

Perfusion index as a predictor of hypotension following induction of general anaesthesia with propofol-An observational study



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ABSTRACT

Background: Perfusion index (PI) is a somewhat novel parameter evaluating the pulsatility of blood in the extremities, calculated using the infrared spectrum as a component of plethysmography waveform processing. **Aims and Objectives:** To obtain a cutoff value of pre-anesthesia PI, which may be helpful for the prediction of hypotension following anesthetic induction with propofol. **Materials and Methods:** This descriptive observational research was carried out at the Sree Gokulam medical college and research foundation, Venjaramoodu, Trivandrum, Kerala, from June 2020 to June 2021. A total of 174 patients of age group 17–60 years, with ASA 1 or 2 scheduled for surgery under general anesthesia, were included. The parameters (systolic blood pressure [SBP], diastolic blood pressure, mean arterial pressure, PI, and SPO₂) were recorded until 5 min of induction. Intravenous (IV) fentanyl 2 µg/kg was administered, propofol injected was given slowly at a rate of 10 mg per every 5 s, titrated to loss of verbal communication responseuronium 0.1 mg/kg IV was administered. The calculation for hypertension was done 5 min after anesthesia. The predictive validity of PI was calculated, keeping SBP as the standard gold test. For statistical analysis coGuide software. **Results:** The cutoff value for PI at 5 min was low (≤ 2.45) for 27 (90%) participants and high (> 2.45) for 3 (10%) participants. With a sensitivity of 90% in predicting hypotension and specificity of 87.50%, false-positive rate was 12.50%, false-negative rate was 10, positive predictive value was 60% (95 CI 44.43–74.30%), the negative predictive value (NPV) was 97.67%, and the total diagnostic accuracy was 87.93%. **Conclusion:** With the current study's findings, we conclude that PI cutoff value 2.45 can be used to predict hypotension following anesthetic induction with propofol. It has a high NPV with fair diagnostic accuracy.

Key words: Perfusion index; Propofol; General anesthesia; Hypotension; ROC curve

INTRODUCTION

The issue of hemodynamic aberrations during anesthesia on adverse outcomes is a critical clinical crisis. Previous studies conclude that hypotension and hypertension during general anesthesia are shown to be associated with harmful outcomes in cardiac and noncardiac surgery patients.¹⁻³

The perfusion index (PI) is defined as the ratio between the range of absorption of a non-pulsatile blood flow (venous, capillary, arterial non-pulsating, tissue) and suitably long light wave (infrared, red) by pulsatile blood flow (arterial)

versus and is expressed as a numerical value.⁴ PI is a non-invasive measurement of the perfusion state of peripheral blood vessels. To date, the PI has been used to predict low blood pressure,⁵ recognize initial success indicators of peripheral and central nerve blocks,^{6,7} assess pain,^{8,9} evaluate systemic vascular resistance (SVR),^{10,11} indicate the success of sympathectomy for hyperhidrosis,¹² and identify the incidence of hypotension after spinal anesthesia.¹³

Propofol is considered an IV anesthetic agent of ultra-fast action. It is rapidly metabolized, mainly in the liver, to inactive compounds excreted in the urine. There are low

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changes in the incidence of untoward hemodynamics. Propofol decreases cerebral metabolism, blood flow, and less persistent intracranial pressure.¹⁴ A previous study concluded that the PI could predict hypotension following propofol induction, especially before endotracheal intubation, and had a very high negative predictive value (NPV).⁵ Mostafa et al., in their study, found Patients with pulmonary edema showed a greater risk for the development of intradialytic hypotension.¹⁵ Previous literature does not provide cutoff values for the individual's pre-induction SVR.

Aims and objectives

To obtain a cutoff value of pre-anesthesia PI, which may be helpful for the prediction of hypotension following anesthetic induction with propofol.

MATERIALS AND METHODS

The current study was a descriptive observational study conducted at the Sree Gokulam medical college and research foundation, Venjaramoodu, Trivandrum, Kerala, from June 2020 to June 2021. Ethical approval was obtained from the institutional review board (Ref: SGMC-IEC-No: 31/401/12/2018) of the center concerned. Informed written consent was obtained before the study started, and confidentiality was maintained throughout. One hundred and seventy-four patients aged 17–60 years with ASA 1 or 2 scheduled for surgery under general anesthesia were included. Patients with hypertension, vasoactive medications, difficult airway, and pregnancy were excluded from the study. Approval from the ethical committee was obtained, and written consent from each participant was obtained before assigning them to the survey.

Hypotension was defined as mean arterial pressure (MAP) <60 mmHg and treated when it was <55 mmHg in the current study by Möller Petrun et al.,¹⁶ Bradycardia was termed as heart rate (HR) <50 bpm or decreased by more than 30% below baseline value, whichever was lesser and was treated with atropine 0.6 mg IV boluses.¹⁷ The parameters (diastolic blood pressure [DBP], systolic blood pressure [SBP], PI, MAP, and SPO₂) were recorded every minute until 5 min of induction. On reception in the operation theatre, the connection of pulse oximeter (Intellivue MP40 Anaesthesia monitor non-invasive BP, Philips Medizin Systeme, GmbH 71034, Boeblingen, Germany) and electrocardiogram was obtained.

Documentation of baseline values (DBP, SBP, HR, PI, and MAP) was done. Intravenous infusion of Ringer's lactate was administered at 100 mL/h. Intravenous (IV) fentanyl 2 µg/kg was administered, after which injection

of propofol was administered slowly at a rate of 10 mg per every 5 s, titrated to loss of verbal communication response vecuronium 0.1 mg/kg IV was administered.

The parameters were recorded every minute until 5 min. The lungs were ventilated with 100% O₂ for 5 min before the trachea was intubated with an appropriately sized endotracheal tube by a consultant anesthesiologist. Maintenance of anesthesia was established with 50% N₂O in oxygen, along with sevoflurane 2%. The parameters were recorded at 1-min intervals till 10 min after intubation. MAP <65 mmHg was treated instantly by quick intravenous fluid administration and Mephentermine 6 mg IV boluses. The incidence of hypotension was calculated at 5 min after anesthesia (effect of induction agent). The predictive validity of PI was calculated, keeping SBP as the standard gold test.

Sample size

As per the study by Mehandale and Rajasekhar,⁵ the incidence of hypotension based on SBP criteria was 30%, and PI at 5 min showed 93% sensitivity in predicting hypotension. Other parameters considered were 95% confidence interval and 15% precision for sensitivity. The required sample size, as per the details mentioned above, was 174.

Statistical methods

Summary statistics were used to analyze data by the study's objectives. SBP, DBP, and PI, etc., were expressed as the mean, 95% confidence interval (CI; lower and upper bounds), median, minimum and maximum, whereas count and % were reported for age group and gender variables. ROC curve technique was used to find the diagnostic accuracy of the PI at 5 min to predict episodes of hypotension. The predictive power of the PI on hypotension was assessed by calculating the sensitivity, specificity, positive predictive value (PPV), NPV, and accuracy. P<0.05 was reported as statistical significance. Data were analyzed using coGuide software, V.22.¹⁸

RESULTS

A total of 174 subjects were included in the final analysis.

The mean age was 38.68±13.02 years, ranging from 17 to 60 years, 59 (33.91%) were aged up to 30 years, 43 (24.71%) were aged between 41 and 50 years, and 36 (20.69%) were aged between 31–40 years and 51–60 years for each, the gender was male for 60 (34.48%) participants and female for 114 (65.52%) participants (Table 1).

The mean SBP, DBP, and MAP at different periods (baseline, 1–15 min) are reported in the above table. As

per the follow-up time increases from 1 min to 15 min, all vitals showed increment as a whole (Table 2).

PI was high at 3, 5 and 6 min compared to other periods as 4.76 ± 13.57 , 4.07 ± 2.01 , and 4.12 ± 2.05 , respectively. SPO_2 was maintained almost static during the follow-up time, with minor fluctuations at some point of time (Table 3). In the study, 2 (1.15%) participants had mephentermine at 4 min, 28 (16.09%) at 5 min, 1 (0.57%) at 6 min and 7 min for each. The IV fluid bolus was reported in 1 (0.57%), participant at 2 min, 4 (2.3%) at 3 min, 9 (5.2%) at 4 min, 20 (11.5%) at 5 min, and 1 (0.57%) at 7 min.

Among the participants who reported hypotension, the PI at 5min was low (≤ 2.45) for 27 (90%) participants and high (> 2.45) for 3 (10%) participants. There was a statistically significant relationship in PI at 5min between hypotension ($P < 0.001$) (Figure 1).

The PI 5 min score had a sensitivity of 90% (95% CI 73.47–97.89%) in predicting hypotension, specificity was 87.50% (95 CI 80.97–92.42%), False positive rate was 12.50% (95 CI 7.58–19.03%), false-negative rate was 10% (95 CI 2.11–26.53%), PPV was 60% (95 CI 44.43–74.30%), NPV was 97.67% (95 CI 93.65–99.52%), and the total diagnostic accuracy was 87.93% (95 CI 82.14–92.37%) (Table 4).

Table 1: Summary of baseline parameter (n=174)

Parameter	Summary (%)
Age (in years)	38.68±13.02 (ranged 17–60)
Age group	
Up to 30 years	59 (33.91)
31–40 years	36 (20.69)
41–50 years	43 (24.71)
51–60 years	36 (20.69)
Gender	
Male	60 (34.48)
Female	114 (65.52)

Table 2: Summary of blood pressure at different time periods (n=174)

Parameter	SBP	DBP	MAP
Baseline	129.95±8.59 (104–153)	83.7±7.47 (60–98)	99.12±7.08 (78–114.33)
At 1 min	119.06±7.61 (95–137)	72.32±6.07 (53–88)	87.9±5.73 (69–101.67)
At 2 min	112.83±8.68 (90–131)	67.56±5.81 (50–83)	82.65±6.2 (65.33–95.67)
At 3 min	108.72±9.95 (88–128)	65.37±5.8 (52–80)	79.82±6.73 (64–93)
At 4 min	105.93±10.74 (84–127)	63.47±6.25 (50–77)	77.62±7.34 (62–92.33)
At 5 min	104.02±11.54 (79–127)	62.35±6.81 (48–77)	76.24±8 (60.67–93)
At 6 min	105.3±9.63 (86–124)	64.41±4.97 (53–75)	78.04±5.83 (67.33–91)
At 7 min	116.4±13.02 (91–165)	74.19±8.44 (50–97)	88.26±9.46 (63.67–119.67)
At 8 min	121.2±9.99 (98 to 156)	78.22±6.89 (61–96)	92.15±9.7 (8–116)
At 9 min	122.55±7.1 (102–136)	78.56±5.57 (63–91)	93.22±5.39 (78.33–105.33)
At 10 min	123.23±5.77 (107–134)	78.72±4.98 (69–92)	93.56±4.4 (82.67–103)
At 15 min	122.8±4.92 (108–133)	78.09±5.12 (65–93)	93±4.11 (82.33–102)

SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MAP: Mean arterial pressure

DISCUSSION

The current research hypothesized that baseline PI would help predict hypotension following induction of general anesthesia with propofol. The results of this study satisfy our aim and are in line with the hypothesis, as we found a statistically significant relationship of < 0.001 between PI and hypotension. The area under the ROC curve (AUC) for predictive validity of PI at 5 min in predicting hypotension was 0.937 and showed a high statistical significance of < 0.001 .

Hypotension often takes place on induction of anesthesia, commonly assigned to hypovolaemia and the hemodynamic effects of anesthetic agents.¹⁹ In 1995, MASIMO first introduced the PI, which is an oximetry reliability indicator, but nowadays, it is obtainable on other monitors.²⁰ During non-invasive blood pressure and HR stays, the foundation of hemodynamic monitoring. To obtain vital real-time hemodynamic insight, continuous monitoring of systemic blood pressure or even -flow requires invasive or advanced modalities that create a barrier is required. The peripheral PI (PPI) is gained non-invasively and continuously by standard photoplethysmography.²¹⁻²³ It is also purported to be an indicator of SVR.¹⁰

Our study results were similar to a study conducted by Mehandale and Rajasekhar, who found a correlation between PI and the incidence of hypotension. $PI < 1.05$ was associated with a higher incidence of hypotension, and at 5 min, the area under the ROC curve was 0.816, 95% confidence interval (CI) (0.699–0.933), $P < 0.001$.⁵ Another research by Duggappa et al., supported our study findings as they observed a significant correlation between baseline $PI > 3.5$ and the number of episodes of hypotension ($r_s 0.416$, $P < 0.001$). The AUC was 0.848 in their study.¹⁷

It was observed that there were major fluctuations in SBP from 1 min to 15 min of the following uptime.

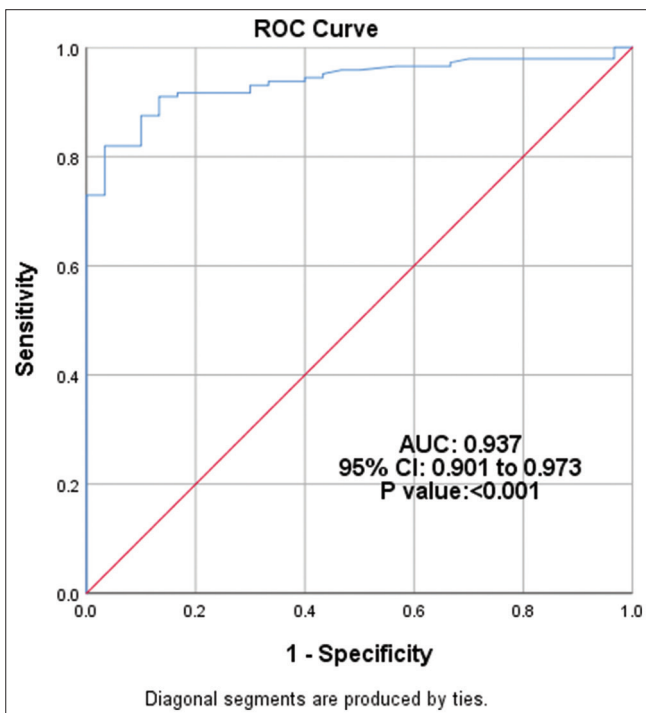
Table 3: Summary of PI and SPO₂ at different time periods (n=174)

Time periods	Perfusion index	SPO ₂
Baseline	3.14±1.96 (0.34–10.10)	99.24±0.94 (97–100)
At 1 min	3.38±1.97 (0.49–10.10)	99.27±0.88 (97–100)
At 2 min	3.57±2 (0.55–10.90)	99.32±0.85 (97–100)
At 3 min	4.76±13.57 (0.83–181)	99.3±0.86 (97–100)
At 4 min	3.91±2.01 (0.94–11)	98.72±7.34 (3.13–100)
At 5 min	4.07±2.01 (0.93–10.78)	99.29±0.87 (97–100)
At 6 min	4.12±2.05 (0.56–10.80)	98.18±10.47 (1.56–100)
At 7 min	3.81±1.9 (0.20–10.80)	99.29±0.86 (97–100)
At 8 min	3.63±1.86 (0.87–10.78)	99.37±0.83 (97–100)
At 9 min	3.53±1.79 (0.83–10)	99.39±0.84 (97–100)
At 10 min	3.5±1.8 (0.86–10.10)	99.4±0.82 (97–100)
At 15 min	3.5±1.76 (0.87–10.10)	99.44±0.81 (97–100)

PI: Perfusion index

Table 4: Predictive validity of perfusion index 5 min in predicting hypotension (n=174)

Parameter	Value (%)	95% CI	
		Lower (%)	Upper (%)
Sensitivity	90.00	73.47	97.89
Specificity	87.50	80.97	92.42
False positive rate	12.50	7.58	19.03
False negative rate	10.00	2.11	26.53
Positive predictive value	60.00	44.33	74.30
Negative predictive value	97.67	93.35	99.52
Diagnostic accuracy	87.93	82.14	92.37

**Figure 1:** Predictive validity of perfusion index at 5 min in predicting hypotension (ROC analysis)

Compared to the baseline parameter SPB showed a decrease in values from 1 min to 7 min; there was a major

increase from 8 min to 15 min. Values of the DBP and MAP demonstrated minor fluctuations. Data show that DBP and MAP values decreased at 15 min follow-ups compared to the baseline parameter value. MAP below 55 mmHg is known to produce harmful outcomes even if it lasts for a short while.²⁴ Similarly, in a prospective observational study, results confirmed that hypotension based on the SBP criterion showed a statistically significant correlation with PI, both during the first 5 min ($r_{pb} = -0.503$, $P < 0.001$) and 15 min ($r_{pb} = -0.296$, $P = 0.037$).⁵ Therefore, it may be securely described that PI depends on SBP, and their association is bimodal (low PI was present with both high and low SBP). PI >1.05 recommends that propofol induction is improbable to result in hypotension. Current study findings revealed that SPO₂ was maintained throughout the follow-up time except at 4 min and 6 min, where it showed a decrease in the value. Our observation was when the PI was increased, SPO₂ values were seen to decrease, but there was no major change. A study by Thijssen et al., showed that the correlation between the (SPO₂-SaO₂) and PI difference was low; the (SPO₂-SaO₂) difference showed slight improvement with higher PI values.²⁵ In a prospective, an observational study was done with the primary aim of finding whether the different clinical stages of anesthesia were related to changes in the PI authors found that while induction, the mean normalized PI rose from 0.0 to 4.2, and then declined to 0.470 when the subjects gained consciousness. $P < 0.001$ using repeated measures ANOVA test. The normalized PI was correlated with MAC values ($r^2 = 0.33$, 95% CI 0.18–0.47, $P < 0.01$).²⁶

In our study, the sensitivity of PI 5min in predicting hypotension was 90%, and the specificity was 87.50%. The false-negative rate was 10% (95 CI 2.11–26.53%), PPV was 60%, with a NPV of 97.67%. The total diagnostic accuracy was 87.93%. Our results were in line with the study by Mehandale and Rajasekhar in their study baseline PI of 1.05 projected any incidence of intraoperative hypotension at 5 min after propofol-based induction with a specificity of 71%, a sensitivity of 93%, a PPV 68%, and NPV 98%. At 15 min, the AUC was 0.676, 95% CI (0.517–0.834), $P = 0.039$. Baseline PI of 1.25 predicted any incidence of intraoperative hypotension at 15 min with a sensitivity of 79%, specificity of 48%, PPV of 54%, and NPV of 86%.⁵ Another research found that the ROC curve yielded 3.85 as a more appropriate cutoff with a well-balanced 76% sensitivity and specificity.¹⁷

Limitations of the study

The limitation of the study was record maintenance of the total dose of propofol which would have given an idea regarding the total amount of drug required for an individual. The current study was a single-center study;

hence, we suggest more research on this topic with multi-cent study designs.

CONCLUSION

The current study's findings conclude that PI with a cutoff value of 2.45 is a helpful tool for predicting hypotension following anesthetic induction with propofol. It has a high NPV with fair diagnostic accuracy. It can be safely used for the prediction of hypotension following anesthetic induction with propofol.

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ETHICS STATEMENT

Ethical approval was obtained from the institutional review board [Ref: SGMC-IEC-no.31/401/12/2018] of the centre concerned. Informed written consent was obtained before the study started and confidentiality was maintained throughout.

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Authors' Contributions:

YSB- Has conceptualized the study and played primary role in compiling, analysis and interpretation of the data. **RKR, AS, VM, YSB**- All the drafts were prepared, reviewed and final draft was approved. **AS**- Have contributed in fine tuning of the proposal, contributed in data collection and entry. Reviewed the results and contributed to preparation and review of drafts. All the authors have read and approved final version of the manuscript. All the authors take complete responsibility for the content of the manuscript.

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