-risk elderly patients.

Hypovolemia was traditionally considered as a risk factor for PIH. However, preoperative hypovolemia assessed by passive leg raising test was not significantly associated with PIH in this cohort. Consistent with previous study in which preoperative goal-directed fluid therapy to reach euvolemia could not significantly reduce PIH,[27] this suggested that hypovolemia was not the sole reason for PIH. Previous study discovered that patients with PIH presented with significantly lower heart rate variability,[28] indicating that autonomic dysfunction might play a role in PIH. One study suggested that pupil maximum constriction velocity, an indicator for autonomic function, could be a predictor for post-induction hypotension.[29] We noticed that over one-third patient experienced bradycardia during the period of post-induction hypotension, suggesting regression of baroreflex and autonomic tone dysfunction in these patients. Autonomic dysfunction is a rather prevalent phenomenon in frail patients.[30,31] In our cohort, autonomic function was briefly assessed by measuring orthostatic blood pressure. Consistent with previous studies, orthostatic hypotension was more predominant in frail patients in our cohort, presented with reduced reactivity to physical stress and postural change.[10,30–34] Therefore, we hypothesize that the association between frailty and higher risk of PIH and early intraoperative hypotension may be attributed to the impaired autonomic function and cardiovascular regulation in these frail patients. Future studies with quantifiable measurements of autonomic function, such as heart rate variability, baroreflex sensitivity test or pupillary light reflex, are needed to further confirm this hypothesis.

Our study also observed that frail patients were at higher risks of postoperative complications, especially infection-related complications, in concordance with previous studies.[35] Frail patients were at higher risks for anemia, hypo-albuminemia, malnutrition, sarcopenia, and chronic inflammation,[36,37] which might attribute to poorer wound healing and difficulties in early postoperative mobilization. Several studies have focused on multimodal prehabilitation program to improve patients' perioperative functional capacity and postoperative outcomes,[38,39] yet the optimal prehabilitation strategies remain to be further explored.

This study also has several limitations. For ethical considerations, this study is designed as an observational study without strict and standard induction protocol, only recommended titrating of induction medications for clinical safety. The attending anesthesiologists could choose appropriate induction methods according to individual situations. In order to reduce the influence of different anesthesia protocol on PIH, patients who received total intravenous anesthesia were excluded from the data analysis; however, this might also bring selection bias. In future studies, standardized anesthesia induction protocols may be preferred to limit confounding factors. However, the results of this study also found that even if the induction regimen combined with etomidate was adopted in frail patients, the incidence of PIH could not be avoided, which further suggested the importance of preoperative frailty assessment. The majority population of frail patients in this cohort were with gastrointestinal tumor, which might influence the external validity or generalizability of the result in other non-cardiac surgical population. Although this study was the first study illustrating that preoperative frailty was associated with post-induction hypotension, the duration and severity of PIH could be further analyzed in future quantitative studies. Lastly, as a clinical observational cohort study, the mechanism behind frailty and post-induction hypotension requires further studies to elucidate.

Conclusion

In conclusion, frail elderly patients are at higher risk for post-induction hypotension after general anesthesia, suggesting impaired autonomic regulation in frail patients. Although future studies are needed to further explore its underlying mechanism, preoperative frailty assessment might assist anesthesiologists to identify high-risk patients to optimize their anesthesia plan.

Abbreviations

ACEI, angiotensin-converting enzyme inhibitors; ARB, angiotensin receptor blockers; ASA, American Society of Anesthesiologists; BMI, body weight index; CCB, channel blockers; CCI, comprehensive complication index; CI, confidence intervals; CKD, chronic kidney disease; eIOH, early intraoperative hypotension; MD, mean difference;

MNA-SF, Mini Nutritional Assessment - Short Form; PIH, post-induction hypotension; POD, postoperative day; QoR-15,15 item Quality of recovery score; RCRI, revised cardiac risk index; RR, rate ratio; SD, standard deviation.

Data Sharing Statement

Deidentified participant data analyzed during the current study are available from the corresponding author (Dr Li Xu) upon reasonable request.

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Disclosure

The authors report no conflicts of interest in this work.

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