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ORIGINAL RESEARCH

Factors Influencing Preoperative Blood Pressure Fluctuations in Patients Undergoing Elective Surgery: A Retrospective Observational Study

Zifei Cheng[1], Lihui Zhang[1], Minglei Liu[1], Dali Liang[1], Yue Li[1], Xiansong Huang[1], Li Peng[2]

[1]Department of Anesthesiology, Hulunbuir People's Hospital, Hulunbuir, Inner Mongolia, People's Republic of China; [2]Department of Science and Education, Hulunbuir People's Hospital, Hulunbuir, Inner Mongolia, People's Republic of China

Correspondence: Li Peng, Department of Science and Education, Hulunbuir People's Hospital, Hulunbuir, Inner Mongolia, 021000, People's Republic of China, Tel +86 134 6575 5846, Email penglidoctor@163.com

Purpose: To investigate the factors influencing preoperative blood pressure fluctuations in patients undergoing elective surgery.

Patients and Methods: This retrospective observational study included 776 patients who underwent elective surgery between January and October 2021. Preoperative blood pressure fluctuations were defined las a systolic or diastolic change exceeding 20% compared to baseline measurements taken one day prior to surgery. Patients were divided into two groups: the elevated blood pressure group (n=328) and the non-fluctuating group (n=448). Multivariate logistic regression analysis was employed to identify independent risk factors associated with blood pressure fluctuations.

Results: Among the 776 patients (335 males and 441 females), the average systolic blood pressure increased by 12.98 ± 19.33 mmHg, and diastolic blood pressure increased by 6.67 ± 13.20 mmHg on the day of surgery compared to the previous day. Preoperative blood pressure fluctuations exceeding 20% were observed in 42.27% of patients. Multivariate logistic regression revealed that older age (OR = 1.021; 95% CI: 1.007–1.035; P = 0.003), preoperative hypertension (OR = 1.785; 95% CI: 1.142–2.807; P = 0.011), and shorter sleep duration the night before surgery (OR = 0.835; 95% CI: 0.747–0.932; P = 0.001) were independent risk factors for blood pressure fluctuations.

Conclusion: Significant increases in preoperative blood pressure were observed upon patient entry into the operating room. Older age, preoperative hypertension, and inadequate sleep duration were identified as independent risk factors for blood pressure fluctuations. These findings underscore the need for targeted preoperative interventions to minimize blood pressure variability, particularly in elderly and hypertensive patients with inadequate sleep duration.

Keywords: risk factors, sleep duration, hypertension, anesthesia management, systolic and diastolic variability, perioperative hemodynamics

Introduction

Blood pressure (BP) is a critical vital sign and a key parameter guiding anesthesia management.[1–3] It serves as an indicator of end-organ perfusion for the brain, heart, and kidneys, which are particularly susceptible to ischemia.[4] Effective perioperative BP control is closely linked to postoperative organ recovery and the incidence of complications.[5] Previous studies have indicated that maintaining perioperative BP fluctuations within 20% of baseline values is essential, as fluctuations exceeding 30% are associated with significantly higher risks of postoperative cardiovascular events.[6,7]

Perioperative BP is routinely measured every five minutes during anesthesia and surgery. Effective BP management encompasses the entire perioperative period—including preoperative, intraoperative, and postoperative phases—typically spanning three to four days.[8] Uncontrolled BP fluctuations can lead to prolonged hospitalization, increased healthcare costs, and serious complications such as stroke, acute coronary syndrome, or renal failure, thereby elevating perioperative mortality risks.[9,10]

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Optimizing hemodynamics is thus a cornerstone of safe anesthesia practice. However, there is a lack of consensus on defining baseline BP and its role in intraoperative BP management, which has generated considerable debate.[11] Many studies rely on BP measurements taken immediately before anesthesia induction as a reference, but this approach may not account for multifactorial influences on BP during the perioperative period, such as environmental changes, emotional stress, and preexisting medical conditions.[12–14]

Therefore, this study aims to investigate preoperative BP fluctuations in patients undergoing elective surgery and to identify key influencing factors. The findings are intended to guide clinicians in achieving more precise BP control, minimizing perioperative adverse events, and enhancing patient safety.

Materials and Methods

Study Design and Participants

This retrospective cohort study followed the guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement to ensure the transparency and completeness of reporting. This study analyzed data from 776 patients who underwent elective non-cardiac surgery at Hulunbuir People's Hospital between January and October 2021. Inclusion criteria were patients aged 18 years or older, scheduled for elective non-cardiac surgery, classified as American Society of Anesthesiologists (ASA) physical status I–III, and with an expected surgery duration of less than 5 hours. Exclusion criteria included preoperative blood pressure (BP) ≥180/90 mmHg, based on the Expert Consensus on Perioperative Hypertension Management; severe hepatic or renal dysfunction; significant cerebrovascular or cardiovascular disease; and patients undergoing day-case surgery, obstetric procedures, or emergency surgeries.

To analyze preoperative blood pressure (BP) fluctuations, patients were categorized into two groups based on a predefined operational definition. The Elevated BP Group (n = 328) included patients whose systolic or diastolic BP exceeded 20% of their baseline values, while the Non-Fluctuating BP Group (n = 448) comprised those whose systolic or diastolic BP remained within 20% of their baseline values. Baseline BP was defined as the average of two consecutive measurements taken one day prior to surgery under standardized conditions, as detailed in the BP Monitoring and Data Collection section.[15] These operational definitions were used to categorize patients in the study. The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Ethics Committee of Hulunbuir People's Hospital. Given the retrospective nature of the study, which involved the use of pre-existing data without direct interaction or intervention with participants, a waiver for written informed consent was granted by the Ethics Committee.

BP Monitoring and Data Collection

Blood pressure measurements were performed using an automated electronic sphygmomanometer (Omron Healthcare Co., Kyoto, Japan) under standardized conditions in a quiet, temperature-controlled room maintained at 15–25 °C. Patients were instructed to avoid smoking, caffeine, and tea for at least 30 minutes before measurements and to rest in a supine position for 15–20 minutes prior to BP readings. Measurements were taken on the right upper arm with the cuff positioned at heart level. Two consecutive readings were recorded at one-minute intervals and averaged; if the difference between the two readings exceeded 5 mmHg, a third reading was taken, and the two closest values were averaged. BP was recorded at four specific time points: one day before surgery (baseline), between 6:00 AM and 7:00 AM on the day of surgery (morning of surgery), upon entry to the operating room (preoperative entry), and immediately after surgery (postoperative). Additional data collected included demographic information (age, gender, occupation, educational level), medical history (preexisting conditions such as hypertension, diabetes, and cardiovascular diseases), and preoperative assessments. Preoperative assessments comprised self-reported sleep duration on the night before surgery, anxiety levels assessed using the Spielberger State-Trait Anxiety Inventory (STAI), ASA physical status classification, and baseline BP values.

To ensure data quality and internal validity, all collected data were independently reviewed by two researchers. Any discrepancies were resolved through discussion, and in cases of uncertainty, a third senior investigator was consulted. Furthermore, all statistical analyses were independently cross-checked by an experienced statistician to ensure consistency and robustness.

Statistical Analysis

Statistical analyses were performed using SPSS version 22.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Comparisons of continuous variables between groups were conducted using independent sample t-tests or one-way analysis of variance (*ANOVA*), and categorical variables were compared using Chi-squared (χ^2) tests or Fisher's exact tests as appropriate. Variables with a P-value less than 0.05 in univariate analysis were included in a multivariate logistic regression model to identify independent risk factors for preoperative BP fluctuations. Stepwise regression was employed to address potential multicollinearity among variables, and odds ratios (ORs) with 95% confidence intervals (CIs) were calculated to quantify associations. Additionally, Spearman's rank correlation was used to assess relationships between BP fluctuations and continuous variables such as age and sleep duration. Statistical significance was set at a two-tailed P-value of less than 0.05.

Results

Preoperative Blood Pressure Differences

Systolic blood pressure (SBP) increased significantly by 12.98 ± 19.33 mmHg on the day of surgery compared to one day before surgery ($P < 0.05$). Diastolic blood pressure (DBP) increased by 6.67 ± 13.20 mmHg ($P < 0.05$). Table 1 summarizes the variations in systolic and diastolic BP at different preoperative time points: baseline (T1), morning of surgery (T2), and entry into the operating room (T3). The percent change in SBP and DBP at T3 were 10.24% and 8.68%, respectively.

Participant Characteristics

A total of 776 patients were included in the study, divided into two groups based on BP fluctuations: the Fluctuating BP Group (n = 328) and the Non-Fluctuating BP Group (n = 448). The Fluctuating BP Group had a significantly older mean age (55.15 ± 15.60 years vs 50.13 ± 15.87 years, $P < 0.0001$) and poorer sleep duration (5.53 ± 1.77 vs 6.21 ± 1.56, $P < 0.0001$) compared to the Non-Fluctuating BP Group. The two groups showed similar distributions in terms of gender, BMI, ethnicity, and preoperative health conditions ($P > 0.05$ for most comparisons). Detailed participant characteristics are summarized in Table 2.

Factors Influencing Preoperative Blood Pressure Fluctuations

Univariate Analysis

Among the 776 patients, 328 (42.27%) showed BP fluctuations exceeding 20% from baseline, with 298 patients experiencing increases and 30 showing decreases. These patients were categorized into two groups: Fluctuating BP Group (n = 328) and Non-Fluctuating BP Group (n = 448). Univariate analysis (Table 2) identified several factors significantly associated with BP fluctuations, including age, preoperative anxiety, ASA classification, and sleep duration ($P < 0.05$). For instance, the Fluctuating BP Group had a significantly older mean age (55.15 ± 15.60 vs 50.13 ± 15.87 years, $P < 0.001$) and reported poorer sleep duration (5.53 ± 1.77 vs 6.21 ± 1.56, $P < 0.001$). Preoperative anxiety was significantly associated with BP fluctuations in univariate analysis ($P = 0.0003$), but did not remain an independent risk factor in multivariate logistic regression, suggesting its effect is likely modulated by other factors such as preoperative hypertension, age, and sleep duration.

Table 1 Changes in Blood Pressure at Preoperative Time Points

Class	Time Point Comparison	Δ-Value (Mean ± SD)	t	P-value	Percent Change Rate (%)
Systolic Pressure	T2 - T1	2.38 ± 13.90	−16.90	< 0.0001	1.88
	T3 - T1	12.98 ± 19.33		< 0.0001	10.24
Diastolic Pressure	T2 - T1	1.26 ± 11.10	−11.68	< 0.0001	1.64
	T3 - T1	6.67 ± 13.20		< 0.0001	8.68

Abbreviations: Δ-Value, change in blood pressure compared to T1 baseline; T1, one day before surgery; T2, morning of surgery; T3, upon entry into the operating room; P, statistical significance ($P < 0.05$).

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Table 2 Univariate Analysis of Participant Characteristics and Preoperative BP Factors

Variable	Fluctuating Group (n = 328)	Non-Fluctuating Group (n = 448)	SMD	Test Statistic	P-value
Demographics					
Age (mean ± SD, years)	55.15 ± 15.60	50.13 ± 15.87	0.319	59950	<0.0001
Female (%)	57.3	56.5	0.017	0.03	0.8720
BMI (mean ± SD, kg/m²)	24.82 ± 3.94	24.85 ± 3.59	0.010	73439	0.9916
Ethnicity (%)			0.131	3.14	0.2083
Han nationality	74.4	70.5			
Mongolian nationality	18.9	19.2			
Other	6.7	10.3			
Health Conditions (%)					
Preoperative hypertension	36.3	37.3	0.021	0.04	0.8345
Preoperative diabetes	6.7	4.0	0.12	2.28	0.1312
Lifestyle Factors (%)					
Smoking	17.99	16.07	0.051	0.37	0.5439
Drinking	9.15	8.59	0.031	0.09	0.7601
Preoperative Conditions (%)					
History of surgery	44.5	41.1	0.07	0.78	0.3766
Ureter	44.5	43.8	0.015	0.02	0.8902
Stomach tube	5.5	3.1	0.117	2.11	0.1464
T1SBP (mean± SD, mmHg)	123.39±15.57	129.08±15.76	0.364	87441	<0.0001
T1DBP (mean± SD, mmHg)	73.41±10.75	79.29±10.51	0.553	72093	0.6821
T1HR (mean± SD, mmHg)	73.26±8.99	73.92±10.72	0.067	74656	0.7005
Sleep duration (mean ± SD)	5.53 ± 1.77	6.21 ± 1.56	0.405	89847	<0.0001
Preoperative anxiety (%)	40.5	27.9	0.269	13.08	0.0003
ASA classification (%)				6.47	0.0394
- I level	45.4	52.0			
- III level	11.6	6.9			

Notes: P, statistical significance (P < 0.05).
Abbreviations: SMD, standardized mean difference.

Multivariate Logistic Regression Analysis

Multivariate analysis (Table 3) revealed that older age (OR = 1.02, 95% CI: 1.003–1.037, P = 0.022), higher BMI (OR = 1.05, 95% CI: 1.003–1.098, P = 0.038), preoperative hypertension (OR = 1.76, 95% CI: 1.08–2.86, P = 0.023), and shorter sleep duration (OR = 0.83, 95% CI: 0.74–0.93, P = 0.002) were independent predictors of BP fluctuations. These results underscore the importance of modifiable factors such as sleep duration in minimizing BP fluctuations.

Stepwise Regression Analysis

Stepwise regression analysis confirmed that age, preoperative hypertension, and sleep duration were the primary independent risk factors for BP fluctuations, consistent with the multivariate logistic regression results. No additional significant variables were identified, reinforcing the robustness of these findings.

Correlation Analysis Between Age, Sleep Duration, and BP Fluctuations

A significant positive correlation was observed between age and BP fluctuations (r = 0.342, P < 0.001), with each additional year of age associated with a 0.2 mmHg increase in BP fluctuation (Figure 1). Conversely, sleep duration showed a significant negative correlation with BP fluctuations (r = −0.281, P < 0.001), with each additional hour of sleep reducing BP fluctuation by approximately 1 mmHg (Figure 2).

Table 3 Multivariate Logistic Regression Analysis of BP Fluctuations

Variable	B	Wald	Odds Ratio (95% CI)	P-value
Demographics				
Age (years)	0.02	5.24	1.02 (1.003–1.037)	0.0221 **
BMI (kg/m²)	0.05	4.30	1.05 (1.003–1.098)	0.0381 **
Mongolian nationality (ref: Han)	0.02	0.01	1.02 (0.67–1.55)	0.9235
Clinical Characteristics				
Preoperative hypertension	0.56	5.16	1.76 (1.08–2.86)	0.0231 **
Comorbidities	0.05	0.06	1.05 (0.68–1.62)	0.8104
Preoperative Conditions				
Sleep duration (hours)	−0.18	9.76	0.83(0.74–0.93)	0.0018 **
Anxiety	0.30	2.20	1.35(0.91–2.01)	0.1380
ASA II (ref: ASA I)	0.01	0.00	1.02(0.67–1.53)	0.9447
ASA III (ref: ASA I)	0.13	0.13	1.14(0.56–2.34)	0.7152

Notes:: P, statistical significance; **, statistically significant at P < 0.05.
Abbreviations: OR, odds ratio; CI, confidence interval.

Discussion

The present study demonstrated a significant increase in patients' blood pressure (BP) on the day of surgery compared to one day prior, with systolic BP (SBP) rising by 12.98 ± 19.33 mmHg and diastolic BP (DBP) by 6.67 ± 13.20 mmHg.

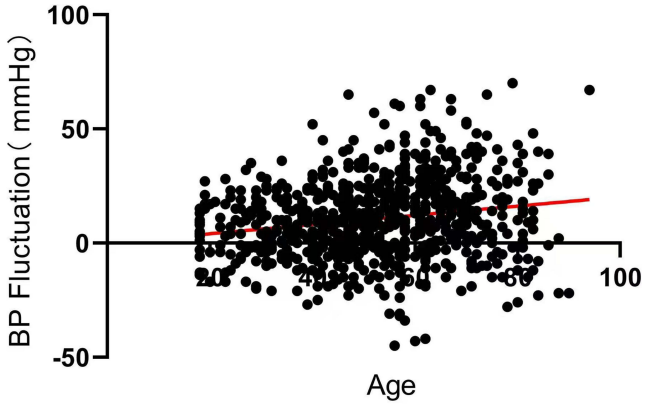

Figure 1 Blood pressure fluctuation vs age. This scatter plot shows the relationship between age and blood pressure fluctuation (mmHg), with a regression line fitted to the data (Y = 0.2022*X + 0.03247). Each point represents an individual participant.

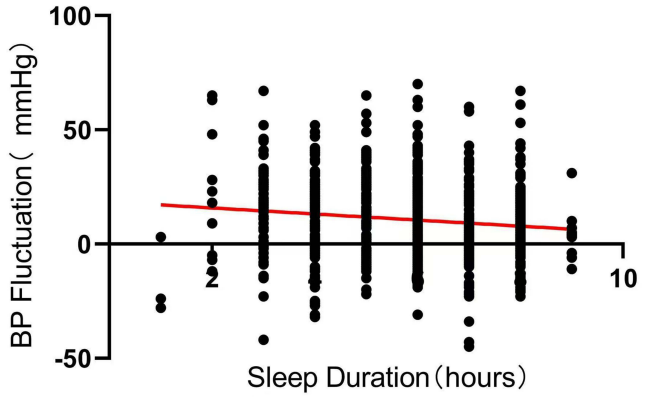

Figure 2 Blood pressure fluctuation vs sleep duration. This scatter plot shows the relationship between sleep duration (hours) and blood pressure fluctuation (mmHg), with a regression line fitted to the data (Y = −1.327*X + 18.46). Each point represents an individual participant.

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These elevations represent the highest BP levels observed during the perioperative period and were consistent across genders and age groups upon entry into the operating room.[16,17] This finding aligns with previous studies suggesting that the unfamiliar operating room environment, interaction with medical staff, and preoperative anxiety contribute to elevated BP levels.[18–20] For instance, van Klei et al reported significantly higher SBP and mean arterial pressure upon entry to the anesthesia preparation room, reflecting a stress-induced physiological response.[21] Our results underscore the importance of careful BP monitoring and management during this critical preoperative period.

Multivariate regression analysis identified age, preoperative hypertension, and sleep duration as independent risk factors for preoperative BP fluctuations. Older patients exhibited greater BP variability, with each additional year of age corresponding to a 0.2 mmHg increase in fluctuation (OR = 1.021; 95% CI: 1.007–1.035; P = 0.003). This finding is consistent with the conclusions observed by Kawasaki et al in their study on hemodynamic fluctuations following anesthetic induction, where they also found a close relationship between age and hemodynamic fluctuations.[22] This can be attributed to age-related physiological changes such as decreased vascular elasticity and increased arterial stiffness, as well as a higher prevalence of comorbidities like hypertension and diabetes.[23–25] As noted by Mokhtar et al (2010), patients with diabetes exhibit significantly increased blood pressure variability due to vascular sclerosis and reduced compliance.[26] These factors contribute to hemodynamic instability, highlighting the need for prioritized BP management in elderly patients to minimize perioperative complications.

Preoperative hypertension emerged as a significant predictor of BP fluctuations, with hypertensive patients having a 1.785-fold higher likelihood of experiencing variability (OR = 1.785; 95% CI: 1.142–2.807; P = 0.011). Heightened sympathetic nervous system activity and altered vascular responses in hypertensive individuals exacerbate BP instability.[27,28] As Mancia and Grassi pointed out, abnormal sympathetic activation is a key factor contributing to blood pressure instability in hypertensive patients, which is consistent with our findings.[29] Additionally, increased emotional stress and anxiety commonly observed in these patients may further aggravate BP fluctuations. These findings emphasize the necessity of targeted preoperative interventions for hypertensive patients, such as optimizing antihypertensive therapy and implementing stress-reduction techniques.

Sleep duration was found to be a protective factor against BP fluctuations. Each additional hour of sleep on the night before surgery was associated with a decrease in BP variability (OR = 0.835; 95% CI: 0.747–0.932; P = 0.001). Poor sleep is known to increase hypothalamic-pituitary-adrenal axis activity, leading to elevated cortisol levels, reduced vascular compliance, and heightened sympathetic excitability—all contributing to BP variability.[30] Our findings are consistent with the research by Sajadieh et al, which also found a significant association between insufficient sleep duration, elevated blood pressure, and reduced heart rate variability.[31] Therefore, improving preoperative sleep duration may thus serve as an effective strategy to stabilize BP in surgical patients.

Although preoperative anxiety was found to be significantly associated with blood pressure fluctuations in the univariate analysis, it did not emerge as an independent risk factor in the multivariate logistic regression analysis. This may be due to the confounding effects of other variables such as age, preoperative hypertension, and sleep duration, which might have overshadowed the role of anxiety in BP fluctuations. While anxiety is a well-established factor in BP variability, its impact might be moderated by these other perioperative conditions. Future studies could explore the impact of anxiety on preoperative blood pressure fluctuations with more comprehensive and consistent methods of anxiety assessment, which may help better understand its contribution to BP variability.

These results have important implications for clinical practice. Relying solely on BP measurements taken upon entry to the operating room may overestimate intraoperative BP, potentially leading to unnecessary interventions or complications. Instead, baseline BP measurements obtained in a calm, quiet environment one day before surgery should inform perioperative BP management.[32] Particular attention should be given to elderly patients and those with preoperative hypertension. Incorporating strategies such as individualized antihypertensive regimens, anxiety reduction interventions, and sleep optimization into preoperative protocols may enhance hemodynamic stability.[33] For example, implementing sleep hygiene education or prescribing short-term sleep aids could reduce BP variability and improve patient outcomes.[34]

Study Limitations

This study has several limitations. First, it is a retrospective observational design, which introduces potential biases, including selection and information bias. Data were collected from medical records, and some variables, such as anemia, hypoalbuminemia, and comorbidities like hyperthyroidism or hypothyroidism, were not systematically documented and could not be included in the analysis. Additionally, factors like regular hypertension treatment, pheochromocytoma and bowel preparation were not consistently recorded, which may have influenced blood pressure fluctuations and were not considered in the analysis. Finally, the single-center nature of the study limits its generalizability. Future prospective and multicenter studies that address these limitations will provide more robust insights into the factors influencing pre-operative blood pressure fluctuations.

Conclusion

In conclusion, preoperative BP was significantly elevated upon entry into the operating room compared to baseline measurements. Age, preoperative hypertension, and shorter sleep duration were identified as independent risk factors for BP fluctuations, with older age and inadequate sleep contributing to greater variability. These findings emphasize the need for comprehensive perioperative management strategies that include accurate baseline BP assessments, targeted interventions for high-risk patients, and efforts to improve preoperative sleep duration. Implementing such measures is essential to ensure optimal perioperative hemodynamic stability and reduce the risk of complications, ultimately enhancing patient safety and surgical outcomes.

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Disclosure

The authors report no conflicts of interest in this work.

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