

Incidence and Predictors of Intraoperative Hypotension in Patients Undergoing Non-Cardiac Surgery Under General Anaesthesia: A Prospective Observational Study

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Abstract

Introduction: Intraoperative hypotension is a common complication during general anaesthesia and is associated with adverse outcomes, including myocardial injury, acute kidney injury, prolonged hospitalization, and increased mortality. Identifying its incidence and perioperative predictors may facilitate early recognition, appropriate haemodynamic management, and reduction of postoperative complications.

Aims: To determine the incidence of intraoperative hypotension and identify demographic, clinical, surgical, and anaesthetic factors independently predicting its occurrence among patients undergoing non-cardiac surgery under general anaesthesia.

Materials and Methods: The present study was a Prospective Observational Study. This Study was conducted 12 months. Department of Anaesthesiology JIS Medical College and Hospital, Ludhiana, Punjab 141206. Study population 100.

Result: Intraoperative hypotension was more frequent among older patients (58.4 ± 12.6 vs 49.7 ± 13.1 years; $p=0.001$), ASA III patients (45.0% vs 20.0%; $p=0.006$), those undergoing major surgery (60.0% vs 38.3%; $p=0.034$), and patients requiring vasopressors (72.5% vs 13.3%; $p<0.001$). Higher fluid administration was also significantly associated with hypotension (62.5% vs 35.0%; $p=0.007$).

Conclusion: Intraoperative hypotension represents an important perioperative complication in patients receiving general anaesthesia. Determining its incidence and identifying significant predictors can help anaesthesiologists recognise high-risk patients, optimise perioperative management, ensure timely haemodynamic intervention, and potentially reduce hypotension-related organ dysfunction and adverse postoperative outcomes.

Keywords: Intraoperative hypotension; General anaesthesia; non-cardiac surgery; Incidence; Predictors; Haemodynamic instability; Blood pressure; Anaesthesia.

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Introduction

Intraoperative hypotension (IOH) is a frequent and serious complication during general anesthesia for non-cardiac surgery, characterized by a significant reduction in blood pressure that can lead to adverse postoperative outcomes such as organ injury and increased mortality. The occurrence of IOH has been strongly linked to negative sequelae including acute kidney injury, myocardial injury, and impaired cerebral perfusion, underscoring its clinical importance. Various studies report differing incidences of IOH depending on the patient population and definitions used, with early intraoperative hypotension (eIOH) incidence

ranging from approximately 21% to over 40% in specific cohorts [1].

Multiple factors predict the likelihood of intraoperative hypotension in patients undergoing general anesthesia. Advanced age consistently emerges as a significant predictor, reflecting reduced physiological reserve and altered cardiovascular responsiveness among elderly patients. Frailty, characterized by a decline in functional capacity and increased vulnerability to stress, further elevates the risk of post-induction hypotension, particularly in elderly cohorts [2]. Comorbidities such as end-stage renal disease (ESRD), diabetes mellitus requiring chronic

antidiabetic therapy, and anemia also contribute to hypotension risk, along with intraoperative elements including the type and dose of anesthetic drugs, surgical urgency (emergency procedures), and substantial intraoperative blood loss [3].

Preoperative cardiovascular assessment parameters have been investigated as predictors of IOH. Echocardiographic markers, such as the presence of regional wall motion abnormalities and a low TAPSE/PASP ratio reflecting compromised right ventricular function, have shown significant associations with post-induction hypotension [4,5]. Additionally, pre-anesthetic stroke volume variation can independently predict the decrease in cardiac output and hypotension following anesthesia induction [6]. These findings highlight the value of preoperative hemodynamic evaluation in stratifying risk and guiding anesthetic management to prevent hypotensive episodes.

Intraoperative hypotension has further been linked to longer-term outcomes. Notably, its duration and severity during surgery have been independently associated with increased one-year postoperative mortality, emphasizing that intraoperative blood pressure stability has prognostic significance beyond the immediate perioperative period [7]. This evidence collectively supports the critical need to identify patients at risk for IOH and to implement tailored anesthetic strategies, including the careful selection of anesthetic agents and proactive hemodynamic support, to mitigate its incidence and associated complications during non-cardiac surgery under general anesthesia.

Materials and Methods

Study design: Prospective Observational Study.

Place of study: Department of Anaesthesiology, JIS Medical College and Hospital, Ludhiana, Punjab-141206, India.

Period of study: 12 months.

Study Population: The study population will comprise 100 adult patients undergoing non-cardiac surgical procedures under general anaesthesia at the Department of Anaesthesiology, JIS Medical College and Hospital, Ludhiana, Punjab, during the 12-month study period. Patients will be prospectively followed from induction of anaesthesia until completion of surgery to assess the incidence and predictors of intraoperative hypotension.

Sample Size: 100 words.

Inclusion Criteria

- Adult patients aged ≥ 18 years undergoing elective or emergency non-cardiac surgery under general anaesthesia.
- Patients willing to participate and providing written informed consent.

Exclusion criteria

- Patients undergoing cardiac surgery or receiving regional anaesthesia alone.
- Patients with pre-existing haemodynamic instability or incomplete perioperative records.

Study Variable

- **Demographic and clinical variables:** Age, sex, BMI, ASA physical status, comorbidities, and preoperative blood pressure.
- **Surgical variables:** Type of surgery, duration of surgery, urgency of surgery, and estimated blood loss.
- **Anaesthetic variables:** Induction agents, maintenance agents, airway technique, fluid administration, and vasopressor use.
- **Haemodynamic variables:** Baseline blood pressure, intraoperative systolic/diastolic blood pressure, mean arterial pressure, and duration of hypotension.
- **Primary outcome variable:** Incidence of intraoperative hypotension, defined according to the study's pre-specified blood pressure threshold.

Statistical Analysis: For statistical analysis, data were initially entered into a Microsoft Excel spreadsheet and then analysed using SPSS (version 27.0; SPSS Inc., Chicago, IL, USA) and GraphPad Prism (version 5). Numerical variables were summarized using means and standard deviations, while Data were entered into Excel and analyzed using SPSS and GraphPad Prism. Numerical variables were summarized using means and standard deviations, while categorical variables were described with counts and percentages. Two-sample t-tests were used to compare independent groups, while paired t-tests accounted for correlations in paired data. Chi-square tests (including Fisher's exact test for small sample sizes) were used for categorical data comparisons. P-values ≤ 0.05 were considered statistically significant.

Result

Table 1: Demographic Characteristics

Variable	Hypotension Present (n=40)	Hypotension Absent (n=60)	Total (N=100)	p-value
Age (years), Mean $\pm$ SD	58.4 $\pm$ 12.6	49.7 $\pm$ 13.1	53.2 $\pm$ 13.3	0.001
<40 years	4 (10.0%)	15 (25.0%)	19 (19.0%)	
40–59 years	14 (35.0%)	27 (45.0%)	41 (41.0%)	
≥ 60 years	22 (55.0%)	18 (30.0%)	40 (40.0%)	
Male	25 (62.5%)	32 (53.3%)	57 (57.0%)	0.363
Female	15 (37.5%)	28 (46.7%)	43 (43.0%)	

Table 2: Anthropometric Characteristics

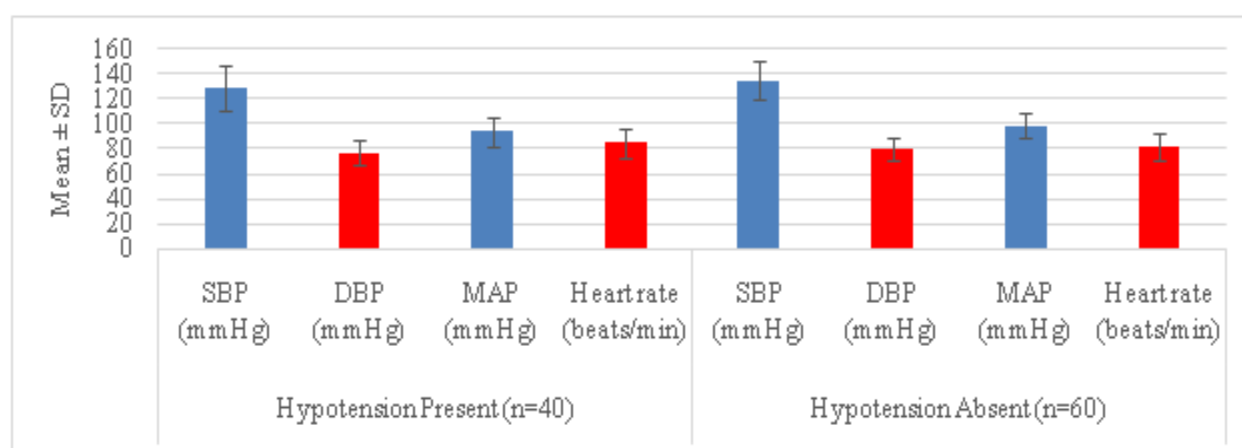
Variable	Hypotension Present (n=40)	Hypotension Absent (n=60)	Total (N=100)	p-value
BMI (kg/m ²), Mean $\pm$ SD	25.8 $\pm$ 3.9	25.1 $\pm$ 3.6	25.4 $\pm$ 3.7	0.352
<18.5	3 (7.5%)	4 (6.7%)	7 (7.0%)	
18.5–24.9	16 (40.0%)	27 (45.0%)	43 (43.0%)	
25–29.9	15 (37.5%)	22 (36.7%)	37 (37.0%)	
≥ 30	6 (15.0%)	7 (11.7%)	13 (13.0%)	0.913

Table 3: ASA Physical Status and Comorbidities

Variable	Hypotension Present (n=40)	Hypotension Absent (n=60)	Total (N=100)	p-value
ASA I	5 (12.5%)	18 (30.0%)	23 (23.0%)	0.006
ASA II	17 (42.5%)	30 (50.0%)	47 (47.0%)	
ASA III	18 (45.0%)	12 (20.0%)	30 (30.0%)	
Hypertension	21 (52.5%)	20 (33.3%)	41 (41.0%)	0.057
Diabetes mellitus	13 (32.5%)	12 (20.0%)	25 (25.0%)	0.163
IHD	8 (20.0%)	4 (6.7%)	12 (12.0%)	0.048
CKD	6 (15.0%)	3 (5.0%)	9 (9.0%)	0.098

Table 4: Surgical Characteristics

Variable	Hypotension Present (n=40)	Hypotension Absent (n=60)	Total (N=100)	p-value
Elective surgery	27 (67.5%)	50 (83.3%)	77 (77.0%)	0.071
Emergency surgery	13 (32.5%)	10 (16.7%)	23 (23.0%)	
Major surgery	24 (60.0%)	23 (38.3%)	47 (47.0%)	0.034
Minor surgery	16 (40.0%)	37 (61.7%)	53 (53.0%)	
Duration >2 hours	26 (65.0%)	22 (36.7%)	48 (48.0%)	0.008
Duration ≤ 2 hours	14 (35.0%)	38 (63.3%)	52 (52.0%)	

**Figure 1: Preoperative Clinical Characteristics**

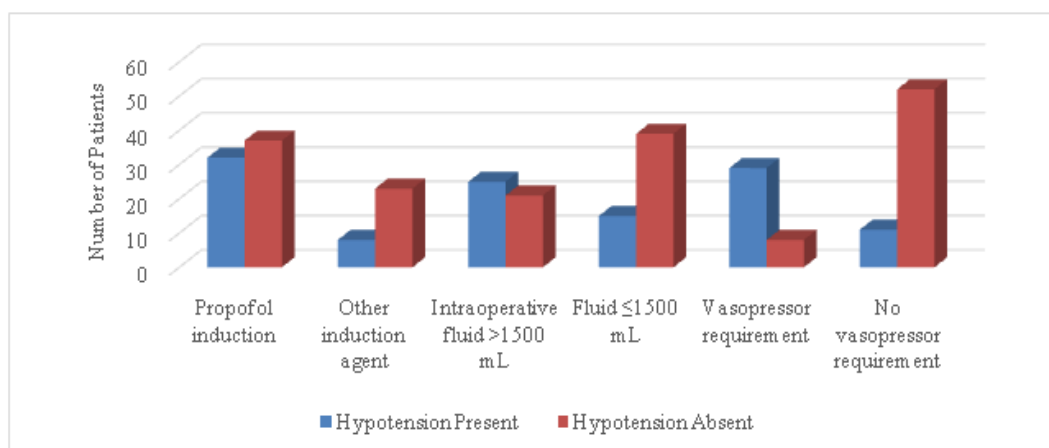


Figure 2: Anaesthetic and Perioperative Characteristics

The mean age of the study population was 53.2 ± 13.3 years. Among patients with intraoperative hypotension, the mean age was 58.4 ± 12.6 years, compared with 49.7 ± 13.1 years among those without hypotension ($p=0.001$). In the hypotension group, 4 patients (10.0%) were aged <40 years, 14 patients (35.0%) were aged 40–59 years, and 22 patients (55.0%) were aged ≥ 60 years, whereas in the non-hypotension group, 15 patients (25.0%), 27 patients (45.0%), and 18 patients (30.0%), respectively, belonged to these age groups. Regarding sex, 25 patients (62.5%) with hypotension were male and 15 patients (37.5%) were female, compared with 32 patients (53.3%) and 28 patients (46.7%), respectively, in the non-hypotension group ($p=0.363$). [Table 1]

The mean BMI of the study population was 25.4 ± 3.7 kg/m². Among patients with intraoperative hypotension, the mean BMI was 25.8 ± 3.9 kg/m², compared with 25.1 ± 3.6 kg/m² among those without hypotension ($p=0.352$). In the hypotension group, 3 patients (7.5%) had BMI <18.5 kg/m², 16 patients (40.0%) had BMI 18.5–24.9 kg/m², 15 patients (37.5%) had BMI 25–29.9 kg/m², and 6 patients (15.0%) had BMI ≥ 30 kg/m². In the non-hypotension group, 4 patients (6.7%), 27 patients (45.0%), 22 patients (36.7%), and 7 patients (11.7%), respectively, belonged to these BMI categories ($p=0.913$). [Table 2]

The ASA physical status distribution showed that 5 patients (12.5%) with hypotension were classified as ASA I, 17 patients (42.5%) as ASA II, and 18 patients (45.0%) as ASA III, compared with 18 patients (30.0%), 30 patients (50.0%), and 12 patients (20.0%), respectively, among those without hypotension, with a statistically significant difference ($p=0.006$). Regarding comorbidities, hypertension was present in 21 patients (52.5%) with hypotension and 20 patients (33.3%) without hypotension ($p=0.057$). Diabetes mellitus was present in 13 patients (32.5%) and 12 patients (20.0%), respectively ($p=0.163$). IHD was present in 8 patients (20.0%) with hypotension compared

with 4 patients (6.7%) without hypotension, showing a statistically significant association ($p=0.048$). CKD was present in 6 patients (15.0%) with hypotension and 3 patients (5.0%) without hypotension ($p=0.098$). [Table 3]

Regarding surgical characteristics, 27 patients (67.5%) with intraoperative hypotension underwent elective surgery, while 13 patients (32.5%) underwent emergency surgery, compared with 50 patients (83.3%) and 10 patients (16.7%), respectively, among those without hypotension ($p=0.071$). Major surgery was performed in 24 patients (60.0%) with hypotension and 23 patients (38.3%) without hypotension, whereas minor surgery was performed in 16 patients (40.0%) and 37 patients (61.7%), respectively, showing a statistically significant association ($p=0.034$). Regarding duration of surgery, 26 patients (65.0%) with hypotension had surgery lasting >2 hours and 14 patients (35.0%) had surgery lasting ≤ 2 hours, compared with 22 patients (36.7%) and 38 patients (63.3%), respectively, among those without hypotension ($p=0.008$). [Table 4]

The mean preoperative SBP was 128.6 ± 17.4 mmHg among patients with hypotension and 134.9 ± 15.8 mmHg among those without hypotension ($p=0.055$). The mean DBP was 76.8 ± 10.2 mmHg in the hypotension group and 80.4 ± 9.1 mmHg in the non-hypotension group ($p=0.067$). The mean MAP was 94.1 ± 11.4 mmHg and 98.6 ± 10.3 mmHg, respectively, showing a statistically significant difference ($p=0.041$). The mean heart rate was 84.6 ± 12.1 beats/min in patients with hypotension and 81.2 ± 10.7 beats/min in those without hypotension ($p=0.142$). [Figure 1]

Regarding anaesthetic and perioperative characteristics, propofol was used for induction in 32 patients (80.0%) with hypotension and 37 patients (61.7%) without hypotension, while other induction agents were used in 8 patients (20.0%) and 23 patients (38.3%), respectively, showing a statistically significant association ($p=0.049$).

Intraoperative fluid administration >1500 mL was observed in 25 patients (62.5%) with hypotension compared with 21 patients (35.0%) without hypotension, whereas fluid administration ≤1500 mL was observed in 15 patients (37.5%) and 39 patients (65.0%), respectively ($p=0.007$). Vasopressor requirement was present in 29 patients (72.5%) with hypotension and 8 patients (13.3%) without hypotension, while 11 patients (27.5%) and 52 patients (86.7%), respectively, did not require vasopressors ($p<0.001$). [Figure 2]

Discussion

The present study evaluated demographic, clinical, surgical, haemodynamic, and anaesthetic characteristics among 100 patients undergoing non-cardiac surgery under general anaesthesia. The mean age was 53.2 ± 13.3 years, with patients who developed intraoperative hypotension being significantly older than those without hypotension (58.4 ± 12.6 vs 49.7 ± 13.1 years; $p=0.001$). Patients aged ≥60 years constituted 55.0% of the hypotension group compared with 30.0% of the non-hypotension group. Male patients constituted 62.5% and 53.3% of the respective groups, with no significant association between sex and hypotension ($p=0.363$). Kim et al. [8] demonstrated the potential value of continuous intraoperative monitoring and predictive modelling for early identification of patients at risk of intraoperative hypotension.

Regarding anthropometric characteristics, the mean BMI was 25.8 ± 3.9 kg/m² among patients with hypotension compared with 25.1 ± 3.6 kg/m² among those without hypotension ($p=0.352$). The distribution of BMI categories was also comparable between the groups ($p=0.913$), indicating that BMI was not significantly associated with intraoperative hypotension. Lee et al. [9] emphasized the importance of individualized blood-pressure optimization strategies in patients undergoing major non-cardiac surgery under general anaesthesia.

The ASA physical status showed a significant association with intraoperative hypotension. ASA III patients accounted for 45.0% of the hypotension group compared with 20.0% of the non-hypotension group, while ASA I patients constituted 12.5% and 30.0%, respectively ($p=0.006$). Hypertension was present in 52.5% of patients with hypotension compared with 33.3% without hypotension ($p=0.057$), while diabetes mellitus was present in 32.5% and 20.0%, respectively ($p=0.163$). IHD was significantly more frequent among patients with hypotension (20.0% vs 6.7%; $p=0.048$), whereas CKD was present in 15.0% and 5.0%, respectively ($p=0.098$). Lonjaret et al. [10] emphasized the importance of adequate perioperative arterial pressure management and

recognition of cardiovascular risk factors before and during surgery.

Surgical characteristics demonstrated significant associations with intraoperative hypotension. Major surgery was performed in 60.0% of patients with hypotension compared with 38.3% without hypotension ($p=0.034$). Similarly, surgery lasting >2 hours was observed in 65.0% of patients with hypotension compared with 36.7% without hypotension ($p=0.008$). Emergency surgery was more frequent among patients with hypotension (32.5% vs 16.7%), although this difference was not statistically significant ($p=0.071$). Mangano et al [11] highlighted the importance of surgical and patient-related physiological factors in determining perioperative risk and postoperative outcomes.

Preoperative haemodynamic measurements showed that the mean SBP was 128.6 ± 17.4 mmHg among patients with hypotension compared with 134.9 ± 15.8 mmHg among those without hypotension ($p=0.055$). Mean DBP was 76.8 ± 10.2 and 80.4 ± 9.1 mmHg, respectively ($p=0.067$). However, mean MAP was significantly lower among patients who developed hypotension (94.1 ± 11.4 vs 98.6 ± 10.3 mmHg; $p=0.041$). Mean heart rate was 84.6 ± 12.1 beats/min in the hypotension group compared with 81.2 ± 10.7 beats/min in the non-hypotension group ($p=0.142$). Marcucci et al. [12] demonstrated that strategies specifically aimed at avoiding hypotension may be clinically important during non-cardiac surgery. The significant difference in MAP observed in the present study is clinically relevant because mean arterial pressure is an important determinant of systemic organ perfusion. Patients with lower baseline MAP may have less haemodynamic reserve and may therefore be more vulnerable to reductions in blood pressure following induction of anaesthesia. Qin et al. [13] reported that intraoperative hypotension is associated with increased postoperative risks in patients undergoing non-cardiac surgery, supporting the importance of early detection and prevention.

Regarding anaesthetic characteristics, propofol was used for induction in 80.0% of patients with hypotension compared with 61.7% of those without hypotension, showing a statistically significant association ($p=0.049$). Other induction agents were used in 20.0% and 38.3%, respectively. Propofol-induced reductions in vascular tone and arterial pressure may contribute to haemodynamic instability, particularly among patients with limited cardiovascular reserve. Quintero et al. [14] demonstrated that pharmacological agents administered during general anaesthesia can produce clinically relevant cardiovascular effects, emphasizing the need for careful haemodynamic monitoring.

Intraoperative fluid administration >1500 mL occurred in 62.5% of patients with hypotension compared with 35.0% of those without hypotension ($p=0.007$). Conversely, fluid administration ≤ 1500 mL was observed in 37.5% and 65.0%, respectively. This association should be interpreted cautiously because increased fluid administration may have been a response to blood loss or pre-existing haemodynamic instability rather than a direct cause of hypotension. Saugel et al. [15] emphasized individualized perioperative blood-pressure management based on continuous assessment of the patient's haemodynamic requirements.

Vasopressor requirement was present in 72.5% of patients with hypotension compared with 13.3% of those without hypotension ($p<0.001$). Although this represented the strongest association observed, vasopressor use should primarily be regarded as a marker or consequence of haemodynamic instability because these drugs are administered to treat or prevent hypotension. Appropriate monitoring and timely intervention remain essential to maintain adequate organ perfusion during anaesthesia. The findings of the present study are also comparable with observations from other prospective observational research. Zewdu et al. [16] reported that intraoperative hypotension is a common perioperative problem and identified several patient-related and perioperative factors associated with its development. In the present study, older age, higher ASA status, IHD, major surgery, prolonged operative duration, lower MAP, propofol induction, greater fluid administration, and vasopressor requirement were associated with hypotension, whereas sex, BMI, diabetes mellitus, CKD, SBP, DBP, and heart rate were not significantly associated.

Conclusion

The present prospective observational study demonstrated that intraoperative hypotension is a clinically important event among patients undergoing non-cardiac surgery under general anaesthesia. Older age, higher ASA physical status, IHD, major surgery, prolonged operative duration, lower preoperative MAP, propofol induction, higher intraoperative fluid administration, and vasopressor requirement were associated with hypotension. In contrast, sex, BMI, diabetes mellitus, CKD, SBP, DBP, and heart rate showed no significant association. These findings highlight the multifactorial nature of intraoperative haemodynamic instability. Comprehensive preoperative risk assessment, identification of vulnerable patients, careful anaesthetic planning, continuous blood-pressure monitoring, and timely haemodynamic intervention are essential to minimize the potential adverse consequences of intraoperative hypotension.

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