

The Association Between Extubation Time and Perioperative Outcomes in Valve Surgery Patients: A Retrospective Study

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Abstract

Background

For patients undergoing valve repair, how soon the tracheal tube is removed may shape postoperative recovery. Late extubation has been tied to heavier vasoactive support and longer intensive care. We examined whether extubation timing tracked with perioperative outcomes in 127 patients who had valve repair surgery.

Methods

This single-center retrospective review covered patients treated between March 2023 and May 2025, divided by extubation timing into early (≤ 6 h) and late (> 6 h) groups. Vasoactive support was quantified as the vasoactive-inotropic score indexed to ICU hours (VISmean). Group differences were tested with the Mann–Whitney U test or Fisher’s exact test, and multivariable linear regression on log-transformed outcomes adjusted for age, sex, heart failure, mitral regurgitation, and NYHA class.

Results

After adjustment, late extubation was associated with a higher VISmean (geometric mean ratio + 35.3%, 95% CI + 13.4% to + 61.5%, $P = 0.0009$), longer ICU stay (+ 28.6%, + 6.0% to + 56.2%, $P = 0.011$), and longer operation time (+ 8.7%, + 2.1% to + 15.8%, $P = 0.010$). No interaction with valve pathology reached significance.

Conclusions

Late extubation in valve repair patients is associated with heavier vasoactive support and longer ICU stay. These associations may reflect underlying disease severity more than the timing of extubation itself.

Background

Valve surgery is the definitive treatment for many forms of valvular heart disease, including aortic stenosis, mitral regurgitation, and tricuspid regurgitation [1,2]. Repair or replacement of the affected valve improves prognosis and quality of life [3], yet the operation itself and the postoperative course remain demanding.

The timing of extubation is a central decision after surgery [4]. Early extubation shortens mechanical ventilation and ICU stay and reduces complications [8,9], but some patients cannot be extubated early because of unstable hemodynamics or poor respiratory function.

Late extubation has been associated with ventilator-associated pneumonia, deep venous thrombosis, and reintubation [10–12], and higher vasoactive requirements may prolong ICU stay [13]. Whether these associations hold specifically in valve repair patients is less clear.

We therefore examined the association between extubation timing and vasoactive support, ICU stay, operation time, and complications in valve repair patients, and tested whether valve pathology modified these associations.

Methods

Study design and population

This retrospective single-center study included patients who underwent cardiac valve repair (valvuloplasty) between March 2023 and May 2025. Of the 136 patients screened, 127 were enrolled. Inclusion required age over 18 years and elective valve repair surgery. We excluded 9 patients who had valve replacement or non-valvuloplasty procedures, plus those with intraoperative death, death within 24 h of surgery, or incomplete data.

Data were retrieved from the institutional electronic medical record system. The study was approved by the Ethics Committee of Shanghai Fourth People's Hospital (approval No. 2025054-001); informed consent was waived because the study was retrospective.

Grouping

Patients were split into early (≤ 6 h, $n = 45$) and late (> 6 h, $n = 82$) extubation groups according to postoperative intubation duration.

Data collection

We recorded demographics (age, sex, body mass index) and baseline characteristics (hypertension, diabetes mellitus, respiratory disease, NYHA class, ASA status), intraoperative variables (operation time, cardiopulmonary bypass time, fluid balance, and anesthetic and vasoactive agents), and postoperative outcomes (vasoactive-inotropic score, ICU stay, operation time, pulmonary infection, pleural effusion, and reintubation). Time from extubation to ambulation (SRT) was recorded as a marker of early mobilization.

Statistical analysis

Analyses were performed in R, with two-sided $P < 0.05$ considered significant. Continuous variables were tested for normality (Shapiro–Wilk); skewed variables are reported as median (interquartile range) and compared with the Mann–Whitney U test, normally distributed variables as mean $\pm$ SD compared with

the t-test, and categorical variables with the chi-square test or Fisher's exact test. Variables with missing values were analysed using available cases (complete-case analysis), and no imputation was performed. VISmean was defined as the vasoactive-inotropic score divided by ICU hours. Because all patients underwent valve repair and inter-group differences in vasoactive requirements were small, the mean VIS captured differences in vasoactive drug use better than the peak VIS. Multivariable linear regression on log-transformed outcomes adjusted for age, sex, heart failure, mitral regurgitation, and NYHA class; interactions were tested by adding a group $\times$ subgroup term. Restricted cubic splines (RCS) were used to explore nonlinear associations.

Results

Patient characteristics

The cohort comprised 127 valve repair patients (early $n = 45$, late $n = 82$). Mean age was 43.3 ± 10.5 years and was similar between groups, as were BMI, sex, comorbidities, valve pathology, and NYHA/ASA status (Table 1). Mitral regurgitation was the most common lesion (80.3%), followed by mitral stenosis (74.0%), tricuspid regurgitation (59.8%), aortic insufficiency (52.0%), and aortic stenosis (11.0%); heart failure was present in 27.6%. No baseline characteristic differed significantly between the early and late extubation groups (Table 1).

Table 1
Baseline characteristics of the included patients.

Variable	Early (≤ 6 h, n = 45)	Late (> 6 h, n = 82)	P
Age (years), mean $\pm$ SD	42.4 $\pm$ 10.0	43.8 $\pm$ 10.8	0.446
BMI (kg/m ²), mean $\pm$ SD	22.9 $\pm$ 3.1	22.7 $\pm$ 3.2	0.671
Female sex, n (%)	31 (68.9)	60 (73.2)	0.759
Hypertension, n (%)	3 (6.7)	5 (6.1)	1.000
Diabetes mellitus, n (%)	0 (0.0)	1 (1.2)	1.000
Respiratory disease, n (%)	1 (2.2)	3 (3.7)	1.000
Mitral regurgitation, n (%)	35 (77.8)	67 (81.7)	0.765
Mitral stenosis, n (%)	33 (73.3)	61 (74.4)	1.000
Heart failure, n (%)	16 (35.6)	19 (23.2)	0.198
Aortic insufficiency, n (%)	25 (55.6)	41 (50.0)	0.679
Aortic stenosis, n (%)	3 (6.7)	11 (13.4)	0.376
Tricuspid regurgitation, n (%)	26 (57.8)	50 (61.0)	0.871
NYHA class III/IV, n (%)	24 (53.3)	39 (47.6)	0.662
ASA class IV, n (%)	33 (73.3)	65 (79.3)	0.588

Perioperative outcomes

The late-extubation group had a higher VISmean, longer ICU stay, and longer operation time than the early group (Table 2). Intraoperative fluid balance was also greater in the late group. Bypass time, midazolam, rocuronium, drain time, and time to ambulation did not differ. Pulmonary infection, pleural effusion, and reintubation were more frequent in the late group, but the study had little power for these rare events.

Table 2
Perioperative outcomes of the included patients.

Outcome	Early (≤ 6 h, n = 45)	Late (> 6 h, n = 82)	P
VISmean, median [IQR]	2.22 [0.78–3.37]	3.24 [1.96–4.63]	0.002
ICU stay (h), median [IQR]	72.00 [69.00–92.58]	93.79 [69.75–140.33]	0.017
Operation duration (h), median [IQR]	5.17 [4.83–5.67]	5.61 [5.17–6.23]	0.005
CPB time, median [IQR]	2.58 [2.22–125.00]	3.22 [2.51–135.50]	0.066
Intake/output (mL), median [IQR]	950 [550–1300]	1150 [710–1785]	0.025
Midazolam (mg), median [IQR]	7.00 [7.00–9.00]	7.00 [5.00–10.00]	0.662
Rocuronium (mg), median [IQR]	130 [80–130]	130 [100–140]	0.312
Drain time (h), median [IQR]	27.07 [25.04–28.83]	26.00 [21.87–35.78]	0.279
Time to ambulation (h), median [IQR]	16.17 [14.33–35.50]	20.89 [13.25–38.83]	0.246
Pulmonary infection, n (%)	0 (0.0)	4 (4.9)	0.296
Pleural effusion, n (%)	5 (11.1)	15 (18.3)	0.322
Reintubation, n (%)	0 (0.0)	4 (4.9)	0.296

Subgroup analysis

No valve lesion or comorbidity modified the association between extubation timing and VISmean (all P for interaction > 0.05 ; Figs. 1–4).

Nonlinear associations

RCS analysis revealed significant nonlinear associations between extubation time and ICU stay ($P < 0.001$; Fig. 5A), vasoactive-inotropic score ($P < 0.001$; Fig. 5B), and operation duration ($P < 0.001$; Fig. 5D). These associations plateaued beyond a certain threshold, suggesting that the relationship between extubation time and outcomes is not linear.

Discussion

In 127 valve repair patients, late extubation was independently associated with heavier vasoactive support, longer ICU stay, and longer operation time after adjustment. These results are consistent with reports linking late extubation to poorer outcomes in cardiac surgery [14–16].

The higher VISmean in the late group reflects a greater need for pharmacological support of blood pressure and cardiac output, which makes careful hemodynamic management in the hours after surgery

a priority.

Longer ICU stay accompanied late extubation, in line with studies showing that patients who need prolonged vasoactive support leave the ICU later [22,23].

These associations should not be read as causal. Patients who were sicker, needed more vasoactive drugs, or had longer operations were more likely to be extubated late and to fare worse afterward; extubation timing is best viewed as a marker of disease severity and recovery rather than an independent risk factor.

Not all late extubation reflected severe illness, however. Some patients returned to the ICU late in the day and were kept intubated overnight as a safety precaution rather than extubated in the evening. Had these patients been excluded, the difference in extubation duration between patients of different illness severity would likely have been more pronounced.

Valve pathology and comorbidity did not modify the association between extubation timing and outcomes, suggesting the association held across lesion types.

Several limitations deserve mention. The study was retrospective and single-center, which limits causal inference and generalizability. Unmeasured factors such as postoperative monitoring protocols and anesthesia techniques could confound the results. The sample was small for rare complications, leaving the study underpowered to detect differences in pulmonary infection, pleural effusion, or reintubation. Finally, VISmean is a time-averaged measure and differs from the peak VIS used in other studies.

Conclusions

In valve repair patients, late extubation is associated with heavier vasoactive support, longer ICU stay, and longer operation time, associations that likely reflect disease severity. Whether earlier extubation improves recovery remains an open question.

Abbreviations

VIS

Vasoactive-Inotropic Score

VISmean

Vasoactive-Inotropic Score indexed to ICU hours

ICU

Intensive Care Unit

IQR

Interquartile Range

NYHA

New York Heart Association

ASA
American Society of Anesthesiologists
RCS
Restricted Cubic Splines
SRT
time from extubation to ambulation
BMI
Body Mass Index
CI
Confidence Interval
SD
Standard Deviation

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Shanghai Fourth People's Hospital (approval No. 2025054-001). The requirement for informed consent was waived owing to the retrospective nature of the study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

Ding Zhang and Qing Peng conceived and designed the study, performed the statistical analyses, and drafted the manuscript. Yuan Huang, Jian Song, Xiaoxiao Sun, and Jian Li collected the clinical data. Yinggang Zheng processed the data. Zongping Fang conceived the study, designed and optimized the study protocol, and critically revised the manuscript. All authors read and approved the final manuscript.

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Not applicable.

Data Availability

Ding Zhang and Qing Peng conceived and designed the study, performed the statistical analyses, and drafted the manuscript. Yuan Huang, Jian Song, Xiaoxiao Sun, and Jian Li collected the clinical data. Yinggang Zheng processed the data. Zongping Fang conceived the study, designed and optimized the study protocol, and critically revised the manuscript. All authors read and approved the final manuscript.

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Figures

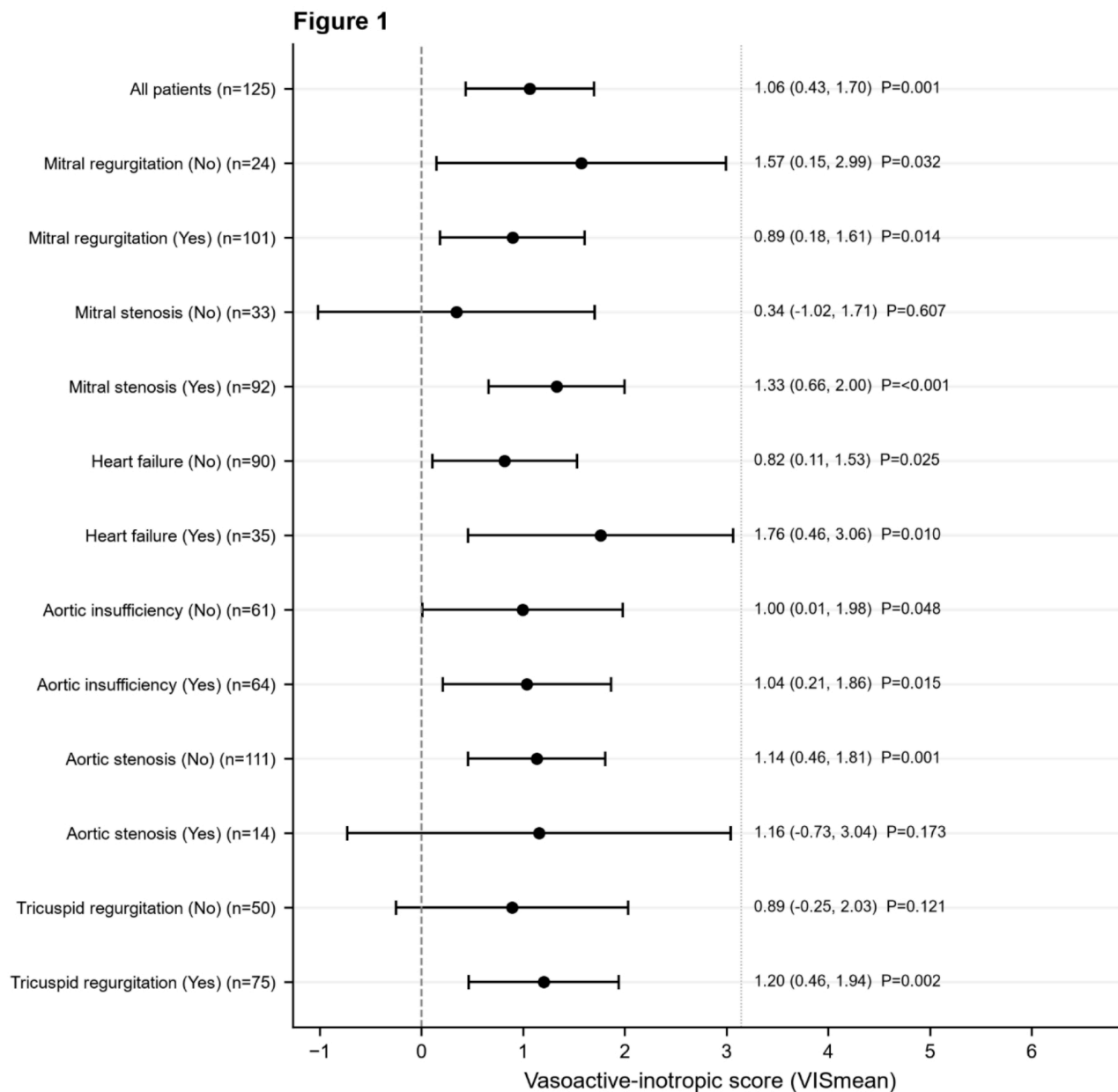


Figure 1

Subgroup analysis for the vasoactive-inotropic score (VISmean).

Subgroup analysis showed the factors may affecting vasoactive-inotropic score in valve surgery.

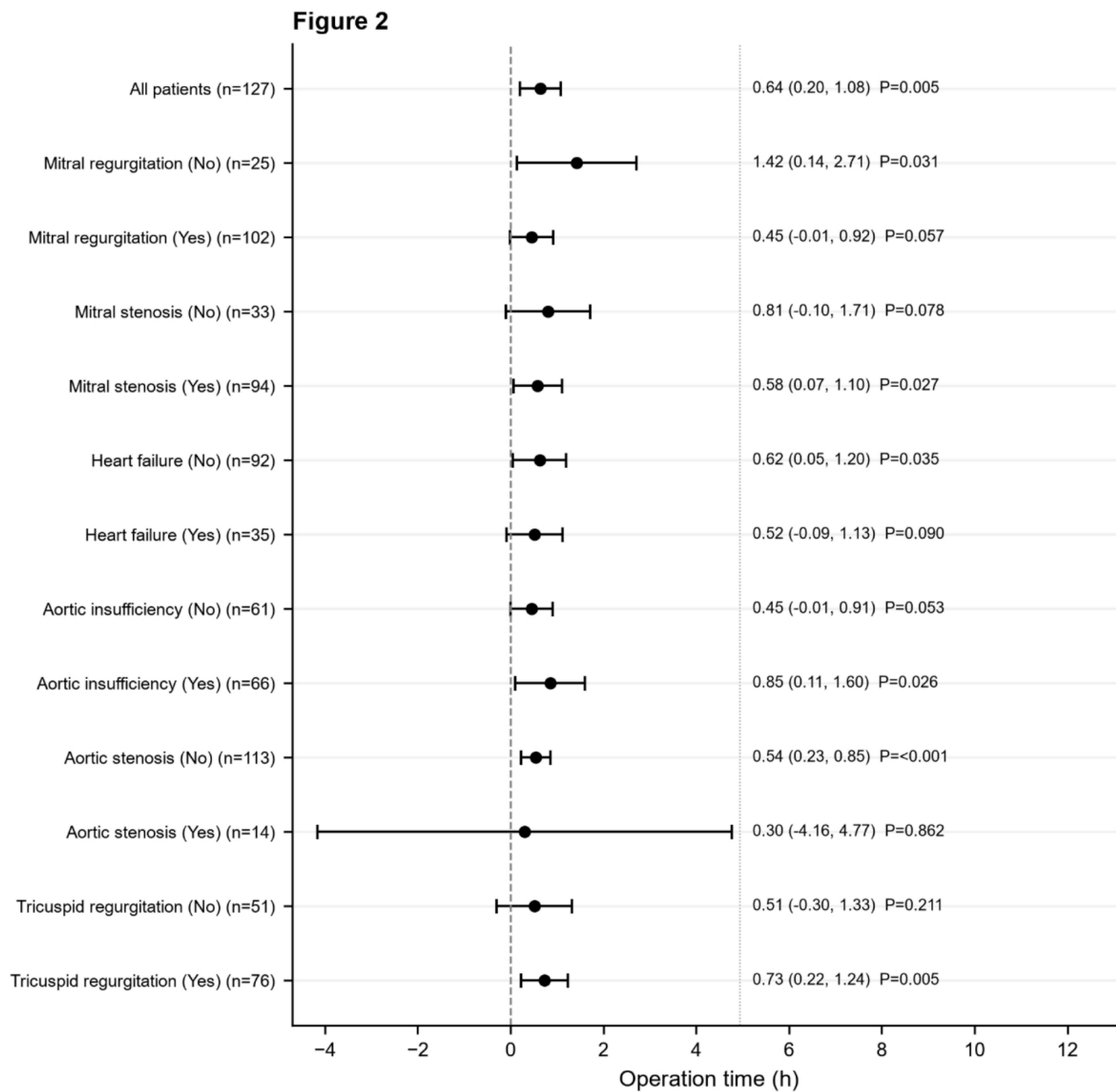


Figure 2

Subgroup analysis for operation time.

Subgroup analysis showed the factors may affecting operation time in valve surgery.

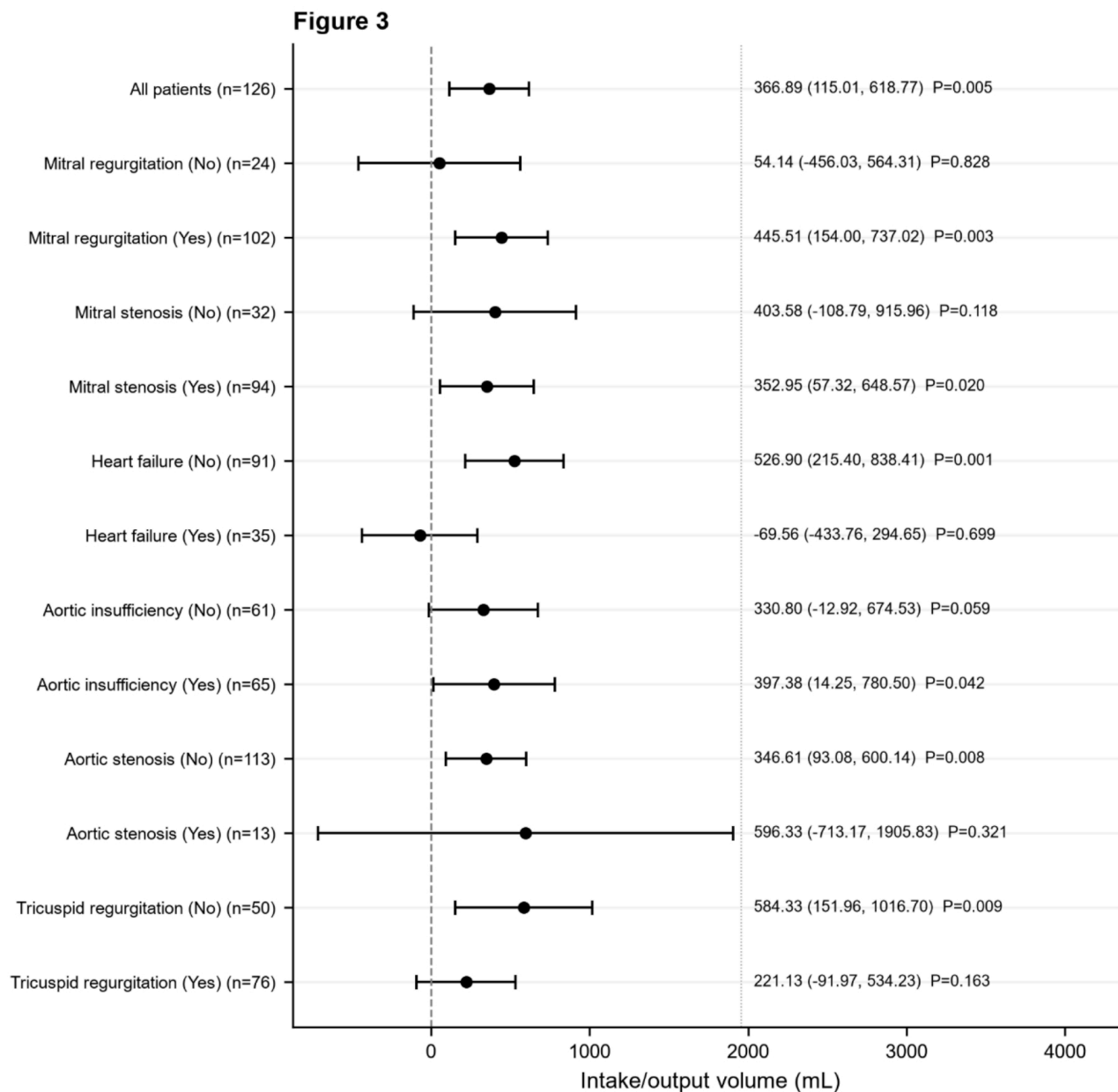


Figure 3

Subgroup analysis for intake/output volume.

Subgroup analysis showed the factors may affecting intake/output in valve surgery.

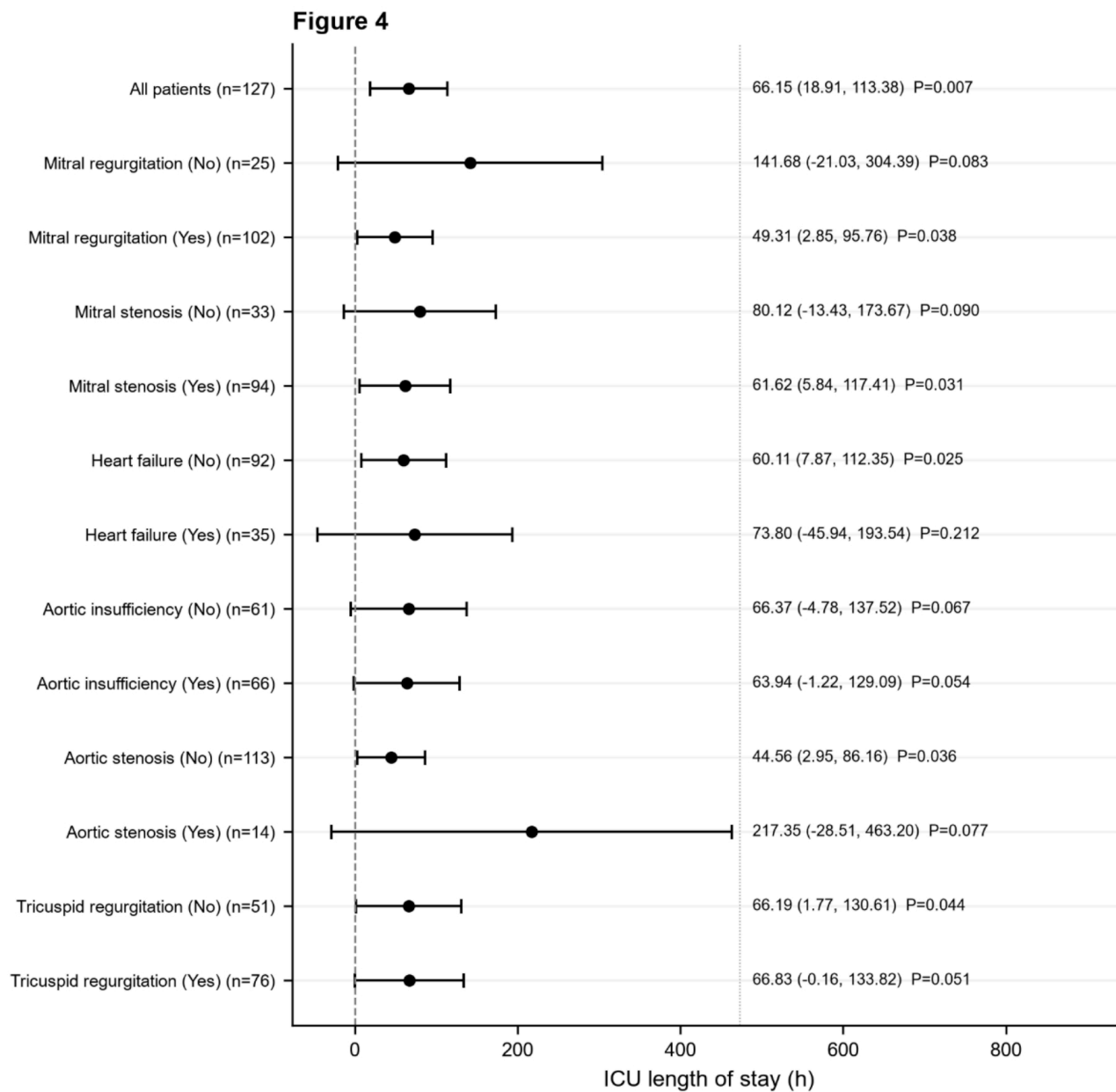


Figure 4

Subgroup analysis for ICU length of stay.

Subgroup analysis showed the factors may affecting length of ICU days in valve surgery.

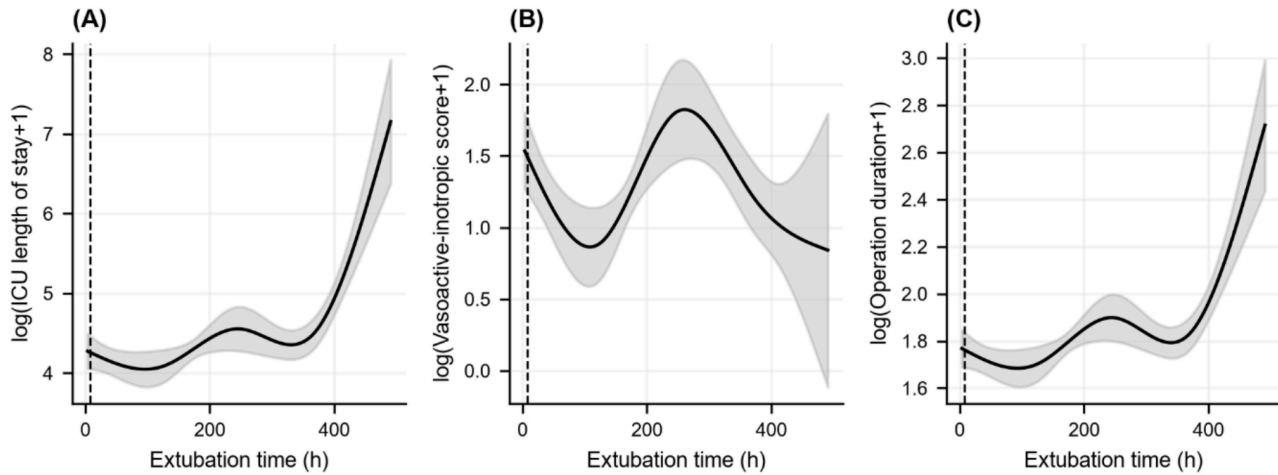


Figure 5

Nonlinear association between extubation time and clinical parameters. (A) ICU length of stay. (B) Vasoactive-inotropic score. (C) Operation duration.

The relationship between extubation time and various clinical parameters. A, The nonlinear-relationship between extubation time and length of stay in ICU; B, The nonlinear-relationship between extubation time and vasoactive inotropic score; C, The nonlinear-relationship between extubation time and time to extubation; D, The nonlinear-relationship between extubation time operation time.