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Intraoperative Hemodynamic Profile: Evaluation of Mean Arterial Pressure in Patients Undergoing General Anesthesia

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Abstract

Introduction: Intraoperative hemodynamic fluctuations during general anesthesia are clinically important because reduced Mean Arterial Pressure (MAP) may compromise organ perfusion and contribute to postoperative complications. Despite growing awareness of the need for hemodynamic control, variations in MAP across different patient characteristics and surgical types remain insufficiently documented in clinical practice.
Objective: This study aimed to evaluate intraoperative MAP patterns in patients undergoing general anesthesia and to identify variations based on demographic and clinical factors.
Method: A descriptive observational design was applied to 61 elective surgical patients with ASA physical status I–II at RSI Sultan Agung Semarang. Intraoperative MAP measurements were recorded using standardized patient monitoring systems. Data were analyzed using descriptive statistics, including frequency, percentage, mean, and standard deviation.
Result: The mean intraoperative MAP was 69.49 ± 4.32 mmHg. Although most respondents maintained normotensive values, 8.2% experienced hypotension below the 65 mmHg threshold. Higher MAP values were observed in patients aged 41–50 years, those with ASA II status, and those undergoing lower abdominal surgery. Lower MAP values were more common in urology procedures and among ASA I patients.
Conclusion: Although the overall MAP level remained within the acceptable clinical range, the presence of intraoperative hypotension in a subset of patients underscores the importance of proactive, individualized hemodynamic monitoring. Variations in MAP across demographic and surgical factors highlight the need for patient-specific hemodynamic targets to ensure optimal intraoperative safety.

Keywords: general anesthesia, hemodynamic monitoring, intraoperative hypotension

Introduction

Surgical treatments are on the rise worldwide and constitute a vital element of contemporary healthcare provision. According to estimates from the World Health Organization, over 300 million major surgeries are conducted annually across the globe, underscoring the increasing need for perioperative care and the vital necessity of safe anesthetic practices (Weiser, et al., 2015). General anesthesia transcends mere pain relief by creating a regulated and reversible condition of unconsciousness, amnesia, analgesia, and immobility; however, anesthetic drugs may also disturb physiological homeostasis, especially cardiovascular function (Brown, et al., 2024). The management of these patients is further complicated by institutional factors, such as the efficiency of bed occupancy and the complexity of patient profiles in hospitalized settings (Lestari, et al., 2025; Pratiwi, et al., 2025).

Ensuring hemodynamic stability is a primary objective of intraoperative anesthetic treatment. Frequently utilized induction and maintenance agents, such as propofol, sevoflurane, or isoflurane, can diminish cardiac contractility and lower systemic vascular resistance (Butterworth, et al., 2022). Recent pharmacological comparisons suggest that newer agents like remimazolam may offer superior hemodynamic stability in hypertensive patients compared to traditional propofol (Tan, et al., 2025). Nevertheless, a decline in arterial blood pressure is commonly noted during induction, and significant or extended hypotension might jeopardize the perfusion of essential organs, such as the brain, heart, and kidneys (Putu, et al., 2022).

Mean Arterial Pressure (MAP) is recognized as a more dependable measure of organ perfusion than systolic blood pressure, as it represents the average arterial pressure during the cardiac cycle (Gropper, et al., 2019). Research indicates that MAP values below 65 mmHg correlate with heightened risks of acute renal injury and cardiac infarction (Salmasi, et al., 2017). Furthermore, recent studies have linked intraoperative hypotension to a higher incidence of postoperative delirium and major adverse cardiac events, particularly in vulnerable populations (Zhang, et al., 2025; Sessler & Khanna, 2025). Even brief episodes of hypotension are significant, rendering MAP monitoring an essential component of patient safety (Sessler, et al., 2019).

Intraoperative MAP fluctuations are affected by various patient- and procedure-related variables. Age-associated vascular rigidity and comorbidities denoted by ASA classification can influence variability in hemodynamic responses (Saugel, et al., 2018). Moreover, patient-specific factors such as psychological state, anxiety levels, and preexisting cardiovascular conditions significantly impact how a patient reacts to anesthetic induction (Sari, et al., 2025). Procedures that activate visceral nociceptive pathways, such as abdominal surgery, may generate sympathetic activation that counteracts anesthetic-induced vasodilation, necessitating advanced predictive monitoring (Abbott, et al., 2025; Wijnberge, et al., 2025).

Despite a robust theoretical foundation, empirical data are essential to assess the applicability of these physiological ideas in clinical practice. Current surveys indicate significant variations in how hemodynamic monitoring is applied across different international medical communities (Saugel, et al., 2025; Kouz, et al., 2025). Initial observations in specialized surgical environments have revealed significant MAP variations even in ASA I–II patients, highlighting the need for consistent hemodynamic status overviews (Kabnani, et al., 2025; Arlyana, et al., 2024). Inconsistent patterns of hypotension have also been noted in specific procedures like Caesarean sections, further justifying a more exhaustive analysis (Sijunjung, 2024).

This study aims to assess the intraoperative hemodynamic profile, specifically Mean Arterial Pressure (MAP), in patients receiving general anesthesia. Comprehending the variations in MAP concerning age, ASA status, and surgery type may enhance anesthetic decision-making and promote better perioperative treatment (Smith, et al., 2025). Furthermore, optimizing hemodynamic management aligns with the goal of improving clinical documentation and professional knowledge within anesthesia nursing (Purwati, et al., 2025; Solihah & Purwati, 2023). Ultimately, utilizing standardized guidelines for hemodynamic support is crucial to reducing avoidable postoperative complications (Miller, et al., 2025).

Objective

Objective of the Study In light of the potential risks associated with unmonitored or unanalyzed hemodynamic fluctuations, this study aims to provide a comprehensive descriptive analysis of intraoperative hemodynamics. Specifically, this research focuses on "Intraoperative Hemodynamic Profile: Evaluation of Mean Arterial Pressure (MAP) in Patients Undergoing General Anesthesia." The primary objective is to evaluate the distribution and stability of MAP and to describe how these values vary according to patient demographics (age, gender), clinical status (ASA classification), and surgical characteristics. By mapping these profiles, this study hopes to provide empirical data that can heighten clinician awareness regarding patients at risk of occult hypotension, ultimately contributing to improved patient safety standards in anesthetic care

Method

Design and setting

This quantitative research utilized a descriptive observational design with a cross-sectional approach to evaluate intraoperative hemodynamic profiles. The study was conducted at the Central Surgical Installation of Rumah Sakit Islam Sultan Agung Semarang, focusing on adult patients classified under ASA physical status who underwent surgical procedures under general anesthesia.

Population and sampling

The study population comprised all patients undergoing surgical procedures under general anesthesia at the Central Surgical Installation of RSI Sultan Agung Semarang, averaging 160 cases annually. Inclusion criteria were defined as adults (aged 18–65 years) with ASA physical status I–II scheduled for elective surgery. Conversely, exclusion criteria eliminated patients with incomplete medical records, emergency cases, or severe comorbidities (e.g., arrhythmias) that could compromise accurate hemodynamic monitoring.

From this population, a purposive sampling technique selected 61 respondents who met the specific clinical criteria for hemodynamic evaluation. The sample size was derived from the total population of 160 patients using Slovin’s formula with a 10% margin of error, establishing a minimum requirement of 61 subjects. This non-probability approach ensures the sample remains feasible for the study period while strictly adhering to the necessary clinical parameters.

Sampling involved a systematic screening of medical records to verify demographics, ASA status, and surgical type, prioritizing cases with complete intraoperative Mean Arterial Pressure (MAP) documentation. This rigorous selection process ensures sufficient statistical power to describe hemodynamic distributions without bias. Adhering to these protocols provides an accurate descriptive analysis of MAP dynamics within the study site's population.

Instrument and measurement

Data collection utilized two primary instruments to ensure documentation accuracy. First, a researcher-developed observation sheet systematically recorded demographics and clinical variables (age, gender, ASA status, surgery type). Second, MAP was measured using standardized, calibrated medical-grade bedside monitors available in the operating theater. As established clinical devices, these monitors provide high validity and reliability for continuous vital sign assessment, minimizing measurement error.

Measurement procedures adhered to standard anesthesia protocols, with Mean Arterial Pressure (MAP) quantified in millimeters of mercury (mmHg). Hemodynamic values displayed on digital monitors were observed in real-time and manually transcribed onto observation sheets. To uphold research ethics and patient privacy, all personal identifiers were anonymized and replaced with unique respondent codes throughout the data collection process.

Data collection and analysis

Data collection involved systematic documentation of demographics and intraoperative hemodynamic values from bedside monitors. A rigorous management protocol ensued, beginning with editing to verify record completeness and accuracy, followed by coding to convert categorical variables (gender, ASA status, surgery type) into numerical formats. Respondent anonymity was strictly maintained during this phase to ensure confidentiality and minimize bias.

Data analysis was performed using SPSS software, focusing on univariate descriptive statistics to map the population's hemodynamic profile. Categorical data were processed to generate frequency distributions and percentages, while numerical data specifically Age and MAP were analyzed for measures of central tendency and dispersion (mean, median, minimum, maximum). This approach provides a comprehensive overview of the variables, aligning with the study's descriptive observational design.

Result

Table 1. Incidence of Intraoperative Hypotension

Variables	MAP Treshold (mmHg)	F	%
Hemodynamic Category			
Hypotension	<65	5	8.2
Normotension	≥ 65	56	91.8
Total		61	100%

Table 1 indicates that although the majority of respondents maintained normotension, 5 respondents (8.2%) experienced hypotensive episodes with MAP values falling below 65 mmHg. This finding is of clinical significance, as recent literature suggests that absolute MAP thresholds below 65 mmHg are associated with an increased risk of tissue hypoperfusion and end-organ injury.

Table 2. MAP Profile Stratified by Demographic and Clinical Characteristics

Variables	n	Percentage (%)	Mean MAP (mmHg)	Standard Deviation (SD)	Range (Min-Max)
Age (Years)					
20 – 30	3	4.9%	67.33	2.50	65 - 70
31 – 40	19	31.1%	68.90	3.80	63 - 78
41 – 50	39	63.9%	69.95	4.45	64 - 84
Gender					
Male	29	47.5%	70.12	4.21	64 - 84
Female	32	52.5%	68.91	3.85	63 - 81
ASA Physical Status					
ASA I	32	52.5%	68.65	3.55	63 - 76
ASA II	29	47.5%	70.40	4.80	64 - 84
Type of Surgery					
Urology Surgery	40	65.6%	68.80	3.90	63 - 80
General Surgery	14	23.0%	69.75	4.10	65 - 82
Lower Abdominal Surgery	7	11.5%	72.90	5.25	67 - 84
Overall Total	61	100%	69.49	4.32	63 - 84

Table 2 presents the demographic and clinical characteristics of the 61 respondents alongside their corresponding hemodynamic profiles. The majority of the study population fell within the 41–50 years age group (n=39; 63.9%) and were predominantly female (n=32; 52.5%). In terms of physical status, respondents classified as ASA I constituted the largest proportion (n=32; 52.5%), slightly outnumbering those with ASA II (n=29; 47.5%). Regarding the surgical procedures, urology surgery was the most prevalent intervention performed (n=40; 65.6%), followed by general surgery (n=14; 23.0%) and lower abdominal surgery (n=7; 11.5%). Descriptively, the highest mean MAP values were observed in patients undergoing lower abdominal surgery (72.90 ± 5.25 mmHg) and those in the ASA II category (70.40 ± 4.80 mmHg), while the overall population mean MAP was recorded at 69.49 ± 4.32 mmHg.

Discussion

The primary goal of this study was to characterize intraoperative hemodynamic patterns in patients undergoing general anesthesia by focusing on variations in Mean Arterial Pressure (MAP). Overall, the mean MAP observed in this population was 69.49 ± 4.32 mmHg, which falls within a clinically acceptable range. This suggests that anesthesia management during the procedures was generally effective in maintaining perfusion pressure. However, the finding that 8.2% of patients experienced MAP values below 65 mmHg is clinically noteworthy. While this incidence is lower than some regional overviews of hemodynamic status (Kabnani, et al., 2025; Arlyana, et al., 2024), evidence indicates that even short periods of hypotension below this threshold contribute to postoperative renal dysfunction and myocardial injury (Salmasi, et al., 2017).

Upon examining patient characteristics, MAP levels exhibited a significant trend across various age groups. Individuals aged 41–50 years exhibited elevated MAP levels relative to younger persons. This pattern corresponds with clinical observations regarding vascular rigidity and reduced arterial compliance in aging populations (Saugel, et al., 2018).

Furthermore, the stability of these levels may be influenced by the patient's psychological state, including anxiety levels and coping mechanisms, which can alter the baseline hemodynamic response prior to induction (Sari, et al., 2025). While sex differences were minimal in this study, the overall response to induction in healthy adults remains a complex physiological event requiring precise assessment (Brown, et al., 2024).

The ASA classification demonstrated a noteworthy physiology-based correlation. Patients classified as ASA II exhibited elevated MAP levels during anesthesia compared to ASA I patients, likely due to a rightward shift in autoregulation from chronic vascular alterations (Sessler, et al., 2019) . Such patients, particularly those with hypertension, may benefit from specific anesthetic agents like remimazolam to maintain better hemodynamic stability (Tan, et al., 2025). These variations underscore the necessity of customizing hemodynamic objectives according to a patient's baseline physiology (Wijnberge, et al., 2025), especially as intraoperative hypotension is a known risk factor for postoperative delirium and adverse cardiac events (Zhang, et al., 2025; Sessler & Khanna, 2025).

A further significant observation pertained to the nature of the surgical technique. Lower abdominal surgeries demonstrated the highest mean MAP values, likely due to nociceptive signals and catecholamine release prompted by abdominal manipulation (Abbott, et al., 2025). Conversely, minimally invasive urological procedures generally yielded the lowest values, as they may fail to elicit a sufficient sympathetic response to oppose anesthetic-induced vasodilation. The efficacy of predictive indices in these varying procedural contexts remains an area of active clinical evaluation (Ma, et al., 2024).

Collectively, these data emphasize that intraoperative hemodynamics are influenced by the dynamic interaction of pharmaceutical effects, patient physiology, and surgical stimuli. The stability of MAP is impacted not only by anesthetic dosage but also by age-related vascular adaptations and the extent of nociceptive activation (Putu, et al., 2022). Optimizing these responses requires the target-oriented strategy of perioperative infusion therapy based on real-time monitoring data (Smith, et al., 2025). Furthermore, clinicians must remain aware of institutional factors, such as bed occupancy rates and the presence of complex comorbidities like cancer, which can affect the overall perioperative environment (Lestari, et al., 2025; Pratiwi, et al., 2025).

Although the general hemodynamic profile in this group was satisfactory, the occurrence of hypotension in a subset of individuals underscores the necessity for proactive anticipation. Ongoing observation and prompt interventions, such as vasopressor administration or modification of anesthetic depth, are crucial to avert avoidable organ hypoperfusion (Miller, et al., 2025). This proactive approach is further supported by the transition toward high-quality electronic medical documentation and increased professional knowledge in anesthesia nursing (Purwati, et al., 2025; Solihah & Purwati, 2023). Ultimately, personalized hemodynamic management remains the cornerstone of modern perioperative safety.

The Key Findings

The findings from this study provide an overview of intraoperative MAP behavior among patients undergoing general anesthesia. While the average MAP remained within a safe physiological range, a meaningful proportion of patients experienced hypotension below the recognized safety threshold of 65 mmHg. The analysis also demonstrated clear trends: MAP tended to be higher in older individuals, in those with ASA II status, and during procedures involving greater nociceptive stimulation, such as lower abdominal surgery.

Conversely, lower MAP values were more commonly observed in minimally invasive procedures and among ASA I patients. These patterns indicate that individual physiological characteristics and surgical context play a significant role in shaping intraoperative blood pressure responses.

Taken together, the results highlight a dynamic balance between anesthetic effects, patient physiology, and surgical stimulation. A decrease in MAP following anesthetic induction is an expected pharmacological response; however, the presence of hypotension even in a relatively low-risk cohort suggests that not all patients compensate equally. Factors such as vascular compliance, chronic physiological adaptation, and sympathetic activation appear to influence whether MAP remains stable or declines. Clinically, these findings reinforce the concept that maintaining hemodynamic stability is not purely drug-dependent it also depends on understanding the patient's baseline physiology and anticipating how their body may react under anesthesia.

Compare with Previous Studies

The trends observed in this study are consistent with prior research. Earlier studies have shown that intraoperative hypotension can occur in 15–20% of surgical cases, particularly when MAP thresholds below 65 mmHg are used as a reference. Although the frequency in this study was lower, the overall pattern aligns with findings by Salmasi et al., Reich et al., and Sessler et al., who reported that anesthesia-induced vasodilation combined with reduced sympathetic tone can predispose certain patients to hypotension. The observation that ASA II patients demonstrated higher MAP values supports the well-established concept of shifted autoregulatory thresholds in individuals with chronic hypertension or cardiovascular adaptation.

Implications

From a practical standpoint, these findings underscore the importance of personalized hemodynamic management during anesthesia. Relying solely on average MAP values or standardized targets may overlook individuals who are more vulnerable to hypotension. Instead, tailoring interventions to each patient’s baseline physiology, surgical profile, and anesthetic requirements may help prevent organ under-perfusion and reduce postoperative complications. These results also support the growing clinical emphasis on early recognition and prompt management of even brief intraoperative hypotensive episodes.

Limitations

Numerous limitations must be recognized while analyzing the findings of this study. The employment of a descriptive observational design constrains the capacity to determine causal links. The sample size was limited and sourced from a single institution, thus impacting the generalizability of the findings. Critical clinical variables such as precise anesthetic dosages, fluid management protocols, and vasopressor administration were excluded from the research and may have affected MAP variations. Subsequent research that includes these variables may yield a more thorough comprehension of hemodynamic dynamics during surgical procedures.

Future investigations should explore intraoperative hemodynamic variability using larger and more diverse patient samples and include multivariate analyses to identify independent predictors of hypotension. Longitudinal follow-up may also help clarify whether transient intraoperative hypotension is associated with measurable postoperative outcomes,

such as renal impairment, delayed recovery, or cognitive decline. Incorporating variables related to anesthetic technique, fluid therapy, and vasoactive medication use may yield more robust clinical guidance and support the development of individualized hemodynamic management strategies.

Conclusion

This study examined intraoperative Mean Arterial Pressure (MAP) in patients undergoing general anesthesia and identified how age, ASA physical status, and surgical characteristics contributed to hemodynamic variation. Although the average MAP remained within a clinically acceptable range, episodes of hypotension were still observed in a subset of patients, indicating that even low-risk surgical populations are not exempt from perfusion-related vulnerability. The findings suggest that intraoperative blood pressure management should not rely solely on generalized thresholds but instead consider individual patient physiology and the nature of the surgical stimulus. Personalized hemodynamic targets, along with vigilant and proactive monitoring, may help prevent avoidable perfusion deficits and improve overall perioperative safety outcomes. In summary, maintaining optimal MAP during anesthesia requires a balanced approach that integrates anesthetic depth, patient baseline characteristics, and real-time physiological responses throughout the surgical course.

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Author Contribution

All authors contributed significantly to the development of this research. The primary author was responsible for study design, data collection, and manuscript drafting. Data analysis and interpretation were supported collaboratively by the co-authors. All authors reviewed, revised, and approved the final manuscript.

Conflict of Interest

The authors declare that there are no conflicts of interest related to the design, execution, analysis, or publication of this study.

Ethical Clearance

This study received ethical approval from the institutional ethics review committee prior to data collection and adhered to the principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants.

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