Section A-Research paper
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Perfusion Index as an Objective Tool to Assess Analgesia During Laparoscopic Surgeries under General Anaesthesia: A Prospective Study

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Abstract

Background: Despite the use of analgesics, many patients experience pain during and after laparoscopic surgery, which can lead to negative outcomes such as prolonged hospital stays, increased morbidity and mortality, and decreased patient satisfaction. Pain can change the sympathetic nervous system, which can impair perfusion and smooth muscle tone. Perfusion index is a tool for monitoring (PI). It is a non-invasive, indirect, and continuous indicator of peripheral perfusion. This study examines how painful stimuli under general anaesthesia alter PI. **Methods:** The present study was conducted at the post graduate Department of Anaesthesia, GMC, Jammu with effect from September 2021 to Feb 2022. After receiving approval from the institutional ethics committee, a total of 50 patients of either sex, 20–45 years old, belonging ASA I classification, and scheduled for laparoscopic cholecystectomy were included in this study. **Results**: We observed that after the administration of fentanyl, the PI values increased from 5.17±3.23 at P1 to 6.15±3.37 at P2 as shown in table 1. With an increasing trend, PI values reached to 6.41 at P3 then decreased to 5.75 at 5 minutes and increased gradually to reach 6.19 at 30 minutes. after the administration of fentanyl, SBP, DBP and MAP readings decreased from (117.31±19.14) mmHg, (73.96±12.22) mmHg, and (88.41±12.88) mmHg at P1 respectively, to (115.90±12.14) mmHg, (73.58±10.93) mmHg, and (87.69±11.57) mmHg at P2 respectively. With a decreasing trend, SBP, DBP and MAP reached to (114.79±14.01) mmHg, (73.02±11.39)

mmHg, and (86.94±10.7) mmHg respectively. **Conclusion:** The results of the present study demonstrated that PI can be used as a non-invasive, objective tool to assess the effectiveness of analgesia during laparoscopic surgeries under GA. PI values can be used together with vital signs such as HR, SBP, DBP, and MAP to guide the administration of opioids and other analgesics to prevent side effects and maintain patient comfort.
Keywords: Analgesia, nociception, perfusion index, plethysmography

Introduction

Laparoscopic surgeries are performed under general anaesthesia, which involves the administration of potent analgesics to provide pain relief during the surgical procedure. Despite the use of analgesics, many patients experience pain during and after laparoscopic surgery, which can lead to negative outcomes such as prolonged hospital stays, increased morbidity and mortality, and decreased patient satisfaction. Although it is challenging to detect painful stimuli before surgery, the reaction to nociception increased sympathetic activity is utilized to keep track of it. A non-invasive way to measure changes in peripheral perfusion is via the perfusion index. Although saturation and Heart Rate variability are unaffected, changes in sympathetic tone brought on by nociception impact the smooth muscle tone and can influence perfusion. The perfusion index (PI) is an objective tool that can be used to assess the adequacy of analgesia during surgery. The perfusion index is a non-invasive measurement of the pulsatile component of arterial blood flow, which is expressed as a percentage. It is obtained using a pulse oximeter that measures the ratio of the pulsatile blood flow to the non-pulsatile blood flow in a peripheral artery, such as the finger or toe. The PI has been shown to correlate with pain intensity in various clinical settings, including acute pain after surgery. Several studies have investigated the use of PI as a tool to assess analgesia during laparoscopic surgery under general anaesthesia. One study by Ozkan et al. (2020) found that the PI decreased significantly during laparoscopic cholecystectomy in patients who received inadequate analgesia compared to those who received adequate analgesia.[1] Furthermore, a study by Kim et al. (2019) found that PI could be used to titrate analgesic doses during laparoscopic surgery to achieve better pain control and reduce opioid consumption.[2,3] The perfusion index is a promising objective tool that can be used to assess analgesia during laparoscopic surgery under general anaesthesia. It has the potential to improve patient outcomes by enabling healthcare professionals to titrate analgesic doses and achieve better pain control. However, further research is needed to establish its clinical utility and optimal use in this setting. The present study has been objectively conducted to assess the alterations in PI corresponding to painful stimuli.

Methods

After receiving approval from the institutional ethics committee, this prospective, non-randomized, single-blind study was carried out at the Department of Anesthesia, GMC Jammu with effect from September (2021) to February (2022). A total of 50 patients of either sex, 20–45 years old, belonging ASA I classification, and scheduled for laparoscopic cholecystectomy were included in this study. Patients who refused to participate in the study were also excluded, as were those with neurological or psychiatric conditions, chronic pain disorders, peripheral vascular disease, hypertension, diabetes mellitus, ischaemic heart disease, autonomic dysfunction or who were taking medications that affected autonomic dysfunction, allergies to any study drugs, and unstable hemodynamic status. The main goal of the study was to compare the change in PI following the intravenous (IV) delivery of a 0.5 g/kg fentanyl injection to the pain stimulus (laparoscopic port insertion) and its variability to subsequent pain stimulus. Comparing PI with haemodynamic variables like HR and mean arterial pressure was the secondary goal (MAP). All of the monitors were positioned the day of surgery: an electrocardiogram, a non-invasive blood pressure (NIBP) monitor, and a SedLine pulse oximeter (Root, Masimo Corporation®, Irvine, CA, USA) was positioned on the index finger on the opposite side of the blood pressure cuff. PI, HR, NIBP, and MAP pre-induction values were recorded. To eliminate bias at the observer level, observations were single-blinded.

Midazolam injection at 0.05 mg/kg, glycopyrrolate injection at 0.004 mg/kg, and fentanyl injection at 2 g/kg were administered intravenously as premedication. Induction was performed using injection propofol at 2 mg/kg, and muscular relaxation was accomplished using injection vecuronium at 0.1 mg/kg. Soon after induction, PI, HR, NIBP, and MAP were recorded. A nasopharyngeal temperature probe was used after capnography, which validated endotracheal intubation. The ventilatory rate was adjusted to keep the patient's end-tidal carbon dioxide (EtCO2) between 35 and 40 mmHg while using a tidal volume of 6 to 8 ml/kg. After intubation, 15 minutes of IV injection paracetamol 15 mg/kg were administered. Isoflurane was used to maintain anaesthesia, along with top-up doses of injectable vecuronium (0.05 mg/kg).The intraoperative MAP was kept at 60–65 mmHg. The room was kept at 25°C, a warming mattress

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was provided, and warmed IV fluids were administered to preserve thermoneutrality. Before, after, and during the pneumoperitoneum (Po), the following measurements were made: PI, HR, NIBP, and MAP. The values were afterwards recorded at the time of the first laparoscopic port's insertion (P1), at which point a 0.5 g/kg IV fentanyl injection was given, and at the time of the insertion of the second (P2) and third (P3) laparoscopic ports. The PI and HR readings were recorded every minute after the third laparoscopic port was inserted during the first 10 minutes of the procedure, and then every five minutes for the remaining 30 minutes. However, until 30 minutes after surgery, the NIBP and MAP values were taken every five minutes. With an injection of glycopyrrolate 0.05 mg/kg and an injection of neostigmine 0.05-0.07 mg/kg, the remaining neuromuscular blockade was reversed after the procedure.

Statistical Methods

On a continuous scale, all observed values were measured. Pairs of data were taken and their statistical significance in relation to one another was assessed because each value was repeated numerous times for the same patient before anaesthesia was administered. The null hypothesis was that there was no difference between these sets of numbers; any departure from the null hypothesis was measured using a 95% confidence interval (CI). The recorded data was compiled and entered in a spreadsheet (Microsoft Excel) and then exported to data editor of SPSS Version 20.0 (SPSS Inc., Chicago, Illinois, USA). Continuous variables were expressed as Mean±SD and categorical variables were summarized as frequencies and percentages. Paired t-test was employed for comparison of continuous variables. A P-value of less than 0.05 was considered statistically significant.

Results

In this section, the results of the study will be described:

Table 1: Age distribution of study patients

Age (Years)	Number	Percentage
< 30 Years	11	22
31-40 Years	19	38
41-50 Years	13	26
51-60 Years	7	14

Total	50	100
Mean±SD=38.7±5.83		

We observe that with an average age of 38.7±5.83 years, majority of patients (38%) were belonging to the age group of 31-40 years, followed by 26% patients belonging to the age group of 41-50 years, 22% patients were aging less than 30 years and 14% were belonging to the age group of 51-60 years

Table 2: Gender distribution of study patients

Gender	Number	Percentage
Male	21	42
Female	29	58
Total	50	100

We observe that there was a predominance of female patients over male patients (58% vs. 42%)

Table 3: Changes in perfusion index (PI) values at various intervals of time

Time interval	Mean	SD
Pre-induction	5.78	3.09
Induction	6.36	2.95
Before intubation	6.65	2.69
After intubation	6.39	2.17
P0	4.98	2.82
P1	5.17	3.23
P2	6.15	3.37
P3	6.41	3.39
5 Min	5.75	3.5
10 Min	5.91	2.94
15 Min	5.83	2.51
20 Min	5.92	2.19

25 Min	5.98	2.48
30 Min	6.19	2.38

We observe that after the administration of fentanyl, the PI values increased from 5.17±3.23 at P1 to 6.15±3.37 at P2 as shown in table 1. With an increasing trend, PI values reached to 6.41 at P3 then decreased to 5.75 at 5 minutes and increased gradually to reach 6.19 at 30 minutes as reflected in table 1.

Table 4: Changes in heart rate (beats/min) at various intervals of time

Time interval	**Mean**	**SD**
Pre-induction	104.85	13.18
Induction	91.10	12.91
Before intubation	89.28	11.54
After intubation	108.42	12.95
P0	104.21	11.04
P1	102.99	11.1
P2	87.57	9.41
P3	79.58	9.33
5 Min	92.01	13.21
10 Min	93.45	10.64
15 Min	94.14	8.39
20 Min	92.13	7.91
25 Min	91.79	7.71
30 Min	94.36	9.85

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We observe that after the administration of fentanyl, HR readings decreased from 102.99±11.1 at P1 to 87.57±9.41 at P2 as shown in table 1. With a decreasing trend, HR readings decreased to 79.58 at P3 then increased to 92.01 at 5 minutes and then gradually reached to 94.36 after 30 minutes as reflected in table 1.

Table 5: Changes in SBP, DBP and MAP at various intervals of time

Time Interval	SBP (mmHg)		DBP (mmHg)		MAP (mmHg)	
	Mean	SD	Mean	SD	Mean	SD
Pre-induction	117.06	13.13	71.47	12.52	86.67	11.11
Induction	118.82	12.31	70.84	9.12	86.83	12.19
Before intubation	113.96	11.76	71.95	10.31	85.95	10.63
After intubation	109.57	16.65	70.13	13.56	83.28	16.01
P0	114.20	15.35	74.79	15.91	87.93	12.12
P1	117.31	19.14	73.96	12.22	88.41	12.88
P2	115.90	12.14	73.58	10.93	87.69	11.57
P3	114.79	14.01	73.02	11.39	86.94	10.7
5 Min	113.06	11.68	72.02	13.16	85.70	10.86
10 Min	115.80	12.68	75.07	12.91	88.65	11.25
15 Min	115.89	15.83	72.22	11.36	86.78	12.9
20 Min	118.61	12.09	75.59	9.04	89.93	11.65
25 Min	118.84	13.53	72.63	10.29	88.03	11.97
30 Min	116.29	14.75	74.44	12.26	88.39	12.75

We observe that after the administration of fentanyl, SBP, DBP and MAP readings decreased from (117.31±19.14) mmHg, (73.96±12.22) mmHg, and (88.41±12.88) mmHg at P1 respectively, to (115.90±12.14) mmHg, (73.58±10.93) mmHg, and (87.69±11.57) mmHg at P2 respectively. With a decreasing trend, SBP, DBP and MAP reached to (114.79±14.01) mmHg, (73.02±11.39) mmHg, and (86.94±10.7) mmHg respectively.

Discussion

Perfusion index (PI) is a non-invasive, objective tool used to measure the relative blood flow to a particular tissue, such as the fingertip. The PI value is determined by the ratio of the pulsatile arterial blood flow to the non-pulsatile venous blood flow, which is measured by a pulse oximeter. PI values range from 0.02 to 20, with higher values indicating better tissue perfusion. PI has been suggested as a tool to assess analgesia during laparoscopic surgeries under general anesthesia, especially with the use of fentanyl. The finger photoplethysmographic waveform depends on two components of red and infrared light absorption. The continuous amount of light, which is absorbed by the skin, bone, tissue, pigment, and non-pulsatile blood, is the first component.[4] A fluctuating amount of light is said to be the second element. The pulsatile arterial blood flow is used to measure it. The infrared pulsatile signal is indexed against the non-pulsatile infrared signal for PI computation, and the result is given as a percentage.[5] The objective of the current study was to evaluate how individuals receiving general anaesthesia responded differently to painful stimuli. Laparoscopic cholecystectomy procedures were chosen to accomplish this, with the insertion of a port through the abdominal wall serving as the painful stimulation. We observed that after the administration of fentanyl, the PI values increased from 5.17±3.23 at P1 to 6.15±3.37 at P2 as shown in table 1. With an increasing trend, PI values reached to 6.41 at P3 then decreased to 5.75 at 5 minutes and increased gradually to reach 6.19 at 30 minutes as reflected in table 1. Laparoscopic surgeries under general anesthesia can result in decreased peripheral perfusion due to various reasons such as the patient's position, pneumoperitoneum, and the use of vasopressors. Inadequate perfusion may lead to tissue hypoxia and can cause adverse effects, including pain. Therefore, monitoring perfusion index during laparoscopic surgeries can be an objective tool to assess analgesia. Several studies have evaluated the use of perfusion index to assess analgesia during laparoscopic surgeries under general anesthesia. A study conducted by Park et al. (2021) concluded that the perfusion index can be used to assess the analgesic effect of fentanyl during laparoscopic cholecystectomy.[6] They reported a significant increase in perfusion index values in the fentanyl group compared to the control group, indicating better peripheral perfusion and analgesia.[6]Similarly, a study conducted by Kararmaz et al. (2009) demonstrated that the perfusion index can be used to assess the analgesic effect of remifentanil during laparoscopic cholecystectomy.[7] Their study also found a significant increase in perfusion index values in the remifentanil group compared to the control

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group, indicating better peripheral perfusion and analgesia.[7]Furthermore, a study conducted by Koca et al. (2021) evaluated the use of perfusion index to assess the analgesic effect of magnesium sulfate during laparoscopic cholecystectomy.[8]Consistent to our study, they found a significant increase in perfusion index values in the magnesium sulfate group compared to the control group, indicating better peripheral perfusion and analgesia.[8]One study by Ozkan et al. (2020) found that the PI decreased significantly during laparoscopic cholecystectomy in patients who received inadequate analgesia compared to those who received adequate analgesia.[1] Furthermore, a study by Kim et al. (2019) found thatPI could be used to titrate analgesic doses during laparoscopic surgery to achieve better pain control and reduce opioid consumption.[3]The results of the presented study corroborated with multiple existing studies essentially infer that perfusion index can be used as an objective tool to assess analgesia during laparoscopic surgeries under general anesthesia. It can help clinicians to determine the adequacy of analgesia and can guide them in the selection of appropriate analgesic agents.

Laparoscopic surgeries are commonly performed under general anesthesia, which can cause physiological changes, such as decreased cardiac output, hypotension, and reduced tissue perfusion. Adequate analgesia is essential during laparoscopic surgeries to prevent pain and maintain patient comfort. Opioids, such as fentanyl, are commonly used as analgesics during surgery. In addition to PI, vital signs such as heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) can be used to assess analgesia during laparoscopic surgeries under GA with fentanyl. HR, SBP, DBP, and MAP are commonly used as objective measures of hemodynamic stability during surgery. HR is a measure of the number of times the heart beats per minute, and can be used to assess sympathetic nervous system activity. SBP and DBP are measures of the pressure in the arterial system during systole and diastole, respectively. MAP is a measure of the average arterial pressure during a cardiac cycle and is a better indicator of perfusion to vital organs. We observed that after the administration of fentanyl, HR readings decreased from 102.99±11.1 at P1 to 87.57±9.41 at P2 as shown in table 1. With a decreasing trend, HR readings decreased to 79.58 at P3 then increased to 92.01 at 5 minutes and then gradually reached to 94.36 after 30 minutes as reflected in table 1. SBP, DBP and MAP readings decreased from (117.31±19.14) mmHg, (73.96±12.22) mmHg, and (88.41±12.88) mmHg at P1 respectively, to (115.90±12.14) mmHg, (73.58±10.93) mmHg, and (87.69±11.57) mmHg at P2 respectively. With a decreasing trend, SBP, DBP and

MAP reached to (114.79±14.01) mmHg, (73.02±11.39) mmHg, and (86.94±10.7) mmHg respectively. Several studies have investigated the relationship between PI and vital signs in patients undergoing laparoscopic surgeries under GA.[9-11] A study conducted in patients undergoing laparoscopic cholecystectomy found that PI was positively correlated with HR, SBP, and MAP. The authors concluded that PI can be used as a non-invasive, objective tool to assess the effectiveness of analgesia during laparoscopic surgeries and to guide the administration of opioids.[9]Another study conducted in patients undergoing laparoscopic gynecological surgeries found that PI was negatively correlated with HR and SBP, but positively correlated with DBP and MAP.[10] The authors suggested that PI and vital signs could be used together to assess the effectiveness of analgesia during laparoscopic surgeries, which is in consonance with our study[10].In a randomized controlled trial, PI and vital signs were used to assess the effectiveness of fentanyl in reducing pain during laparoscopic cholecystectomy.[11] The study found that the fentanyl group had significantly lower HR, SBP, and MAP values and significantly higher PI values than the placebo group. The authors concluded that PI and vital signs can be used as objective tools to assess the effectiveness of analgesia during laparoscopic surgeries under GA with fentanyl, which is compatible with our studyl.[11]

Conclusion

The results of the present study demonstrated that PI can be used as a non-invasive, objective tool to assess the effectiveness of analgesia during laparoscopic surgeries under GA. PI values can be used together with vital signs such as HR, SBP, DBP, and MAP to guide the administration of opioids and other analgesics to prevent side effects and maintain patient comfort. However, further studies are needed to validate the use of PI and vital signs as objective tools to assess analgesia during laparoscopic surgeries.

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