Evaluating Perfusion Index as A Marker for Post-Operative Pain in Post-Anesthesia Care Unit: An Observational Study

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Abstract

Introduction: Postoperative pain management is critical for enhancing recovery and minimizing complications. Traditional subjective measures, such as the Visual Analog Scale, may not always provide accurate pain assessments, particularly in non-communicative patients. The Perfusion Index, a non-invasive measure of peripheral perfusion, has emerged as a potential objective marker for pain assessment.

Objective: This study aimed to evaluate the Perfusion Index as a tool for assessing and managing postoperative pain in the Post-Anesthesia Care Unit and to compare its efficacy with the qNOX score.

Methodology: After ethical approval, an observational study was conducted on 80 patients undergoing elective laparoscopic surgeries under general anesthesia at Acharya Shri Chander College of Medical Sciences, Jammu. Baseline data were collected, and both Perfusion Index and qNOX scores were measured at various time points postoperatively. Pain severity was assessed using Visual Analog Scale, with analgesics administered based on predefined criteria.

Results: Statistical analysis revealed a significant decrease in Perfusion Index immediately after extubation ($p < 0.05$), returning to baseline levels during Post-Anesthesia Care Unit ($p > 0.05$). Visual Analog Scale scores remained below 3 throughout the postoperative period, and qNOX scores showed minimal variation. Pearson correlation analysis indicated weak negative correlations between Perfusion Index and both Visual Analog Scale and qNOX scores.

Conclusion: The findings suggest that while the Perfusion Index may correlate with Visual Analog Scale for assessing postoperative pain in the Post-Anesthesia Care Unit, the qNOX score is not a reliable objective parameter for this purpose. Future studies should explore broader surgical contexts and larger sample sizes to better understand the utility of Perfusion Index in pain assessment.

Keywords: Perfusion Index, Postoperative Pain, Visual Analog Scale, qNOX Score, Post-Anesthesia Care Unit

Introduction

Pain is a multifaceted experience encompassing both sensory and emotional components, often associated with actual or potential tissue damage. According to the International Association for the Study of Pain, while pain typically serves an adaptive role, unrelieved postoperative pain can lead to significant adverse effects on physiological and psychological well-being, impacting various systems including respiratory (atelectasis, pneumonia), cardiovascular (hypertension, arrhythmia), and gastrointestinal systems (nausea, delayed bowel movement)[1,2].Therefore, effective pain management is crucial, as surgical outcomes heavily depend on it.

Traditionally, pain assessment has relied on subjective measures such as the Visual Analog Scale (VAS), which allows patients to self-report pain intensity. Despite its widespread use, the VAS may not always provide an accurate reflection of pain, particularly when patients are unable to communicate effectively. This limitation can lead to inadequate pain management, either through under-treatment or overtreatment[3]. Various studies have explored objective pain assessment tools, including the surgical stress index and the analgesic nociception index, to address these challenges[4,5].

One promising tool for pain assessment is the Perfusion Index (PI), which measures the ratio of pulsatile to non-pulsatile blood flow, serving as a non-invasive indicator of peripheral perfusion. The PI is expressed as a percentage and varies based on individual physiological conditions, offering a potential marker for assessing pain[6]. Increased PI may indicate effective pain relief, while a decrease may reflect heightened pain levels.

Additionally, the qNOX monitor (qCON 2000 plus, Quantum Medical, Barcelona, Spain) has been developed to evaluate analgesic depth using Electroencephalogram and Electromyogram data. The qNOX score ranges from 0 to 99, providing insights into a patient's likelihood of responding to noxious stimuli. Although this tool shows promise in monitoring analgesia, its availability in clinical settings may be limited.

Given the lack of reliable objective parameters for assessing postoperative pain in the Post-Anesthesia Care Unit (PACU), this study aims to compare the Perfusion Index with the qNOX score. We hypothesize that the PI may serve as a useful surrogate marker for pain assessment and management in the PACU, contributing to improved pain management strategies in clinical practice. By exploring this correlation, we aim to

enhance our understanding of objective pain assessment methodologies in the postoperative setting.

Objective of the Study

The present research was conducted to evaluate the use of Perfusion index as a tool for the assessment and management of postoperative pain in Post Anesthesia Care Unit.

Methodology

After obtaining approval from the Institutional Ethical Committee the present randomized study was conducted in the Department of Anesthesiology and Critical Care, Acharya Shri Chander College of Medical Sciences and Hospital, Jammu. Informed written consent was obtained from the patients taking part in the study preoperatively. The sample size for the study came out to be 80.

The study included patients who underwent elective laparoscopic surgeries under general anesthesia, all of whom were classified as ASA I or II in terms of physical status. Participants were between 18 and 60 years of age, and only cooperative and mentally stable individuals were included.

Patients who underwent emergency surgeries, or with pre-existing neurological psychiatric conditions, chronic pain disorders, peripheral vascular disease, or surgeries lasting more than two hours were excluded.

A pre-anesthetic check-up was conducted one day prior to surgery, which included a detailed history, general and systemic examination, and airway assessment for all patients. Routine and any specific investigations required for the patient were undertaken. Basic demographic data, including age, weight, height, and BMI (Body Mass Index), were recorded. All patients were kept fasting for 8 hours before surgery and received 40 mg Pantoprazole and 0.25 mg Alprazolam orally the night before.

On the morning of surgery, a wide bore intravenous line was secured, and Ringer Lactate infusion was started at 1 ml/kg/hr. Baseline parameters (Non-Invasive Blood Pressure, Oxygen Saturation, pulse, and temperature) were recorded. Perfusion Index (PI) was measured using a PHILIPS healthcare monitor, and qNOX was recorded with a CONOX monitor after the patient was positioned supine on the operating table. General anesthesia was induced with Fentanyl (1 μg/kg), Propofol (2 mg/kg), and Vecuronium (0.1 mg/kg) for muscle relaxation. After intubation, anesthesia was maintained with 33% oxygen, 66% nitrous oxide, and Isoflurane at 1 MAC. Paracetamol (1 g) was infused over 10 minutes for intraoperative analgesia, with Fentanyl repeated at 0.5 μg/kg if surgery exceeded one hour.

At the end of surgery, neuromuscular blockade was reversed with Neostigmine (0.05 mg/kg) and Glycopyrrolate (0.01 mg/kg). After extubation, all parameters were recorded and the patient was transferred to PACU. Upon arrival in the PACU, all parameters including PI, pain severity using visual analog scale and qNOX were recorded. The PI, qNOX score and VAS score were recorded every 10 minutes until the patient was pain-free for 20 minutes or VAS score equalling to 3 , qNOX score > 60, and PI returning to baseline.

If qNOX < 60, VAS > 5 or PI decreased by 15% from baseline, patients were given Fentanyl (1 μg/kg, max 2 μg/kg) and, if pain still persisted, inj Diclofenac (75 mg IV). Any adverse events were noted.

Results

Statistical analysis was conducted using IBM SPSS version 21. Continuous data were expressed as mean ± standard deviation and compared using the paired t-test. The results (see Table 1) indicated a significant decrease in the Perfusion Index immediately after extubation (p < 0.05), which gradually returned to baseline levels as the patient was transferred to the PACU (p > 0.05), where it remained within normal range.

Table 1: Changes in Perfusion Index (PI) at Baseline, After Extubation, and During Recovery in PACU

Perfusion Index (PI)	Mean	Standard Deviation	p-value
Baseline	5.05	2.11	-
After extubation	4.63	2.07	0.048*
PACU	5.08	2.11	0.888
After 10 min	5.01	2.08	0.874
After 20 min	5.21	1.9	0.480

Building on the analysis of the Perfusion Index, we also examined the relationship between pain levels and VAS scores in the post-operative period (See Table 2). The results indicated that the Visual Analog Scale (VAS) scores remained below 3 at all-time intervals during the post-operative period, with a score of 0 indicating no pain and a score of 3 representing very mild pain. Consistent with these findings, the Perfusion Index showed little variation when compared to the VAS scores.

Table 2: Changes in VAS Score at Baseline, After Extubation, and During Recovery in PACU

VAS Score	Mean	Standard Deviation	p-value
Baseline	0	0	-
After Extubation	1.61	0.58	0.001*
PACU	2.19	0.48	0.001*
After 10 Min	2.39	0.61	0.001*
After 20 Min	2.54	0.5	0.001*

Similarly, the evaluation of the qNOX scores (see Table 3) in our study remained within normal limits at all time intervals when compared to baseline, with p-values less than 0.05.

Table 3: Changes in qNOX at Baseline, After Extubation, and During Recovery in PACU

qNOX Score	Mean	Standard Deviation	p-value
Baseline	97.86	1.18	-
After Extubation	97.40	1.23	0.013*
PACU	97.29	1.58	0.010*
After 10 Min	97.19	1.54	0.002*
After 20 Min	96.50	2.06	0.001*

Pearson's Correlation Analysis was performed to study the relationship between Perfusion Index, qNOX and VAS. The results have been illustrated in Table 4 and 5. The qNOX score remained stable within normal limits at all-time intervals compared to baseline (p-value > 0.05). A significant decrease was observed in the Perfusion Index immediately after extubation (p-value < 0.05), which then returned to baseline levels as the patient was transferred to the PACU (p-value > 0.05), remaining within normal values. Throughout the postoperative period, both the Visual Analog Scale (VAS) and Perfusion Index showed minimal variation.

Table 4: Correlation Analysis between Perfusion Index and qNOX

Perfusion Index	Qnox				
	Baseline	After Extubation	PACU	After 10 Min	After 20 Min
Baseline	0.05	0.14	-0.05	-0.17	-0.00
After Extubation	0.08	0.02	0.05	-0.13	-0.07
PACU	0.07	0.14	0.03	-0.14	-0.04
After 10 Min	-0.16	-0.01	-0.02	-0.19	-0.09
After 20 Min	0.05	0.17	0.08	-0.19	-0.10

Upon applying Pearson's correlation, we found a weak negative correlation between the two measures.

Table 5: Correlation Analysis between Perfusion Index and VAS Score

Perfusion Index	VAS Score				
	Baseline	After Extubation	PACU	After 10 Min	After 20 Min
Baseline	-	-0.07	-0.09	-0.19	0.02
After Extubation	-	-0.17	-0.09	-0.20	-0.08
PACU	-	-0.04	-0.19	-0.02	0.16
After 10 Min	-	-0.09	-0.12	-0.01	-0.04
After 20 Min	-	-0.04	-0.07	-0.19	0.01

Discussion

Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or related to such damage. For patients, pain often signifies disease and suffering; for doctors, it serves as a symptom; and for physiologists, it is a distinct sensation with its own anatomical and physiological pathways, starting from the receptors and culminating in the brain cortex. Unmanaged postoperative pain can activate the sympathetic nervous system and trigger the release of stress hormones, which can negatively impact the respiratory, cardiovascular, and gastrointestinal systems.

Reducing pain during surgery and managing post-operative pain is of crucial importance as the outcome of surgery depends greatly on effective pain management. Several pain assessment tools have been used in the past to assess pain objectively like photoplethysmography derived parameters, analgesia nociception index, skin conductance, EEG derived indices (qCON and qNOX) although more further studies are required. Another parameter that can be used to measure pain objectively is the Perfusion Index, as displayed on a pulse oximeter.

The Perfusion Index represents the ratio of the pulsatile component of blood flow to the non-pulsatile

component, providing an indirect and non-invasive assessment of peripheral perfusion. Typically monitored with pulse oximeters, it serves as a reliable indicator of the accuracy of pulse oximeter readings, enhancing the sensitivity of the sensor. The Perfusion Index is expressed as a percentage and has been utilized by various researchers as an early indicator of successful nerve blocks[4] and sympathectomies, as well as for predicting hypotension following spinal anesthesia during cesarean delivery[7].

Perfusion Index has also been utilized as a predictor of high illness severity in neonates and to detect stress responses during anesthesia[5]. It may decrease due to increased vasomotor tone and peripheral vasoconstriction when the sympathetic nervous system is activated by pain[6]. Conversely, the Perfusion Index may increase when pain is effectively managed with adequate analgesics[5]. Based on this premise, the present study aimed to evaluate whether the Perfusion Index can serve as a marker for assessing and managing surgical pain in the post-anesthesia care unit. Additionally, we sought to correlate the Perfusion Index with the Visual Analog Scale, hemodynamic parameters, and the qNOX score.

A significant decrease in the Perfusion Index immediately after extubation (p-value < 0.05) was observed, which then returned to baseline levels as the patient was transferred to the PACU (p-value > 0.05), remaining within normal limits. Various studies suggest that the Perfusion Index is expected to decrease with the onset of pain. For instance, Tapar et al. (2018) utilized the Perfusion Index to assess acute postoperative pain and found that it decreased in the PACU in response to pain, subsequently increasing after analgesic administration[8]. They concluded that the Perfusion Index

can be a valuable tool for postoperative pain assessment and response to analgesics.

Similarly, Surekha et al. (2022) examined the changes in Perfusion Index in response to painful stimuli and its variability following intravenous fentanyl administration[9]. Their findings indicated a decrease in the Perfusion Index with pain, which increased after fentanyl was given, suggesting that the Perfusion Index can effectively monitor nociception in anesthetized patients receiving analgesia. Additionally, Kumar et al. (2019) correlated the Perfusion Index with the Visual Analog Scale (VAS) to evaluate its utility in assessing postoperative pain in patients undergoing laparoscopic cholecystectomy[10].

After surgery, the Perfusion Index (PI) and Visual Analog Scale (VAS) readings were noted, when patients requested analgesia and again 30 minutes after analgesia administration. We found a significant increase in the PI and a decrease in VAS, suggesting that the PI can be an effective tool for assessing postoperative pain in the PACU. However, in our study, the PI did not vary significantly, likely due to the nature of the laparoscopic cholecystectomy, which typically results in less postoperative pain, coupled with the use of multimodal analgesia. Similar findings were reported by Kwon et al. (2019), who studied the correlation between intraoperative PI and acute postoperative pain in patients undergoing laparoscopic colorectal surgery[11]. Their results indicated that adequate intra- and postoperative analgesia influenced PI values, thus aligning with our conclusions.

We also noted that mean body temperature remained stable across all time points in the PACU, indicating no impact on PI variations. Studies by Lee et al. (2021) and Hara et al. (2021) suggest that PI can be influenced by

body temperature[12,13], but this was not evident in our study.

The mean oxygen saturation was close to baseline throughout the study period, and the VAS scores remained below 3, indicating minimal pain. The PI showed little variation in relation to VAS, and a Pearson correlation revealed a weak negative correlation between the two. This is consistent with previous studies by Mohammed et al. (2015) and Tapar et al. (2018), which suggested that while PI may serve as a useful indicator, it should be considered alongside other pain assessment tools[14,8].

Finally, the qNOX score remained stable across all time points compared to baseline, corroborating findings from Ledowski et al. (2019), who noted that qNOX scores at the end of surgery were not predictive of postoperative pain in the PACU[2].

Conclusion

Based on the present study, we conclude that while perfusion index may correlate well with the Visual Analog Scale (VAS) score for assessing postoperative pain in the Post-Anesthesia Care Unit (PACU), qNOX is not an effective objective parameter for this purpose. To establish a stronger correlation between the perfusion index and VAS for pain assessment, future research should employ a different study design and include a larger cohort of patients across various surgical procedures.

Our study focused solely on laparoscopic cholecystectomies, which typically have a short duration (26.53 ± 4.91 minutes). Since we administered multimodal analgesia pre-emptively, none of our patients reported pain in the postoperative period, preventing us from correlating the perfusion index with pain levels in the PACU.

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