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Role of Perfusion Index as a Tool for Acute Post-operative Pain Assessment: An Observational Study

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Abstract

Background: A painful stimulus can produce vasoconstriction and a decrease in perfusion index (PI). The visual analog scale (VAS) is the most common pain assessment scale. However, it is affected by psychometric instability. This study was designed to evaluate the correlation between VAS as a subjective indicator of pain and PI as an objective indicator of pain. *Materials and Methods:* At the post-anesthesia care unit, the perfusion index was checked to 50 adult patients of ASA-I who underwent laparoscopic surgery. At the time of the first request for analgesia (T1) VAS was recorded together with the PI, heart rate (HR), Mean Arterial Blood Pressure (MAP), peripheral oxygen saturation and following which analgesia was given. Thirty minutes thereafter, (T2) second measurements for the mentioned parameters were taken. *Results:* The PI was significantly higher at T2 than at T1 (mean increase % = 90% vs 81.4%). This increase was associated with a statistically significant decrease in VAS, HR, and MAP. This means that the PI increases with adequate relief from pain, as indicated by a decrease in VAS, HR, and MAP. A decrease in VAS was associated with an increase in PI, but the correlation was not statistically significant as the degree of the increase in PI in relation to the decrease in VAS was variable among patients. *Conclusion:* PI can be added to other indicators of pain assessment in the post-anesthesia care unit.

Keywords: Pain; Perfusion index; Post-anesthesia care unit; Visual analog pain score.

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Introduction

Un-relieved post-operative pain can result in serious side effects that affect the respiratory system (atelectasis, retention of secretions, pneumonia), the cardiovascular system (hypertension, arrhythmias, coronary ischemia), the gastrointestinal system (decreased bowel movement, nausea, vomiting) and the endocrinal system (increased catecholamine secretion). It also promotes thromboembolism by delaying mobilization.[1]

The International Association for the Study of Pain (IASP) defines pain as 'An unpleasant sensory and emotional experience associated with actual or

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potential tissue damage, or described in terms of such damage'.[2] Effective pain management requires careful assessment and continuous review of pain. The objectives of pain assessment are to measure the severity of pain, select the appropriate analgesic, and estimate the response to treatment. Pain is a subjective symptom as the individual can describe his own feelings. Thus, emotional and psychological factors may interfere with the assessment of the physical component of pain. Self-report pain scales have been the most common pain assessment tools over the years. The visual analogue scale (VAS) is the most common pain assessment scale.[3–5] Both VAS and numeric rating scale have been proven to be superior to a four-point verbal categorical rating scale.[6] However, their validity cannot be established in every environment because of the difference in psychometric stability.[7]

The pulse oximetry system can measure the perfusion index (PI) at the monitored site by calculating the relation between pulsatile and static blood in peripheral tissues. The PI is an indirect, non-invasive, and continuous measure of peripheral perfusion. It ranges from 0.02% (very weak pulse strength) to 20% (very strong pulse strength). It can also measure PI in conjunction with oxygen saturation and pulse rate by simple application of the pulse Oximeter probe to the finger. By knowing, the highest recorded PI, the best monitoring site for pulse oximetry can be identified. The changes in sympathetic nervous tone affect smooth muscle tone and can alter the level of perfusion.

Temperature, volume, and anesthetics can affect the perfusion at the extremities by causing vasoconstriction and vasodilatation, which can cause a decrease in PI or an increase in PI, respectively. The measurement of PI is not affected by Heart Rate (HR) variability, SpO_2, or oxygen consumption.[8,9]

Most anesthetics produce a vasodilator effect while pain induces vasoconstriction. A study had investigated whether a painful stimulus can produce vasoconstriction and a decrease in PI in normothermic anesthetized patients.[8] The researchers found that the PI decreased during painful stimuli in anesthetized volunteers at different concentrations of sevoflurane. They hypothesized that an increased PI after anesthetic administration can be an early indicator of successful anesthesia, whereas absence of this increase may be an early warning of anesthetic failure. Hence, it could be a valuable tool for pain assessment under anesthesia.

Laparoscopic surgery is associated with severe acute post-operative pain unless it is well managed. As far as we know, no study has investigated the correlation between VAS as a subjective indicator of pain and PI as an objective indicator of pain. This correlation can be of great help in analgesic guidance in Post-anesthesia Care Unit (PACU) and unconscious patients in ICUs.

Aim of Work

The aim of the study was to correlate pulse co-oximetry PI with VAS and evaluate the possibility of its use as an objective tool for post-operative pain assessment.

Materials and Methods

A prospective, observational study was performed in Indira Gandhi Institute of Medical sciences, Patna after obtaining the approval of the Ethical Committee and informed written consent from patients undergoing elective Laparoscopic surgery.

Inclusion Criteria

Patients of ASA-I, aged *18–50 years*, who were conscious enough to co-operate and whose mental status was normal in the immediate post-operative period were enrolled in the study.

Exclusion Criteria

Patients with pre-existing cardiovascular, pulmonary or metabolic diseases or history of a neurological, psychiatric or chronic pain disorder, who were taking psychotropic drugs, patients with allergy to any drug used in the study, those with unstable hemodynamic status, and unconscious were excluded.

Pre-operatively, patients were trained on how to express their pain level using VAS to increase their familiarity with the scale. VAS is a subjective tool that depends on the patient's self-expression. The scale consists of a *10 cm* horizontal line. Patients can make a mark on the line according to their pain intensity that can range from *0 to 10*.

The patients were premedicated with intravenous (I.V.) *1 mg* midazolam, *40 mg* pantoprazole, *75 μg* palonosetron and *8 mg* dexamethasone. In the operating room, standard monitors were applied like ECG, pulse oximeter and non-invasive arterial blood pressure monitor. Pre-oxygenation was carried out for *3 min* by means of a face mask with 100% oxygen. Anesthesia was induced by I.V. fentanyl *2 μg/kg*, propofol *2.5 mg/kg* and atracurium

0.5 mg/kg. After endotracheal intubation, capnography and a temperature nasopharyngeal probe were applied. The lungs were ventilated with a tidal volume of *6–8 ml/kg* and the ventilatory rate was adjusted to maintain $EtCO_2$ between *35* and *40 mm Hg*. Maintenance was done with 1.5 MAC isoflurane and top-up doses of atracurium. Analgesia was maintained with I.V. fentanyl at *0.5 μg/kg/h*. The intra-operative Mean Arterial Blood Pressure (MAP) was kept around *60 mm Hg*. Patients who required I.V. nitroglycerine or ephedrine were excluded from the study. Warm I.V. Ringer's acetate solution was infused to replace fluid deficit and basal fluid requirements. The patient was kept warm by maintaining the room temperature at 25°C. At the end of the operation the muscle relaxant was reversed and all patients trachea were extubated and sent to the PACU.

At the post-anesthesia care unit

The following monitors were attached to the patient: ECG, non-invasive arterial blood pressure monitor and finger tip Pulse Oximeter (Romsons's Oxee Check). The Oximeter probe used to monitor the PI was attached to the middle fingertip of the hand contralateral to the site of blood pressure monitoring and was wrapped in a towel to decrease heat loss and interference by ambient light. An oxygen mask was applied if SpO_2 was below 90%. The patients were kept warm with wool blankets, warm I.V. fluids, and a warm air-forced device.

Observation

All patients were observed until they asked for analgesia like at the time of the first request for analgesia (T1) VAS for pain intensity was recorded, together with the PI. Simultaneously, HR, MAP and peripheral oxygen saturation were also noted. For all patients analgesia was achieved with I.V. morphine at *0.05 mg/kg* and I.V. *1 g* paracetamol vial.

Thirty minutes after post-operative analgesia (T2), second measurements of the above-mentioned parameters were taken simultaneously like VAS for pain intensity, PI, HR, MAP, peripheral oxygen saturation, and axillary temperature.

Statistical analysis

Data were statistically described in terms of mean ± SD. Comparison of the time point values was done using the paired *t*-test. *P* - values less than 0.05 were considered statistically significant. All statistical calculations were performed using the computer program SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, Illinois, USA) release 15 for Microsoft Windows (2006).

Power analysis

Power analysis was carried out by comparing all variables between the two study time points. The paired *t*-test was chosen to perform the analysis. α-Error level was fixed at 0.05 and the sample size at 50 participants. The statistical power of our comparisons is shown in the (**Table 1)** below. Calculations were performed using PS Power and Sample Size Calculations Software, version 3.0.11, for MS Windows (William D. Dupont and Walton D. Vanderbilt, USA).

Results

The study initially comprised 62 patients who underwent laparoscopic surgery. All patients who met the inclusion criteria were enrolled in the study. Twelve patients were excluded as they required I.V. nitroglycerine or ephedrine intra-operatively. Finally, 50 patients completed the study. The demographic characteristics of the patients were as follows: Sex, 24 women and 26 men; age, *34.24 ± 12.53 years*; and BMI, *24.76 ± 4.27 kg/m*^{2}. There was a statistically significant increase in PI at T2 than at T1. The mean increase % equalled 90.0 ± 81.4% (**Table 1**).

Table 1: The perfusion index, visual analog scale, mean arterial pressure, and heart rate at T1 and T2, their difference between T2 and T1.

***N* = 50**	**Perfusion Index (PI)**	**Visual Analogue Scale (VAS)**	**MAP (*mm Hg*)**	**HR (*beats/min*)**
T1 (at first request of analgesia)	1.08 ± 1.04	6.75 ± 1.34	84.58 ± 11.24	81.68 ± 13.76
T2 (*30 min* after analgesia)	1.76 ± 1.71	1.86 ± 1.24	81.48 ± 10.14	78.49 ± 12.64
Difference between T2 and T1	0.81 ± 0.94	-4.63 ± 1.44**	-3.4 ± 3.64**	-11.08 ± 5.94**

Values were presented by mean ± SD, *N = Number of patients*.

***Highly Significance** ($p < 0.001$).*

Discussion

Pain is a subjective and personal experience that makes objective measurements impossible.[6] However, the increase in sympathetic nervous tone caused by pain can affect the PI, which can be a guide for the given analgesics in PACU. This tool for pain assessment can eliminate the variations in personality, age, sex, and cultural background. It can also eliminate psychological factors such as fear, anxiety, depression, and anger.

In this study, the PI was significantly higher at T2 than at T1 (mean increase % = 94.3 ± 82.7%). This increase was associated with a statistically significant decrease in VAS, HR, and MAP. The mean decrease % was 70.5 ± 19.88%, 11.1 ± 7.2%, and 3.96 ± 5.01% in VAS, HR, and MAP, respectively. This means that the PI increases with adequate relief from pain as indicated by a decrease in VAS, HR, and MAP. A decrease in VAS was associated with an increase in PI but the correlation was not statistically significant as the degree of the increase in PI in relation to the decrease in VAS was variable among patients.

This study was similar to a study conducted by Hagar *et al.* in which an electrical current was applied to the anterior thigh in two healthy volunteers anesthetized with propofol and maintained with sevoflurane at different concentrations (1, 1.5, 2, 2.5%).[8] This painful stimulus produced a significant increase in HR and MAP with a significant decrease in PI. They concluded that the PI may be of clinical value in assessing pain in the anesthetized state.

A new-generation finger tip pulse oximeter (Romsons's Oxee Check) is easily available and the easiest of all peripheral perfusion assessment modalities. It enables physicians to obtain reliable measurements even under difficult clinical conditions: Patient's movements, hypotension, hypothermia, or electromagnetic field of other devices because of the presence of reference signal calculations, the adaptive filter, and transformation of a single saturation signal.

Pain can alter the endocrine system leading to increased catecholamine secretion causing vasoconstriction.[1] It was reflected as decreased PI with high VAS, but after receiving analgesia the PI increased significantly.

PI was used before for prediction of the onset of successful regional sympathetic blocks, by measuring PI before and after block, like the onset of the epidural anesthesia, which was associated with an increase in PI [10–11]

Conclusion

Perfusion index can be added to other indicators of pain assessment in PACU. It is easy, non invasive, free of subjective interpretation and low time consuming.

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