How to Cite:
Dey, J., Rajasab, F. D., Ramchandran, H., Kulkarni, P., & Cherian, S. S. (2022). Variability of perfusion index as a new parameter in different types of Anaesthesia techniques: An observational study. *International Journal of Health Sciences*, *6*(S6), 10550–10561. https://doi.org/10.53730/ijhs.v6nS6.12821

Variability of perfusion index as a new parameter in different types of Anaesthesia techniques: An observational study

Dr. Jaimini Dey
Senior Resident, Dept of Anaesthesiology, MVJMC&RH, Bengaluru, India
Email:jaiminidey@gmail.com

Dr. Farha Deeba Rajasab,
Assistant Professor, Dept of Anaesthesiology, MVJMC&RH, Bengaluru, India,
Email: farharaj86@gmail.com

Dr. Haripriya Ramchandran,
Assistant Professor, Dept of Anaesthesiology, MVJMC&RH, Bengaluru, India
Email: haripri20@gmail.com

Dr. Prasad Kulkarni,
Professor and HOD, Dept of Anaesthesiology, MVJMC&RH, Bengaluru, India
Email: prasadkulk@yahoo.com

Dr. Sherley S. Cherian,
Associate professor, Dept of Anaesthesiology, MVJMC&RH, Bengaluru, India,
*Corresponding author email: dr.sherley@gmail.com

Abstract---Aims and objectives: To monitor perfusion index in each patient in immediate pre-operative period; To assess co-relation of perfusion index with other hemodynamic parameters observed simultaneously; and To observe variation in perfusion index with different anesthesia techniques- general anesthesia, neuraxial blockade and peripheral nerve blocks. Methodology: 50 cases each under ASA class I, II or III posted for elective surgeries under brachial plexus nerve blocks, neuraxial and general anesthesia were included. The perfusion index, heart rate, systolic and diastolic blood pressure was monitored in the immediate pre-operative period and after induction of anesthesia at 5, 10 and 15 mins. Results: In our study, it was noted perfusion index increased significantly from the baseline ($p<0.001$) in all the three anesthesia techniques. Systolic, diastolic pressure and heart rate showed significant decrease at 5, 10 and 15mins post anesthesia but in patients under general anesthesia category, decrease in heart rate was significant at 15 mins ($p<0.001$).

Conclusion: In this study, it was concluded that perfusion index could be a simpler tool to assess the onset of anesthesia and help predicting the change in hemodynamic parameters that occurs with it.

Keywords---hemodynamic parameters, perfusion index, pulse oximeter.

Introduction

Perfusion index is a newer, dynamic, numerical, simple, cost-effective, non-invasive and continuous measure of peripheral perfusion obtained from pulse oximeter estimating the pulsatility of blood in the extremities, calculated using infrared spectrum as part of plethysmography waveform processing [1]. The PI is the ratio of the pulsatile to the non-pulsatile blood flow in person's peripheral tissue such as finger-tips, ear-lobes and can be used to identify the sympathetic vascular tone and changes in blood volume. In states of vasodilation, an increase in pulsatile flow can lead to an increase in PI [2]. It helps in predicting hemodynamic responses to anesthetic techniques, drugs and intra-operative stimuli. A rise in PI from the baseline indicates the onset of successful anesthesia [3].

Neuraxial anesthesia leads to motor, sensory and sympathetic blockade. The sympathetic fibres are myelinated and small, hence, sympatholysis typically occurs before the sensory & motor blockade [4]. Lumbar sympathectomy causes interruption of the sympathetic system (α1-receptors blockade) of the lower limb, leading to vasodilation and improves the flow of microcirculation. The confirmation of the success of the sympathetic block is usually done by resolution of symptoms, such as reduced nociception and decreased sweating, and clinically by assessing the rise of local temperature [5]. The use of PI in the prediction of peripheral block success has been reported for infraclavicular brachial plexus block, axillary brachial plexus block, interscalene brachial plexus block, and sciatic nerve block as they provide good analgesia and anesthesia. It has been useful to the anesthesiologists to avoid the airway during the coronavirus pandemic for all surgeries feasible under regional blocks [6]. PI predicted the need for vasopressor therapy in severe sepsis and as a tool for pain assessment in critically ill patients [7,8].

Peripheral perfusion index (PPI) could be a useful for monitoring patients during spontaneous breathing trial (SBT) as patients with successful weaning showed higher augmentation of the PPI during the SBT compared to patients with failed weaning [9]. The use of PI for prediction of success of reimplanted body parts, restoration of peripheral perfusion after cardiopulmonary bypass, and estimation of volume status in trauma patients are being considered [7]. Tests like skin conductance response, various sweat tests, skin plethysmography, increase in blood flow by xenon (Xe133) clearance, laser doppler flowmetry, distal perfusion pressure, capillary oxygen tension, venous oxygen tension, saturation, and muscle metabolism, etc. have been reported for the assessment of sympathetic blockade but are cumbersome and not universally available. Most plethysmography devices these days in modern operating rooms are equipped to

show the PI [5]. Most anesthetic agents act by causing peripheral vasodilation. Clinical studies in patients have demonstrated that an increase in perfusion index is an early indicator that anesthesia has initiated peripheral vasodilation that typically occurs with the onset of anesthetic effects. The present study hypothesizes that perfusion index will be a parameter to monitor hemodynamic changes in different techniques of anesthesia and correlates with onset of anesthesia [3].

Aims and Objectives

- To monitor perfusion index in each patient in immediate pre-operative period.
- To assess co-relation of perfusion index with other hemodynamic parameters observed simultaneously.
- To observe variation in perfusion index with different anesthesia techniques- neuroaxial blockade, general anesthesia and peripheral nerve blocks.

Methodology

Sample size

50 cases each under ASA class I, II or III posted for elective surgeries under brachial plexus nerve blocks, neuraxial and general anesthesia were included. The perfusion index, heart rate, systolic and diastolic blood pressure was monitored in the immediate pre-operative period and after induction of anesthesia at 5, 10 and 15 mins.

Source of data

Patients admitted for elective surgery at MVJ Medical College and Research Hospital, from November 2019 to October 2021.

Statistical Analysis

The data was analyzed using Student's t test and represented in the form of tables and graphs.

Results

Table 1
Age Distribution

Age (in years)	Number of patients studied
18-35	17
36-45	49
46-55	53
>55	31
Total	150

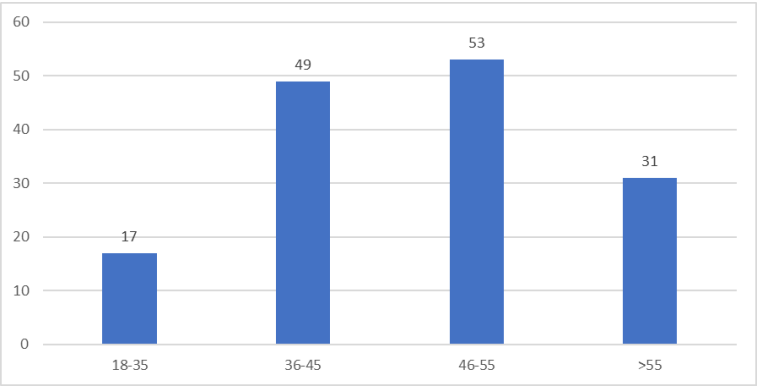

Figure 1. Age distribution

Age Distribution (in years)

Table 2
Gender Distribution

Gender	Number of patients studied	%
Male	88	59
Female	62	41
Total	150	100

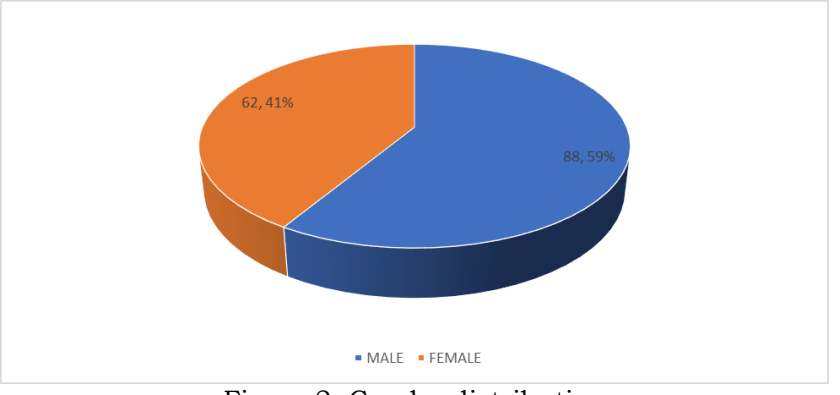

Figure 2. Gender distribution

Gender distribution

Table 3
ASA grade of patients studied

ASA grade	Number of patients studied
I	36
II	89
III	25
Total	150

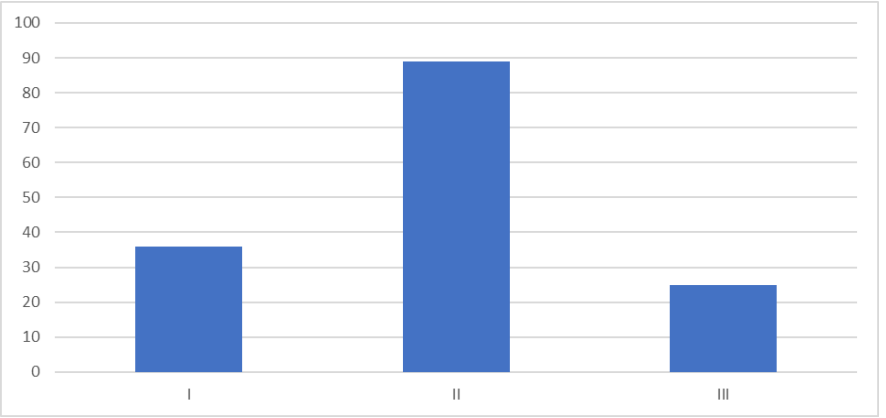

Figure 3. ASA grade of patients studied

ASA grading of patients studied

Table 4
Changes in Heart Rate pre anesthesia and post anesthesia at 5 mins, 10 mins and 15 mins in patients under General Anesthesia

	Pre-anesthesia		Post anesthesia at 5 mins		p-value
Heart rate (beats/min)	Mean	SD	Mean	SD	
	82.48	7.82	81.66	6.35	0.488
			Post anesthesia at 10 mins		
			79.32	4.81	0.004
			Post anesthesia at 15 mins		
			77.50	5.23	<0.001

Under general anesthesia, the heart rate decreased post induction and significant at 15 mins where ($p<0.001$).

Table 5
Changes in Systolic Blood Pressure pre anesthesia and post anesthesia at 5 mins, 10 mins and 15 mins in patients under General Anesthesia

	Pre-anesthesia		Post anesthesia at 5 mins		p-value
Systolic Blood Pressure (mm Hg)	Mean	SD	Mean	SD	
	130.78	11.48	121.32	14.87	<0.001
			Post anesthesia at 10 mins		
			119.56	11.47	<0.001
			Post anesthesia at 15 mins		
			119.08	10.88	<0.001

Under general anesthesia, the systolic blood pressure decreased significantly post induction at 5, 10 and 15 mins ($p<0.001$).

Table 6
Changes in Diastolic Blood Pressure pre anesthesia and post anesthesia at 5 mins, 10 mins and 15 mins, in patients under General Anesthesia

	Pre-anesthesia		Post anesthesia at 5 mins		p-value
Diastolic Blood Pressure (mm Hg)	Mean	SD	Mean	SD	
	79.92	9.30	74.94	8.99	<0.001
			Post anesthesia at 10 mins		
			74.16	6.68	<0.001
			Post anesthesia at 15 mins		
			73.64	6.87	<0.001

Under general anesthesia, the diastolic blood pressure decreased significantly post induction at 5, 10 and 15 mins ($p<0.001$).

Table 7
Changes in Perfusion Index pre anesthesia and post anesthesia at 5 mins, 10 mins and 15 mins, in patients under General Anesthesia

	Pre-anesthesia		Post anesthesia at 5 mins		p-value
Perfusion index	Mean	SD	Mean	SD	
	7.00	2.05	9.97	2.41	<0.001
			Post anesthesia at 10 mins		
			10.70	2.24	<0.001
			Post anesthesia at 15 mins		
			11.13	2.20	<0.001

Under general anesthesia, there was significant increase in perfusion index post induction at 5, 10 and 15 mins ($p<0.001$).

Table 8
Changes in Heart Rate pre anesthesia and post anesthesia at 5 mins, 10 mins, 15 mins, in patients under Neuraxial Anesthesia

	Pre-anesthesia		Post anesthesia at 5 mins		p-value
Heart rate (beats/min)	Mean	SD	Mean	SD	
	82.40	7.89	75.70	7.71	<0.001
			Post anesthesia at 10 mins		
			74.80	6.77	<0.001
			Post anesthesia at 15 mins		
			73.02	7.21	<0.001

The heart rate decreased significantly at 5, 10 and 15 mins after neuraxial blockade ($p<0.001$).

Table 9
Changes in Systolic Blood Pressure pre anesthesia and post anesthesia at 5 mins, 10 mins and 15 mins, in patients under Neuraxial Anesthesia

	Pre-anesthesia		Post anesthesia at 5 mins		p-value
Systolic Blood Pressure (mm	Mean	SD	Mean	SD	
	132.10	10.70	123.44	11.32	<0.001

Hg)			Post anesthesia at 10 mins		
			120.28	8.23	<0.001
			Post anesthesia at 15 mins		
			119.80	8.97	<0.001

The systolic blood pressure decreased significantly at 5, 10 and 15 mins after neuraxial blockade (p<0.001).

Table 10
Changes in Diastolic Blood Pressure pre anesthesia and post anesthesia at 5 mins, 10 mins and 15 mins, in patients under Neuraxial Anesthesia

	Pre-anesthesia		Post anesthesia at 5 mins		p-value
Diastolic Blood Pressure (mm Hg)	Mean	SD	Mean	SD	
	80.18	7.01	74.54	6.75	<0.001
			Post anesthesia at 10 mins		
			73.12	5.58	<0.001
			Post anesthesia at 15 mins		
			71.58	5.94	<0.001

The diastolic blood pressure decreased significantly at 5, 10 and 15 mins after neuraxial blockade (p<0.001).

Table 11
Changes in Perfusion Index pre anesthesia and post anesthesia at 5 mins, 10 mins and 15 mins, in patients under Neuraxial Anesthesia

	Pre-anesthesia		Post anesthesia at 5 mins		p-value
Perfusion index	Mean	SD	Mean	SD	
	5.70	1.70	8.23	1.80	<0.001
			Post anesthesia at 10 mins		
			9.07	1.77	<0.001
			Post anesthesia at 15 mins		
			9.53	1.79	<0.001

There was significant increase in perfusion index at 5, 10 and 15 mins after neuraxial blockade (p<0.001).

Table 12
Changes in Heart Rate pre anesthesia and post anesthesia at 5 mins, 10 mins, 15 mins, in patients under Brachial plexus block

	Pre-anesthesia		Post anesthesia at 5 mins		p-value
Heart rate (beats/min)	Mean	SD	Mean	SD	
	78.92	8.62	74.96	8.62	<0.001
			Post anesthesia at 10 mins		
			73.26	6.64	<0.001
			Post anesthesia at 15 mins		
			73.84	7.66	<0.001

The heart rate decreased significantly at 5, 10 and 15 mins after brachial plexus block (p<0.001).

Table 13
Changes in Systolic Blood Pressure pre anesthesia and post anesthesia at 5 mins, 10 mins and 15 mins, in patients under Brachial plexus block

	Pre-anesthesia		Post anesthesia at 5 mins		p-value
Systolic Blood Pressure (mm Hg)	Mean	SD	Mean	SD	
	133.40	8.66	130.22	7.59	<0.001
			Post anesthesia at 10 mins		
			124.12	7.53	<0.001
			Post anesthesia at 15 mins		
			123.56	6.41	<0.001

The systolic blood pressure decreased significantly at 5, 10 and 15 mins after brachial plexus block (p<0.001).

Table 14
Changes in Diastolic Blood Pressure pre anesthesia and post anesthesia at 5 mins, 10 mins and 15 mins, in patients under Brachial plexus block

	Pre-anesthesia		Post anesthesia at 5 mins		p-value
Diastolic Blood Pressure (mm Hg)	Mean	SD	Mean	SD	
	80.68	8.29	78.12	7.15	<0.001
			Post anesthesia at 10 mins		
			75.22	6.14	<0.001
			Post anesthesia at 15 mins		
			73.48	5.29	<0.001

The diastolic blood pressure decreased significantly at 5, 10 and 15 mins after brachial plexus block (p<0.001).

Table 15
Changes in Perfusion Index pre anesthesia and post anesthesia at 5 mins, 10 mins and 15 mins, in patients under Brachial plexus block

	Pre-anesthesia		Post anesthesia at 5 mins		p-value
Perfusion index	Mean	SD	Mean	SD	
	5.27	2.12	8.06	2.48	<0.001
			Post anesthesia at 10 mins		
			9.08	2.59	<0.001
			Post anesthesia at 15 mins		
			9.34	2.62	<0.001

There was significant increase in perfusion index at 5, 10 and 15 mins after brachial plexus block (p<0.001).

Discussion

Perfusion index is a newer, non-invasive parameter which can be used as a measure of peripheral perfusion using a pulse oximeter. It is a valuable method during anesthetic practice to predict hemodynamic response to anesthetic drugs techniques. PI is sensitive to several things such as temperature of the finger, exogenous vasoactive drugs, sympathetic nervous system tone and stroke volume.

Most anesthetic agents act by causing peripheral vasodilation. Clinical studies in adults and pediatric patients have demonstrated that an increase in perfusion index is an early indicator that anesthesia has initiated peripheral vasodilation that typically indicates onset of anesthesia at the physiological level. This prospective observational study includes patients of both genders, aged above 18 years belonging to ASA class I, II, or III admitted for elective surgery under neuro-axial, general anesthesia and peripheral nerve blocks at MVJ Medical College and Research Hospital, from November 2019 to October 2021. 150 cases posted for elective surgery under neuro-axial blocks, general anesthesia and peripheral nerve blocks (50 cases each).

In our study, for patients under general anesthesia, baseline mean heart rate (82.48), mean SBP (130.78), mean DBP (79.92), mean PI (7.00); after induction there was decrease in heart rate at 5mins (81.66), 10mins (79.32) and 15mins (77.50), significant decline in SBP (mmHg) after giving anesthetic drugs at 5mins (121.32), 10mins (119.56), 15mins (119.08) and decline in DBP (mmHg) at 5mins (74.94), 10mins (74.16), at 15mins (73.64). It was noted PI increased at 5mins (9.97), 10 mins (10.70), 15 mins (11.13) post induction. For patients under neuraxial anesthesia, at baseline- mean heart rate (82.40), mean SBP (132.10), mean DBP (80.18), mean PI (5.70) after sub-arachnoid or epidural anesthesia, there was decrease in heart rate at 5mins (75.70), 10mins (74.80) and 15mins (73.02), significant decline in SBP (mmHg) after giving local anesthetic drugs, at 5mins (123.44), 10mins (120.28), 15mins (119.80) and decline in DBP (mmHg) at 5mins (74.54), 10mins (73.12), at 15mins (71.58). It was noted PI increased at 5mins (8.23), 10 mins (9.07), 15 mins (9.53).

In the patients who underwent upper limb surgeries under brachial plexus block, the baseline mean heart rate was (78.92), mean SBP (133.40), mean DBP (80.68), mean PI (5.27); after nerve block there was significant decrease in heart rate at 5mins (74.96), 10mins (73.26) and 15mins (73.84), significant decline in SBP (mmHg) at 5mins (130.22), 10mins (124.12), 15mins (123.56) and decline in DBP (mmHg) at 5mins (78.12), 10mins (75.22), at 15mins (73.48) and significant increase in PI at 5mins (8.06), 10 mins (9.08), 15 mins (9.34). In a study by Kumar A, Nadkarni A.V[1], it was reported that mean heart rate increased from baseline(63.28) to (99.25) in patients under general anesthesia with ETT at the end of 5mins, indicating a stress response of endotracheal intubation due to sympathetic stimulation, but the change in perfusion index from 1.27 to 1.75 corroborates with our study and for patients with neuraxial anesthesia mean heart rate decreases from 82.3 to 69.1 and mean PI increases from 1.91 to 2.5 from baseline to end of 5 mins and the findings are similar to our study.

In another study by Mizuno J, Morita Y, Kakinuma A, Sawamura S[10], after induction of general anesthesia, there was significant decreases in SBP, DBP and no significant change in HR; before anesthesia SBP in mmHg (142 ± 29), DBP in mmHg (82 ± 10), HR in beats/min (75 ± 11) and after induction SBP (104 ± 26), DBP (61 ± 16) and HR (71 ± 13). A significant increase in PI from 2.1 ± 1.7 % to 3.8 ± 2.3 % which is similar to our study, wherein SBP, DBP and HR decreased and PI increased. In a study by Choudhary VK et al[11] on 80 patients undergoing elective surgeries under general anesthesia divided into 2 groups: Group A (n=40)-tracheal intubation with Macintosh laryngoscope, Group B (n=40)-tracheal

intubation with McCoy laryngoscope, it was observed that the increase in heart rate for Group A was +24.7% and for Group B it was +14.8% from the baseline immediately after laryngoscopy and intubation. Thereafter, there was a decreasing trend in heart rate till 10 mins in both the groups. SBP started increasing in both the groups immediately post laryngoscopy and intubation, the maximum increase in systolic blood pressure for Group A was +12.3% and for Group B it was +4.4% from the baseline after laryngoscopy and intubation. Diastolic blood pressure showed a significant rise immediately post laryngoscopy and intubation in both the groups. Thereafter, it started decreasing steadily in both the groups. On comparing the two groups it was observed that the maximum increase in diastolic blood pressure for Group A was +15.5% and for Group B it was +4.9% from the baseline after laryngoscopy and intubation. Perfusion index was statistically significant immediately post laryngoscopy and intubation till 4 mins in between the groups. It became statistically significant again at 7th min post laryngoscopy and intubation in between the groups. Perfusion index started decreasing from baseline immediately post laryngoscopy and intubation, and thereafter started increasing steadily in each time interval.

In a study by Choudhary M, Kumar P, Batra V, Dubey M, Bhargava A K[3] conducted a prospective observational study on 100 patients undergoing spinal anesthesia, mean heart rate at baseline was 87.44±16.52 showing initial significant increase at 1 minute, 2 minutes and 3 minutes (P<0.001), decreased to 87.72±17.77 (p>0.05), 86.84±52.20 (p>0.05), 77.17±15.04 (P- 0.001) at 5, 10 and 15 minutes. The baseline SBP (mmHg) was 154.05±21.57 which decreased to 130.46±24.95; 125.18±21.14; 123.71±20.60 at 5, 10 and 15 minutes respectively; baseline DBP (mmHg) was 87.99±12.18 which decreased significantly to 76.51±14.27; 72.19±11.58; 72.23±11.03 at 5, 10 and 15 mins respectively. At baseline, perfusion index of upper limb was 1.19±1.02 which decreased to 1.01±0.78; 0.93±0.65; 0.85±0.57 at 5 minutes, 10 minutes, 15 mins respectively as opposed to our study where HR, SBP, DBP decreases from baseline after neuraxial block while PI increases.

Boztas N et al[2] performed a study on 128 patients scheduled for elective surgery under spinal anesthesia and observed that there was a statistically significant difference between pre- and post-anesthetic measurements of PI, MAP, t, and HR (p<0.001). The baseline PI measurements started to differ at 2nd min with significant linear increase in PI (p<0.001), significant linear decrease in MAP (p<0.001) and HR (p<0.001) which is similar to the results in our study. Veena, Karthik S L, Ankad V[12] conducted a study on 95 patients undergoing elective upper limb procedures under ultrasound-guided supraclavicular block. It showed that baseline PI is comparable (p >0.05) in both blocked and unblocked arm. PI increased in blocked arm compared with baseline value after 5 minutes of SCB. PI values among blocked and unblocked arm (p <0.001) at 10, 20 and 30mins interval were highly significant. In our study, PI in patients who underwent brachial plexus blocks showed an increasing trend at 5mins (8.06±2.48),10mins (9.08±2.59) and 15mins (9.34±2.62) after injecting local anesthetic agent (baseline PI 5.27±2.12). In a study conducted by Devadas V, Ekambaram K, Sundar R, Dinesh K G[13] on 30 patients aged 1-10 years with ASA physical status I and II, scheduled for routine and emergency infra umbilical surgeries and lower limb surgeries, in whom caudal block was indicated, were divided randomly into two

groups P and C. In group P, PI increased significantly from the baseline while MAP and heart rate decreased at 5, 10, 15 and 20 mins after caudal block. In grp C, MAP and heart rate decreased and PI markedly increased compared to the baseline suggesting that PI can be an earlier and more reliable indicator in detecting the success of caudal block compared to the other parameters. The results correlated to our study. The above results corroborated with our hypothesis that perfusion index can be a parameter to monitor hemodynamic changes in different techniques of anesthesia and correlates with onset of anesthesia.

Conclusion

We studied the variation in perfusion index and other hemodynamic parameters before and after onset of anesthesia in 150 patients with 50 under each category of neuraxial block, general anesthesia and brachial plexus block. The rise in perfusion index in each category of patients after injection of anesthetic agents validated with the vasodilation which occurs after sympatholysis under anesthesia whereas the systolic, diastolic blood pressure and heart rate showed a declining trend in our study especially in patients under general anesthesia category, decrease in heart rate was significant at 15mins post induction, which is similar to previous studies. It was demonstrated that perfusion index can be used as a tool to assess the efficacy of anesthesia, for predicting the hemodynamic responses to anesthetic drugs, techniques of anesthesia, to surgical pressor response correlating to the related to depth of anesthesia and during emergence from anesthesia.

There are few limitations of using perfusion index. Photo plethysmographic analysis is sensitive to patient movement, and PI is also easily decreased by few factors such as stress and anxiety that can induce sympathetic activation, which in turn induces peripheral vasoconstriction. Along with other tests like skin conductance response, bispectral analysis by laser doppler flowmetry, capillary oxygen tension, increase in blood flow by Xenon (Xe133) clearance, perfusion index can be an auxiliary tool to assess the onset and depth of anesthesia. Besides, use of perfusion index in the prediction of success of reimplanted body parts, restoration of peripheral perfusion after cardiopulmonary bypass and estimation of volume status in trauma patients can be considered.

References

1. Abdelnasser A, Abdelhamid B, Elsonbaty A, Hasanin A and Rady A: Predicting successful supraclavicular brachial plexus block using pulse oximeter perfusion index. British Journal of Anaesthesia 2017; 119(2): 276–80.
2. Arora P, Dey S and Neema P K: Utility of perfusion index for objective assessment of successful lumbar sympathetic block: a case report. American Society of Interventional Pain Physicians 2021; 5(3): 141-143.
3. Boztas N et al: Perfusion index as a predictor of successful spinal anesthesia: a time-dependent receiver operating characteristics curve analysis. Southern Clinics of Istanbul Eurasia 2021; 32(2): 125-130.

4. Choudhary M, Kumar P, Batra V, Dubey M, Bhargava A.K: To study the role of perfusion index in assessing efficacy of spinal anaesthesia. International Journal of Current Research 2017 Nov; 09(11): 60620-625.
5. Choudhary VK et al: Comparison of hemodynamic responses along with perfusion index to tracheal intubation with MacIntosh and McCoy laryngoscopes. International Journal of Research in Medical Sciences 2018 May; 6(5): 1673-81.
6. Devadas V, Ekambaram K, Sundar R, Dinesh K G: Effectiveness of perfusion index (pi)as an early predictor of successful caudal block in children under general anaesthesia- an observational study. Indian Journal of Applied Research 2019 July; 9(7): 80-82.
7. Elshal M M, Hasanin A M, Mostafa M, Gamal R M: Plethysmographic Peripheral Perfusion Index: Could It Be a New Vital Sign? Frontiers in Medicine 2021; 8: 651909.
8. Kumar A, Nadkarni A.V: The variability of perfusion index as a new parameter in different types of anaesthesia techniques and its correlation with surgical stress and recovery from anaesthesia: An observational clinical study. Journal of Medical Science and Clinical Research 2017 Jan; 05(01): 15196-265.
9. Lal J, Bhardwaj M, Malik A, Bansal T: A study to evaluate the change in perfusion index as an indicator of successful ultrasound-guided supraclavicular block. Indian Journal of Anaesthesia 2021; 65: 738-43.
10. Lotfy A et al: Peripheral perfusion index as a predictor of failed weaning from mechanical ventilation. Journal of Clinical Monitoring and Computing 2021; 35: 405–412.
11. Mizuno J, Morita Y, Kakinuma A, Sawamura S: General anaesthesia induction using general anaesthetic agents and opioid analgesics increases Perfusion Index (PI) and decreases Pleth Variability Index (PVI): Observational clinical study. Sri Lankan Journal of Anaesthesiology 2012; 20(1): 7-12.
12. Sinsinbar S S, Nainani M, Chittora S P: Perfusion index (pi) as an early predictor of neuraxial blockade during spinal anaesthesia in caesarean section. International Journal of Scientific Research 2018 Jan; 7(1): 20-22.
13. Veena, Karthik S. L., Ankad V: Pulse oximeter perfusion index as a predictor of successful supraclavicular brachial plexus block. International Journal of Recent Surgical and Medical Sciences 2021.