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THE IMPORTANCE OF PEAK INSPIRATORY FLOW ASSESSMENT IN REAL-TIME CLINICAL PRACTICE

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Abstract
In order to assess peak inspiratory flow (PIF) in 100 patients with obstructive respiratory pathology as part of the selection of an inhalation device for optimizing inhalation respiratory therapy, a functional study of PIF was conducted using the In-Check DIAL device (Clement Clarke International Ltd., UK) with an imitation of an inhaler of resistance on inspiration, where the device panel took into account the flows: R0 without resistance and 4 levels of resistance, including R1 - low resistance, R2 - medium-low, R3 - medium, R4 - medium-high resistance. The results of the clinical study showed a high proportion of patients (34%-85%) whose peak inspiratory air flow when using inhalers is below the level required for optimal inhalation through inhalation devices with medium-low, medium and medium-high resistance, as a result of which patients receive an insufficient dose of drugs, they experience more frequent exacerbations and hospitalizations compared to patients who are able to create an inhalation flow adequate to the resistance of the inhaler. Suboptimal values of peak inspiratory flow, determined by phenotypic predictors, including female gender, height less than 1.6 m, BMI less than 20 kg/m2 or more than 30 kg/m2, age over 70 years, clinical and functional markers, including the degree of clinical severity of dyspnea according to mMRC more than 3 points, the severity of obstructive disorders FEV1 less than 50% of the expected, and the features of the clinical course, characterized by a high frequency of exacerbations requiring 2 or more hospitalizations, are declared the main component for choosing an inhalation device with optimal resistance, ensuring the effectiveness of therapy for obstructive respiratory pathology, including COPD and asthma, a predictor of treatment effectiveness, optimization of control and a decrease in the frequency of exacerbations requiring frequent hospitalizations. Evaluation of peak inspiratory flow in patients with obstructive respiratory pathology, based on phenotypic, clinical and functional characteristics and variants of the disease course, and its suboptimal peak inspiratory flow in comparison with the level of inhaler resistance can help clinicians to personalize the selection of an inhaler in patients with exacerbation of obstructive respiratory pathology and optimize the choice of an inhalation device in a stable course of the disease.

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Keywords: peak inspiratory flow (PIF), suboptimal peak inspiratory flow (sPIF), metered-dose inhaler (MDI), dry powder inhaler (DPI)

Relevance

Global initiatives GOLD and GINA, as well as national clinical guidelines for the treatment of bronchial asthma (BA), emphasize that BA and COPD are chronic diseases requiring continuous control and therapeutic efforts, including the prevention of exacerbations [GOLD, 2023; Chuchalin A.G., Avdeev S.N., Aisanov Z.R., 2022; Reddel H.K., Bacharier L.B., Bateman E.D. et al., 2021; Chuchalin A.G., Avdeev S.N., Aisanov Z.R., 2022]. The cornerstone of therapy for these diseases is the use of inhaled medications, and achieving optimal disease control largely depends on the correct use of inhalers and the appropriate choice of inhalation devices [Venkatesan P., 2023].

The use of standard pressurized metered-dose inhalers (pMDIs) requires specific breathing maneuvers, such as a slow and deep inhalation, as well as precise coordination between inhalation and device actuation [Laube B.L., Janssens H.M., de Jongh F.H. et al., 2011]. Several studies have reported that 81% of inhalations using pMDIs are performed with critical errors [Crompton G.K., 1982; Rootmensen G.N., van Keimpema A.R., Jansen H.M., de Haan R.J., 2010], which can lead to poor drug delivery to the airways, worsened disease control, and increased medication use [Rootmensen G.N., van Keimpema A.R., Jansen H.M., de Haan R.J., 2010].

In fact, 76% of patients using pMDIs and 49–54% of those using breath-actuated pMDIs make at least one error during inhalation [Molimard M., Raherison C., Lignot M. et al., 2003].

Dry powder inhalers (DPIs) generate a respirable fraction of medication through sufficient peak inspiratory flow (PIF), which depends both on the patient's physical ability and on the correct performance of the inhalation maneuver [Mahler D.A., Demirel S., Hollander R. et al., 2022]. Regarding DPIs, 4–94% of patients use them incorrectly, and 25% have never been trained in their proper use [11]. The most common errors when using DPIs are insufficient exhalation before inhalation (not reaching functional residual capacity) and inadequate inspiratory flow [Lavorini F., Magnan A., Dubus J.C. et al., 2008].

The optimal dose delivered by a DPI depends on the peak inspiratory flow generated against the specific inhaler's resistance, which differs among devices. If the patient is unable to generate the required inspiratory effort, the flow is considered suboptimal [Mahler D.A., 2020; Ghosh S., Ohar J.A., Drummond M.B., 2017].

Incorrect inhalation technique and suboptimal inspiratory flow can worsen clinical outcomes and increase the risk of repeated exacerbations and hospitalizations within the next 30–90 days [Alqahtani J.S., Aldabayan Y.S., Aldhahir A.M. et al., 2021; Loh C.H., Peters S.P., Lovings T.M., Ohar J.A., 2017; Leving M., Wouters H., de la Hoz A. et al., 2021].

About 20% of patients hospitalized for COPD exacerbation are re-hospitalized within 30 days after discharge [Loh C.H., Peters S.P., Lovings T.M., Ohar J.A., 2017]. In the study by C.H. Loh et al. (2017), which included patients hospitalized for COPD exacerbations, 52% had suboptimal inspiratory flow. Patients with suboptimal PIF had shorter time to next hospitalization (65.5 vs. 101 days; $p = 0.009$) and shorter time to next medical visit (63.5 vs. 144 days; $p = 0.002$) compared to those with optimal inspiratory flow [Loh C.H., Peters S.P., Lovings T.M., Ohar J.A., 2017].

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According to the literature, PIF does not match the resistance of the prescribed inhaler in 32–77% of stable COPD cases and in 50–100% during exacerbations [Sharma G., Mahler D.A., Mayorga V.M. et al., 2017; Mahler D.A., Niu X., Deering K.L., Dembek C., 2022; Harb H.S., Laz N.I., Rabea H., Abdelrahim M.E.A., 2020; Broeders M.E., Molema J., Hop W.C. et al., 2004; Clark B., Wells B.J., Saha A.K. et al., 2022].

In Uzbekistan, studies measuring peak inspiratory flow in clinical practice have not been conducted, mainly due to the lack of devices such as the portable In-Check DIAL™ G16 (Clement Clarke International Ltd., UK).

Therefore, identifying phenotypic predictors and clinical–functional markers associated with suboptimal PIF is of great relevance. This would enable personalized selection of inhalers based on patients' inspiratory flow values during exacerbations of obstructive respiratory diseases, as well as optimization of device choice during stable disease, which is also supported by the Expert Council conclusions [Aisanov Z.R., Arkhipov V.V., Avdeev S.N. et al., 2020].

Purpose of the study: To determine the clinical significance of peak inspiratory flow (PIF) in patients with obstructive respiratory diseases for the purpose of optimizing inhalation therapy through the appropriate selection of inhalation devices.

Materials and Methods: The study was conducted at the Pulmonology Department of the Republican Specialized Center of Phthisiology and Pulmonology named after Academician Sh. Alimov. The study included 100 patients, comprising 50 patients with COPD stages II–IV (GOLD, 2022) and 50 patients with bronchial asthma (GINA, 2022). All participants underwent a comprehensive clinical and laboratory examination, including anthropometric measurements (body weight, height, and BMI calculation) and instrumental assessment of lung function. This included flow–volume curve analysis and static lung volume measurements such as vital capacity (VC) and forced vital capacity (FVC) using a portable MicroLab device. The main clinical and functional characteristics of the examined patients are presented in Table 1.

Table 1

Main clinical and functional characteristics of the examined individuals

Parameters		clinical nosology	
		COPD, n=50	BA, n=50
Age, years		65,8±0,99 [63,9÷67,7]	59,6±1,7 [56,3÷62,9]
Duration of illness, years		13,1±1,55 [10,1÷16,1]	12,6±1,22 [10,2÷15,0]
Height, m		1,67±0,01 [1,65÷1,69]	1,63±0,01 [1,61÷1,65]
Weight, kg		69,8±2,1 [65,7÷73,9]	80,4±2,3 [75,9÷84,9]
Body mass index, kg/m2		24,9±0,8 [23,3÷26,5]	30,2±0,9 [28,4÷32,0]
mMRC dyspnea score	1	4 (8,0)	3 (6,0)
	2	6 (12,0)	17 (34,0)
	3	22 (44,0)	30 (60,0)
	4	17 (34,0)	-
mMRC dyspnea score		3,0±0,14 [2,73÷3,27]	2,54±0,08 [2,38÷2,71]
FEV1	>50%	11 (22,0)	20 (40,0)
	30-50%	14 (28,0)	19 (38,0)
	<30%	25 (50,0)	11 (22,0)
FEV1, % of predicted		37,7±2,2 [33,4÷42,0]	46,34±2,66 [41,13÷51,55]
FVC, % of expected		40,6±2,2 [36,3÷44,9]	48,4±2,6 [43,3÷53,5]

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YELLOW, % of expected		43,9±1,9 [40,2÷47,6]	53,5±2,3 [49,0÷58,0]
$PO_{inhalation}$		0,92±0,08 [0,76÷1,08]	1,23±0,10 [1,03÷1,43]
$E_{inhalation}$		1,14±0,09 [0,96÷1,32]	1,45±0,11 [1,23÷1,67]
Frequency of exacerbations, once a year		3,4±0,17 [3,07÷3,73]	4,3±0,28 [3,75÷4,85]
Frequency of exacerbations	Up to 2 times	13 (26,0)	11 (22,0)
	3-4 times	30 (60,0)	20 (40,0)
	5 or more times	7 (14,0)	19 (22,0)
Frequency of hospitalizations, once a year		2,24±0,12 [2,0÷2,48]	2,72±0,22 [2,29÷3,15]
Hospitalization rate	Up to 2 times	35 (70,0)	30 (60,0)
	More than 2 times	15 (30,0)	20 (40,0)
Charlson Comorbidity Index		5,5±0,20 [5,11÷5,89]	5,1±0,20 [4,7÷5,5]
Charlson Comorbidity Index	0 points	-	-
	1 point	-	-
	2 points	1 (2,0)	2 (4,0)
	3 points	1 (2,0)	7 (14,0)
	4 points	13 (26,0)	5 (10,0)
	5 points	8 (16,0)	15 (30,0)
	6 points	14 (28,0)	12 (24,0)
	7 points	10 (20,0)	9 (18,0)
	8 points	3 (6,0)	-

The assessment of peak inspiratory flow (PIF) was carried out using the In-Check DIAL device (Clement Clarke International Ltd., UK). PIF was measured by simulating inhaler resistance during inspiration. The device panel accounted for airflow at R0 (no resistance) and four resistance levels, including R1 (low resistance), R2 (medium-low), R3 (medium), and R4 (medium-high resistance).

According to most literature sources, optimal PIF (oPIF) values are considered to be >90 L/min for R0 and >60 L/min for R1–R4. Lower values were classified as suboptimal PIF (sPIF), which are associated with a significant decrease in the therapeutic effectiveness of inhaler use [Sharova N.V., Cherkashin D.V., Sobolev A.D., Soloviev I.A., 2022; Sanders M.J., 2017; Sharova N.V., Cherkashin D.V., Sobolev A.D., Makiev R.G., Partsernyak S.A., Erdneev B.A., 2023].

Statistical analysis of the results was performed using Microsoft Office Excel 2003 and Statistica 10.0 software packages, applying standard descriptive statistical methods. Differences between groups were assessed using the Mann–Whitney test for continuous variables and Fisher's exact test for discrete variables. The Wilcoxon test was used to evaluate dynamics. Statistical characteristics for continuous variables were described using medians and quartiles. Differences were considered statistically significant at $p < 0.05$.

Results and Discussion: The results of the study showed that during exacerbations, a considerable proportion of patients with COPD and BA demonstrated inspiratory flow values

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significantly lower than those required to generate sufficient inspiratory effort corresponding to the inhaler's resistance. The data presented in Table 1 illustrate a progressive decline in PIF values with increasing device resistance. Specifically, PIF ranged from 110–120 L/min when simulating R0 (no resistance) to 50–60 L/min at R4 (medium-high resistance), both among COPD and BA patients.

This pattern indicates that as the inhaler's internal resistance increases, many patients are unable to achieve the optimal inspiratory flow required for effective drug delivery, which may lead to reduced therapeutic efficiency during periods of disease exacerbation.

Table 1

PIF and sPIF values when simulating inhaler resistance in patients with obstructive respiratory disease

Indicator/ resistance	Control healthy, n= 25 PI, l/min	COPD, n=50			BA, n=50		
		PIF, l/min	sPIF n,%	n, %	PIF, l/min	sPIF n,%	%
R0	120 [120÷120]	106 [100÷112]	74 [69÷79]	8 (16,0)	104 [98÷110]	58 [45÷71]	7 (14,0)
R1	120 [100÷120]	84 [78÷90]	43 [33÷53]	4 (8,0)	84 [71÷91]	38 [25÷53]	5 (10,0)
R2	110 [100÷110]	67 [60÷70]	48 [44÷52]	17 (34,0)	65 [59÷71]	42 [37÷47]	19 (38,0)
R3	100 [90÷100]	65 [61÷74]	44 [39÷49]	16 (32,0)	64 [57÷71]	41 [40÷44]	21 (38,0)
R4	90 [80÷90]	54 [50÷58]	45 [42÷48]	32 (64,0)	54 [49÷59]	41 [38÷44]	28 (56,0)

According to the study data, when simulating R0 and R1 resistance, the frequency of suboptimal PIF (sPIF) values was observed in 8.0–16.0% of COPD exacerbation cases and in 10.0–14.0% of asthma exacerbation cases. This indicates that the majority of COPD and asthma patients during exacerbations are able to effectively use inhalation devices such as pMDIs, Respimat, and Breezhaler.

It was found that at the hospital stage, both COPD and asthma patients demonstrated a high proportion of individuals unable to achieve optimal PIF when using inhalation devices with higher resistance: For medium-low resistance (R2), 34% of COPD patients and 38% of asthma patients were unable to generate sufficient inspiratory effort. For medium resistance (R3), this was 32% in COPD and 38% in asthma. For medium-high resistance (R4), this reached 64% in COPD and 56% in asthma patients.

In this context, the use of inhalation devices with medium-low resistance (R2) such as Accuhaler and Ellipta, medium resistance (R3) such as Turbuhaler S and AirFluSal, and medium-high resistance (R4) such as Easyhaler C and Turbuhaler, without prior PIF assessment, should be considered inappropriate. This is because in COPD patients, sPIF values

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ranged from 44 to 48 L/min, and in asthma patients, sPIF values were up to 42 L/min, which is insufficient for effective drug delivery through these devices.

The study also compared certain phenotypic and clinical characteristics of obstructive respiratory diseases with PIF and sPIF values, including sex, age, height and body constitution, clinical and functional disease parameters (such as dyspnea, FEV_1, and respiratory muscle fatigue) as well as disease course characteristics (Tables 2–3).

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Table 2
PIF indicators and the incidence of sPIF in patients with obstructive respiratory disease, taking into account phenotypic data

	sex				Height				Body mass index					
	Men, n=64		Women, n=36		Less than 1.6 m, n=22		More than 1.6 m, n=78		≤20, n=12		21-30, n=50		>30, n=38	
	PIF, l/min	sPIF n, %	PIF, l/min	sPIF n, %	PIF, l/min	sPIF n, %	PIF, l/min	sPIF n, %	PIF, l/min	sPIF n, %	PIF, l/min	sPIF n, %	PIF, l/min	sPIF n, %
R0	112,0 [109÷115]	4 (6,0)	93,0 [85÷101]	11 (30,0)	88,0 [78÷98]	9 (41,0)	110,0 [106÷114]	6 (8,0)	104,0 [93÷115]	2 (17,0)	109,0 [104÷114]	5 (10,0)	100,0 [93÷107]	8 (21,0)
R1	92,0 [87÷97]	1 (2,0)	71,0 [63÷79]	8 (22,0)	67,0 [57÷77]	7 (32,0)	89,0 [84÷94]	2 (3,0)	81,0 [67÷95]	1 (8,0)	87,0 [80÷94]	4 (8,0)	81,0 [73÷89]	4 (10,0)
R2	72,0 [68÷76]	15 (23,0)	54,0 [47÷61]	21 (58,0)	50,0 [41÷59]	16 (73,0)	69,0 [65÷73]	20 (26,0)	63,0 [53÷73]	5 (42,0)	67,0 [61÷73]	17 (34,0)	63,0 [56÷70]	14 (37,0)
R3	73,0 [68÷78]	13 (20,0)	52,0 [45÷59]	24 (67,0)	51,0 [42÷60]	15 (68,0)	69,0 [64÷74]	22 (28,0)	62,0 [52÷72]	4 (33,0)	66,0 [60÷72]	17 (34,0)	62,0 [54÷70]	16 (42,0)
R4	58,0 [55÷61]	29 (45,0)	45,0 [36÷44]	31 (86,0)	44,0 [37÷51]	19 (86,0)	56,0 [53÷59]	41 (53,0)	49,0 [42÷56]	8 (67,0)	55,0 [50÷60]	27 (54,0)	53,0 [48÷58]	25 (66,0)

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Data analysis revealed that the prevalence of suboptimal peak inspiratory flow (sPIF) among women was 1.85 times higher than among men, accounting for 89.0% (39.0 [36–42] L/min) compared to 48.0% (45.0 [42–48] L/min), with lower PIF values observed in women (45–93 L/min) versus men (58–112 L/min).

Among patients over 50 years of age, a higher frequency of sPIF was observed in flows simulating R2–R4 resistance levels, corresponding to medium-low to medium-high internal resistance of inhalation devices, along with reduced PIF parameters: 62.0 [50–72] L/min, 59.0 [48–70] L/min, and 46.0 [35–52] L/min, respectively, for R2–R4.

Patients with obstructive respiratory diseases and a height below 1.6 m were 1.5 times more likely to exhibit sPIF, with a mean value of 38.0 L/min, compared to patients taller than 1.6 m, whose mean sPIF was 44 L/min. Shorter patients demonstrated significantly lower PIF values across flows simulating internal resistance levels R0–R4, by 20.0%, 25.0%, 27.0%, 26.0%, and 21.0%, respectively, compared to taller patients.

Patients with obstructive respiratory diseases and a body mass index (BMI) below 20 kg/m² (18.2 ± 0.5 kg/m², n = 12) or above 30 kg/m² (34.4 ± 0.7 kg/m², n = 38) had significantly lower PIF values across flows simulating internal resistance levels R0–R4 compared with patients with normal BMI. The deviations in PIF values for the two groups were 5% and 8% at R0, 7% at R1, 6% at R2, 5% and 6% at R3, and 11% and 4% at R4, respectively. The frequency of sPIF among individuals with BMI below 20 kg/m² and above 30 kg/m² was 1.2 times higher than in patients with normal BMI values, with an average of 41.0 [37–45] L/min.

Clinical symptom analysis showed that among patients with obstructive respiratory diseases included in the study, 7.0% reported dyspnea during brisk walking or slight exertion (mMRC grade 1), characterized by FEV_1 at 56.4 ± 6.5% of predicted, FVC at 55.6 ± 7.4% of predicted, and VC at 59.4 ± 6.0% of predicted.

Twenty-three percent of patients stated that “shortness of breath forces them to walk slower than people of the same age” (mMRC grade 2). In this group, functional parameters were: FEV_1 49.9 ± 4.2% of predicted, FVC 51.9 ± 4.2% of predicted, and VC 55.4 ± 4.0% of predicted.

Fifty-two percent of patients reported that “shortness of breath causes them to stop when walking” (mMRC grade 3), with corresponding values of FEV_1 36.7 ± 2.2% of predicted, FVC 41.1 ± 2.1% of predicted, and VC 45.2 ± 1.7% of predicted.

Seventeen percent of patients experienced dyspnea during dressing, which limited their activity to the home environment (mMRC grade 4). These patients had pronounced functional impairments, with FEV_1 31.0 ± 4.5% of predicted, FVC 38.1 ± 2.1% of predicted, and VC 45.2 ± 1.7% of predicted.

The characteristics of PIF and the frequency of sPIF across different clinical–functional cohorts are shown in Table 3. The frequency of sPIF among patients with very severe dyspnea (mMRC grade 4) was 2.7 times higher than among those with mild dyspnea (mMRC grade 1), amounting to 76.0% versus 28.0%, respectively. Patients with very severe dyspnea had significantly lower PIF values across simulated internal resistance levels R0–R4 compared to patients with mild dyspnea: by 10.0% at R0, 15.0% at R1, 9.0% at R2, 9.0% at R3, and 21.0% at R4.

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Table 3
PIF indicators and the incidence of sPIF during resistance simulation in patients with obstructive respiratory pathology, taking into account the clinical and functional characteristics of the disease

	MRC, ball								Forced expiratory volume in 1 second			
	1, n=7		2, n=23		3, n=52		4, n=17		≤50, n=69		>50, n=31	
	PIF, l/min	sPIF n, %	PIF, l/min	sPIF n, %	PIF, l/min	sPIF n, %	PIF, l/min	sPIF n, %	PIF, l/min	sPIF n, %	PIF, l/min	sPIF n, %
R0	111,0 [100÷120]	1 (14,0)	107,0 [100÷114]	2 (9,0)	102,0 [96÷108]	10 (19,0)	100,0 [95÷105]	2 (12,0)	104,0 [99÷109]	11 (16,0)	108,0 [101÷115]	4 (13,0)
R1	95,0 [70÷120]	2 (28,0)	85,0 [76÷94]	1 (4,0)	83,0 [76÷90]	5 (10,0)	81,0 [70÷92]	1 (6,0)	82,0 [76÷88]	7 (10,0)	88,0 [79÷97]	2 (6,0)
R2	74,0 [54÷94]	2 (28,0)	66,0 [58÷74]	8 (35,0)	65,0 [59÷71]	18 (35,0)	67,0 [56÷78]	5 (29,0)	63,0 [59÷67]	28 (40,0)	70,0 [56÷70]	8 (26,0)
R3	69,0 [48÷90]	1 (14,0)	67,0 [58÷76]	10 (43,0)	63,0 [57÷69]	20 (38,0)	63,0 [55÷71]	7 (41,0)	63,0 [58÷68]	28 (40,0)	69,0 [61÷77]	9 (29,0)
R4	66,0 [53÷79]	2 (28,0)	54,0 [48÷60]	13 (56,0)	53,0 [49÷57]	32 (62,0)	52,0 [45÷59]	12 (71,0)	52,0 [48÷56]	44 (64,0)	56,0 [51÷61]	16 (52,0)

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The results of the study also revealed that with increasing severity of obstructive disorders, the frequency of suboptimal peak inspiratory flow (sPIF) increased significantly: by 2.8 times at simulated resistance R0, by 3.5 times at R1–R3, and by 2.8 times at R4, accompanied by reduced PIF parameters by 4%, 7%, 10%, 9%, and 7%, respectively, for R0–R4. Reduced PIF values and a higher frequency of sPIF among patients with obstructive respiratory pathology and FEV_1 less than 50% of the predicted value correlated with severe ventilatory impairment, including vital capacity (VC) of 39.9 ± 1.53% of the predicted value, inspiratory volume (E_insp) of 1.43 ± 0.10 L, inspiratory reserve volume (IRV) of 0.58 ± 0.09 L, and a discriminant diaphragm fatigue index (DFI) of 13.5 ± 0.98.

The study findings indicated that suboptimal inspiratory flow values have clinical significance for patients with obstructive respiratory diseases, as demonstrated by the higher prevalence of sPIF among patients with two or more hospitalizations per year (65.0%) compared to those with a single hospitalization per year (57.0%) (Table 4).

Table 4

PIF indicators and the incidence of sPIF during resistance simulation in patients with obstructive respiratory pathology, taking into account the characteristics of the disease course

	Exacerbations/hospitalization, once a year				Hospitalization, once a year			
	2 exacerbations/ 1 hospitalization		2 exacerbations/ 2 hospitalizations		1 time, n=14		2 or more, n=86	
	PIF, l/min	sPIF n, %	PIF, l/min	sPIF n, %	PIF, l/min	sPIF n, %	PIF, l/min	sPIF n, %
R0	94,0 [73÷116]	1 (11,0)	109,0 [103÷115]	-	99,0 [84÷114]	1 (7,0)	105,0 [101÷109]	2 (2,0)
R1	79,0 [59÷99]	1 (11,0)	86,0 [74÷98]	1 (7,0)	88,0 [72÷104]	1 (7,0)	84,0 [79÷89]	8 (9,0)
R2	58,0 [44÷72]	3 (33,0)	64,0 [52÷76]	6 (40,0)	63,0 [52÷74]	4 (28,0)	63,0 [61÷69]	31 (36,0)
R3	58,0 [41÷75]	4 (44,0)	62,0 [51÷73]	6 (40,0)	65,0 [50÷80]	5 (36,0)	65,0 [60÷70]	36 (42,0)
R4	47,0 [35÷59]	5 (55,0)	51,0 [42÷60]	11 (73,0)	52,0 [42÷62]	8 (57,0)	53,0 [50÷56]	55 (64,0)

According to the results of our own study, suboptimal peak inspiratory flow (PIF) can be considered a predictor of the risk of repeated hospitalizations. Among patients with an exacerbation frequency of up to two times per year and two hospitalizations per year, the prevalence of suboptimal inspiratory flow values was 1.3 times higher compared to the group of patients with the same frequency of exacerbations but only one hospitalization per year.

Summarizing the results of the clinical study, a high proportion of patients (34%–85%) were identified whose peak inspiratory flow through inhalers was below the level required for optimal inhalation when using inhalation devices with medium-low, medium, and medium-high resistance. As a result, these patients receive an insufficient dose of medication and experience more frequent exacerbations and hospitalizations compared to patients who are able to generate an inspiratory flow adequate to the inhaler's resistance.

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Suboptimal peak inspiratory flow values, determined by phenotypic predictors — including female sex, height less than 1.6 m, BMI below 20 kg/m² or above 30 kg/m², and age over 70 years — as well as by clinical and functional markers such as pronounced dyspnea with an mMRC score above 3 points, severe obstructive impairment with FEV_1 less than 50% of the predicted value, and clinical course features characterized by frequent exacerbations requiring two or more hospitalizations per year, represent a key factor for selecting an inhalation device with optimal resistance. Such selection ensures the effectiveness of therapy for obstructive respiratory diseases, including COPD and bronchial asthma, and serves as a predictor of treatment efficacy, improved disease control, and reduced frequency of exacerbations requiring repeated hospitalizations.

Given the limited availability of peak inspiratory flow (PIF) assessment in real-world clinical practice, when prescribing an inhaler, the physician should not only evaluate the patient's ability to generate a peak inspiratory effort proportional to the resistance of the specific inhaler—based on clinically "highly significant," "significant," and "less significant" characteristics—but also consider each exacerbation requiring hospitalization as a predictor of the patient's inability to produce sufficient peak inspiratory flow to overcome medium-low, medium, medium-high, or high inhaler resistance. In such cases, therapy should be adjusted by switching to inhalation devices with no or low resistance, such as pressurized metered-dose inhalers with spacers (pMDI–spacer), Respimat, or Breezhaler.

Maximum therapeutic benefit can be achieved through the use of alternative inhalation systems (e.g., liquid inhalers or nebulizers) that allow for "slow and steady" inhalation, with inspiratory flow rates of 15–30 L/min.

Assessment of peak inspiratory flow in patients with obstructive respiratory diseases—based on phenotypic and clinical–functional characteristics as well as disease course patterns—and evaluation of suboptimal PIF relative to inhaler resistance can assist clinicians in personalizing inhaler selection during disease exacerbations and optimizing inhalation device choice in stable disease conditions.

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