Original article

Comparison of non-invasive haemodynamic monitors of stress response to endo-tracheal intubation with perfusion index in patients undergoing elective surgery

Sushila Lama Moktan[1], Manan Karki [2]

Abstract

Introduction: Laryngoscopy and intubation is always associated with a short term reflex sympathetic pressor response. The perfusion index is an indirect, non-invasive, and continuous measure of peripheral perfusion by pulse oximeter which can detect the stress response to intubation similar to heart rate, systolic blood pressure and diastolic blood pressure.

Methods: This prospective observational study enrolled sixty-five normotensive patients of American society of anesthesiologists physical status grade I and II scheduled for elective surgery under general anaesthesia. Tracheal intubation was performed after induction with intravenous fentanyl, propofol and vecuronium. Heart rate, Systolic and Diastolic Blood Pressure and Perfusion Index were measured before induction of anesthesia, before intubation and one minute, three minutes, five minutes after the insertion of the endotracheal tube. Increase in heart rate by ≥10 beats per minute, systolic and diastolic blood pressure by ≥15 millimeters of mercury and decrease in Perfusion index ≥10% after endotracheal intubation as compared to preintubation value were considered positive haemodynamic changes.

Results: Endotracheal intubation produced a significant increase in heart rate and blood pressure whereas perfusion index decreased significantly. Our study showed that perfusion index response criterion achieved 97.7% (Confidence interval 97.58-97.86) sensitivity in detecting the stress response to insertion of endotracheal tube whereas systolic and diastolic blood pressure achieved sensitivity of 90% and 92% respectively.

Conclusion: Perfusion Index is easier, reliable and non-invasive alternative to conventional haemodynamic criteria for detection of stress response to endotracheal intubation.

Keywords: Endotracheal intubation; Haemodynamic changes; Perfusion index; Stress response

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Introduction

The airway management during general anesthesia are known to induce clinical changes in haemodynamic variables as first described by Reid and Brace.[1-3] The transitory rise in autonomic response to intubation starts after 30 seconds and lasts for less than 10 minutes due to increase in catecholamine concentrations.[4-6] Perfusion index (PI) measured by the pulse oximeter is the ratio of pulsatile to non-pulsatile blood flow in peripheral tissue. Intubation induced stress response mediates peripheral vasoconstriction that results in a decrease in the pulsatile component of PI.[7]

The pressor response to intubation is an established phenomenon but very few studies are present that compare the indices of non-invasive haemodynamic stress response and PI. Given its cost effectiveness and definite value with less chance of error, it is practically an applicable method of evaluating sympathetic tone.

Therefore, this study was used to evaluate the efficacy of PI as a non-invasive monitor of hemodynamic response to endotracheal intubation as compared to heart rate, systolic and diastolic blood pressure.

Methods

It was a prospective observational study performed at Kathmandu Medical College Teaching Hospital over a period of nine months (September 2018 to June 2019). The patients were posted from various departments for elective surgery under general anaesthesia requiring tracheal intubation. Institutional ethical approval and patients' written consent were obtained prior to the study. The study included the patients of either sex, aged between 18 and 60 years of American Society of Anaesthesiologists physical status (ASA PS) grade I or II. Patients with hypertension, cardiac, pulmonary, renal, peripheral vascular disease, gastroesophageal reflux, chronic pain, cervical spine disease, anticipated difficult intubation, pregnant women, emergency surgery and any patients who did not give their consent were excluded from the study. Total of seventy patients were included in the study with 10% drop out .The sample size was calculated by using the formula:

Sample (n) = $2(SD)^2(Z_{\alpha/2}+Z_\beta)^2/d^2$,
where SD-standard deviation from previous study =1.8,[8]
$Z_{\alpha/2}$: 1.96 at α= 0.05,
Z_β: 0.842 at 80% power,
d: difference between mean values=3.6-2.7=0.9.

After confirming adequate nil per oral status and the consent, patient was taken to the operation room. In the operation theatre, the peripheral line was secured with 18G intravenous cannula and intravenous fluid was started. The operation room temperature was maintained at 21 to 24 Degree Celsius. Baseline systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure, heart rate (HR), oxygen saturation and the Perfusion index was monitored using a Mindray™ iMEC15 monitor (Mindray Medical International Limited, Shenzhen, China). The PI upper and lower limits reported by the manufacturer were 0.02% and 20.0% respectively. The pulse oximeter probe used to monitor the PI was attached to the index fingertip of contralateral hand of BP monitoring and was wrapped with the towel to prevent the direct ambient light and minimise heat loss. The elements that might interfere with the correct measurement of perfusion index by pulse oximeter, like nail polish, movement of the patient, henna pigmentation was carefully corrected and if not possible, different site was used.

After recording the baseline vital readings, anaesthesia was induced with intravenous Fentanyl 2µg/kg, Propofol 2.5 mg/kg and Vecuronium 0.1 mg/kg. After four minutes, laryngoscopy was performed using Macintosh laryngoscope and intubated using cuffed tracheal tube of internal diameter 7-7.5 mm for women and 7.5-8 mm for men. The patient who required external laryngeal manipulation or more than one attempt for the intubation was excluded from the study. All the tracheal intubation was performed by the same researcher anaesthesiologist. Five patients were excluded due to unanticipated difficult airway (three patients required external laryngeal manipulation during intubation and two patients were intubated on second attempt). Patient was then mechanically ventilated and end-tidal carbon dioxide was maintained at 30-35 mmHg. Anaesthesia was maintained with air and oxygen of 50% and Isoflurane at 1-1.5 minimal alveolar concentration. HR, SBP, DBP and PI were measured before induction of anaesthesia, before intubation and one minute, three minutes and five minutes after intubation. The positive response to device insertion was 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 endotracheal tube.[8]

Statistical analysis was performed using the programme SPSS evaluation version 25 for windows. Numerical data were presented as mean ± SD, and categorical data as proportions (%). Continuous variables at time points were compared using Friedman's ANOVA with Wilcoxon signed ranked test for pair wise comparison.

Results

Out of 70 patients, five patients were excluded from the study due to unanticipated difficult airway. So, only 65 patients were enrolled in our study, out of which 22 were male and 43 were female with the mean age of 36±11 years. The patient characteristics included body mass index, which was 22.8±2.7 kg/m2 and the ASA-PS grading, where 52(80%) patients were grade I and 13(20%) were grade II. Measurements of baseline haemodynamic indices including HR, SBP, DBP and PI are presented in **Table 1**.

Table 1. Baseline haemodynamic variables.

Baseline parameters	Values
HR	86.03 ±5.1 beats per minute
SBP	126.83±11.28 mm of Hg
DBP	78.69±9.08 mm of Hg
PI	1.94±1.56 %

(All data are presented as means ± SDs, HR: heart rate, SBP: systolic blood pressure, DBP: diastolic blood pressure, PI: perfusion index.)

Table 2 shows the changes in the HR, SBP, DBP and PI before intubation and one minute, three minutes and five minutes after the intubation.

Table 2. Time trend of hemodynamic changes.

Time points	HR (/min)	SBP (mm of Hg)	DBP (mm of Hg)	PI (%)
Preintubation	72±10	100±16	59±12	6.4±2.9
1min	90±15	131±20	83±14	3.3±1.9
3min	85±12	115±15	72±12	5.3±2.8
5min	81±10	108±10	65±10	6.1±3.3

(All data are presented as means ± SDs.)

Table 3. Comparison of positive haemodynamic stress response HR, SBP, DBP and PI between preintubation values and at 1min, 3mins and 5 mins after intubation.

Change in heart rate	/min (Mean ± SD)	P value
Preintubation vs 1min	18.6±4.9	<0.001
Preintubation vs 3 mins	14.7± 1.5	<0.001
Preintubation vs 5 mins	11.2± 1.7	<0.001
Change in SBP	**mm of Hg (Mean ± SD)**	
Preintubation vs 1min	31.7± 4.5	<0.001
Preintubation vs 3 mins	15.9± 1.5	<0.001
Preintubation vs 5 mins	8.1± 6.0	0.169
Change in DBP	**mm of Hg (Mean ± SD)**	
Preintubation vs 1min	24.6± 2.4	<0.001
Preintubation vs 3 mins	15.8± 1.1	<0.001
Preintubation vs 5 mins	6 2±.3.1	0.271
Change in PI	**% (Mean ± SD)**	
Preintubation vs 1min	3.13± 1.09	<0.001
Preintubation vs 3 mins	1.16 ± 0.11	<0.001
Preintubation vs 5 mins	0.39 ± 0.32	0.435

(Statistically significant at P<0.017, All data are presented as means ± SDs.)

The HR, SBP, DBP and PI were statistically significant (p value <0.017) at first and third minutes of intubation as they are compared with the pre-intubation value as shown in **Table 3**.

Based on the criteria,[9] **Table 4** showed that, insertion of endotracheal tube caused maximum percentage of increase in HR, SBP, and DBP. Similarly, PI showed maximum percentage of positive stress responses at first minute of intubation as compared to third and fifth minute of intubation.

Table 4. Comparison of haemodynamic 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 increase in >10bpm	41(63)	40(61.5)	24(36.9)
SBP increase in >15mm of Hg	52(80)	36(55.4)	29(44.6)
DBP increase in >15mm of Hg	48(73.8)	33(50.8)	15(23.1)
PI decrease in >10%	63(96.9)	34(52.3)	27(41.5)

The sensitivity, specificity, positive and negative predictive values are derived using the first minute data. As previous studies has shown a significant co-relation between HR and endotracheal intubation, SBP, DBP, PI are plotted against the HR in **Table 5**.[10,11]

Discussion

This study is aimed at comparing the PI with HR, SBP and DBP following endotracheal intubation. The reflexive response to the laryngoscopy and the presence of endotracheal tube causes a cardiovascular system reaction[12,13] that leads to an average rise in heart rate by 20% and blood pressure by 40-50% which is maximum after one minute of intubation and last for about five to ten minutes.[14] In the pulse oximeter, a variable amount of light is absorbed by pulsating arterial flow (AC) and a constant amount of light is absorbed by non- pulsating blood and tissue (DC). So, the ratio of pulsating to non-pulsating signal is referred as the "perfusion index" = AC×100/DC%. Pulse oximeter displays the PI as a numerical value derived from its plethysmographic wave signal which reflects the real time changes in peripheral flow.

Table 5. Sensitivity, specificity, positive and negative predictive values based on one minute value of the haemodynamic criteria for stress response (n=65).

Parameters			Diagnostic accuracy measures	Values (%)	95% confidence interval
	HR		Sensitivity	90.2%	89.95-90.53
SBP	Significant	Nonsignificant	Specificity	37.5%	36.88-38.12
Significant	37	15	PPV	71.1%	70.76-71.54
Nonsignificant	4	9	NPV	69.2%	68.42-70.03
	HR		Sensitivity	92.7%	92.42-92.93
DBP	Significant	Nonsignificant	Specificity	58.33%	57.70-58.96
Significant	38	10	PPV	79.16%	78.79-79.53
Nonsignificant	3	14	NPV	82.35%	81.77-82.93
	HR		Sensitivity	97.72%	97.58-97.86
PI	Significant	Nonsignificant	Specificity	4.16%	3.91-4.42
Significant	40	23	PPV	65.15%	64.78-65.51
Nonsignificant	1	1	NPV	50%	47.78-52.21

Based on the criteria for haemodynamic positive stress response to intubation conducted in previous study,[9] we observed changes in HR, SBP, DBP and PI following intubation. There was a significant (P< 0.017) increase in heart rate at one minute when compared to pre-intubation value. Similarly, heart rates at third and fifth minutes were also significantly increased. Changes in the systolic blood pressure at one and three minutes when compared to pre-intubation were statistically significant, whereas SBP at five minutes was not significant (p value = 0.16). Diastolic blood pressure at one and three minutes was significantly increased (p < 0.017) when compared to pre-intubation value but not at five minutes (p=0.27). The Perfusion Index at first and third minutes were statistically significant but not at fifth minutes as compared to pre-intubation value.

Our study exhibited that the PI was decreased by >10% in 63 (96.9%) out of 65 in the first minute after endotracheal tube insertion followed by 34(52.3%) and 27(41.5%) at 3rd and 5th minutes respectively. Heart rate was increased by 10 beats per minute in 41(63%) patients at 1 minute of intubation. Systolic and diastolic blood pressure was increased by 15 mm of Hg in 52 (80%) and 48(73.8%) patients respectively during the first minute which was similar to the study performed by Waghalkar. P et.al.[8] The main finding of the present study was that percentage PI response criterion achieved 97.7% (CI 97.58-97.86) sensitivity in detecting the stress response to insertion of endotracheal tube in adult patients. On the other hand, SBP and DBP achieved sensitivity of 90% and 92% respectively in detecting haemodynamic stress responses in this population. In a study by Hosam et al[9] the sensitivity of PI, SBP and DBP criterions were 100%, 44.4%, 55.6% respectively in the detection of stress post-insertion where our value of PI was similar but not the SBP and DBP.

Mowafi et al showed 100% sensitivity of PI and SBP of 90% similar to our outcome, PI sensitivity of 97.7% and SBP of 90.2% (CI 89.95-90.53) and they concluded that PI is a reliable alternative to conventional haemodynamic criteria for detection of an intravascular injection of epidural test dose in propofol-anesthetized adult patients.[15]

Perfusion Index has been considered a useful tool for accurately monitoring changes in peripheral perfusion in real time. Based on these previous studies, PI reflects changes in peripheral microcirculation, and these are correlated with vascular status, hypothermia, sympathetic reactions, and function of the circulatory system.[16,17] 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.[18,19] Continuous evaluation of peripheral perfusion during the perioperative period would be useful for the assessment of haemodynamic responses to anaesthetic drugs, techniques and to intraoperative stimuli.[20]

There were some limitations in our study. The patients included were only of ASA grade I or II and the study did not include any patients with difficult airway or hypertension, so results might not be applicable to patients with ASA grade of more than II as well as the patients with difficult airway and hypertension. Peripheral nerve stimulator was not used to measure the action of the neuromuscular blocking agent prior to the intubation.

Conclusion

Perfusion Index is an accurate numerical index which is a reliable and simple substitute to conventional hemodynamic stress response for endotracheal intubation with better sensitivity than heart rate, systolic blood pressure and diastolic blood pressure.

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