

journal homepage: <https://www.pjcm.net/>

## Pakistan Journal of Chest Medicine

Official journal of Pakistan Chest Society



# Optimal Finger Selection for Perfusion Index Measurement in Patients with Stable Chronic Obstructive Pulmonary Disease

Derallah A Lindra<sup>1✉</sup>, Savira<sup>2</sup>, Diniwati Mukhtar<sup>3</sup>, Helwiyah Umniyati<sup>3</sup>, Endang Purwaningsih<sup>3</sup>, Ahmad Rusdan H Utomo<sup>3</sup>, Faisal Yunus<sup>4</sup>

<sup>1</sup>Kolonel Abundjani General Hospital/ Biomedical Science Doctoral Program, University of Yarsi, Jakarta - Indonesia <sup>2</sup>Kolonel Abundjani General Hospital, Jakarta - Indonesia <sup>3</sup>Biomedical Science Doctoral Program, University of Yarsi, Jakarta - Indonesia <sup>4</sup>Department of Pulmonology and Respiratory Medicine, Faculty of Medicine, Universitas Indonesia, Jakarta - Indonesia

## Corresponding Author:

### Derallah A Lindra

Kolonel Abundjani General Hospital/  
Biomedical Science Doctoral  
Program,  
University of Yarsi,  
Jakarta - Indonesia.  
Email: lindradera@gmail.com

## Article History:

Received: Mar 02, 2026  
Revised: May 13, 2026  
Accepted: Jun 25, 2026  
Available Online: Sep 02, 2026

## Author Contributions:

DAL conceived idea, S drafted the study, DM HU collected data, EP AR did statistical analysis and interpretation of data, DAL FY critical reviewed manuscript. All approved final version to be published.

## Declaration of conflicting interests:

The authors declare that there is no conflict of interest.

## How to cite this article:

Lindra DA, Savira, Mukhtar D, Umniyati H, Purwaningsih E, Utomo ARH, Yunus F. Optimal Finger Selection for Perfusion Index Measurement in Patients with Stable Chronic Obstructive Pulmonary Disease. Pak J Chest Med. 2026;32(03):197-202.

## ABSTRACT

**Background:** Chronic obstructive pulmonary disease (COPD) may effect chronic hypoxemia due to ventilation-perfusion mismatch. The perfusion index (PI) based on pulse oximetry reflects peripheral perfusion and may vary by measurement site.

**Objective:** To evaluated differences in PI values among fingers to determine the most reliable site for PI measurement in patients with COPD.

**Methodology:** This descriptive observational studywith a cross-sectional design among patients with stable COPD attending the Pulmonology Clinic at Kolonel Abundjani General Hospital in August 2025. Subjects were recruited using consecutive sampling. Patient characteristics, including sex, age, smoking history, and Brinkman index, were obtained from medical records. Perfusion index measurements were taken from all fingers of both hands using a pulse oximeter and analyzed using descriptive statistics.

**Results:** A total of 22 patients with stable COPD were included. Most participants were male (86.4%) and aged over 55 years (86.4%), with the majority having a history of smoking and a Brinkman index of 200–600 (45.5%). The highest mean PI value in the right hand was observed in the ring finger ( $4.89 \pm 3.12$ ), while in the left hand it was found in the index finger ( $5.59 \pm 3.41$ ). PI values tended to be higher in several fingers of the left hand. A significant difference was observed only in the middle finger between the right and left hands ( $p = 0.012$ ). Age and smoking history were not significantly associated with PI values ( $p > 0.05$ ).

**Conclusion:** PI measurements in patients with stable COPD varied across different fingers. The thumbs showed relatively more stable values and may represent more reliable sites for PI assessment.

**Keyword:** COPD; Perfusion Index; Finger Measurement; Oxygen Monitoring

## Introduction

Chronic obstructive pulmonary disease (COPD) is a respiratory disorder characterized by progressive, persistent airflow limitation accompanied by structural damage to lung tissue.

This condition is primarily caused by chronic airway inflammation resulting from prolonged exposure to cigarette smoke or other harmful airborne particles and gases. The clinical manifestations of COPD included dyspnea, chronic cough, and sputum production, with disease severity ranging from asymptomatic stages to severe respiratory failure.<sup>1</sup> In Indonesia, the current prevalence of COPD is estimated to range between 3.6% and 5.6%, with an increasing trend reported in recent years. Epidemiological data also indicate that COPD prevalence is higher among men than women and is more commonly observed in individuals living in rural areas, those aged  $\geq 40$  years, smokers, and workers exposed to hazardous dust or gases.<sup>2</sup>

Ventilatory impairment and gas exchange abnormalities in COPD can lead to chronic hypoxemia due to ventilation-perfusion (V/Q) mismatch and reduced oxygen diffusion across the alveolar membrane. These pathophysiological changes make monitoring oxygenation status an essential component in the clinical evaluation of patients with COPD. International guidelines recommend non-invasive techniques for oxygenation monitoring, particularly in patients with chronic lung diseases or respiratory disorders.<sup>3</sup> In addition, alterations in peripheral perfusion may influence the quality of signals obtained from oxygen monitoring devices, thereby affecting the evaluation of peripheral perfusion parameters relevant to the interpretation of oxygenation measurements.

Pulse oximetry is a widely used non-invasive technique for continuous monitoring of arterial saturation. Its operating principle is based on the differential absorption of infrared and red light by deoxyhemoglobin and oxyhemoglobin, which allows the calculation of the proportion of oxygen-bound hemoglobin in arterial blood. The perfusion index (PI) is the ratio of static (non-pulsatile) blood flow to pulsatile blood flow in peripheral tissues. This parameter primarily reflects the strength of peripheral perfusion at the monitoring site rather than the oxygen content of the blood.

The PI can quickly assess whether the sensor placement site is appropriate for pulse oximetry monitoring. The PI typically ranges from 0.02%, indicating very weak pulsatile flow, to about 20%, reflecting strong pulsatile blood flow. Sites with higher PI values are generally considered more suitable for monitoring. Because PI is a relative parameter, its value may vary depending on physiological conditions, individual patient characteristics, and the monitoring site. Measurements obtained from different anatomical locations may

therefore yield different PI values. In particular, PI values may vary when measured on different fingers. Consequently, the range of PI values considered normal may differ among patients.<sup>6</sup>

In patients with COPD, the PI represents a valuable parameter for assessing and monitoring peripheral perfusion. It may provide early warning signs of clinical deterioration, support decisions about oxygen therapy, and improve overall patient management, particularly in critically ill or unstable conditions. In COPD patients, impaired oxygen delivery to tissues often occurs not only because of reduced arterial oxygen saturation ( $SpO_2$ ), but also because of circulatory disturbances associated with chronic hypoxia, increased pulmonary pressure, and systemic inflammation.<sup>8</sup>

Despite the increasing clinical use of the PI in monitoring peripheral perfusion, the optimal finger location for PI measurement in patients with COPD persists unclear. Therefore, this research tended to determine differences in PI values among fingers and to determine the most reliable site for PI measurement in patients with COPD.

Objective: To evaluate differences in PI values among fingers to determine the most reliable site for PI measurement in patients with COPD.

## Methodology

This research used a descriptive, observational, cross-sectional design. The research was conducted among patients diagnosed with stable COPD who attended the Pulmonology Clinic at Kolonel Abundjani Bangko General Hospital. The study population included all patients with stable COPD who visited the Pulmonology Clinic in August 2025. Subjects were recruited using consecutive sampling, in which all eligible patients who met the inclusion criteria during the study period were included until the required sample size was reached. Patients were excluded if they had another concomitant pulmonary disease, such as asthma, pulmonary tuberculosis, or interstitial lung disease. Data on subject characteristics were obtained from medical records, including sex, Age, Smoking history, and Brinkman Index. After confirmation of the COPD diagnosis, perfusion index (PI) measurements were performed on all fingers of both hands using a pulse oximeter. The measurements included the Right thumb, Right index finger, Right middle finger, Right ring finger, right little finger, Left thumb, Left index finger, left middle finger, Left ring finger, and left little finger. All perfusion index values were recorded for analysis. Data were analyzed using descriptive and inferential statistics. Categorical variables were shown as percentages and frequencies, while continuous variables were displayed as means  $\pm$  standard deviations. Differences in perfusion index (PI) values between corresponding fingers of the right and left hands were determined through a paired t-test. The Pearson correlation test was employed to

assess the relationship between subject characteristics (age and Brinkman index) and PI values. Statistical analyses were carried out using IBM SPSS Statistics version 25, with  $p < 0.05$  considered statistically significant.

## Results

After screening the samples derived from the exclusion and inclusion criteria, a total of 22 patients diagnosed with COPD were included in this study. Among the study cases, 19 (86.4%) were male, and the majority (19; 86.4%) were older. Most subjects also had a history of smoking, with the highest proportion having a Brinkman index of 200–600 (45.5%), indicating substantial exposure to tobacco-related risk factors within this population. Regarding perfusion index (PI) measurements, the right hand showed the highest mean PI in the ring finger ( $4.89 \pm 3.12$ ), whereas the left hand showed the highest mean PI in the index finger ( $5.59 \pm 3.41$ ). Overall, PI values measured on several fingers of the left hand tended to be higher than those measured on the right hand (Table 1).

The analysis demonstrated considerable variability in PI values across all fingers. The coefficient of variation ranged from 56% to 114% in the right hand and from 58% to 120% in the left hand. The lowest variation in the right hand was observed in the thumb (56%), while in the left hand it was found in the thumb (58%). In contrast, the highest variation was observed in the right index finger (114%) and the left little finger (120%). The left middle finger had the highest mean perfusion index, at 6.25. The relatively lower variation in both the right and left thumbs suggests that PI measurements at these sites tend to be more stable than those obtained from other fingers.

The analysis presented no statistically significant difference in PI values between the left and right thumbs ( $p = 0.156$ ). Similarly, no significant difference was discovered between the right and left index fingers ( $p = 0.567$ ). Comparable results were also found for the left and right ring fingers ( $p = 0.414$ ) and the right and left little fingers ( $p = 0.787$ ), showing no statistically significant differences. In contrast, a significant difference was discovered in the middle finger between the right and left hands. The statistical test yielded a  $t$  value of  $-2.752$  with

Table 1. Characteristics of Patients with Stable of Chronic Obstructive Pulmonary Disease

| Characteristics |            |               | Frequency              | Percentage (%) |
|-----------------|------------|---------------|------------------------|----------------|
| Gender          |            |               |                        |                |
| Male            |            |               | 19                     | 86,4           |
| Female          |            |               | 3                      | 13,6           |
| Age             |            |               |                        |                |
| < 40 Years      |            |               | 0                      | 0              |
| 40-55 Years     |            |               | 3                      | 13,6           |
| >55 Years       |            |               | 19                     | 86,4           |
| Brinkman Index  |            |               |                        |                |
| <200            |            |               | 6                      | 27,3           |
| 200-599         |            |               | 10                     | 45,5           |
| ≥600            |            |               | 6                      | 27,3           |
| Perfusion Index | Right-hand | Thumb         | $3,74 \pm 2,12^*$      |                |
|                 |            | Index finger  | $3,45 (0,5-12,9)^{\#}$ |                |
|                 |            | Middle finger | $4,00 (0,2-9,6)^{\#}$  |                |
|                 |            | Ring finger   | $4,89 \pm 3,12^*$      |                |
|                 |            | Little finger | $3,90 (0,3-14,3)^{\#}$ |                |
|                 | Left Hand  | Thumb         | $4,33 \pm 2,50^*$      |                |
|                 |            | Index finger  | $5,59 \pm 3,41^*$      |                |
|                 |            | Middle finger | $6,25 (1,1-18,3)^{\#}$ |                |
|                 |            | Ring finger   | $4,35 (0,3-18,7)^{\#}$ |                |
|                 |            | Little finger | $3,85 (0,3-15,9)^{\#}$ |                |

\*Mean: #Median

Table 2. Coefficient of Variation of the Perfusion Index

| Finger        | Mean | SD   | Coefficient of Variation (%) |
|---------------|------|------|------------------------------|
| Right-hand    |      |      |                              |
| Thumb         | 3,74 | 2,11 | 56                           |
| Index finger  | 3,45 | 3,95 | 114                          |
| Middle finger | 4,00 | 3,26 | 81                           |
| Ring finger   | 4,89 | 3,12 | 63                           |
| Little finger | 3,90 | 4,04 | 103                          |
| Left-hand     |      |      |                              |
| Thumb         | 4,33 | 2,49 | 58                           |
| Index finger  | 5,59 | 3,41 | 61                           |
| Middle finger | 6,25 | 4,35 | 69                           |
| Ring finger   | 4,35 | 4,85 | 111                          |
| Little finger | 3,85 | 4,63 | 120                          |

a sig.  $p = 0.012$ , indicating that the perfusion index in the left middle finger was higher than in the right middle finger. The Pearson correlation test demonstrated no significant association between age and PI values across all fingers of both the left and right hands ( $p > 0.05$ ). This finding indicates that increasing age was not significantly related to changes in perfusion index values among patients with stable COPD. Similarly, no significant relationship was discovered between the Brinkman index and PI values across all fingers ( $p > 0.05$ ). The correlation coefficients obtained for each finger indicated weak to very weak associations. These findings suggest that smoking history, as assessed by the Brinkman index, was not significantly associated with perfusion index values. Overall, age and smoking history were not significantly related to perfusion index values in patients with stable COPD.

## Discussion

This research showed that most of participants were male (86.4%) and older than 55 years (86.4%), which is consistent with the epidemiological pattern of COPD, where the prevalence is higher among older men due to

prolonged exposure to cigarette smoking. Yunus et al. (2019) reported that most COPD patients treated at Persahabatan Hospital were men aged  $\geq 60$  years, reflecting the cumulative exposure to respiratory risk factors.<sup>8</sup> A cohort study conducted in Japan also demonstrated an increasing incidence of COPD among men with advancing age, particularly among smokers.<sup>9</sup> Most subjects in the present study had a Brinkman index of 200–600 (45.5%), indicating moderate to heavy tobacco exposure. This discovery is consistent with the research by Mulyawan and Setiawan (2024), which reported a significant association between the Brinkman index and decreased lung function.<sup>10</sup> However, a community-based study in Indonesia suggested that the Brinkman index may not always serve as an independent predictor of COPD after multivariate analysis.<sup>11</sup> In addition, the variation in perfusion index values across different fingers observed in this research is consistent with the findings of Swain et al. (2022), who reported significant differences in perfusion index measurements among fingers, possibly influenced by variations in peripheral vascular supply.<sup>7</sup>

The data in this study also demonstrated considerable variability in perfusion index (PI) values across all fingers,

Table 3. Comparison of Perfusion Index Between the Fingers of the Right and Left Hands

| Finger        | Right (Mean $\pm$ SD) | Left (Mean $\pm$ SD) | p Value |
|---------------|-----------------------|----------------------|---------|
| Thumb         | 3,74 $\pm$ 2,11       | 4,33 $\pm$ 2,49      | 0,156   |
| Index finger  | 3,45 $\pm$ 3,95       | 5,59 $\pm$ 3,41      | 0,567   |
| Middle finger | 4,00 $\pm$ 3,26       | 6,25 $\pm$ 4,35      | 0,012*  |
| Ring finger   | 4,89 $\pm$ 3,12       | 4,35 $\pm$ 4,85      | 0,414   |
| Little finger | 3,90 $\pm$ 4,04       | 3,85 $\pm$ 4,63      | 0,787   |

\* Paired t-test  $p < 0,05$

Table 4. Correlation Between Subject Characteristics and Perfusion Index

|                | Right-hand        |                   |                    |                   |                   | Left-hand         |                   |                    |                   |                  |
|----------------|-------------------|-------------------|--------------------|-------------------|-------------------|-------------------|-------------------|--------------------|-------------------|------------------|
|                | T                 | I                 | M                  | R                 | L                 | T                 | I                 | M                  | R                 | L                |
| Age            | r=0,38<br>p=0,09  | r=0,19<br>p=0,41  | r=-0,002<br>p=0,99 | r=-0,08<br>p=0,72 | r=0,08<br>p=0,72  | r=-0,11<br>p=0,64 | r=0,04<br>p=0,87  | r=-0,005<br>p=0,98 | r=0,05<br>p=0,81  | r=0,22<br>p=0,33 |
| Brinkman Index | r=-0,10<br>p=0,65 | r=-0,18<br>p=0,43 | r=-0,08<br>p=0,72  | r=-0,12<br>p=0,59 | r=-0,02<br>p=0,94 | r=-0,18<br>p=0,42 | r=-0,03<br>p=0,89 | r=-0,29<br>p=0,18  | r=-0,26<br>p=0,25 | r=0,03<br>p=0,89 |

T:Thumb, I:Index, M:Midle, R:Ring, L:Little

with coefficients of variation ranging from 56% to 114% in the right hand and 58% to 120% in the left hand. This variability suggests that PI values may be influenced by the measurement site. These discoveries are consistent with those of Swain et al. (2022), who reported significant differences in PI values between fingers with low to moderate agreement.<sup>7</sup> Lima et al. (2005) also noted that PI is influenced by peripheral perfusion dynamics and hemodynamic conditions, which may lead to variability between individuals and measurement sites.<sup>12</sup> However, Aboy et al. (2011) reported that peripheral perfusion values in healthy individuals tend to remain relatively stable under controlled environmental conditions. The lower variation observed in the thumb in the present study may be related to the vascular supply from the radial artery, whereas the higher variation observed in the index and little fingers may reflect greater sensitivity of peripheral perfusion to local blood flow changes.<sup>13</sup>

The findings of this study indicate that most fingers did not show significant differences in PI values between the left and right hands, except for the middle finger, which demonstrated a higher value in the left hand ( $p = 0.012$ ). This result is consistent with the research from Swain et al. (2022), who reported that although variations in PI values may occur among different fingers, differences between the two hands are generally not statistically significant.<sup>7</sup> Lima and Bakker (2005) also suggested that PI is primarily influenced by peripheral perfusion and local vascular tone; therefore, differences between body sides are typically minimal under stable hemodynamic conditions.<sup>12</sup> However, Shelley (2007) reported that factors such as hand dominance, peripheral temperature, and microcirculatory conditions may contribute to variations in perfusion among fingers and between hands.<sup>14</sup> The difference observed in the middle finger in this study may be related to its dual vascular supply from the radial and ulnar arteries, which may influence local perfusion variability.<sup>15</sup>

Further analysis in this study demonstrated that age and the Brinkman index were not significantly associated with PI values across all fingers ( $p > 0.05$ ). These discoveries recommend that in patients with stable COPD, demo-

graphic factors and smoking history may not be directly related to peripheral perfusion changes. This result is consistent with the findings of Lima and Bakker (2002), who reported that PI primarily reflects acute peripheral perfusion conditions influenced by hemodynamic factors such as vascular tone and peripheral temperature rather than demographic characteristics.<sup>12</sup> Hales et al. (2013) also reported no strong correlation between age and PI values under physiologically stable conditions.<sup>15</sup> Nevertheless, Middlekauff et al. (2014) suggested that chronic exposure to cigarette smoke may lead to microvascular dysfunction, which could potentially reduce peripheral blood flow. The discrepancy between these discoveries may be related to differences in research populations, clinical conditions, and methods used for perfusion assessment.<sup>16</sup>

## Strengths

The present study investigates the underexplored issue of perfusion index (PI) variation across fingers in patients with chronic obstructive pulmonary disease (COPD). It is one of the first studies to systematically assess all ten fingers within this population. The use of consecutive sampling minimized selection bias. Collecting measurements from both hands allowed for reliable within-subject comparisons. Comprehensive statistical analyses enhanced the robustness of the findings. The identification of the thumb as the most stable site provides practical guidance for clinical PI monitoring.

## Limitations

Several limitations should be acknowledged. The small sample size reduces statistical power, and the single-center, cross-sectional design restricts generalizability. Uncontrolled physiological and environmental variables, as well as insufficient data on COPD severity and comorbidities, limit adjustment for confounders. Measurement protocols and device specifications were not detailed. Additionally, the absence of a control group or follow-up restricts broader interpretation of the findings.

## Conclusion

Perfusion index (PI) assessments in patients with stable COPD demonstrated considerable variability across different fingers of both hands. However, no significant differences were discovered between the right and left hands except in the middle finger and neither age nor smoking history indicated a significant association with PI values, while the thumbs exhibited relatively more stable measurements.

## References

1. Singh D, Agusti A, Anzueto A, Barnes PJ, Bourbeau J, Celli BR, et al. Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Lung Disease: the GOLD science committee report 2019. *Eur Respir J.* 2019; 53(5):1900164. DOI:10.1183/13993003.00164-2019.
2. Riskesdas RI. Riset Kesehatan Dasar. Jakarta: Kemenkes RI. 2013.
3. Amalakanti S, and Mohan RP. Pulse oximetry overestimates oxygen saturation in COPD. *Respir Care.* 2016;61(4):423-27. DOI:10.4187/respcare.04435.
4. Batista KS, Cézar ID, Benedetto IG, Silva RMC, Wagner LE, Silva DP, et al. Continuous monitoring of pulse oximetry during the 6-minute walk test improves clinical outcomes prediction in COPD. *Respir Care.* 2023;68(1):92-100. DOI:10.4187/respcare.10091.
5. Dogru S, Parent AA, Coppel J, Karaman T, Aydinli B, and Demir ZA. Perfusion Index: Identifying the Optimal Finger for Accurate Measurement. *Iran Red Crescent Med J.* 2024, 10(1):1-5.
6. Sun X, He H, Xu M, and Long Y. Peripheral perfusion index of pulse oximetry in adult patients: a narrative review. *Eur J Med Res.* 2024, 29(1):457. DOI:10.1186/s40001-024-02048-3.
7. Swain SM, Lata M, Kumar S, Mondal S, Behera JK, and Mondal H. A Cross-Sectional Study on the Agreement of Perfusion Indexes Measured on Different Fingers by a Portable Pulse Oximeter in Healthy Adults. *Cureus.* 2022, 14(5):e24853. DOI: 10.7759/cureus.24853.
8. Yunus F, Ariawan WP, and Nurwidya F. Smoking Behaviors and Related Factor in Indonesian Patients with Chronic Obstructive Pulmonary Disease in National Reference Hospital for Respiratory Diseases. *Pak J Chest Med.* 2019;25(1):6-10.
9. Kojima S, Sakakibara H, Motani S, Hirose K, Mizuno F, Ochiai M, et al. Incidence of Chronic Obstructive Pulmonary Disease, and the Relationship between Age and Smoking in a Japanese Population. *J Epidemiol.* 2007;17(2):54-60. DOI:10.2188/jea.17.54.
10. Mulyawan E, and Setiawan JA. The correlation between smoking cumulative dose based on Brinkman Index with peak expiratory flow rate. *J Gen Fam Med.* 2024;25(4):193-7. DOI:10.1002/jgf2.694.
11. Sari DM, Besral B, Djuwita R, Damayanti T, and Murtiani F. Prevalence and Predictors of COPD in Indonesian Smokers Attending Posbindu Community Health Centers: A Cross-Sectional Analysis. *Media Publikasi Promosi Kesehatan Indonesia.* 2026;9(2):284-5. DOI: 10.56338/mparki.v9i2.9428.
12. Lima A, and Bakker J. Noninvasive monitoring of peripheral perfusion. *Intensive Care Med.* 2005;31(1): 1316-1326. DOI:10.1007/s00134-005-2790-2.
13. Aboy M, McNames J, Thong T, Tsunami D, Ellenby MS, and Goldstein B. An automatic beat detection algorithm for pressure signals. *IEEE Trans Biomed Eng.* 2005;52(10):1662-70. DOI: 10.1109/TBME.2005.855725.
14. Shelley KH. Photoplethysmography: beyond the calculation of arterial oxygen saturation and heart rate. *Anesth Analg.* 2007;105(6 Suppl):S31-S36. DOI: 10.1213/01.ane.0000269512.82836.c9.
15. Hales JRS, Stephens FRN, Fawcett AA, Daniel K, Sheahan J, Westerman RA, et al. Observations on a new non-invasive monitor of skin blood flow. *Clin Exp Pharmacol. Physiol.* 1989, 16(5): 403-15. DOI:10.1111/j.1440-1681.1989.tb01578.x.
16. Middlekauff HR, Park J, and Moheimani RS. Adverse effects of cigarette and noncigarette smoke exposure on the autonomic nervous system: mechanisms and implications for cardiovascular risk. *J Am Coll Cardiol.* 2014, 64(16): 1740-50. DOI:10.1016/j.jacc.2014.06.1201.