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ORIGINAL ARTICLE

Evaluation of Preoperative Perfusion Index Measurement to Predict Propofol-Related Hypotension in Procedural Sedation

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Abstract

Introduction: Hypotension is a common problem during colonoscopy with procedural sedation. Perfusion index (PI) has been shown to be predictive of hypotension following the induction of general anesthesia. We hypothesized that PI could predict hypotension during colonoscopy and that a cut-off value could be determined at which hypotension is more common.

Methods: One hundred and fifty adults belonging to the American Society of Anesthesiologists' physical status I/II, undergoing elective colonoscopy under procedural sedation with propofol, were enrolled in this prospective, observational study. PI, heart rate, blood pressure, and oxygen saturation were recorded during colonoscopy. Hypotension was defined as a mean arterial pressure (MAP) of <65 mmHg.

Results: The incidence of hypotension with predefined MAP criteria was 13%. Baseline PI <1.9 predicted any episode of hypotension with a sensitivity of 73.7%, specificity of 59.3%, positive predictive value (PPV) of 32.5%, and negative predictive value (NPV) of 89%. The area under the ROC curve (AUC) was 0.651 (95% confidence interval: 0.567–0.729, p=0.0275).

Discussion and Conclusion: The perfusion index could be a potential parameter to predict hypotension during propofol sedation. It had a moderately high sensitivity value and a very high negative predictive value.

Keywords: Colonoscopy; hypotension; perfusion index; propofol.

Intraoperative hypotension (IOH), which may lead to impaired organ perfusion, is a significant challenge faced by anaesthesiologists and has been shown to be associated with adverse outcomes.[1,2] Prediction and early recognition of hypotension have clinical importance in preventing hypoperfusion-related injury.

Propofol, a widely used sedative-hypnotic agent, is well-suited for endoscopic procedures due to its rapid onset, short recovery time, and improved patient satisfaction.[3,4] Despite its beneficial pharmacological properties, propofol reduces systemic vascular resistance and is associated with intraoperative hypotension.[5]

Perfusion index (PI), a parameter derived from the waveform of pulse plethysmography, represents the ratio between pulsatile and non-pulsatile signals. Previous studies have demonstrated that PI can be a reliable tool for assessing vascular tone and may facilitate the detection of hypotension after general anaesthesia.[6,7]

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A recent meta-analysis showed that IOH is a common problem encountered during sedation with propofol for colonoscopy.[8] Patients undergoing colonoscopy have patient- and procedure-related factors (such as bowel preparation, age, and comorbidities) that may make them susceptible to IOH and are therefore a well-reasoned group to monitor closely for propofol-induced hypotension. Prediction and early recognition of hypotension during procedural sedation are less well studied.

We hypothesised that PI could be used as a good predictor of propofol-induced hypotension during colonoscopy.

Materials and Methods

The prospective observational study was carried out in a tertiary care hospital after receiving institutional ethics committee approval (2022.10.27-65/22-101) between 02.01.2023 and 03.03.2023. This study was conducted in accordance with the Declaration of Helsinki. One hundred and fifty adults aged between 18–65 years, who were evaluated as American Society of Anesthesiologists' (ASA) Physical Status I and II in the preoperative examination, undergoing elective colonoscopy under procedural sedation were recruited after obtaining written and verbal informed consent. Patients with heart failure, arrhythmia, peripheral arterial disease, malnutrition, and those undergoing an emergent procedure were excluded.

Premedication, which consisted of midazolam (0.02–0.03 mg/kg) and fentanyl (0.5 mcg/kg), was administered intravenously. In the theatre, an electrocardiograph, non-invasive blood pressure monitor (Drägerwerk AG & Co. KGaA, Infinity Kappa, Lübeck, Germany), pulse oximeter (Masimo Rainbow Pulse Co-Oximetry, Masimo Corporation, Irvine, CA), and processed electroencephalography (Medtronic, BiSpectral Index Monitoring System, Minneapolis, USA) were connected, and baseline values (oxygen saturation, PI, heart rate [HR], systolic [SAP], diastolic [DAP], and mean [MAP] blood pressure, BIS value) were recorded. Intravenous infusion of Ringer's lactate was started at 100 mL/h.

Except for baseline PI, all other measurements were performed in the lateral decubitus position. Subsequently, induction was performed with propofol (1–1.2 mg/kg) to achieve a target BIS value of 61–70. Maintenance was provided with 10 mg bolus doses of propofol with the same target BIS value. During the post-induction period, blood pressure was measured from the dependent arm at 3-minute intervals for the first 10 minutes, followed by 5-minute intervals, and corresponding vital signs and PI were recorded. Hypotension was predefined as MAP<65 mmHg and was treated with rapid intravenous fluid administration (Ringer's lactate, 4 mL/kg). In case of failure, 5 mg ephedrine was administered.

Power analysis was performed at the level of sensitivity of PI to predict hypotension during colonoscopy using receiver operating characteristic (ROC) curve analysis. Based on a previous study with an incidence of hypotension during colonoscopy standing at 20%, an area under the receiver operating curve (AUROC) of 0.7 with a null hypothesis AUROC of 0.5, and using a power value of 0.90 and a 0.05 α error, the minimum sample size was calculated as 130 (MedCalc v.20.218, MedCalc Software, Ostend, Belgium).[9] Considering the possibility of data loss, 150 patients were included in the study. Data were collected using Microsoft 365 – Excel (Microsoft Corporation, Redmond, Washington) and analyzed with MedCalc v.20.218 (MedCalc Software, Ostend, Belgium).

After all data were collected, the patients were divided into two groups based on hypotension occurrence. Descriptive statistics for continuous variables were given as mean±standard deviation for those that conformed to a normal distribution and median (minimum-maximum) for those that did not. Whether the data conformed to a normal distribution was examined with the Shapiro-Wilk test. For categorical variables, descriptive statistics are given as frequency and percentage (N (%)).

In the analysis of relationships between dependent and independent variables, in independent group comparisons

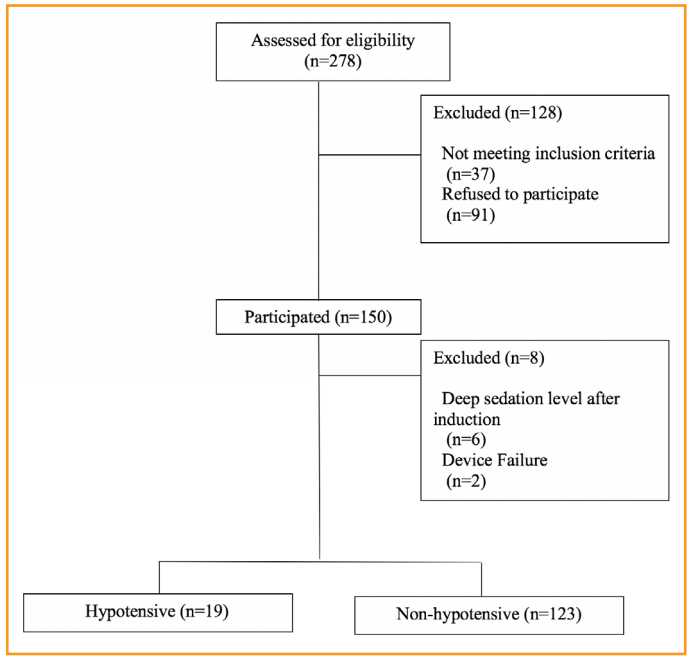

Figure 1. Flow diagram.

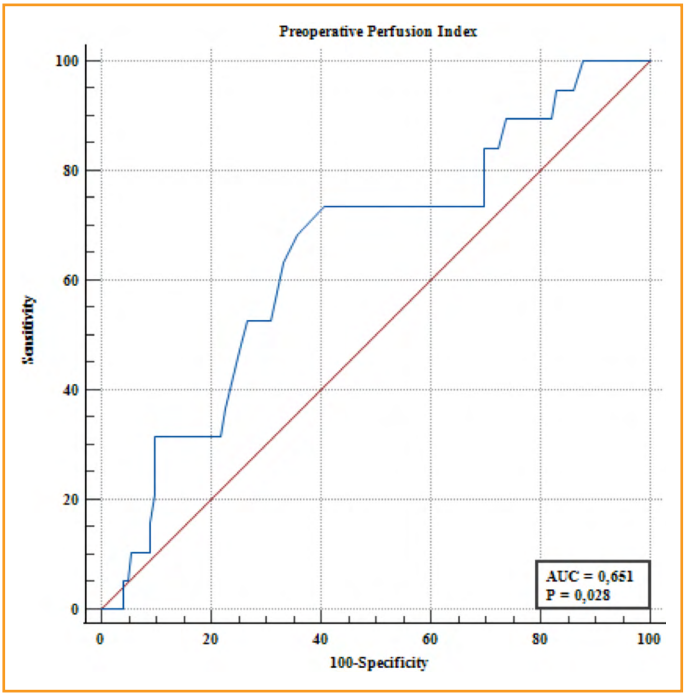

Figure 2. Reciever Operating Characteristic (ROC) curve of the baseline perfusion index for predicting decreased mean arterial bloood pressure during colonoscopy. AUC – area under the curve.

of continuous variables, the Mann-Whitney U test was used for two independent groups that did not comply with a normal distribution, and the two-sample t-test was used for those that did comply. Pearson's Chi-square analysis, Yates' correction, and Fisher's exact test were used to compare categorical variables between groups. Receiver operating characteristic (ROC) curve analysis was used to determine the threshold value. The significance level was accepted as $p<0.05$.

Results

One hundred and fifty patients participated in our study, and 142 completed it. Eight patients were excluded due to a deep sedation level after induction (below 60), which was measured by the BIS monitor, and because data could not be obtained due to device failure (Fig. 1).

Based on the criteria we defined previously, 19 patients (13.38%) experienced hypotension throughout the study. Baseline characteristics and procedure time are shown in Table 1. The PI value of patients who developed hypotension was significantly lower compared to those who did not develop hypotension. Baseline SAP, DAP, and MAP showed statistical differences between groups (p=0.023).

ROC curves were constructed for PI, with the area under the ROC curve being 0.651 (95% confidence interval: 0.567–0.729, p=0.027) (Fig. 2). A baseline PI lower than 1.9 revealed predictive ability for the development of any hypotension episode during the entire procedure, with a sensitivity of 73.7%, specificity of 59.3%, positive predictive value of 32.5%, and negative predictive value of 89%.

Discussion

The main finding of our study was that PI has the potential to be a useful parameter in predicting IOH during colonoscopy. ROC curve analysis showed that PI has a reliable predictive ability for IOH during colonoscopy when its baseline value is below 1.9.

Hypotension is a commonly encountered challenge during colonoscopy.[8] In our study, IOH was defined as MAP falling below 65 mmHg on any measurement. This limit has been recommended as 60 mmHg in recently published literature by Saugel et al.[10] In our study, to eliminate the risk of overestimation caused by measurements made on the dependent arm, hypotension was defined as MAP<65 mmHg.

PI is derived from pulse oximeter photoplethysmography signals, which anaesthesiologists use in everyday practice. PI represents vascular tone and stroke volume in the cardiovascular system. The former reflects the balance between sympathetic and parasympathetic tone, while the latter mirrors local blood volume variations at systole, affected by systemic and local factors.

Bowel preparation before colonoscopy has significant physiological effects on the body, mainly related to dehydration.[11] In a previous study conducted by Van Genderen et al.,[12] PI was shown to have the ability to predict central hypovolemia before decompensation occurs. Compensation is mainly governed by sympathetic activation. As a consequence, high vascular tone may result in a low PI. Although individual blood pressure measurements were within acceptable normal limits for induction in our study, the low PI values observed in patients who experienced hypotension could be explained by these physiological changes. This makes patients susceptible to decompensation, and IOH may develop in these patients due to sympathectomy and vasodilation caused by propofol.

Previous studies have demonstrated the effectiveness of PI in predicting hypotension in different conditions.[6,7,13] Core findings from these studies suggest that PI may be an effective parameter in predicting hypotension that develops in the post-induction period, especially before intubation. The mechanism of this hypotension observed

after the induction of general anesthesia is similar to that seen during colonoscopy. The level of anesthetic depth and the extent of sympathetic blockade, which are propofol-dosage-related physiological changes, were more evident in these trials. This difference between our study and previous studies may explain why our cut-off value was lower than other reported results.

When we compared our results with another trial that investigated the usefulness of PI in predicting hypotension after spinal anesthesia for caesarean section, the reported cut-off value was higher. This difference could be explained by the distinct mechanisms involved. In these patients, physiological changes due to pregnancy, such as low systemic vascular resistance, increased cardiac output, and total blood volume, result in higher preoperative PI values.

This study has several limitations. First, our study population consists of ASA I/II patients aged 18–65 years. These results may not be extrapolated to elderly patients, in whom the mechanism of intraoperative hypotension may be different.[14] Second, the measurement of PI before and after bowel preparation could have been more valuable in detecting hypovolemia, and the net difference may have been more useful in predicting IOH. However, we could not provide these measurements due to institutional limitations. Third, we measured PI after premedication, which may have caused partial sympatholytic changes, potentially attenuating the difference. Lastly, hypotensive episodes may have gone undetected due to intermittent noninvasive blood pressure measurements.

Conclusion

To the best of our knowledge, this is the first study investigating the effectiveness of PI in predicting hypotension during sedation. Previous research and our findings suggest that PI may be a good indicator for predicting hypotension in this group of patients. To reach a definitive conclusion, future studies are needed on this subject.

Ethics Committee Approval: The study was approved by University of Health Sciences Türkiye, Hamidiye Clinical Research Ethics Committee (No: 65/22-101, Date: 27/10/2022).

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