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Original Article

Factors Affecting the Frequency of Hypotension in Patients Undergoing General Anesthesia

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ABSTRACT

Background: General anesthesia induction-related hypotension is a clinically relevant perioperative event that may occur after anesthetic induction because of vasodilation, reduced systemic vascular resistance, myocardial depression, and impaired compensatory cardiovascular responses. Identification of routinely measurable factors associated with peri-induction blood pressure changes may support safer anesthetic monitoring and early intervention. Objective: To determine pre- and post-induction blood pressure patterns and assess their association with age, sex, body mass index, diabetes status, and propofol dosage among patients undergoing general anesthesia. Methods: This prospective observational study included 182 patients undergoing general surgical procedures under general anesthesia at Surgical Unit 03, Services Hospital, Lahore, from December 2025 to March 2026. Data were collected using a structured proforma and included demographic characteristics, BMI category, diabetes status, propofol dosage, and pre- and post-induction systolic and diastolic blood pressure scores. Data were analyzed using SPSS version 21.0, with bivariate testing applied to assess associations between predictor variables and blood pressure outcomes. Results: The mean age was 37.49 ± 15.16 years, and 97 participants were male. The mean coded systolic blood pressure score decreased from 4.98 ± 1.37 before induction to 2.88 ± 1.29 after induction. Age was significantly associated with pre-induction systolic blood pressure ($p = 0.015$) and post-induction systolic blood pressure ($p = 0.044$). BMI category was associated with pre-induction systolic blood pressure ($p = 0.006$), while sex was associated with pre-induction systolic and diastolic blood pressure ($p = 0.045$ and $p = 0.047$). Diabetes status and propofol dosage were not significantly associated with any blood pressure outcome. Conclusion: Age was the most consistent factor associated with peri-induction systolic blood pressure, while BMI and sex were associated mainly with baseline blood pressure status. Future studies should report raw blood pressure values, standardized hypotension thresholds, and adjusted effect estimates. Keywords: General anesthesia; hypotension; blood pressure; propofol; body mass index; diabetes mellitus.

INTRODUCTION

Hypotension during the peri-induction phase of general anesthesia is a clinically important hemodynamic event because induction agents, loss of sympathetic tone, vasodilation, reduced venous return, and absence of surgical stimulation may collectively lower systemic arterial pressure soon after anesthesia is initiated. Although there is no single universally accepted definition of perioperative hypotension, systolic blood pressure below 90 mmHg, diastolic blood pressure below 60 mmHg, mean

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arterial pressure below clinically accepted safety thresholds, or a substantial reduction from baseline are commonly used to identify clinically relevant hypotensive episodes. General anesthesia induction-related hypotension is particularly important because it may occur before surgical incision, at a time when anesthetic drugs exert cardiovascular depressant effects without the counterbalancing sympathetic response produced by operative stimulation (1).

The mechanisms underlying post-induction hypotension are multifactorial. General anesthetic agents may reduce systemic vascular resistance through vasodilation, decrease myocardial contractility, blunt compensatory autonomic responses, and alter preload, while adjunctive opioids and neuromuscular blocking agents may further contribute to hemodynamic instability in susceptible patients (2,3). Propofol is widely used as an induction agent because of its rapid onset and favorable recovery profile, but it is also associated with peripheral vasodilation and sympathoinhibition, which may produce clinically meaningful reductions in arterial blood pressure, especially when used with potent analgesics or in patients with limited cardiovascular reserve (2,3). Even short periods of intraoperative or peri-induction hypotension have been associated in previous literature with postoperative complications, including myocardial injury, acute kidney injury, stroke, and increased perioperative morbidity, making early recognition of patient-level risk factors clinically relevant for anesthetic planning and monitoring (4).

Several patient-related and anesthetic-related factors have been proposed as contributors to hypotension after induction of general anesthesia. Increasing age may reduce physiological reserve and impair compensatory cardiovascular responses, while body mass index may influence baseline hemodynamic status, drug distribution, airway and ventilation dynamics, and perioperative cardiovascular stress. Diabetes mellitus may contribute through autonomic dysfunction, vascular stiffness, and altered cardiovascular regulation, although its observed effect may vary according to disease duration, medication use, glycemic control, and sample composition. Sex-related differences in body composition, vascular tone, baseline blood pressure, and drug pharmacokinetics may also influence peri-induction blood pressure patterns. Previous studies have reported associations between induction-related hypotension and age, baseline blood pressure, anesthetic drug exposure, pre-existing cardiovascular risk, and perioperative clinical characteristics; however, findings vary across populations, settings, anesthetic protocols, and definitions of hypotension (5–7).

Despite the recognized clinical importance of general anesthesia induction-related hypotension, local evidence remains limited regarding the frequency of hypotension and its association with routinely available demographic and clinical factors among patients undergoing general surgery in hospital-based practice. Simple variables such as age, sex, body mass index, diabetes status, baseline blood pressure, and induction drug dose are readily available before or during induction and may assist anesthesia teams in anticipating hypotensive episodes, strengthening monitoring, and planning timely intervention. However, these variables require clear evaluation using a defined hypotension endpoint and clinically interpretable pre- and post-induction blood pressure measurements.

Using a PICO-oriented framework, the population of interest in the present study comprised patients undergoing general anesthesia for general surgical procedures; the exposures of interest were age, sex, body mass index, diabetes status, and propofol dosage; the comparison was between patients or categories with different demographic and clinical characteristics; and the outcome was pre- and post-induction blood pressure status, including hypotension after induction. Therefore, this study aimed to determine the frequency of hypotension before and after induction of general anesthesia and to assess the association of pre- and post-induction blood pressure with age, sex, body mass index, diabetes status, and propofol dosage among patients undergoing general anesthesia.

MATERIALS AND METHODS

This prospective observational study was conducted to assess peri-induction blood pressure status and factors associated with hypotension among patients undergoing general anesthesia. The study was carried out under the Department of Health Professional Technologies, Faculty of Allied Health Sciences, The University of Lahore, Pakistan, with data collection performed in Surgical Unit 03 of Services Hospital, Lahore. The study duration was four months, from December 2025 to March 2026. A hospital-based observational design was appropriate because the objective was to evaluate naturally occurring pre- and post-induction blood pressure patterns and their association with routinely measurable patient and anesthetic factors without assigning any intervention or altering standard anesthetic care.

A total of 182 patients undergoing general surgical procedures under general anesthesia were enrolled using a purposive sampling technique. Patients aged 13 to 83 years who were scheduled to undergo surgery under general anesthesia and provided informed consent were included. Patients with known cardiac disease were excluded to reduce confounding from pre-existing cardiovascular pathology that could independently alter peri-induction hemodynamic responses. Diabetes mellitus was retained as a study variable because diabetic status was one of the prespecified clinical factors assessed for association with blood pressure before and after induction.

Data were collected using a structured proforma developed from previous literature and adapted for the variables required in the present study. The proforma recorded demographic and clinical characteristics, including age, sex, body mass index category, diabetes status, propofol dosage, pre-induction systolic and diastolic blood pressure, and post-induction systolic and diastolic blood pressure. Body mass index was categorized as underweight, normal weight, or overweight according to the study classification used during data collection. Diabetes status was recorded as diabetic or non-diabetic based on the patient's clinical history. Propofol dose was recorded in milligrams as administered during induction of general anesthesia.

Blood pressure was assessed before induction of general anesthesia and again after induction during the peri-induction period before full surgical stimulation. Systolic and diastolic blood pressure values were recorded for each participant, and hypotension was interpreted using clinically relevant low blood pressure thresholds consistent with the study definition of systolic blood pressure below 90 mmHg and/or diastolic blood pressure below 60 mmHg. Pre-induction blood pressure represented baseline hemodynamic status immediately before anesthetic induction, whereas post-induction blood pressure represented the early hemodynamic response following administration of induction medication. The primary outcome was the presence and frequency of hypotension after induction of general anesthesia, and the secondary analytical focus was the association of pre- and post-induction systolic and diastolic blood pressure with age, sex, body mass index, diabetes status, and propofol dosage.

The sample size was calculated using the single-population proportion formula, $n = Z^2P(1 - P)/d^2$, where P represented the expected proportion of hypotension reported in previous literature, d represented the acceptable margin of error, and Z represented the standard normal value corresponding to a 95% confidence level. Using an expected hypotension proportion of 36.5%, a 7% margin of error, and a 95% confidence level, the required sample size was calculated as 182 participants (8).

Data were entered into SPSS version 21.0 for statistical analysis after checking for completeness and consistency. Continuous variables such as age and propofol dosage were summarized using mean and standard deviation when distributional assumptions were appropriate, while categorical variables such as sex, BMI category, and diabetes status were summarized using frequencies and percentages. Pre- and post-induction systolic and diastolic blood pressure were analyzed to determine the frequency of hypotension and to assess blood pressure changes after induction. Associations between patient-related and anesthetic-related factors and pre- and post-induction blood pressure were evaluated using bivariate statistical tests appropriate to the measurement level of each variable. For continuous or ordinal variables, correlation-based analysis was applied where appropriate, while categorical comparisons were interpreted according to group distribution and statistical significance. A p-value below 0.05 was considered statistically significant. To strengthen interpretability, results were planned to be reported with the direction of association and clinically meaningful estimates wherever available, rather than relying only on p-values.

Potential bias was addressed by using a structured data collection proforma, applying the same eligibility criteria across participants, recording blood pressure at standardized peri-induction time points, and entering all data into a predefined SPSS spreadsheet before analysis. Confounding was considered during interpretation because variables such as age, sex, BMI, diabetes status, baseline blood pressure, and propofol dosage may influence peri-induction hemodynamic response. Data integrity was maintained by reviewing completed forms for missing or inconsistent entries before final analysis and by using the same operational definitions for all participants.

Written permission was obtained from the University of Lahore before data collection, and informed consent was obtained from all participants prior to enrollment. The study was conducted according to ethical principles for observational human research, with confidentiality maintained during data handling and analysis. No experimental intervention was introduced, and patient management followed routine anesthetic and surgical care.

RESULTS

A total of 182 patients undergoing general anesthesia were included in the analysis. The mean age of participants was 37.49 ± 15.16 years, with an age range of 13 to 83 years. Of the total participants, 97 were male and 85 were female, representing 53.3% and 46.7% of the sample, respectively. Body mass index classification showed that 44 patients were underweight, 96 had normal weight, and 42 were overweight, corresponding to 24.2%, 52.7%, and 23.1% of the sample, respectively. Diabetes mellitus was present in 18 participants, while 164 participants were non-diabetic, indicating that diabetic patients represented 9.9% of the study population. The mean propofol dose administered during induction was 136.21 ± 25.84 mg, with recorded doses ranging from 100 to 200 mg.

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants

Variable	Category / Measure	n (%) or Mean ± SD	Minimum–Maximum
Total participants	—	182 (100.0)	
Age, years	Continuous	37.49 ± 15.16	13–83
Sex	Male	97 (53.3)	
	Female	85 (46.7)	
Body mass index category	Underweight	44 (24.2)	
	Normal weight	96 (52.7)	
	Overweight	42 (23.1)	
Diabetes status	Diabetic	18 (9.9)	
	Non-diabetic	164 (90.1)	
Propofol dosage, mg	Continuous	136.21 ± 25.84	100–200

Pre- and post-induction blood pressure values were available in the manuscript as coded blood pressure scores rather than raw systolic and diastolic measurements in mmHg. The mean pre-induction systolic blood pressure score was 4.98 ± 1.37, whereas the mean post-induction systolic blood pressure score decreased to 2.88 ± 1.29. This indicates a reduction in systolic blood pressure score after induction. In contrast, the mean diastolic blood pressure score was 3.87 ± 1.03 before induction and 4.46 ± 0.91 after induction. Because the original manuscript does not provide the category definitions for these coded scores, these values should be interpreted as coded peri-induction blood pressure indicators rather than direct clinical blood pressure values in mmHg.

Table 2. Pre- and Post-Induction Blood Pressure Scores

Blood Pressure Variable	N	Minimum	Maximum	Mean ± SD
Pre-induction systolic blood pressure score	182	2	9	4.98 ± 1.37
Pre-induction diastolic blood pressure score	182	1	7	3.87 ± 1.03
Post-induction systolic blood pressure score	182	1	9	2.88 ± 1.29
Post-induction diastolic blood pressure score	182	1	6	4.46 ± 0.91

Bivariate analysis was performed to assess the association of age, diabetes status, propofol dosage, BMI category, and sex with pre- and post-induction systolic and diastolic blood pressure scores. Age was significantly associated with pre-induction systolic blood pressure score (p = 0.015) and post-induction systolic blood pressure score (p = 0.044), but it was not significantly associated with pre-induction diastolic blood pressure score (p = 0.770) or post-induction diastolic blood pressure score (p = 0.653). BMI category was significantly associated with pre-induction systolic blood pressure score (p = 0.006), while its associations with pre-induction diastolic blood pressure score (p = 0.939), post-induction systolic blood pressure score (p = 0.578), and post-induction diastolic blood pressure score (p = 0.822) were not statistically significant.

Sex was significantly associated with both pre-induction systolic blood pressure score (p = 0.045) and pre-induction diastolic blood pressure score (p = 0.047), but it was not significantly associated with post-induction systolic blood pressure score (p = 0.755) or post-induction diastolic blood pressure score (p = 0.652). Diabetes status showed no statistically significant association with any pre- or post-induction systolic or diastolic blood pressure score, with p-values ranging from 0.267 to 0.833. Propofol dosage also showed no statistically significant association with pre-induction systolic blood pressure score (p = 0.720), pre-induction diastolic blood pressure score (p = 0.316), post-induction systolic blood pressure score (p = 0.069), or post-induction diastolic blood pressure score (p = 0.608). Although the association between propofol dosage and post-induction systolic blood pressure score approached statistical significance, it did not meet the conventional threshold of $p < 0.05$.

Table 3. Association of Clinical and Demographic Factors With Pre- and Post-Induction Blood Pressure Scores

Predictor Variable	Pre-Induction SBP Score p-value	Pre-Induction DBP Score p-value	Post-Induction SBP Score p-value	Post-Induction DBP Score p-value
Age	0.015	0.770	0.044	0.653
Diabetes status	0.551	0.267	0.833	0.688
Propofol dosage	0.720	0.316	0.069	0.608
BMI category	0.006	0.939	0.578	0.822
Sex	0.045	0.047	0.755	0.652

Overall, the findings indicate that systolic blood pressure was more consistently associated with demographic and anthropometric factors than diastolic blood pressure. Age demonstrated significant associations with systolic blood pressure both before and after induction, suggesting that older participants may have had a distinct systolic blood pressure pattern across the peri-induction period. BMI category and sex were associated only with pre-induction blood pressure, indicating that these variables may have influenced baseline hemodynamic status more than post-induction blood pressure response. Diabetes status was not significantly associated with any blood pressure outcome in this sample, although interpretation is limited by the small number of diabetic participants. Propofol dosage was not significantly associated with post-induction systolic or diastolic blood pressure, and therefore the results do not support a statistically significant independent association between the recorded absolute propofol dose and post-induction blood pressure score in the available bivariate analysis.

The available aggregated results show a reduction in mean systolic blood pressure score from 4.98 before induction to 2.88 after induction, supporting the presence of peri-induction systolic blood pressure decline. However, because the manuscript reports coded blood pressure scores rather than raw systolic and diastolic values in mmHg, the exact number and percentage of patients meeting the clinical definition of hypotension could not be directly determined from the summarized table values. For full clinical reporting, the final analysis should include the number and percentage of patients with hypotension before and after induction using a prespecified threshold, along with effect estimates such as correlation coefficients, mean differences, odds ratios, or regression coefficients with 95% confidence intervals.

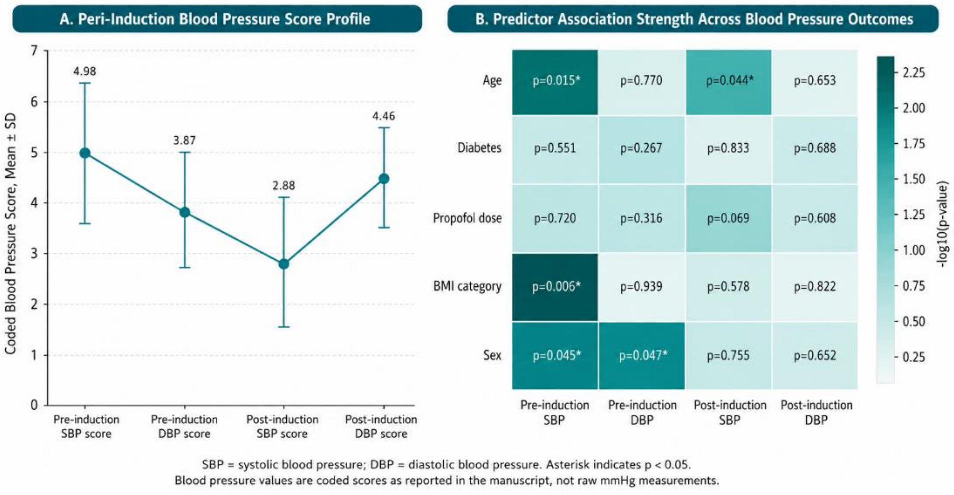

Figure 1 Peri-Induction Blood Pressure Pattern and Predictor Associations in General Anesthesia.

Panel A shows the peri-induction coded blood pressure profile among 182 patients, with mean pre-induction systolic blood pressure score decreasing from 4.98 ± 1.37 to 2.88 ± 1.29 after induction, indicating a marked post-induction systolic decline in the reported score distribution. Mean diastolic blood pressure score increased from 3.87 ± 1.03 before induction to 4.46 ± 0.91 after induction, suggesting that systolic and diastolic responses followed different peri-induction patterns. Panel B demonstrates that age was significantly associated with both pre-induction systolic blood pressure score ($p = 0.015$) and post-induction systolic blood pressure score ($p = 0.044$), while BMI category showed the strongest association with pre-induction systolic blood pressure score ($p = 0.006$). Sex was significantly associated with pre-induction systolic and diastolic blood pressure scores ($p = 0.045$ and $p = 0.047$, respectively), whereas diabetes status and propofol dosage did not show statistically significant associations with any blood pressure outcome; propofol dosage approached but did not reach significance for post-induction systolic blood pressure score ($p = 0.069$).

DISCUSSION

The present study evaluated peri-induction blood pressure patterns and their association with age, sex, body mass index, diabetes status, and propofol dosage among 182 patients undergoing general anesthesia. The principal finding was that the mean coded systolic blood pressure score decreased from 4.98 ± 1.37 before induction to 2.88 ± 1.29 after induction, indicating a measurable post-induction systolic blood pressure decline in the reported score distribution. Age was significantly associated with both pre-induction systolic blood pressure score ($p = 0.015$) and post-induction systolic blood pressure score ($p = 0.044$), while BMI category showed a significant association only with pre-induction systolic blood pressure score ($p = 0.006$). Sex was significantly associated with pre-induction systolic and diastolic blood pressure scores ($p = 0.045$ and $p = 0.047$, respectively), but not with post-induction blood pressure outcomes. Diabetes status and propofol dosage were not significantly associated with any pre- or post-induction systolic or diastolic blood pressure score in the available bivariate analysis.

The significant association between age and systolic blood pressure before and after induction is clinically plausible because advancing age is commonly accompanied by reduced vascular compliance, altered baroreceptor sensitivity, impaired autonomic compensation, and increased susceptibility to anesthetic-induced hemodynamic instability. Previous studies have identified increasing age as an important predictor of hypotension following induction of general anesthesia, particularly in patients with reduced physiological reserve or pre-existing cardiovascular risk factors (7,9–11). Reich et al. reported that older age was associated with hypotension after induction of general anesthesia, supporting the interpretation that age may contribute to systolic blood pressure vulnerability during the peri-induction phase (7). Similarly, studies evaluating post-induction or early intraoperative hypotension have emphasized that hypotensive episodes may occur early after anesthetic administration, often before surgical stimulation, when vasodilatory and myocardial depressant effects of induction drugs are most prominent (9,10). The present findings are consistent with this broader evidence, although interpretation should remain cautious because the current analysis reports p-values without correlation coefficients, adjusted regression estimates, or confidence intervals.

BMI category was significantly associated with pre-induction systolic blood pressure score but not with post-induction systolic or diastolic blood pressure scores. This pattern suggests that BMI may have influenced baseline hemodynamic status more than the immediate post-induction blood pressure response in this sample. Differences in body composition, circulating volume, vascular resistance, and obesity-related cardiovascular loading may affect baseline systolic pressure; however, the absence of a significant post-induction association indicates that BMI category alone may not be sufficient to predict peri-induction blood pressure decline without considering other factors such as baseline blood pressure, propofol dose per kilogram, ASA physical status, anesthetic co-medications, and fluid status. Previous evidence has been inconsistent regarding BMI and intraoperative hypotension. Kalezic et al. reported that BMI did not significantly influence early intraoperative hypotension during thyroid surgery, and the difference between their findings and the present pre-induction association may reflect variation in surgical population, anesthetic protocol, case complexity, and perioperative blood loss profile (14).

Sex was significantly associated with pre-induction systolic and diastolic blood pressure scores but not with post-induction blood pressure scores. This finding may reflect baseline physiological differences in body size, vascular tone, hormonal profile, or blood pressure distribution between male and female participants rather than a sex-specific post-induction response. Because sex was evaluated using bivariate analysis only, the observed association may also be confounded by age, BMI, baseline blood pressure, or propofol dose. Future analyses should assess whether sex remains independently associated with peri-induction blood pressure after adjustment for these variables. In the current data, the absence of significant association between sex and post-induction systolic or diastolic blood pressure suggests that sex alone should not be interpreted as an independent predictor of post-induction hypotension without more robust multivariable modeling.

Diabetes status was not significantly associated with pre- or post-induction systolic or diastolic blood pressure scores in this sample. Although diabetes may contribute to autonomic dysfunction, vascular stiffness, and impaired cardiovascular compensation, only 18 participants in the present study were diabetic, representing 9.9% of the total sample. This small subgroup limits statistical power and reduces confidence in any negative finding. Previous literature has reported variable associations between diabetes and perioperative or orthostatic hypotension, with some studies identifying diabetes as a significant factor and others showing weaker or context-dependent effects (10,13). Therefore, the present finding should be interpreted as absence of a statistically significant association in this sample rather than evidence that diabetes has no clinically relevant role in peri-induction blood pressure instability.

Propofol dosage was not significantly associated with any blood pressure outcome, although its association with post-induction systolic blood pressure score approached statistical significance ($p = 0.069$). This result should not be interpreted as proof that propofol has no hemodynamic effect, because the analysis used absolute dose in milligrams rather than weight-adjusted dose in mg/kg, and did not account for age, baseline blood pressure, opioid co-administration, fluid administration, or other anesthetic factors. Propofol is known to contribute to hypotension through vasodilation, sympathoinhibition, and reduced systemic vascular resistance (2,3). Prior studies have shown that propofol-based induction may be associated with early blood pressure reduction, particularly in vulnerable patients or when combined with other hemodynamically active agents (7,12). The non-significant finding in the present study may therefore reflect limited dose variability, sample characteristics, insufficient adjustment for confounders, or the use of coded blood pressure categories rather than raw blood pressure measurements.

The clinical relevance of the study lies in its focus on simple, routinely available factors that may help identify patients at risk of peri-induction blood pressure instability in general anesthesia. Age showed the most consistent association with systolic blood pressure across both pre- and post-induction measurements, while BMI category and sex were associated mainly with baseline blood pressure status. These findings suggest that pre-induction assessment should not rely solely on anesthetic drug dose, but should incorporate patient-level characteristics and baseline hemodynamic profile. However, because the available analysis is bivariate and does not report effect size, direction of association, confidence intervals, or adjusted estimates, the findings should be considered preliminary and hypothesis-generating rather than definitive.

This study has several important limitations. First, the manuscript reports blood pressure as coded scores rather than raw systolic and diastolic values in mmHg, limiting direct clinical interpretation and preventing precise estimation of hypotension frequency from the summarized data. Second, although the stated study objective included frequency of hypotension, the results do not provide the number and percentage of patients meeting a prespecified hypotension threshold before and after induction. Third, the study used purposive sampling from a single surgical unit, which may limit external validity. Fourth, several clinically relevant confounders were not reported, including ASA physical status, type and duration of surgery, emergency versus elective status, baseline antihypertensive use, fasting duration, premedication, opioid dose, fluid administration, vasopressor use, and timing of post-induction measurement. Fifth, the analysis relied on bivariate p-values without adjusted regression modeling, effect estimates, or confidence intervals. Future studies should use standardized definitions of post-induction hypotension, report raw blood pressure values in mmHg, calculate propofol dose per kilogram, and apply multivariable regression models to identify independent predictors of hypotension.

Overall, the findings indicate that systolic blood pressure declined after induction in the reported coded score profile and that age was significantly associated with systolic blood pressure both before and after induction. BMI category and sex were associated with pre-induction blood pressure, whereas diabetes status and propofol dosage were not significantly associated with peri-induction blood pressure outcomes in the available bivariate analysis. These findings support the need for careful pre-induction risk assessment, especially in older patients, but further analysis using clinically interpretable blood pressure values and adjusted statistical models is necessary before firm predictive conclusions can be made.

CONCLUSION

This study found a post-induction decline in the mean coded systolic blood pressure score among patients undergoing general anesthesia, with age showing significant associations with both pre- and post-induction systolic blood pressure. BMI category and sex were associated mainly with pre-induction blood pressure status, while diabetes and absolute propofol dosage were not significantly associated with pre- or post-induction blood pressure scores in the available bivariate analysis. These findings suggest that age and baseline hemodynamic characteristics may be important considerations during peri-induction monitoring; however, future studies should report raw blood pressure values, define hypotension using standardized clinical thresholds, quantify the exact frequency of post-induction hypotension, and use adjusted regression models to identify independent predictors.

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