Research article

Use of peripheral perfusion index (PI) as a predictor of cardiovascular complications in hospitalized Covid 19 patients - A pilot study

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ABSTRACT

Introduction and Aim: Cardiovascular complications have been associated with fatality in Covid-19 patients. Reduced peripheral perfusion is a marker for cardiovascular dysfunction. Peripheral Perfusion Index (PI) is a non-invasive measure of microvascular perfusion with regards to pulsatile arterial blood flow. The study was aimed at finding the utility of PI as a hemodynamic marker in Covid-19.

Materials and Methods: Observational study done on 58 hospitalised adult Covid-19 patients over a span of 6 days. Each day the hemodynamic parameters such as pulse rate, SpO_2 and Peripheral Perfusion Index (PI) were measured using a finger pulse oximeter. Peripheral Blood pressure was measured using automated BP apparatus. Mean Arterial Pressure (MAP) and pulse pressure (PP) was calculated.

Results: Correlation between PI and other parameters checked using Pearson's test. There was significant positive correlation between PI and PP in day wise analysis during first 2 days with linear regression showing PP can be predicted as a dependant function from PI. This shows the association between PI and systemic cardiovascular function.

Conclusion: PI is a useful measure of peripheral microvascular perfusion and relates to systemic PP. It can be predicted from the results that PI can act as a reliable guide to predict the cardiovascular condition of the patient. As PI is measured from finger pulse oximeter, it is a non-invasive and easy-to-record method, which can be used by untrained personnel in Covid-19 patients.

Keywords: Covid-19; perfusion index; cardiovascular complications.

INTRODUCTION

COVID-19 pandemic caused by the Severe Acute Respiratory Syndrome Corona Virus 2 (SARS-CoV2) has claimed over 5 Million lives globally (1). In India, the total numbers of cases have reached about 30 million with over four lakh Covid-19 related deaths (2). These numbers show there is a high risk of fatal complications arising from Covid-19 infection.

The WHO estimates one in 20 Covid cases will need intensive care treatment, which can include being mechanically ventilated (1). Covid-19 infection is not limited to the lungs but involves other organs as well, including the renal and cardiovascular system. Several mechanisms related to organ dysfunction other than the lungs have been implied in clinical findings. Important of those is circulatory failure as a result of hyperinflammation, micro thrombosis, and heart failure (3, 4). However, data on cardiovascular complications in critically ill Covid-19 patients is still unclear (5).

The available data suggests that the cause of cardiac injury could be viral associated injury to the endothelial cells of cardiovascular system (6) or due to microvascular injury from complement activation (7). Such injury to the heart and vasculature could lead to ineffective arterial circulation and shock (8). The effective management of cardiovascular complication arising from Covid-19 requires hemodynamic monitoring of the patients, especially those in high risk category.

Monitoring of hemodynamic status of patients is routinely done in critical care settings and clinics by a variety of methods ranging from peripheral blood pressure measurements to echocardiogram and arterial catheter based measurement of BP (9, 10). While it is advisable to use non-invasive measures such as echocardiogram to monitor the cardiovascular health of patients with mild-moderate illness, the expertise and manpower required is high for regular measurements (11). Finally considering ease of use as well as being a reliable indicator for hemodynamic status, the usual practice is to measure peripheral BP and to calculate Mean Arterial Pressure (MAP) and Pulse Pressure (PP; 5). This technique requires only basic training in health care and can be used daily at regular intervals when there is an expected hemodynamic compromise as in case of Covid-19 patients.

While searching for other possible techniques to assess circulatory function, cutaneous circulation has been found to be efficient as well as accurate in predicting

the systemic hemodynamic changes (12). The cutaneous microcirculation has emerged as an accessible vasculature representative of the arterial pulse wave features. The changes in systemic microvascular flow and its intensity during the acute phase of Covid-19 may be related to disease progression and prognosis. The evaluation of microvascular perfusion in Covid-19 patients could offer information regarding impending cardiovascular complications (13).

Peripheral Perfusion Index (PI) represents the ratio between the pulsatile and non-pulsatile components of the cutaneous circulation. It is measured by Infrared plethysmographic techniques in a pulse oximeter. The arterial blood flow provides the pulsatile aspect of the cutaneous circulation and hence the index provides an idea of the changes in arterial circulation itself. PI decreases in shock due to decreased arterial component (14). Previous studies have shown evidence that Peripheral Perfusion Index could be a valuable tool in monitoring patients at risk of circulatory failure and can be used as a non-invasive tool to predict patient outcomes (15).

The portable pulse oximeter has become a cheap and effective tool to measure pulse and oxygen saturation from finger tip microcirculation and has been heavily relied upon during the Covid-19 pandemic for monitoring of the patient status in hospitals as well as in home care of patients (16). PI is just another measure available in the Pulse oximeters that can be recorded quickly and non-invasively even by untrained individuals.

This study hypothesises that a change in peripheral perfusion index values during the hospital stay of COVID 19 patients could be used as a tool in predicting cardiovascular complications. The objective of the present study was to assess the utility of peripheral Perfusion Index (PI) measured by finger pulse oximeter as a prognostic marker for cardiovascular complications in Covid-19.

METHODOLOGY

Study design

This is an observational study conducted on Covid-19 positive patients confirmed by RTPCR at Dhanalakshmi Srinivasan Medical College Hospital, Perambalur, Tamil Nadu during September 2021. 58 hospitalised Covid-19 positive patients of age group 18 - 80 were recruited for the study by simple random selection and the study was conducted in 6 days. All the patients were hemodynamically stable at the time of recruitment and did not require mechanical ventilation support. Pregnant women and children were excluded from the study.

Data collection

Ethical approval was obtained from the institute Ethical Committee at Dhanalakshmi Srinivasan Medical College (IECHS/IRCHS/No/109 on 27/7/2021) Data was collected after informed written consent was obtained from all the study participants. Proper Covid-19 protocols were followed while recruitment of patients and data collection. 58 Covid-19 RTPCR positive patients (43 males, 15 females) recruited over a period of 6 days. Each day the pulse rate, Oxygen saturation (with or without external oxygen support) and PI was recorded using Microtek Finger pulse oximeter and Peripheral blood pressure was recorded using Romson's automatic digital BP monitor(model AS-35E). The patient condition with regards to previous days was categorized as positive outcome in case of a progressive improvement in any of the parameters or negative outcome as one which resulted in deterioration of patient condition resulting in a shift to intensive care or referral to higher centre (Fig.1). Due to the longitudinal nature of the study, data for 12 patients out of 58 was collected only for a single day after which they were discharged or transferred for better care.

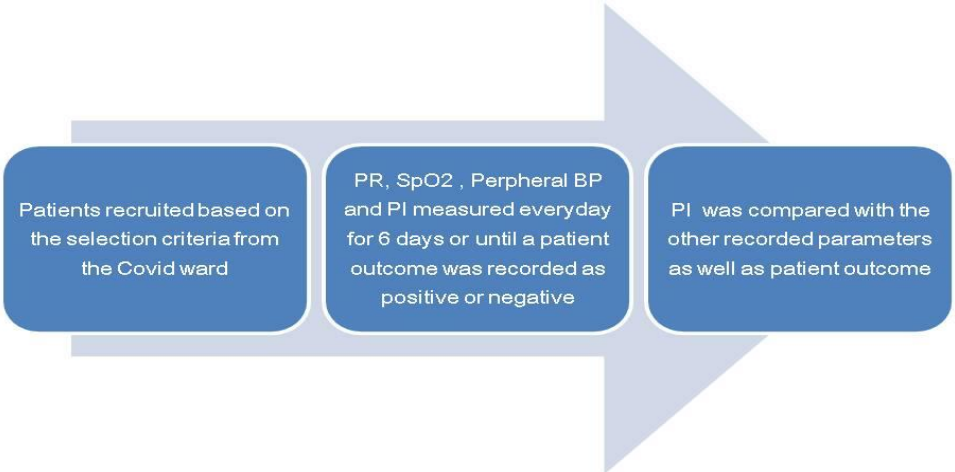

Fig.1: Methodology of the study

Table 1: Baseline data with gender-wise distribution of age, Perfusion Index (PI), Mean Arterial Pressure (MAP), Pulse pressure (PP), Pulse Rate (PR), and SpO2 of the patients shown as mean± standard deviation

Baseline characteristics	Males (n= 43)	Females (n=15)	Total (n= 58)
Age	47.442 ± 14.836	50.133 ± 12.351	48.138 ± 14.180
PI	6.905 ± 3.974	6.207 ± 2.853	6.724 ± 3.705
MAP	92.992 ± 13.400	98.978 ± 12.824	94.540 ± 13.405
PP	46.163 ± 12.333	52.133 ± 18.181	47.707 ± 14.150
SPO_2	92.744 ± 3.995	92.333 ± 5.815	92.638 ± 4.483
PR	89.488 ± 13.068	93.387 ± 24.589	90.497 ± 16.653

Data Analysis

The data was analyzed using Microsoft Excel 2010 and SPSS 21. The hemodynamic parameters were assessed for normality using Shapiro Wilk Test and were found to be normally distributed. The data is described as mean ± standard deviation in the results. Pearson correlation was used to study the association between PI and other hemodynamic parameters as well as patient outcome. Classical Linear Regression was used to find the relationship between the recorded parameters. Repeated measures ANOVA with Bonferroni post-hoc tests was used to asses day wise trends in PI and hemodynamic parameters with respect to patient outcome

RESULTS

Out of the 58, 8 patients were followed up for 6 days, 7 patients were followed up for 5 days, 6 patients followed up for 4 days, 12 patients followed up for 3 days, 13 patients for 2 days and the data of 12 patients were only recorded for a day before they were discharged or moved to a higher facility. Baseline data for day 1 is shown in Table.1 for Age, Perfusion Index (PI), Mean Arterial Pressure (MAP), Pulse Pressure (PP), SpO_2 and Pulse Rate (PR) along with gender wise distribution. Due to the lower sample size, data for day 6 was not analysed.

There was no significant association found between PI and other hemodynamic parameters such as MAP, SBP, DBP, PR or SpO_2. Extremely low PI (less than 0.5%) was associated with low SpO_2 and BP, as noticed from individual values, but the sample was not enough to find any significant association.

Day-wise analysis of changes in PI, PP and MAP with respect to patient outcome (measured as positive or negative) was done using repeated measures ANOVA. There were no significant day-wise trends to be noted.

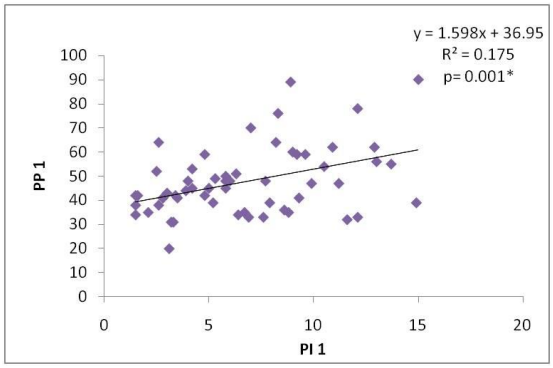

Fig.2a: Scatter plot for PI vs PP on day 1 (* shows significant positive association)

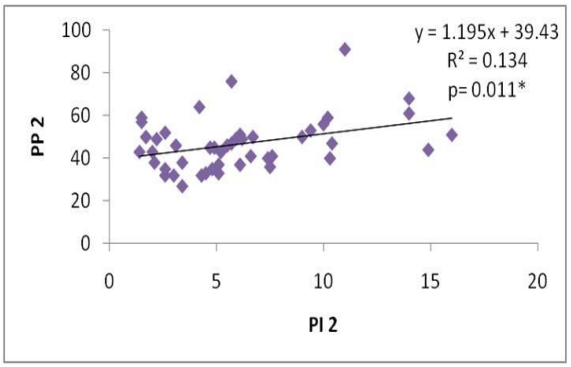

Fig.2b: Scatter plot for PI vs PP on day 2 shows significant positive association

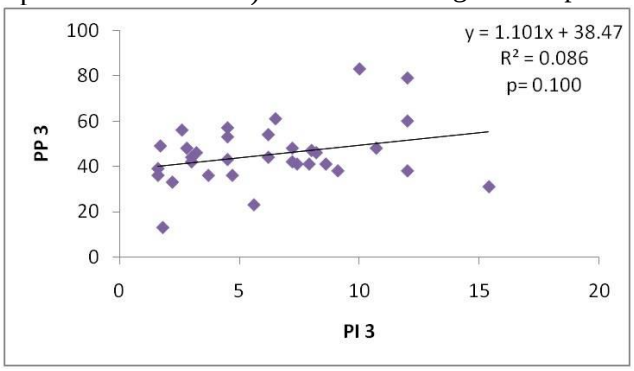

Fig.2c: Scatter plot for Perfusion Index (PI) vs (PP) on day 3 showing a positive trend line

Table 2: Classical linear regression analysis of Pulse Pressure (PP) as dependant variable with Perfusion Index (PI) of corresponding day as dependant variable

Days	Unstandardised co-efficient	Unstandardized PI	F value	P value	R^2
Day 1	36.957	1.599	11.901	0.001*	0.175
Day 2	39.431	1.195	6.836	0.012*	0.134
Day 3	38.474	1.101	0.096	0.096	0.087

*indicates significant p value

Pearson correlation analysis of PI with PR, SpO2, MAP and PP showed association of PP with MAP and PI. Pearson Correlation analysis conditioned on outcome showed there is positive correlation of PI values of days 1, 2 and 3 with their respective PP (Fig.2a, 2b, 2c), While MAP did not show any consistent positive association with PI. Regression analysis of PI with PP showed a significant linear equation where PP can be predicted from PI in day1 and day 2 (Table 2). While there was a positive trend in day 3 it was not found to be significant.

DISCUSSION

The study has shown that there is a positive linear correlation between PI and PP in the first 2 days of the study, implying that PI can be used as a tool that can predict Pulse pressure changes .There was no significant association found in the other days probably due to the lower sample size. Linear regression analysis showed that with enough samples a significant interpretation of the perfusion Index could be made, thus correlating it with the hemodynamic state of COVID 19 patients. Since pulse pressure is a recognised measure of circulatory stability, PI can also be used potentially as a marker of circulatory function in COVID 19 patients.

Heart failure and circulatory compromise is a major complication in COVID 19 patients and have been reported to account for about a large portion of all the COVID 19 complications (17). In patients with prior cardiovascular risk factors the probability of an impending cardiovascular failure is exacerbated (18). Boerma *et al.,* had found a Mean Arterial Pressure (MAP) of 77± 10 mm hg increasing up to 84± 9 mm Hg while the present study found the baseline MAP values to be 92.9 ± 13, which is higher (5). Different studies have analysed the need for continuous hemodynamic monitoring in Covid-19 patients involving BP changes which can be monitored in smaller clinics 10). This is important as the vast majority of COVID 19 patients may not be diagnosed with a cardiovascular complication due to the limitations in health infrastructure (19). Previous studies on non-Covid shock patients have found that PI could be used as a measure to predict onset of shock or to mark its severity (20-22). Studies have shown that PI has been found useful in post-surgical care of patients where hemodynamic monitoring is required (23, 24). It has been previously recorded that PI could be correlated with BP measured using arterial catheter in post surgical patients validating its utility as a stand-in for BP monitoring (25). Studies comparing PI to shock index in Emergency care have found that it is an effective tool in predicting the severity of shock in patients just brought into the emergency and could be used as a tool for efficient triage of patients (26,15). Even though PI have been found useful in hospitalised patients to assess their hemodynamic status their utility in Covid-19 patients as an indicator for cardiovascular complications have remained un-explored.

The present study was conducted in hospitalised COVID 19 patients diagnosed with RT-PCR and their hemodynamic status was assessed daily using traditional means such as Pulse Rate, SpO_2 and Peripheral BP, Mean Arterial Pressure and Pulse Pressure. These regular parameters were compared with Perfusion Index, measured by a finger pulse oximeter. There were no additional costs to the procedure as there was no requirement of any special equipment. Pulse oximeter is an easy-to-use tool that could give accurate measurements of PR, SpO2 and PI from the Infrared plethysmographic readings and is already being used regularly in the hospitals. There is no additional training or manpower required to record Perfusion Index values as it is directly available as percentage values on the pulse oximeter. Not only that any literate patient can be trained to record the PI values themselves without any need for assistance from even care-givers, which is a major strength of the technique given that most of the patients with mild to moderate symptoms are in home isolation and may not have assistance available to record even blood pressure.

In the past months there has been emergence of multiple variants of concern of SARS CoV-2 virus including the delta variant which has been known for increased risk of morbidity and mortality in India. The new variants have shown increasing risk of cardiovascular complications. While the need for regular hemodynamic monitoring of COVID 19 patients is high the health care infrastructure is already over-burdened. It would be ideal to monitor all moderate to severe cases of COVID 19 as well as the high risk patients regularly for hemodynamic instability. But the limited resource available in most

of our primary and secondary care centres, in terms of technology as well as trained manpower, makes it a daunting task. As the number of beds and other facilities are limited our guidelines have shifted in the face of this un-precedented crisis to manage mild cases of COVID 19 with Home-based care (2). In this scenario, Perfusion Index as measured by a regular finger Pulse Oximeter could prove to be a useful tool to assess the cardiovascular risk of patients who could not be provided with hospital care. The patients themselves, or their care-giver can easily record the PI and could be informed to a healthcare-provider for assessing the hemodynamic state with little or no training. Thus a physician can assess the patients' condition remotely and could improve the efficiency of home-based care.

Limitations

The study was carried out for a limited duration of 6 days and the recordings of pulse oximeter and BP were taken only once in a day. It is possible that a longer observational study with 12 hourly or 8 hourly recordings of the hemodynamic parameters could prove to be more useful in predicting any impending cardiovascular complications. A larger study including more sample size could possibly find significant linear relationship between PI and other cardiovascular parameters like Pulse Pressure and Mean Arterial Pressure. The data from present study was insufficient to analyse how age-groups or presence of co-morbidities affect the parameters. We propose that further studies need to be done into the utility of PI as a maker of cardiovascular complications in Covid-19 patients.

CONCLUSION

This study has found that peripheral Perfusion Index (PI) has a positive linear correlation to Pulse Pressure (PP) in hospitalised COVID 19 patients and hence can be used as a marker for hemodynamic stability of the patients. The investigators postulate that this technique could be used as a tool in predicting cardiovascular complications in COVID 19 patients and could specially prove to be useful in case of home-based care of patients.

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CONFLICT OF INTEREST

The authors have no competing interests to declare.

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