Original Article

Concordance Level between Impulse Oscillometry and Spirometry for Pulmonary Function Test

Brigitta Devi Anindita Hapsari[1,2], Melita[1], Sihsusetyaningtyas Tiominar Siregar[1], Hendrastutik Apriningsih[1,2], Artrien Adhiputri[1,3]

[1]Department of Pulmonology and Respiratory Medicine, Faculty of Medicine, Universitas Sebelas Maret, Surakarta, Indonesia
[2]Sebelas Maret University General Hospital, Surakarta, Indonesia
[3]Moewardi Hospital, Surakarta, Indonesia

Abstract

Background: The most widely used lung function test, spirometry, requires constant coaching and more effort. An alternative modality of impulse oscillometry (IOS) was introduced, which is simpler than spirometry, requiring only basic tidal breathing and less cooperation, but with less stringent standards.

Methods: This research was a diagnostic test research with medical records data of patients who underwent spirometry and oscillometry procedures within the same period. The study was conducted in Sebelas Maret University General Hospital from March to September 2024.

Results: A total of 77% of examinations gave the same results, namely restriction in 32 people (30.8%) and obstruction in 48 people (46.2%). Meanwhile, as many as 23% of IOS examinations gave different results compared to spirometry examinations (discordance). Six normal results from spirometry showed the impression of obstruction in IOS. The agreement between the IOS examination and spirometry was moderately significant (*P*=0.0001).

Conclusion: Impulse oscillometry is a useful adjunct to spirometry, which is still the gold standard, especially for patients who are incapable of performing forced maneuvers.

Keywords: IOS, obstruction, oscillometry, restriction, spirometry

Corresponding Author:
Brigitta Devi Anindita Hapsari | Department of Pulmonology and Respiratory Medicine, Faculty of Medicine, Universitas Sebelas Maret - Sebelas Maret University Hospital, Surakarta, Indonesia | brigitta.anindita@staff.uns.ac.id

Submitted: March 10th, 2025
Accepted: October 13th, 2025
Published: October 30th, 2025

J Respirol Indones. 2025
Vol. 45 No. 4: 251-7
https://doi.org/10.36497/jri.v45i4.920

INTRODUCTION

The physiological characteristics of the lungs are reflected in respiratory function tests and pulmonary function tests (PFTs). Tracking the course of the disease, the effectiveness of treatment, identifying lung disease, and explaining dyspnea are all assessed by using PFTs. PFTs have also been used in population studies to examine the relationship between exposures and lung health.[1,2]

There are three main components to the interpretation of technically valid PFT results. First, the categorization of observed data as falling within or outside the normal range in relation to a population of healthy people. This entails taking into account the test's measurement error as well as the biological variability that exists in measures taken by the same person and between measurements taken by the same person. Second, including information about the physiological factors that influence test outcomes in a functional classification of the impairments that have been discovered. Lastly, combining the found patterns with additional clinical information to guide treatment and inform differential diagnosis.[1,2]

The diagnosis of COPD and asthma is assessed by the most widely used lung function test, spirometry. Younger children, the elderly, patients with severe advanced respiratory diseases, and persons with cognitive or neurological impairments cannot perform spirometry since it requires constant coaching and is effort-dependent. Additionally, volume-dependent small airway closure is often exaggerated by the forced expiratory maneuver.[2,3]

Impulse oscillometry (IOS) is an alternate test to assess the respiratory system at various oscillation frequencies. IOS applies a pressure flow oscillation in the subject's tidal breath, resulting in the measurement of resistance and reactance of the respiratory system.[2,3]

The primary benefits of IOS are that it is simpler than spirometry, requiring only basic tidal

breathing; it requires less cooperation; it requires no effort; and it is unlikely to change the tone of the smooth muscles of the airways because IOS is carried out without the need for forceful respiratory maneuvers.[2,3]

Spirometry has long been considered one of the most reliable methods for assessing pulmonary flows and volumes. Its practical limits stem mostly from the fact that it requires a cooperative patient, a skilled and understanding operator, and approved and standardized equipment. Conversely, IOS is very comfortable for the technician to perform and simple for the patients to understand. Since spirometry has numerous aerosol-producing activities that might transmit the causal virus, it could be detrimental in a pandemic scenario like COVID-19. On the other hand, IOS is probably going to generate little to no aerosol while operating.[1,3]

Spirometry has become the gold standard to examine lung function in asthma or COPD because it has international standards and references. When compared to spirometry, IOS has no sufficient standards and reference values. In the former, there are generally no reference rules, and each machine provides a distinct value.[1,3]

Due to limited standards and recommendations for IOS examination, this study will analyze the level of concordance between spirometry and IOS as a lung function examination.

METHODS

This research was a diagnostic test study. The study population was the medical records data of patients who underwent spirometry and IOS procedures within the same period. The study was conducted in Sebelas Maret University General Hospital from March to September 2024. Ethical clearance was approved by the Health Research Ethics Committee, Faculty of Medicine, Sebelas Maret University General Hospital (10/UN27.06.11/KEP/EC/2024).

The inclusion criteria were the medical record data from patients who could perform the maneuver of spirometry and IOS and had complete data in their medical records. The exclusion criteria were the data of patients who were unable to perform spirometry and IOS at the same time, having incomplete medical records, and having mixed results of restriction and obstruction. Sample selection was done using purposive sampling methods. The scheme of sample collection is shown in Figure 1.

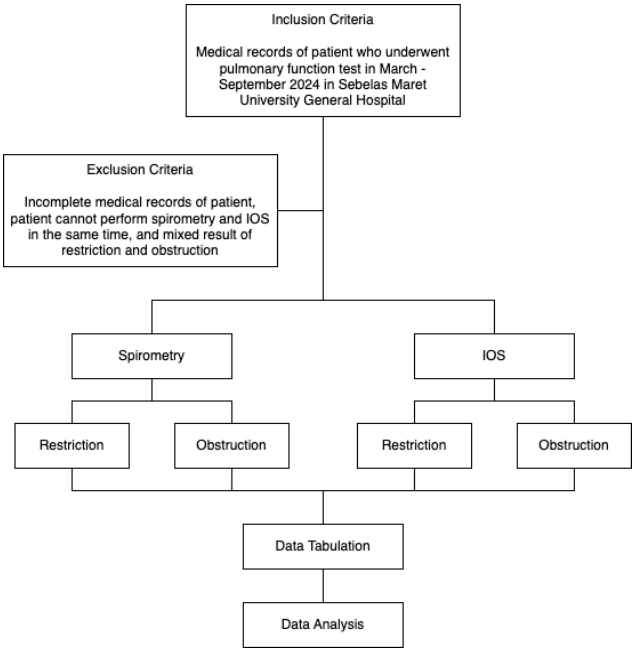

Figure 1. Sample collection of the study

This study compared the results of spirometry and IOS in the form of suitability for restriction and obstruction. A measurement of lung capacity, Forced Vital Capacity (FVC), is typically lower in conditions that result in smaller lungs, such as restriction of the lung disease and abnormalities of the bellows (kyphoscoliosis, neuromuscular weakness). A percentage projected value is obtained by comparing the patient's absolute FVC with that of their peers. A condition known as pseudorestriction, in which the lungs are hyperinflated as a result of severe blockage and air trapping, as well as increased residual volume, can also result in a decrease in FVC.

In healthy adults, the Forced Expiratory Volume in 1 second divided by Forced Vital Capacity (FEV_1/FVC) ratio should be between 75 and 80%. Instead of utilizing the expected percentage, the FEV_1/FVC ratio is calculated using the absolute values of FEV_1/FVC. Airway resistance to expiratory flow lowers FEV_1 in obstructive illnesses. Premature airway closure during expiration can also lower FVC,

though not to the same extent as FEV_1. The FEV_1/FVC ratio decreases as a result. The FEV1/FVC ratio is normal or even higher in restrictive diseases, but the FEV_1, FVC, and TLC are all decreased.[4,5]

Generally speaking, obstructive airway disease is indicated by an FEV_1/FVC ratio of less than 70%. However, it should be noted that the ratio of FEV_1/FVC tends to decrease with age (males over 40 and females over 50). Meanwhile, the lower border of normal (LLN) for FEV_1/FVC is a relevant sign of obstruction with an absolute value of 70% in elderly patients.[4,5]

Data analysis was performed using SPSS 21 for Windows. This research presented the frequency of distribution and the percentage of data. The level of concordance between spirometry and IOS was calculated by means of a test of agreement (Kappa Cohen). The degree of concordance was presented in the 2x2 table. This research also calculated sensitivity, specificity, positive predictive value, and negative predictive value.

RESULTS

This study involved 104 medical records of patients who fulfilled the inclusion criteria, with a total of 104 subjects.

Table 1. Data characteristic of the subject

Subject Characteristic	Mean±Standard Deviation
Age	55.3±15.2
BMI	23.13±5.6
FVC/ predicted	71.9±23.5
FEV1/ predicted	58.2±20.0
FEV1/ FVC	63.6±15.0
R5Hz / predicted	146.6±59.0
R20Hz/ predicted	121.6±41.0
X5Hz/ predicted	48.9±5,147.6
R5-R20	0.15±0.1
Fres	16.5±10.3
Ax	2.00±4.9

Note: BMI=Body Mass Index; FVC=Forced Vital Capacity; FEV_1=Forced Expiratory Volume in 1 second; R5Hz=Resistance at 5 Hz; R20Hz=Resistance at 20 Hz; X5Hz=Reactance at 5 Hz; Fres=Resonant Frequency; Ax=Area of Reactance.

Subjects were divided into 54 men (52%) and 50 women (48%). The subjects were also divided by smoking status (71.2% smokers and 28.8% non-smokers) and comorbidities (27.9% with hypertension, 7.7% with diabetes mellitus, and 4.8% with chronic kidney disease). Another characteristic is shown in Table 1.

All study subjects underwent spirometry and IOS examinations at the same time. The results obtained include restriction, obstruction, and normal compared between the two examinations, as shown in Table 2.

Table 2. IOS and spirometry examinations (n=104)

IOS	Spirometry			*P*	Kappa
	Restriction	Obstruction	Normal		
Restriction	32 (30.8%)	5 (4.8%)	0 (0.0%)		
Obstruction	11 (10.6%)	48 (46.2%)	6 (5.8%)	0.0001	0.557
Normal	0 (0.0%)	2 (1.9%)	0 (0.0%)		

A total of 77% of examinations gave the same results: restriction in 32 subjects (30.8%) and obstruction in 48 subjects (46.2%), respectively. Meanwhile, about 23% of IOS examinations gave different results compared to spirometry examinations (discordance). Six normal results from spirometry showed the impression of obstruction in IOS. The agreement between the IOS examination and spirometry was moderately significant (kappa=0.557; *P*=0.0001).

The assessment of the suitability of spirometry and IOS examination results in this study used a diagnostic test approach, assuming spirometry as the gold standard. The specificity of IOS for detecting obstructive disorders is 75.4%, with a level of conformity/consistency with spirometry (in the form of positive predictive value for obstruction findings) of 81.4%. The specificity of IOS for detecting restriction abnormalities was 90.6%, with a consistency level with spirometry results (in the form of positive predictive value for restriction findings) of 86.5%.

Table 3. PPV and NPV for detecting pulmonary obstruction and restriction

Predictive values	Obstruction	Restriction
PPV	81.4%	86.5%
NPV	86.5%	81.4%

Note: PPV=Positive Predictive Value; NPV=Negative Predictive Value.

DISCUSSION

Impulse oscillometry is a reliable test for evaluating lung function in this patient population,

since it requires less cooperation and effort from the patient. Age-related changes in the aged population, such as muscle weakness and decreased lung elasticity, can have a major effect on pulmonary function and make it challenging to perform adequate effort spirometry and other conventional lung function tests. IOS is less impacted by these modifications to the respiratory system and can offer trustworthy data regarding the mechanical characteristics of the lungs in this population.[3,6]

Consequently, IOS is a useful technique for evaluating lung function in patients of all ages, including elderly people and children, who would have trouble completing conventional pulmonary function tests. In addition, compared to spirometry, which can take up to 15 minutes to complete, IOS testing is a practical alternative for clinical practice because it is a relatively quick and simple process that can be finished in 5 to 10 minutes.[3,6]

Furthermore, IOS has demonstrated improved sensitivity in identifying early indicators of obstructive illness in a number of recent studies and can be used in a comprehensive assessment of lung function. Therefore, a potential tool for detecting abnormalities in lung function and putting the right precautions in place to stop more harm.[3,6]

A total of 104 medical records were examined in order to analyze the characteristics of the patients who participated in this study. These results are in line with previous research that highlights the high rate of comorbidities among patients suffering from respiratory conditions, especially lung cancer. It is commonly known that individuals with lung cancer frequently have concomitant conditions, including diabetes and hypertension. Comorbidities, such as diabetes and hypertension, have a substantial impact on hospital readmission and mortality rates among patients with lung cancer, according to a study in 2021 by Zhu et al.[7]

Given their implications for patient management, the specific comorbidities found in this study—like chronic kidney disease (CKD)—are especially pertinent. The intricate relationships between lung dysfunction and CKD were emphasized by Gembillo et al, who pointed out that patients with CKD frequently display restrictive lung patterns, which can make respiratory management more difficult. This research highlights the necessity of treating patients with respiratory conditions who also have serious comorbidities using a multidisciplinary approach.[8]

For the disorders compatibility between IOS and spirometry, the results showed a significant moderate agreement (kappa=0.557; *P*=0.0001) between IOS examination and spirometry. This is in line with the study of Lu et al, who also obtained mild agreement (kappa=0.322; *P*<0.001) between these two modalities. Several factors that can explain this moderate suitability include: differences in measurement principles (spirometry actively measures air volume and flow, while IOS measures airway impedance during normal breathing) and differences in measured parameters (spirometry focuses on FEV_1 and FVC, while IOS measures the resistance [R5, R20] and reactance [X5] of the airway).[9]

This study obtained an IOS sensitivity of 86.5% and specificity of 81.4%. This result is higher than the military study by Houle et al, who reported a sensitivity of 29.6% and a specificity of 83.3%. This difference can be caused by the characteristics of different subjects (this research is on the general population, while Houle's study is of more homogeneous military personnel) and the abnormality criteria used (this research uses R5-R20 >ULN, while Houle's study used R5 above 150% and X5 below -1.5).[6]

In identifying obstructive and restrictive airway problems, the research findings suggest that the IOS assessment has good specificity and consistency levels with spirometry. IOS had a positive predictive value of 81.4% and a specificity of 75.4% for obstructive diseases. This suggests that patients who actually have airway blockage can be identified with a fair degree of accuracy. In a significant study published in 2017, it was discovered that IOS was able to identify small airway dysfunction earlier than traditional spirometry. The positive predictive results (81.4% for blockage) from the current study are

consistent with this, indicating that IOS may play a part in early illness.[10]

When compared to spirometry findings, IOS has demonstrated a positive predictive value of 81.4% and a specificity of 75.4% for obstructive disorders. This is consistent with research by Saadeh et al, which showed that IOS is superior to spirometry in the diagnosis of chronic obstructive pulmonary disease (COPD) and the tracking of bronchodilator responses. They also suggested that IOS is especially useful in identifying distal airway function, even in cases where spirometry results are normal.[11]

Additionally, Saurabh et al pointed out that IOS characteristics, especially in asthma patients, could highlight important alterations in lung function that spirometry can miss. This suggests that IOS can offer further information about airway congestion that conventional spirometry is unable to detect.[12]

Impulse oscillometry performed better for restrictive diseases, with a positive predictive value of 86.5% and a specificity of 90.6%. This high specificity suggests that people without limiting diseases can be identified with great accuracy. The idea that IOS is sensitive to changes in lung function that might not be visible by spirometry alone was supported by Lu et al's discovery that IOS parameters successfully detected early airway obstruction changes in individuals with COPD.

Cross et al further supported the usefulness of IOS in a variety of therapeutic contexts by emphasizing that it may be a more accurate indicator of lung function in kids at risk for asthma.[13,14] The study by Bickel et al, which discovered a substantial correlation between IOS characteristics and spirometry measures in individuals with restrictive illnesses, also supports these findings.[15]

Several identified advantages of IOS are in accordance with the study of Saadeh et al, such as early detection capabilities (IOS can detect small airway abnormalities before they are visible on spirometry, therefore being useful for early diagnosis and intervention), inspection technique (IOS uses regular breathing, so it is easier to perform and requires no forced breathing maneuvers such as in spirometry), and evaluation of treatment response (IOS is more sensitive in detecting changes after bronchodilators, hence it can help optimize dosage and monitor therapy).[11]

Furthermore, IOS is especially appropriate for populations who would find traditional spirometry difficult, such as small children or elderly patients with serious respiratory disorders, due to its non-invasive nature, which eliminates the need for forceful exhalation. According to Sarkar, who emphasized the successful use of IOS in patients with severe COPD when spirometry could be difficult, this patient-friendly feature of IOS increases its usefulness in clinical practice.[16]

According to these results, IOS may be a useful adjunct to spirometry for evaluating respiratory function, especially in situations when doing traditional spirometry could be difficult. To create more reliable normative values and standardization procedures for IOS measurements across various patient populations, further investigation is necessary.

LIMITATION

There is no standardized IOS reference value yet. Variations between brands or types of equipment may influence results. Requires understanding of more complex IOS parameters. Requires clinical experience for accurate interpretation. The study limitations were a single-center study and no analysis of the mixed results of restriction and obstruction. In the future, we need more studies to investigate.

CONCLUSION

Impulse oscillometry and spirometry complement each other, not replace each other. IOS has the potential to improve respiratory disease diagnosis and patient care, as evidenced by the specificity and positive predictive values found in recent research. However, IOS has the absence of established reference values, equipment unpredictability, parameter complexity, and the requirement for clinical knowledge. These must be resolved to improve its diagnostic value in respiratory medicine.

The combination of the two provides more comprehensive information, IOS for initial screening and therapy monitoring, while spirometry remains the gold standard for diagnostic tools. IOS is more suitable for children and the elderly, also useful in patients who have difficulty performing spirometry.

ACKNOWLEDGMENTS

Authors would like to express appreciation to Sebelas Maret University General Hospital, Faculty of Medicine Sebelas Maret University, and the team for helping to do this research.

CONFLICT OF INTEREST

There were no disclosed potential conflicts of interest related to this article.

FUNDING

This research was supported by grant funding from Sebelas Maret University for the Grant Research Group Program (No. 194.2/UN27.22/PT.01.03/2024).

REFERENCES

1. Stanojevic S, Kaminsky DA, Miller MR, Thompson B, Aliverti A, Barjaktarevic I, et al. ERS/ATS technical standard on interpretive strategies for routine lung function tests. European Respiratory Journal. 2022;60(1):2101499.
2. Sharshar RS, Mohamed ASh. The utility of impulse oscillometry in asthma: A comparison of spirometry versus impulse oscillometry system. Egyptian Journal of Chest Diseases and Tuberculosis. 2017;66(2):207–9.
3. Unnithan J, Krishnamurthy S, Velayuthaswamy N, Srinivasan N. Can oscillometry replace spirometry as a major tool for lung function testing? – An overview. Journal of Association of Pulmonologist of Tamil Nadu. 2024;7(2):54–60.
4. Sewa DW, Ong TH. Pulmonary function test: Spirometry. Proceedings of Singapore Healthcare. 2014;23(1):57–64.
5. Graham BL, Steenbruggen I, Miller MR, Barjaktarevic IZ, Cooper BG, Hall GL, et al. Standardization of spirometry 2019 update. An official American Thoracic Society and European Respiratory Society Technical Statement. Am J Respir Crit Care Med. 2019;200(8):e70–88.
6. Houle MC, Cavacece CT, Gonzales MA, Anderson JT, Hunninghake JC, Holley AB, et al. Correlation of impulse oscillometry with spirometry in deployed military personnel with airway obstruction. Mil Med. 2023;188(Suppl 6):400–6.
7. Zhu D, Ding R, Ma Y, Chen Z, Shi X, He P. Comorbidity in lung cancer patients and its association with hospital readmission and fatality in China. BMC Cancer. 2021;21(1):557.
8. Gembillo G, Calimeri S, Tranchida V, Silipigni S, Vella D, Ferrara D, et al. Lung dysfunction and chronic kidney disease: A complex network of multiple interactions. J Pers Med. 2023;13(2):286.
9. Lu L, Peng J, Zhao N, Wu F, Tian H, Yang H, et al. Discordant spirometry and impulse oscillometry assessments in the diagnosis of small airway dysfunction. Front Physiol. 2022;13:892448.
10. Galant SP, Komarow HD, Shin HW, Siddiqui S, Lipworth BJ. The case for impulse oscillometry in the management of asthma in children and adults. Annals of Allergy, Asthma and Immunology. 2017;118(6):664–71.
11. Saadeh C, Saadeh C, Cross B, Gaylor M, Griffith M. Advantage of impulse oscillometry over spirometry to diagnose chronic obstructive pulmonary disease and monitor pulmonary responses to bronchodilators: An observational study. SAGE Open Med. 2015;3:2050312115578957.
12. Mandilwar S, Thorve SM, Gupta V, Prabhudesai P. Role of impulse oscillometry in diagnosis and follow-up in bronchial asthma. Lung India. 2023;40(1):24–32.
13. Lu L, Peng J, Wu F, Yang H, Zheng Y, Deng Z, et al. Clinical characteristics of airway

impairment assessed by impulse oscillometry in patients with chronic obstructive pulmonary disease: Findings from the ECOPD study in China. BMC Pulm Med. 2023;23(1):52.

14. Saadeh C, Cross B, Saadeh C, Gaylor M. Retrospective observations on the ability to diagnose and manage patients with asthma through the use of impulse oscillometry: Comparison with spirometry and overview of the literature. Pulm Med. 2014;2014:376890.
15. Bickel S, Popler J, Lesnick B, Eid N. Impulse oscillometry: Interpretation and practical applications. Chest. 2014;146(3):841–7.
16. Sarkar S, Jadhav U, Ghewade B, Sarkar S. A comparative observational study of the diagnostic utility of impulse oscillometry versus spirometry in obstructive airway diseases. Cureus. 2024;16(10):e70589.