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Original Research Article

Comparison of perfusion index (PI) with other non-invasive hemodynamic monitors of stress response following endotracheal intubation

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Abstract

Aims and Objective: Aim of the present study was to evaluate efficacy of perfusion index as a non-invasive monitor of hemodynamic responses in comparison to heart rate and blood pressure following insertion of endotracheal tube.
Material and Method: The study enrolling 60 patients of either sex, age between 18-60 years, ASA grade I & II were scheduled for elective surgery under general anesthesia. Anesthesia was induced with intravenous fentanyl 1-2µg/kg, propofol 2.5 mg/kg and rocuronium 0.6 mg/kg. After adequate relaxation intubation of the trachea with a cuffed tracheal tube using direct laryngoscopy was done. Heart rate, noninvasive blood pressure and perfusion index were measured before (baseline values) induction and intubation and after intubation at 1minute, 3minute and 5 minute before starting the surgery.
Results: Insertion of the device produced significant increases in heart rate (of ≥10 bpm) and noninvasive blood pressure (of ≥15 mm Hg) whereas perfusion index was decreased significantly by ≥10%. We found PI response criterion achieve sensitivity of 96.7 % (CI: 88.5-99.6) for detecting the stress response to endotracheal intubation during balanced anaesthesia in adult patients. On other hand SBP and DBP achieved sensitivity of 55.1% (CI: 45.2-64.6) and 63.7 % (CI: 52.7-72.8) respectively.
Conclusions: Perfusion index was reliable indicator for stress response for endotracheal intubation with better sensitivity and specificity as compared to heart rate and blood pressure.
Keywords: Perfusion index, Stress response Endotracheal tube, Laryngoscopy, Sensitivity and Specificity

1. Introduction

Laryngoscopy and Endotracheal Tube insertion are employed for safe conduct of general anesthesia. However both laryngoscopy and intubation are noxious stimuli and are associated with stress responses & hemodynamic responses in the form of laryngo-sympathetic stimulation which is manifested as increase in heart rate and blood pressure [1]. The effect of stimulation at different sites in the respiratory tract on systemic blood pressure was studied in paralyzed cats by Tomori and his co-workers (1969)[2]. It is a valuable objective during anesthetic practice to find out non-invasive methods for predicting the hemodynamic responses to anesthetic drugs, techniques and to intraoperative stimuli.

The perfusion index (PI) derived from a pulse oximeter is calculated as the ratio of the pulsatile blood flow to the non-pulsatile blood in peripheral tissue [3]. It is calculated by expressing the pulsatile signal (during arterial inflow) as a percentage of the non-pulsatile signal, both of which are derived from the amount of infrared (940 nm) light absorbed. Perfusion Index can be used to assess peripheral perfusion dynamics due to changes in peripheral vascular tone [4,5]. From literature review we observed that very few studies were available for presenting the effect of endotracheal tube (ET) insertion on PI versus non-invasive haemodynamic stress responses. In addition, based on internet research; one study correlate between PI and conventional haemodynamic parameters (heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP)) during insertion of different airway devices[6].

The principal goal of the study was to evaluate and compare PI with other non-invasive hemodynamic criteria (HR, SBP and DBP) following ET insertion and Efficacy of PI as non-invasive hemodynamic monitor of stress response.

2. Material and Method

After obtaining institutional ethical committee approval and patients written informed consent, the study was conducted in 60 patients of either sex, aged between 18 to 60 years, ASA grade I and II, posted for elective surgical procedures under general anesthesia. Patients with history of pulmonary, cardiac, CNS, cervical spine disease, gastro esophageal reflux, patient's refusal, anticipated difficult intubation, pregnant patients & full stomach patients were excluded from the study. A detailed pre-anaesthetic evaluation including history, thorough general and systemic examination and all relevant investigations were done for all the patients. After confirming adequate starvation, pre-operative work up and checking consent patient was taken inside operation room.

In the operation theatre, after taking intravenous access and starting suitable IV fluids, baseline Perfusion Index (PI) was monitored using a Mindraysi PM Series Monitor. The PI upper and lower limits reported by the manufacturer were 0.02% and 20.00% respectively. The pulse oximeter probe used to monitor the PI was attached to the middle fingertip of the hand contralateral to the site of BP monitoring and was wrapped in a towel to minimize heat loss and contamination by ambient light. Baseline readings of the oxygen saturation, mean arterial blood pressure (non-invasive), heart rate were recorded. Pre-oxygenation with 100% oxygen for at least 3 min was carried out. Anesthesia was induced with intravenous fentanyl 1-2µg/kg and propofol 2.5 mg/kg and rocuronium 0.6 mg/kg. After adequate relaxation, intubation of the trachea was done with a cuffed tracheal tube of internal diameter 7.5 mm for women and 8.5 mm for men using direct laryngoscopy.

HR, NIBP and PI were measured before induction of anesthesia and before and after intubation 1min 3min and 5 min before starting the surgery. Positive HR, SBP, DBP and PI responses to device insertion were prospectively defined from previous reports as a HR increase of ≥10 bpm, a SBP and DBP increase of ≥15 mm Hg, and a PI decrease ≥10% after the insertion of the devices. Sensitivity, specificity, positive predictive values and negative predictive value were determined for SBP, DBP and PI variables based on HR as the gold standard.

2.1 Statistical analysis

Analysis was performed using the program SPSS evaluation version 15 for windows. Numerical data were presented as mean±SD, and categorical data as proportions (%). Statistical significance will be determined at 95% level of confidence (i.e. differences will be considered statistically significant if P<0.05). Repeated measures ANOVA with post-hoc Tukey test for individual parameters HR, SBP, DBP and PI changes over time was used.

3. Observations and Results

Sixty patients who underwent elective surgery under general anesthesia were selected for the study; the mean age of participant was 28±7.1 with male to female ratio 2:1. Demographic profiles of the patients, baseline values of haemodynamic parameters and perfusion index were shown in table 1.

Table-1: Demographics and baseline values

Parameters	Values
Age (years)	27.9±7.1
Sex (Male: Female)	2:1
ASA (Grade- I: II)	4.5:1
HR (beats/min)	72±10.6
SBP (mm Hg)	94±15
DBP (mm Hg)	58±10
SPO2 (%)	100
Perfusion index	3.6 ±2.3

Table 2 shows the pre induction value and changes of HR, noninvasive blood pressure and PI at various time points. We found significant increase in heart rate at 1 min when compared to baseline values then decreased was observed at 3 and 5 minutes following induction of anaesthesia, (P<0.05). SBP at 1, 3 and 5 minutes when compared to pre-induction are statistically significant. Also, SBP at 3 minutes and 5 minutes were significantly less when compared to 1 minute SBP. DBP at 1 and 3 minutes were significantly increased when compared to pre-induction value. Also, 3 and 5 minute DBP were significantly less when compared to 1 minute and 5 minute value was significantly less than 3 minute. PI at 1 and 3 minutes were significantly reduced as compared to pre-induction value. But, PI at 5 minutes was not significantly different compared to pre-induction value, (P>0.05). Also, 3 minute and 5 minutes PI were significantly more as compared to 1 minute.

Table-2: Changes of HR, SBP, DBP and PI at various time points

Time points	Heart rate (beats/min)	SBP (mmHg)	DBP (mmHg)	PI
Pre-induction	72±11	94±15	58±10	3.6±2.3
1 min	85±14	128±21	76±16	2±1.6
3 min	75±11	114±20	66±14	2.7±1.8
5 min	74±11	102±15	60±12	3.4±2.4

Table 3 shows the change in HR, SBP, DBP and PI as to pre-induction values. In comparison to pre induction values changes in HR, noninvasive blood pressure and perfusion index at 3 minutes and 5 minutes were significantly less as compared to 1 minute change while the change in HR at 5 minute was not significantly (P>0.05) different as compared to 3 minute value. However the changes in SBP, DBP and PI at 5 minute were significantly less as compared to 3 minute.

Table- 3: Change in HR, SBP, DBP and PI as to pre-induction values

Time points	Heart rate (beats/min)	SBP (mmHg)	DBP (mmHg)	PI (%)
1 minute Vs pre-induction	12±16	36±22	20±19	-45.4±22.6
3 minute Vs pre-induction	3±12	20±14	10±14	-14.7±46
5 minute Vs pre-induction	2±5	8±12	4±15	8±52

Based on the haemodynamic criteria (HR, SBP and DBP), the insertion of endotracheal tube showed the greatest percentage of positive stress responses at 1 minute of intubation followed by 3 and 5 minutes; $P<0.05$. Similarly PI showed maximum percentage of positive stress responses at 1 minute of intubation as compared to 3 and 5 minute of intubation, (Table 4).

Table-4: Comparison of hemodynamic stress response in various parameters

Parameter	Number (%) of individuals in 1st minute	Number (%) of individuals in 3rd minute	Number (%) of individuals in 5th minute
HR (beats/min)	28 (46.7)	8 (13.3)	2 (3.3)
SBP(mmHg)	49 (81.7)	46 (76.7)	17 (28.3)
DBP(mmHg)	35 (58.3)	14 (23.3)	15 (25)
Perfusion index	58 (96.7)	39 (65)	17 (28.3)

A comparison of sensitivity and specificity with positive and negative predictive value for different parameter was given in Table 5. Moreover, PI were decreased significantly by 10%, using the PI criterion, we found comparable sensitivity and specificity with positive and negative predictive values i.e. 96.7% (CI 88.5-99.6%). Regarding the SBP and DBP criterions, the sensitivity and specificity were 55.1% (CI 45.2-64.6%), 63.2% (CI 52.7-72.8%) and 100% (CI 71.5-100%), 100% (CI 86.3-100%) respectively. The positive and negative predictive values were 100% (CI 94-100%), 100% (CI 94-100%) and 18.3% (CI 9.5-30%), 41.7% (CI 29.1-59.1%) respectively.

Table- 5: Comparison of sensitivity specificity with different hemodynamic parameters as gold standard

Parameters	Diagnostic accuracy measures	Values (%)	95% confidence intervals (%)
SBP criterion (≥ 15 mmHg)	Sensitivity	55.1	45.2-64.6
	Specificity	100	71.5-100
	Positive predictive value	100	94-100
	Negative predictive value	18.3	9.5-30
DBP criterion (≥ 15 mmHg)	Sensitivity	63.2	52.7-72.8
	Specificity	100	86.3-100
	Positive predictive value	100	94-100
	Negative predictive value	41.7	29.1-59.1
PI criterion (decrease > 10%)	Sensitivity	96.7	88.5-99.6
	Specificity	96.7	88.5-99.6
	Positive predictive value	96.7	88.5-99.6
	Negative predictive value	96.7	88.5-99.6

4. Discussion

Pulse oximetry is a noninvasive method for monitoring a person's oxygen saturation (SO_2). Its reading of SpO_2 (peripheral oxygen saturation) is not always identical to the reading of SaO_2 (arterial oxygen saturation) from arterial blood gas analysis, but the two are reliably enough correlated that the safe, convenient, noninvasive, inexpensive pulse oximetry method is valuable for measuring oxygen saturation in clinical use. Second to electrocardiography, conventional pulse oximetry is the most common method of monitoring of vital functions, particularly in the perioperative period, enabling assessment of arterial blood oxygenation and heart rate. PI is the numerical value of the amplitude of the plethysmo graphic pulse wave that is displayed on many pulse oximeters. The pulsating signal is indexed against the non-pulsating signal and expressed as ratio, it is commonly referred to as the PI = AC/DC x 100%[7]. In general terms, PI reflects the peripheral vasomotor tone [4]. Low PI suggests peripheral vasoconstriction (or severe hypervolemia) and high PI suggests vasodilation. PI is sensitive to several things such as temperature of the finger, exogenous vasoactive drugs, sympathetic nervous system tone (pain, anxiety, and so on) and stroke volume [8]. Although there are several confounders influencing peripheral perfusion, determination of a decrease in PI ≤10% as a threshold for stress response seems to be reasonable [4,5,7-17]. Several studies investigated the effects of low peripheral perfusion caused by hypothermia; vasoconstriction or sympathetic nerve activity [18,19]. Therefore, variation in PI is associated with potentially numerous causes, especially a small variation of 10% as observed in this study. In this context, Landsverk and colleagues investigated variations in plethysmographic waveform amplitude in deeply sedated and mechanically ventilated patients. They observed slow and large spontaneous oscillations in skin microcirculation per laser Doppler flowmetry related to the sympathetic nervous system and presumed that this mechanism determined the large variability of pulse oximetry photoplethysmographic waveform signal [20].

In current study we observed sixty patients undergoing elective surgery under general anaesthesia for stress response during endotracheal intubation, in terms of changes of parameters of before and after the procedure of intubation. Criterions for various parameters to be considered as positive stress response were based on previous studies conducted [21]. We observed changes in HR, SBP, DBP and PI following intubation.

There was significant (P< 0.05) increase in heart rate at 1 min when compared to baseline. Similarly, heart rates at 3 and 5 minutes were significantly decreased. We found Change at 3 minutes and 5 minutes were significantly less as compared to 1 minute change. Also, change at 5 minute was not significantly (P>0.05) different as compared to 3 minute value.

Changes in SBP at 1, 3 and 5 minutes when compared to pre-induction are statistically significant (P<0.05) Also, SBP at 3 minutes and 5 minutes were significantly (P<0.05) less when compared to 1 minute SBP. Sensitivity and specificity was 55.1(CI: 45.2-64.6) and 100(CI: 71.5-100) respectively with Positive Predictive value and Negative predictive value as 100(CI: 94-100) and 18.3(CI: 9.5-30). Takashashi S *et al*. investigated the efficacy of hemodynamic and T-wave criteria for detecting intravascular injection of epinephrine test dose in propofol – anaesthetised adults. The minimal effective dose of epinephrine associated with 100% sensitivity and specificity was 10 mcg based on SBP criterion and was 5 mcg based on HR and T-wave criteria[22]. DBP at 1 and 3 minutes were significantly (P<0.05) increased when compared to pre-induction value. Also, 3 and 5 minute DBP were significantly less when compared to 1 minute DBP and 5 minute value was significantly less than 3 minute. Sensitivity and specificity was 63.2(CI: 52.7-72.8) and 100(CI: 86.3-100) respectively with Positive Predictive value and Negative predictive value as 100(CI: 94-100) and 18.3(CI: 29.1-59.1).

Changes in PI at 1 and 3 minutes were significantly (P<0.05) reduced as compared to pre-induction value. But, PI at 5 minutes was not significantly different compared to pre-induction value. Also, 3 minute and 5 minutes PI were significantly (P<0.05) more as compared to 1 minute. Sensitivity and specificity was 96.7 (CI: 88.5-99.6) and 96.7 (CI: 88.5-99.6)) respectively with Positive Predictive value and Negative predictive value as 96.7 (CI: 88.5-99.6) and 96.7 (CI: 88.5-99.6). Hany A. Mowafi *et al* investigated the efficacy of PI as an indicator for intravascular injection of epinephrine-containing epidural test dose in propofol – anaesthetised adults. PI has been used to reflect an evident response with 100% sensitivity and specificity to epinephrine-containing epidural test dose. HR criterion (≥10 beats/min) was 95% reliable in detecting the intravascular injection of test dose containing epinephrine during TIVA. The sensitivity of SBP criteria was 90%in detecting of IV epinephrine[4]. In our study we found PI response criterion achieve sensitivity of 96.7 % (CI: 88.5-99.6) for detecting the stress response to endotracheal intubation during balanced anaesthesia in adult patients. On other hand SBP and DBP achieved sensitivity of 55.7% (CI: 45.2-64.6) and 63.7 % (CI: 52.7-72.8) respectively. This finding was in contrast to previous studies conducted by Takahashi S*et al*. that showed 100% sensitivity of PI[22,23].

5. Conclusion

In conclusion, perfusion index was reliable indicator for stress response for endotracheal intubation with better sensitivity and specificity as compared to heart rate and blood pressure. The present study provided us with one of many uses of modern monitoring equipments and up gradation in present equipments for monitoring in operation theaters. Perfusion Index is one of these upcoming monitors with its use not only in field of anaesthesia but also in critical care for management of patients and improving the outcome.

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