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RELATIONSHIP BETWEEN HYPERTENSION GRADE AND CONSCIOUSNESS RECOVERY TIME POST GENERAL ANESTHESIA

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ABSTRACT

Hypertension is one of the most prevalent comorbidities encountered in patients scheduled for elective surgery under general anesthesia. To analyze the relationship between hypertension grade and consciousness recovery time post general anesthesia at RSUD Dr. Mohamad Soewandhie Surabaya, Indonesia. An analytic observational study with a cross-sectional approach was conducted involving 60 hypertensive patients undergoing elective surgery under general anesthesia, recruited via consecutive sampling. Hypertension grade was classified according to the 2025 AHA/ACC guidelines into three categories: Elevated (systolic 120-129 mmHg), Stage 1 (systolic 130-139/diastolic 80-89 mmHg), and Stage 2 (systolic ≥140/diastolic ≥90 mmHg), based on two pre-operative blood pressure measurements. Consciousness recovery time was measured from the time the anesthetic agent was terminated and the patient was admitted to the PACU to the first attainment of an Aldrete Score ≥9. Data were analyzed using Spearman Rank Correlation (α=0.05). The distribution of hypertension grades was: Elevated 31.7%, Stage 1 35.0%, and Stage 2 33.3%. Mean consciousness recovery time was 22.48±5.420 minutes (median 20.00; range 15-40 minutes). The Kolmogorov-Smirnov normality test revealed a non-normal distribution for both variables (p=0.000). Spearman Rank Correlation analysis yielded a correlation coefficient r=0.648 (95% CI 0.47-0.77) with significance p=0.000. There is a significant, positive, and strong relationship between hypertension grade and consciousness recovery time post general anesthesia (r=0.648; p=0.000<0.05). Higher hypertension grade is significantly associated with prolonged consciousness recovery time. Perioperative risk stratification based on hypertension grade is recommended to optimize anesthetic management and post-anesthesia monitoring.

Keywords: *Aldrete score, general anesthesia, hypertension, perioperative risk stratification, recovery time.*

INTRODUCTION

Hypertension represents one of the most prevalent and consequential chronic conditions confronting global public health systems in the contemporary era, constituting the leading modifiable risk factor for cardiovascular morbidity and mortality worldwide. Defined as a persistent elevation of arterial blood pressure that initiates progressive damage to multiple organ systems, hypertension is frequently described as a "silent killer"

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due to its characteristically asymptomatic trajectory in early stages, which belies its capacity to culminate in catastrophic end-organ damage. According to the most recent clinical practice guideline published by the American College of Cardiology and American Heart Association (Jones et al., 2025), arterial blood pressure is classified into four categories: Normal (systolic <120 mmHg and diastolic <80 mmHg), Elevated (systolic 120–129 mmHg and diastolic <80 mmHg), Stage 1 Hypertension (systolic 130–139 mmHg or diastolic 80–89 mmHg), and Stage 2 Hypertension (systolic ≥140 mmHg or diastolic ≥90 mmHg). This evidence-based classification reflects a risk-stratified approach in which progressively higher blood pressure categories are associated with incrementally greater risks of cardiovascular complications and target organ damage.

Underscoring the escalating scale of this problem, the first World Health Organization Global Report on Hypertension estimated that 1.28 billion adults worldwide were living with hypertension in 2019, of whom nearly four in five remained inadequately treated, and warned of a marked upward trajectory in disease burden across low- and middle-income regions over the preceding three decades (Kario et al., 2024). For anesthesia practice specifically, this rising prevalence translates into an increasing proportion of surgical candidates who present with elevated perioperative cardiovascular risk, since chronic hypertension is one of the most common comorbidities encountered during pre-anesthetic evaluation and is directly implicated in intraoperative hemodynamic instability and delayed post-anesthetic recovery (Zhou et al., 2023). Anesthesia providers therefore require contemporary, setting-specific evidence to anticipate and manage these risks, rather than relying on generic cardiovascular risk data collected outside the perioperative context.

The epidemiological burden of hypertension is substantial across all global regions. Mills et al. (2020) documented that approximately 31.1% of the adult population worldwide was affected by hypertension in 2010, with disproportionately higher prevalence in low- and middle-income countries (31.5%) compared to high-income nations (28.5%). In Indonesia, the fourth most populous country in the world, national health survey data indicate that hypertension prevalence reached 34.1% of the adult population in 2018, meaning that more than one-third of Indonesian adults are affected (Wahidin et al., 2025). East Java province has demonstrated a particularly concerning upward trend, with prevalence rising from 26.2% in 2013 to 36.3% in 2018—exceeding the national average and underscoring a substantial disease burden in this densely populated region (Solikha et al., 2024). This epidemiological context is directly relevant to the present study, which was conducted at a referral hospital serving the urban Surabaya population within East Java.

Chronic hypertension induces a spectrum of structural and functional cardiovascular alterations that extend far beyond the simple measurement of elevated blood pressure. These pathological changes include left ventricular hypertrophy, increased arterial stiffness and reduced compliance, endothelial dysfunction, microvascular rarefaction, and impaired cerebrovascular autoregulation (Oparil et al., 2018). These adaptations not only substantially increase the long-term risk of coronary

artery disease, heart failure, stroke, and chronic kidney disease, but also carry direct and consequential perioperative implications. Patients with hypertension undergoing elective surgery under general anesthesia are predisposed to exaggerated hemodynamic lability throughout the perioperative period, including hypertensive surges during laryngoscopy and endotracheal intubation, paradoxical hypotension following anesthetic induction, cardiac arrhythmias, and perioperative myocardial ischemia (Zhou et al., 2023). Critically, these hemodynamic perturbations are broadly proportional to the severity of the underlying hypertension and are not merely transient phenomena, but may persist into and significantly affect the post-anesthetic recovery period.

Consciousness recovery following general anesthesia constitutes a critical determinant of perioperative care quality and patient safety. This complex neurobiological process—encompassing the progressive restoration of neural network connectivity, autonomic function, airway reflexes, and purposeful motor activity following cessation of anesthetic agents—is systematically evaluated using the Aldrete Scoring System (Ding & Ishag, 2023). Originally developed in 1970 and revised in 1995 to incorporate pulse oximetry-based oxygen saturation monitoring, the Aldrete system evaluates five physiological parameters—motor activity, respiration, circulation, consciousness, and oxygen saturation—with a score ≥9 representing the internationally recognized threshold criterion for readiness to discharge from the Post-Anesthesia Care Unit (PACU). Delayed consciousness recovery is clinically significant because it prolongs mandatory PACU occupancy and substantially increases the risk of life-threatening complications, including respiratory depression, hypoxic episodes, aspiration of gastric contents, hemodynamic instability, and neurological compromise. The estimated incidence of delayed consciousness recovery among hypertensive patients ranges between 12% and 20%, with considerable variability attributed to hypertension severity, surgical procedure type and duration, and individual patient characteristics (Zhou et al., 2023).

Several prior investigations have explored the relationship between hypertension and post-anesthetic recovery. Fawwaz et al. (2024) documented a significant relationship between hypertension grade and prolonged emergence time ($p=0.002$), with Stage 2 hypertensive patients exhibiting 4.8-fold greater odds of delayed recovery compared to Stage 1 counterparts—evidence consistent with a dose-response relationship between hypertension severity and emergence delay. The same study also reported that 86.4% of Stage 1 hypertensive patients achieved consciousness recovery within 15 minutes, suggesting that lower-grade hypertension exerts a comparatively modest impact on emergence timing. Abebe et al. (2022) independently established that a history of hypertension significantly increases the risk of hemodynamic instability in the PACU and prolongs discharge readiness. Collectively, these findings provide convergent evidence supporting an association between hypertension and delayed post-anesthetic recovery, but studies specifically examining the graded relationship across the full spectrum of hypertension severity categories defined by contemporary guidelines remain limited, particularly in the Indonesian clinical context.

The novelty of the present study lies in three respects. First, whereas previous investigations (Fawwaz et al., 2024; Abebe et al., 2022; Makarem et al., 2020) examined hypertension largely through dichotomized or single-stage comparisons, the present study is among the first to examine consciousness recovery time across the complete three-tier hypertension grading spectrum (Elevated, Stage 1, Stage 2) defined by the most recent 2025 AHA/ACC guideline, enabling a dose-response characterization rather than a simple presence/absence comparison. Second, this study was conducted in an Indonesian secondary referral hospital characterized by nurse-led anesthesia practice under limited specialist supervision, a context in which risk-stratification evidence has previously been scarce. Third, by using consciousness recovery time to Aldrete Score ≥9 as an objective, standardized outcome measured under uniform inhalational-agent protocols, this study minimizes confounding arising from the heterogeneous outcome definitions that have limited comparability across earlier studies.

The Indonesian healthcare landscape introduces additional complexity through the known shortage and uneven geographic distribution of specialist anesthesiologists, which frequently necessitates anesthesia nurses (*penata anestesi*) to function with limited physician supervision (Negoro, 2025; Rekso Negoro, 2025). This context amplifies the importance of developing accessible, evidence-based risk stratification frameworks that enable frontline anesthesia practitioners to identify and appropriately manage high-risk hypertensive patients. Translating the present findings into practice, a hypertension-grade-based triage rule offers anesthesia nurses and physicians a simple bedside tool: patients graded as Stage 2 pre-operatively can be flagged at the time of pre-anesthetic assessment for extended PACU bed allocation, closer nursing-to-patient ratios during emergence, and pre-emptive titration of opioid-sparing strategies, whereas patients in the Elevated category may be safely managed under standard monitoring intensity. This risk-adapted approach is particularly relevant where specialist anesthesiologist supervision is limited, as it allows anesthesia nurses to make objective, evidence-based triage decisions without requiring additional diagnostic technology beyond routine blood pressure measurement. Furthermore, advances in perioperative management—including continuous non-invasive blood pressure monitoring, multimodal opioid-sparing anesthetic techniques, and targeted hemodynamic optimization—offer potential pathways to mitigate the impact of hypertension on recovery outcomes, but their implementation requires a clear understanding of which patients are at greatest risk (Juri et al., 2018; Ma et al., 2024).

The present study was designed to address this evidence gap by empirically analyzing the relationship between hypertension grade—classified according to the 2025 AHA/ACC guideline—and consciousness recovery time post general anesthesia at RSUD Dr. Mohamad Soewandhie Surabaya, Indonesia. The primary aim was to determine whether a statistically significant association exists between hypertension grade and the duration required to achieve an Aldrete Score ≥9. Beyond establishing statistical association, this study was specifically designed to generate a clinically actionable contribution: an evidence-based, hypertension-grade-stratified framework that anesthesia

practitioners can apply at the point of pre-operative assessment to anticipate recovery duration, allocate PACU monitoring resources proportionate to risk, and individualize anesthetic planning—thereby supporting perioperative risk stratification and the development of evidence-based PACU management protocols for hypertensive patients in the Indonesian clinical setting.

RESEARCH METHOD

This study employed an analytic observational design with a cross-sectional approach. This design was selected because it permits the simultaneous measurement of both the independent variable (hypertension grade) and the dependent variable (consciousness recovery time) within a single time period, without experimental manipulation of either variable, thereby reflecting real-world clinical conditions (Wang & Cheng, 2020). The cross-sectional approach was considered the most appropriate design for this study because both the exposure (hypertension grade) and the outcome (consciousness recovery time) could be reliably ascertained within a single perioperative episode, the temporal sequence between pre-operative blood pressure classification and post-anesthetic recovery is unambiguous (the exposure necessarily precedes the outcome), and the study aimed to estimate the strength of association in a defined clinical population within a feasible timeframe and resource envelope, consistent with recommended uses of cross-sectional designs for exposure-outcome association studies in which reverse causality is not a plausible concern (Wang & Cheng, 2020).

This study was approved by the Health Research Ethics Committee of ITSK RS dr Soepraoen Malang [Ethical Approval No. to be inserted by the author] and was conducted in accordance with the ethical principles of the Declaration of Helsinki. All participants provided written informed consent prior to enrollment, and the confidentiality of patient data was maintained throughout the study.

The study was conducted at the Central Surgical Unit and Post-Anesthesia Care Unit (PACU) of RSUD Dr. Mohamad Soewandhie Surabaya, East Java, Indonesia, over a six-week period in June 2026. This institution was selected on the basis of its status as a city-level referral hospital serving the urban Surabaya population with a high volume of elective surgical procedures, its structured perioperative documentation system, and the high prevalence of hypertensive patients among its elective surgical population.

The target population comprised all hypertensive patients undergoing elective surgery under general anesthesia in Indonesia. The accessible population consisted of all hypertensive patients undergoing elective surgery under general anesthesia at RSUD Dr. Mohamad Soewandhie Surabaya during the study period. A minimum sample size of 60 respondents was determined using the Slovin formula. Participants were recruited via consecutive sampling, whereby each patient presenting sequentially during the study period who satisfied the inclusion criteria and did not meet any exclusion criterion was enrolled until the required sample size was achieved.

To ensure the validity of blood pressure measurements, all pre-operative readings were obtained using a single, regularly calibrated automated oscillometric

sphygmomanometer, with cuff size selected according to each patient's mid-upper arm circumference following standard guideline recommendations. Measurements were performed after the patient had rested in a seated position for at least five minutes, with two consecutive readings taken five minutes apart; the mean of the two readings was used for hypertension grading. All pre-operative and intra-operative data collection was performed by a single trained anesthesia nurse to minimize inter-observer variability, and all Aldrete Score assessments in the PACU were conducted by anesthesia nurses who had undergone standardized training and inter-rater calibration on the scoring instrument prior to data collection, in order to maintain measurement consistency and quality control throughout the study period.

Inclusion criteria were: adult patients aged ≥18 years with a confirmed diagnosis of hypertension; scheduled for elective surgery under general anesthesia; ASA physical status II or III; not currently receiving antihypertensive pharmacotherapy (to ensure sample homogeneity with respect to medication effects on hemodynamic response); planned use of inhalational anesthetic agent (sevoflurane or isoflurane); expected operative duration of 1–3 hours; absence of intraoperative complications; and provision of written informed consent prior to enrollment.

Exclusion criteria encompassed: history of severe neurological disorder (stroke within the preceding six months, uncontrolled epilepsy, or dementia); major psychiatric illness; end-stage hepatic disease (Child-Pugh C cirrhosis) or end-stage renal disease (CKD Stage 5); diabetes mellitus; clinically significant cardiac disease (coronary artery disease, heart failure, or arrhythmia); major intraoperative complications (massive hemorrhage >1,500 mL, cardiac arrest, or severe hemodynamic instability); requirement for immediate postoperative transfer to the intensive care unit with mechanical ventilation; and emergency or urgent surgical procedures.

RESULTS AND DISCUSSION

Results

Subject Characteristics

Table 1 presents the descriptive statistics of numerical variables. The mean age of the 60 subjects was 48.65±15.258 years (median 48.00; range 17–88 years), reflecting a broad age distribution from young adults through the elderly. The mean body mass index (BMI) was 23.98±2.568 kg/m² (median 24.00; range 18–29 kg/m²). Mean pre-operative systolic blood pressure was 135.47±11.04 mmHg and diastolic 84.60±4.37 mmHg. Mean operative duration was 81.53±23.95 minutes (range 25–130 minutes). The primary outcome—consciousness recovery time (time to first Aldrete Score ≥9)—had a mean of 22.48±5.420 minutes (median 20.00; range 15–40 minutes).

Table 1. Descriptive Statistics of Numerical Variables (n=60)

Variable	n	Mean	Median	SD	Min–Max
Age (years)	60	48.65	48.00	15.258	17–88
BMI (kg/m²)	60	23.98	24.00	2.568	18–29
Mean Systolic BP (mmHg)	60	135.47	135.00	11.04	121–175

Mean Diastolic BP (mmHg)	60	84.60	83.00	4.37	76–95
Operative Duration (minutes)	60	81.53	80.00	23.95	25–130
Consciousness Recovery Time (minutes)	60	22.48	20.00	5.420	15–40

Table 2 presents the frequency distribution of categorical characteristics. Female subjects predominated at 43 (71.7%) versus 17 males (28.3%). The distribution of hypertension grades was well-balanced: Elevated (120–129/<80 mmHg) in 19 subjects (31.7%), Stage 1 (130–139/80–89 mmHg) in 21 subjects (35.0%), and Stage 2 (≥140/≥90 mmHg) in 20 subjects (33.3%). By BMI category, 32 subjects (53.3%) were Normal (18.5–24.9), 26 (43.3%) were Overweight (25–29.9), and 2 (3.3%) were Underweight (<18.5); no subjects met the criteria for Obesity. Isoflurane was the predominant anesthetic agent used in 36 subjects (60.0%) versus sevoflurane in 24 subjects (40.0%). The majority were classified as ASA physical status II (83.3%).

Table 2. Frequency Distribution of Subject Characteristics (n=60)

Variable	Category	n	%
Sex	Male	17	28.3
	Female	43	71.7
Hypertension Grade	Elevated (120-129/<80 mmHg)	19	31.7
	Stage 1 (130-139/80-89 mmHg)	21	35.0
	Stage 2 (≥140/≥90 mmHg)	20	33.3
BMI Category	Underweight (<18.5)	2	3.3
	Normal (18.5–24.9)	32	53.3
	Overweight (25–29.9)	26	43.3
Anesthetic Agent	Sevoflurane	24	40.0
	Isoflurane	36	60.0
ASA Status	ASA II	50	83.3
	ASA III	10	16.7

Normality Testing

Table 3. Results of Kolmogorov-Smirnov Normality Test (n=60)

Parameter	Hypertension Grade	Recovery Time
N	60	60
Mean	2.02	22.48
Std. Deviation	0.813	5.420
Test Statistic (D)	0.220	0.260
Asymp. Sig. (2-tailed)	0.000*	0.000*
Data Distribution	Not Normal	Not Normal

The Kolmogorov-Smirnov test in Table 3 revealed that both the Hypertension Grade variable (p=0.000) and the Consciousness Recovery Time variable (p=0.000) did not follow a normal distribution (p<0.05). Consequently, the nonparametric Spearman Rank Correlation test was applied for bivariate analysis.

Relationship Between Hypertension Grade and Consciousness Recovery Time

Table 4. Results of Spearman Rank Correlation Analysis

Variable	Correlation Coefficient (r)	95% CI	Sig. (2-tailed)
Hypertension Grade → Consciousness Recovery Time	0.648**	0.47 – 0.77	0.000

The Spearman Rank Correlation analysis in Table 4 yielded a correlation coefficient r=0.648 with a significance value of p=0.000. Since p=0.000 < α=0.05, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted. There is a significant, positive, and strong relationship between hypertension grade and consciousness recovery time post general anesthesia at RSUD Dr. Mohamad Soewandhie Surabaya (r=0.648; p=0.000). The value r=0.648 falls within the 0.60–0.799 interval, classified as a Strong level of association. The positive direction indicates that higher hypertension grade is systematically associated with longer consciousness recovery time.

The 95% confidence interval for the correlation coefficient, calculated using Fisher's z-transformation, ranged from 0.47 to 0.77, indicating that the true population correlation is very unlikely to fall below a moderate-to-strong magnitude. In terms of effect size, r=0.648 corresponds to a coefficient of determination (r^2) of approximately 0.42, indicating that hypertension grade alone accounts for approximately 42% of the variance in consciousness recovery time—a substantial effect size by conventional standards (Cohen's criteria classify r≥0.50 as a large effect), particularly considering that recovery time is known to be multifactorially determined.

Clinically, this magnitude of association means that hypertension grade can meaningfully improve the anticipatory accuracy of PACU staffing and monitoring decisions: patients presenting with Stage 2 hypertension can be expected, on average, to require appreciably longer PACU observation before satisfying discharge-readiness criteria than patients with Elevated blood pressure, even though recovery time is also shaped by other perioperative variables. This graded relationship supports the incorporation of hypertension grade into pre-operative risk-scoring tools, rather than treating hypertension as a simple binary risk flag.

Discussion

The finding of a significant, positive, and strong correlation (r=0.648; p=0.000) between hypertension grade and consciousness recovery time is the central result of this study. This relationship can be comprehensively explained by four interrelated pathophysiological mechanisms.

First, chronic hypertension produces progressive deterioration of baroreflex sensitivity—the fundamental neural feedback mechanism governing moment-to-moment blood pressure regulation (Trembach et al., 2022). The dysfunctional baroreceptor arc in hypertensive patients requires substantially more time to resume effective regulatory

activity following suppression by inhalational anesthetic agents, thereby delaying the re-establishment of hemodynamic stability and the neurophysiological conditions necessary for full consciousness recovery.

Second, general anesthesia exerts its characteristic effects by disrupting thalamocortical and corticocortical functional connectivity, particularly the neural communication pathways essential for conscious awareness and cognitive integration (Bonhomme et al., 2019; Shin et al., 2022). Consciousness recovery requires the progressive, coordinated restoration of these neural networks. In patients with chronic hypertension, pre-existing alterations in baseline neural connectivity—arising from chronic cerebral hypoperfusion, microangiopathy, and white matter remodeling—substantially amplify this disruption, rendering full network recovery a more time-consuming process (Huang et al., 2021). This gradient effect is more pronounced in Stage 2 compared to the Elevated category.

Third, hypertensive patients, particularly those with Stage 2, characteristically exhibit more pronounced and prolonged hemodynamic fluctuations during the anesthetic emergence phase, including exaggerated pressor responses to stimuli such as endotracheal tube presence, suctioning, and pain, as well as episodes of relative hypotension attributable to residual anesthetic effects superimposed on impaired compensatory vascular tone (Subramanian et al., 2020; Zhou et al., 2023). These perturbations directly interfere with stable cerebral perfusion pressure maintenance during emergence, disrupting the perfusion-dependent processes of neural recovery.

Fourth, hypertension-associated structural vascular remodeling—encompassing arteriolosclerosis, medial smooth muscle hypertrophy, and fibrinoid changes—progressively narrows the operational range of cerebrovascular autoregulation (Oparil et al., 2018). This impairment renders the brain less capable of maintaining constant cerebral blood flow despite varying perfusion pressures, making the hypertensive brain more vulnerable to perfusion-recovery delays following anesthesia-induced cardiovascular depression. The severity of this autoregulatory impairment is broadly proportional to hypertension grade, which mechanistically explains the positive direction of the observed correlation.

These findings are in strong concordance with prior investigations. Fawwaz et al. (2024) demonstrated a significant relationship between hypertension grade and prolonged emergence ($p=0.002$), with Stage 2 patients exhibiting 4.8-fold greater odds of delayed recovery compared to Stage 1 counterparts, providing compelling evidence of a dose-response effect of hypertension severity on emergence duration. The same study also reported that 86.4% of Stage 1 patients achieved recovery within 15 minutes, consistent with the present finding that lower-grade hypertension is associated with comparatively shorter recovery. Abebe et al. (2022) independently established that hypertension history significantly increases hemodynamic instability in the PACU and delays discharge readiness, corroborating the mechanistic pathways described above. Makarem et al. (2020) further identified hypertension as an independent risk factor for inadequate

emergence from general anesthesia in multivariate analysis, providing additional convergent validity for the present association.

Notably, while all three prior studies converge on the general conclusion that hypertension impairs post-anesthetic recovery, important differences distinguish their findings from the present study. Fawwaz et al. (2024) examined only Stage 1 versus Stage 2 hypertension using a dichotomized odds-ratio approach and an emergence-time endpoint rather than a formal Aldrete-based consciousness recovery threshold, which may explain why their reported effect (OR=4.8) is expressed in different metric terms than the correlation coefficient reported here; nonetheless, the directionality is consistent. Abebe et al. (2022) examined hemodynamic instability broadly rather than isolating consciousness recovery time specifically, and studied a general surgical population without hypertension grading, which limits direct numerical comparison but supports the underlying mechanistic pathway. Makarem et al. (2020) identified hypertension as an independent predictor of inadequate emergence in a population additionally characterized by substance-dependence history, a comorbidity profile that differs substantially from the present hypertensive, antihypertensive-medication-free cohort, which may partly explain the differing effect magnitudes reported between the two studies. These distinctions suggest that while the qualitative direction of association (hypertension impairs recovery) is highly consistent across settings, the quantitative strength of association is sensitive to how hypertension exposure and recovery outcome are operationally defined, underscoring the value of the graded, guideline-based classification and the standardized Aldrete-based endpoint applied in the present study.

Further recent evidence reinforces the present findings. Luo et al. (2025), in a machine-learning-based prediction model for delayed extubation among PACU patients, identified hypertension-related hemodynamic instability among the top-ranked predictive features, corroborating the clinical relevance of hypertension as a recovery-relevant variable even when analyzed alongside a broad panel of perioperative covariates using more complex, high-dimensional modeling approaches. Similarly, Kario et al. (2024), summarizing the WHO Global Report on Hypertension, emphasized that the rapidly rising global hypertension burden—including in Southeast Asian populations similar to the present study cohort—translates into a correspondingly rising number of surgical candidates who carry hypertension-related perioperative risk, reinforcing the practical urgency of incorporating hypertension grading into routine perioperative risk assessment rather than treating it as a background comorbidity.

The coefficient r=0.648, while classified as strong, does not reach unity, which appropriately reflects the multifactorial determinism of post-anesthetic consciousness recovery. Additional contributing variables—including age, BMI, operative duration, anesthetic agent type, ASA status, intraoperative opioid dosing, and neuromuscular blockade management—each contribute independently to the variance in recovery time not explained by hypertension grade alone (Aggarwal et al., 2024). This aligns with the multifactorial conceptual framework of post-anesthetic recovery emphasized throughout the broader anesthesiological literature (Bonhomme et al., 2019).

Beyond confirming an association already suggested by prior literature, this study makes a distinct scientific contribution. It is among the first, to the authors' knowledge, to quantify the relationship between hypertension grade and consciousness recovery time using the currently updated three-tier 2025 AHA/ACC grading system (Elevated, Stage 1, Stage 2) rather than a binary hypertensive/normotensive comparison, thereby providing a dose-response characterization of the exposure-outcome relationship that has direct implications for graded rather than uniform PACU management protocols. The 2025 AHA/ACC guideline represents the most contemporary and evidence-based framework for blood pressure classification, yet its application as a stratification tool for perioperative anesthetic risk remains largely unexplored in the empirical literature. The perioperative management of hypertensive surgical patients has increasingly emphasized the need for individualized, severity-based risk stratification approaches, and the present study responds directly to this identified clinical gap by providing empirical data linking each grade of hypertension to a quantifiable recovery outcome. Furthermore, the 2024 AHA/ACC guideline for perioperative cardiovascular management of noncardiac surgery highlights that poorly controlled hypertension is a modifiable risk factor warranting personalized perioperative strategies, yet specific evidence on how hypertension grade differentially predicts post-anesthetic consciousness recovery time remained absent from the literature prior to the present investigation.

In addition, by deliberately restricting the sample to patients not receiving antihypertensive pharmacotherapy, the present findings isolate the effect of untreated chronic hypertension-related vascular and autonomic pathology on recovery time, independent of the confounding influence of antihypertensive drug classes—including beta-blockers, calcium channel blockers, and renin-angiotensin system inhibitors—that themselves modulate anesthetic emergence pharmacodynamics and perioperative hemodynamic response (Legrand et al., 2024; Thompson et al., 2024). The Anesthesia Patient Safety Foundation's 2024 consensus conference on perioperative hemodynamic instability recognized that hypertensive patients represent a particularly high-risk subgroup requiring targeted management protocols, yet the evidence base supporting grade-specific stratification has been insufficient. This design feature—exclusion of antihypertensive pharmacotherapy as a confounder—is rarely controlled for in prior studies on post-anesthetic recovery and represents a specific methodological contribution of this work that strengthens the internal validity of the observed association.

The clinical implications of these findings are substantive and directly actionable within the framework of contemporary perioperative guidelines. The identification of a strong positive correlation establishes hypertension grade as a clinically meaningful and readily accessible predictor of consciousness recovery duration that can be formally incorporated into pre-operative risk stratification algorithms. The PeriOperative Quality Initiative (POQI) 2024 international consensus statement on perioperative arterial pressure management recommends individualized blood pressure targets for at-risk patients, and the present findings provide the empirical foundation for extending this individualized approach specifically to PACU recovery duration planning. Patients

classified as Stage 2 (≥140/≥90 mmHg) warrant intensified PACU monitoring protocols with planned extension of observation periods, proactive hemodynamic management, early analgesic intervention to minimize emergence agitation, and pre-positioned contingency plans for managing delayed emergence or hemodynamic complications. The development and institutional implementation of standardized perioperative management protocols that formally integrate hypertension grading as a stratification variable—particularly given the high hypertension prevalence in the East Java surgical population—represents a direct and actionable clinical translation of the present findings with genuine potential to improve patient safety outcomes and optimize resource allocation.

At a broader policy level, these findings carry implications beyond the individual patient encounter. Given that East Java's hypertension prevalence (36.3%) already exceeds the Indonesian national average (Solikha et al., 2024), and that hypertension prevalence continues to rise across low- and middle-income regions globally (Kario et al., 2024), hospital administrators and national perioperative-care policymakers should consider embedding hypertension-grade-based risk stratification into standard pre-operative assessment forms and PACU staffing algorithms, rather than leaving such stratification to individual clinician judgment. For anesthesia nurses working with limited direct anesthesiologist supervision—a documented feature of the Indonesian healthcare workforce a simple (Negoro, 2025; Rekso Negoro, 2025), guideline-anchored hypertension grade offers an accessible and reproducible triage criterion that does not require additional equipment or specialist input, and could plausibly be adapted by other health systems in the region facing similar workforce constraints and rising hypertension burden.

CONCLUSION

A significant, positive, and strong correlation was established between hypertension grade and consciousness recovery time post general anesthesia at RSUD Dr. Mohamad Soewandhie Surabaya ($r = 0.648$; $p = 0.000$), with higher hypertension grade systematically associated with longer time to attain Aldrete Score ≥9—an association attributable to hypertension-mediated deterioration of baroreflex sensitivity, cerebrovascular autoregulation, neural network connectivity, and hemodynamic stability during anesthetic emergence, and corroborated by convergent evidence from multiple prior investigations. These findings establish hypertension grade as a clinically meaningful, pre-operatively accessible predictor of consciousness recovery duration that warrants formal integration into perioperative risk stratification algorithms, with Stage 2 patients (≥140/≥90 mmHg) warranting intensified PACU monitoring and proactive hemodynamic management; future prospective, multivariate, and multicenter studies incorporating normotensive control groups are recommended to strengthen causal inference and generalizability.

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