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Assessment of Pulse Oximeter-Derived Perfusion Index for Evaluating Rescue Analgesia in Postoperative Patients

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ABSTRACT

Background: Postoperative pain often remains underestimated due to challenges in its evaluation. Traditional assessment methods like pain scales and hemodynamic indicators may be complex and occasionally unreliable. The perfusion index (PI), derived from Masimo pulse oximetry, offers a rapid, non-invasive, and objective approach for assessing pain in post-surgical patients.
Objective: To determine the effectiveness of perfusion index as an objective marker for evaluating pain relief following rescue analgesia in postoperative individuals.
Materials and Methods: A total of 120 extubated postoperative patients aged 18–80 years were observed. A Masimo pulse oximeter probe was applied, and data on PI, BPS-NI score, and hemodynamic variables were recorded at the first request for analgesia (T1). Rescue analgesia was administered at this point, and all parameters were reassessed 30 minutes later (T2).
Results: Significant elevation in PI values was noted post analgesia, accompanied by notable reductions in BPS-NI scores, mean arterial pressure (MAP), and heart rate. However, no statistically significant changes were observed in axillary temperature or oxygen saturation.
Conclusion: The pulse oximeter-derived perfusion index is a quick, easy-to-use, and non-invasive tool for evaluating pain and monitoring the effectiveness of rescue analgesia in postoperative settings.

Keywords: Postoperative Pain, Perfusion Index, Pulse Oximetry, Rescue Analgesia.

INTRODUCTION

Pain is frequently under-recognized in the postoperative period due to the inherent difficulties in assessing it accurately. Although tools like the Visual Analogue Scale (VAS) and Numeric Rating Scale (NRS) are commonly employed for pain evaluation, their effectiveness is limited in patients who are unable to communicate effectively (Tapar et al., 2018). Furthermore, the use of physiological signs such as blood pressure and heart rate for pain detection is not always dependable, as these parameters can be influenced by various unrelated clinical conditions (Barr et al., 2013).

The Behavioral Pain Scale (BPS), including its version for non-intubated patients (BPS-NI), has been developed to aid in pain assessment in patients who cannot self-report (Gélinas et al., 2017). However, its complexity and the need for multiple observational points make it a time-consuming and sometimes impractical tool in busy clinical settings (Chanques et al., 2009).

The Masimo SET® pulse oximeter offers an innovative, non-invasive, and objective alternative for evaluating pain. Unlike conventional pulse oximetry that focuses solely on oxygen saturation, this device measures the perfusion index (PI), which reflects the ratio of pulsatile to non-pulsatile blood flow at a specific site. PI serves as an indirect and continuous indicator of peripheral perfusion and varies between 0.02% (indicating weak perfusion) and 20% (indicating strong perfusion)

(Chung et al., 2018). Since pain stimulates the sympathetic nervous system, leading to peripheral vasoconstriction and a subsequent drop in PI, changes in PI can be interpreted as a response to pain intensity (Hagar et al., 2004).

Given the physiological correlation between pain and sympathetic activation, PI has the potential to function as an objective and practical measure for pain assessment in postoperative patients.

AIM OF THE STUDY:
To assess the utility of the perfusion index derived from pulse oximetry as an objective marker for pain intensity following the administration of rescue analgesia in postoperative patients.

MATERIALAND METHODS
This prospective observational study was conducted over a period of one year (June 2021 to May 2022) in the Department of Anaesthesiology and Critical Care at Assam Medical College and Hospital, Dibrugarh. Ethical clearance was obtained from the Institutional Ethics Committee prior to the commencement of the study.

A sample size of 120 extubated postoperative patients was determined using a 95% confidence interval, 90% power, and an expected correlation coefficient of 0.30. Patients aged between 18 and 80 years with an ASA physical status of I to III, who were alert (RASS score ≥ 0), and had undergone surgeries such as appendicectomy, splenectomy, hernia repair, or cholecystectomy were included in the study. Based on baseline perfusion index (PI), participants were categorized into two groups: those with PI > 3.5 and those with PI ≤ 3.5.

Patients were excluded if they had a high fever (>41.1°C), hypothermia (<36°C), pre-existing neurological, psychiatric, or chronic pain disorders, were unconscious (RASS ≤ -1), had received combined general and epidural anaesthesia or transversus abdominis plane blocks, or had severe intraoperative/postoperative bleeding (≥750 mL). Written informed consent was obtained from all participants. All study-related expenses were covered by the investigators.

Study Protocol:
After extubation and full recovery, patients were transferred to the postoperative ward. Standard monitoring equipment was applied and baseline measurements were recorded. Supplemental oxygen was administered via nasal cannula at 4–6 L/min. A pulse oximeter probe was placed on the middle finger and wrapped with a towel to minimize heat loss. Patients were kept warm using woolen blankets and warmed IV fluids (37–41°C), maintaining an axillary temperature between 36.2–37.5°C.

Patients were observed until they requested analgesia. Sedation levels were assessed using the Richmond Agitation Sedation Scale (RASS) upon arrival, and at 1 and 2 hours post-arrival. Intravenous paracetamol (1g) was given every 6 hours, and 5 mg nalbuphine was administered either upon request or when BPS-NI score ≥5, whichever occurred first.

At the time of first rescue analgesia request (T1), the following were recorded: BPS-NI score, PI, heart rate, mean arterial pressure (MAP), oxygen saturation (SpO_2), and axillary temperature. Subsequently, IV paracetamol (1g) and nalbuphine (5mg) were administered. These parameters were re-evaluated 30 minutes later (T2).

Statistical Analysis:
Data analysis was carried out using SPSS for Windows (version 20.0) and Microsoft Excel 2010. Continuous variables were presented as mean ± standard deviation and compared using Student's t-test. Categorical variables were expressed as numbers and percentages and analyzed using Chi-square or Fisher's exact test, as applicable. A p-value < 0.05 was considered statistically significant.

RESULTS
120 post operative patients undergoing appendicectomy, splenectomy, hernia repair, cholecystectomy included in the analysis. Characteristics of study population and operative details shown in table below.

Table 1: characteristics of study population

Variables		PI > 3.5	PI ≤3.5
Sex	Male	33 (55.00%)	32 (53.33%)
	Female	27 (45.00%)	28 (46.67%)
Age (years)	18-30	17 (28.33%)	18 (30.00%)
	31-40	16 (26.67%)	9 (15.00%)
	41-50	8 (13.33%)	13 (21.67%)
	51-60	12 (20.00%)	12 (20.00%)

	61-70	4 (6.67%)	7 (11.67%)
	71-80	3 (5.00%)	1 (1.67%)
Weight (kg)		64.75 ± 13.00	65.75 ± 10.16
ASA	ASA I	18 (30.00%)	18 (30.00%)
	ASA II	26 (43.33%)	30 (50.00%)
	ASA III	16 (26.67%)	12 (20.00%)

Table 2: operative details

Variables		PI > 3.5	PI ≤3.5
Surgical Procedure	Appendicectomy	11 (18.33%)	12 (20.00%)
	Splenectomy	1 (1.67%)	0
	Hernia repair	13 (21.67%)	12 (20.00%)
	Cholecystectomy	35 (58.33%)	36 (60.00%)
Mean operative time (minutes)		65.92 ± 19.52	65.25 ± 20.39
Mean volume of transfuse blood (ml)		178 ± 41.80	185 ± 46.62
Mean intra-operative dosage (mg of morphine equivalent)		5.92 ± 5.47	6.33 ± 5.60
Mean time of first request of analgesia (minutes)		32.83 ± 12.05	34.34 ± 12.98
Request of rescue analgesia (%)	Paracetamol I.V.	60 (100%)	60 (100%)
	Nalbuphine I.V.	8 (13.33%)	29 (48.33%)

Table 3: Showing Mean BPS-NI Score

Mean BPS-NI0 Score	PI > 3.5			PI ≤ 3.5			p value*
	Mean	± S.D.	p value*	Mean	± S.D.	p value*	
Before Analgesia	5.42	0.50	–	5.62	0.61		0.052
30 minutes after Analgesia	3.55	0.62	<0.001*	3.25	0.44	<0.001*	0.003*

Table 3. states mean BPS-NI Score in the group with PI >3.5 decreased significantly 30 minutes after analgesia (P value <0.001). The group with PI≤ 3.5 also showed significant decrease (P value <0.001) after rescue analgesia. There was significant decrease of mean BPS-NI score in the group with PI≤ 3.5 with respect to the group PI>3.5 (P value 0.003) after administration of analgesia.

Table 4: Showing Mean Heart Rate (beats/min)

Mean Heart Rate (beats/min)	PI > 3.5			PI ≤ 3.5			value*
	Mean	± S.D.	p value*	Mean	± S.D.	p value*	
Before Analgesia	98.35	13.03		95.55	10.97		0.205
30 minutes after Analgesia	89.28	10.79	<0.001*	84.42	10.17	<0.001*	0.012*

Table 4. states mean HR in the group with PI >3.5 were decreased significantly after 30 minutes of analgesia (P value <0.001). The group with PI≤ 3.5 also showed significant decrease in mean HR after rescue analgesia (P value<0.001). There was significant decrease of mean HR in the group with PI≤3.5 with respect to the group with PI>3.5 (P value 0.012) after analgesic administration.

Table 5: Showing Mean Arterial Pressure (mmHg)

MAP (mmHg)	PI > 3.5			PI ≤ 3.5			p value*
	Mean	±S.D.	p value*	Mean	±S.D.	p value*	
Before Analgesia	90.12	8.66		88.75	7.68		0.362
30 minutes after Analgesia	82.83	8.45	<0.001*	79.62	7.38	<0.001*	0.028*

Table 5 states MAP (mmHg) in the group with PI >3.5 were decreased significantly after 30 minutes of analgesia (P value <0.001). MAP of the group with PI≤ 3.5 also decreased significantly (P value <0.001) after rescue analgesia. There was significant decrease of MAP in the group with PI≤3.5 compared to the group with PI>3.5(P value of 0.028).

Table 6: Showing Mean Axillary Temperature

Mean Axillary Temperature	PI > 3.5			PI ≤ 3.5			P value*
	Mean	±S.D.	P value*	Mean	±S.D.	P value*	
Before Analgesia	37.45	0.29		37.38	0.24		0.154
30 minutes after Analgesia	37.35	4.83	0.090	37.29	0.26	0.073	0.335

Table 6 states mean axillary temperatures in both the groups showed no significant change after 30 minutes of analgesia. There were no significant differences of mean axillary temperatures of both the groups after analgesic administration. (P value 0.335)

Table 7: Showing Mean SpO2

Mean SpO2 (%)	PI > 3.5			PI ≤ 3.5			P value*
	Mean	±S.D.	p value*	Mean	±S.D.	p value*	
Before Analgesia	98.02	1.02		97.82	0.87		0.250
30 minutes after Analgesia	98.30	1.06	0.138	98.13	1.13	0.088	0.406

Table 7 states mean SpO2 (%) of both the groups showed no significant change after 30 minutes of analgesia. There were no significant differences of mean SpO2 in both the groups after analgesia (P value 0.406).

Table 8: Showing Mean Perfusion Index and Percentage Change in PI >3.5

Mean Perfusion Index	PI > 3.5		Percentage (%) Change	p value*
	Mean	±S.D.		
Before Analgesia	3.89	0.26		
30 minutes after Analgesia	4.28	0.25	90.92	<0.001*

Table 8 states mean PI in the group with PI >3.5 were significantly increased after 30 minutes of analgesia (P value <0.001) with percentage change of 90.02%.

Table 9: Showing Mean Perfusion Index and Percentage in PI ≤3.5

Mean Perfusion Index	PI ≤ 3.5		Percentage (%) Change	p value*
	Mean	±S.D.		
Before Analgesia	1.87	0.81		
30 minutes after Analgesia	2.28	0.84	82.09	0.006*

Table 9 states mean PI in the group with PI ≤3.5 were significantly increased after 30 minutes of analgesia (P value 0.006) with percentage change of 82.09%.

DISCUSSION

Pain is an emotional condition that stimulates the sympathetic nervous system, releases stress hormones which result in vasoconstriction. Patient's pain should be assessed for effective management of postoperative pain. Self-report pain scales cannot be used always due to the difference in psychometric stability of patients. Assessment of these patients may be made possible by detecting the relationship between the perfusion index and pain. Our study showed significant increase of PI with significant decrease of BPS NI score, MAP, heart rate after analgesic administration in both the groups while there was no significant change of mean axillary temperatures and mean SpO2 after analgesia.

Similar to our study (Tapar et al., 2018) found a statistically significant difference between pre-analgesic and post-analgesic PI values and visual analogue scores in a prospective observational study for 89 patients undergoing minor to moderate surgical procedures, they concluded that increase in pain intensity caused decrease PI values. Another study conducted by (Mohamed et al., 2015) on 82 adult patients undergoing lumbar spine discectomy showed significant increase in PI with a decrease of VAS, HR and MAP with adequate relief of pain with use of paracetamol 1g iv and nalbuphine 5mg iv as rescue analgesia in postanaesthetic care unit (Nishimura et al., 2014) in his study observed significant decrease in PI in response to electrical stimulation, they concluded that PI may be a non-invasive method for objective evaluation of pain (Hasanin et al., 2017) also found a difference between MAP, PI, HR and pain intensity before and after the pain caused by positioning in ICU patients.

Limitations of our Study:

Perfusion index measurements are very sensitive to patient's movements. So, to overcome this, perfusion index measurements should be done after patients' stable position and the room temperature of the postoperative ward may interfere with the perfusion index.

CONCLUSION

Pulse oximetry derived perfusion index is a non-invasive, easy method, less time consuming, can be used for evaluating pain and assessing the effectiveness of rescue analgesia in post operative patients. It also eliminates psychological factors so more useful to assess pain and to determine the effectiveness of analgesia in patients suffering from cognitive impairment and dementia.

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