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TRAINING INHALATION TECHNIQUE: DYNAMICS OF SYMPTOMS AND LUNG FUNCTION PARAMETERS IN PATIENTS WITH COPD AND ASTHMA IN REAL-WORLD CLINICAL PRACTICE

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Abstract

Objective: To assess the impact of structured training in inhalation technique and optimization of inhaled treatment regimens on symptoms, quality of life and pulmonary function in patients with COPD and bronchial asthma in real-world clinical practice. *Methods:* This open-label study enrolled 38 adult patients with COPD or asthma who had signs of inadequate disease control and at least one critical inhaler technique error. Over 8 weeks, patients underwent "teach-togoal" training with individualized demonstration, step-by-step practice using pMDIs and DPIs, and provision of written leaflets, while inhalation therapy was simultaneously optimized according to GOLD and GINA recommendations. mMRC, CAT, ACT/ACQ, visual analogue scales and spirometry were assessed. *Results*: Training resulted in a marked reduction in the frequency of critical errors, improvement in symptoms and CAT/ACT/ACQ scores, as well as a moderate increase in FEV1, confirming the clinical relevance of regular assessment and correction of inhalation technique.

Keywords

COPD, bronchial asthma, education, inhalation therapy, inhaler technique, structured training, critical errors, pressurized metered-dose inhaler, dry powder inhaler, CAT, ACT

Inhalation therapy is a key component of COPD and asthma treatment, but its effectiveness directly depends on proper inhalation technique. According to systematic reviews and large observational studies, critical errors in the use of metered-dose and dry-powder inhalers occur in 50–80% of patients and are associated with more severe dyspnea, poorer quality of life, reduced FEV1, and an increased risk of exacerbations. A recent systematic review of patient-reported errors in the use of inhalation devices in patients with COPD confirmed a link between high error rates and worse clinical outcomes, including more severe

symptoms and a higher rate of severe exacerbations. At the same time, randomized and prospective studies have shown that even a single structured session of inhalation technique training with demonstration and the " learn-to --reproduce " method leads to a significant reduction in the number of critical errors, an improvement in CAT/ACT -scores (questionnaires monitoring the effectiveness of COPD and asthma therapy) , and, in some studies, an increase in FEV1 and a reduced risk of exacerbations in elderly patients with COPD and asthma. The updated GOLD 2023 and GINA recommendations emphasize the need for regular assessment of inhalation technique and retraining at each visit as a mandatory element of patient management; however, in real-world practice, these measures are often implemented fragmentarily and without objective outcome assessment. Therefore, conducting a prospective study evaluating the impact of structured inhalation technique training on symptoms, lung function indicators, and quality of life in patients with COPD and asthma in a real-world clinical setting seems relevant and clinically significant [1,2,3,4,5] .

The aim of this study was to evaluate the impact of structured training in inhalation therapy technique (using the teach-repeat method) and optimization of the inhalation drug regimen on the severity of symptoms (dyspnea), quality of life/disease control indicators (CAT in patients with COPD, ACT/ACQ in patients with bronchial asthma) and pulmonary function in patients with COPD and asthma in real-life clinical practice.

Materials and methods. The study was conducted at the Tashkent State Medical University Clinic from September 2024 to June 2025. All participants provided written informed consent prior to inclusion in the study.

A single-center, open-label, prospective study with pre- and post-assessment -was conducted to evaluate changes in respiratory symptom severity, quality of life/disease control, pulmonary function, and inhalation technique in patients with COPD and asthma during an 8-week structured inhalation technique training program and inhalation therapy regimen optimization. The study included 38 patients with a previously established diagnosis of COPD or asthma who consecutively presented to a pulmonology or internal medicine department and had signs of inadequate disease control and/or inhalation technique errors.

Inclusion criteria. Patients were included in the study if the following conditions were met: age ≥18 years; confirmed diagnosis of COPD (according to GOLD) or bronchial asthma (according to GINA); presence of maintenance inhalation therapy (long-acting β2 --adrenergic agonists (LABA), long-acting anticholinergic drugs (LAMA), inhaled glucocorticosteroids (IGCS) and or their combinations);

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presence of at least one of the signs of insufficient control/management: – for COPD: CAT ≥10 and/or mMRC ≥2;
– for asthma: ACT <20 or frequent daytime/nighttime symptoms requiring additional β2 -agonist;
– documented inhalation technique errors according to the checklist -(≥1 critical error) see Table 1;
– willingness to participate in training and follow-up visits.

Exclusion criteria. Patients were excluded if they had at least one of the following: exacerbation of COPD or asthma requiring systemic glucocorticosteroids or hospitalization within the last 4 weeks; · severe comorbidity (CHF functional class IV, end-stage CKD, severe liver failure) that significantly limited participation; · active respiratory disease of a different nature (pneumonia, tuberculosis, etc.); · severe cognitive impairment or mental disorders that interfere with learning and following instructions; · pregnancy, lactation.

Table 1

Critical errors in inhalation technology by device type

Device type	Critical error	Brief description
Dosed inhaler under pressure (including with spacer)	Lack of exhalation before inhalation	The patient does not exhale calmly and completely before inhaling from the inhaler.
Dosed inhaler under pressure	Shallow/ short breath	A shallow, "small" breath instead of a slow and deep one
	Absence coordination of inhalation and pressing	Pressing the balloon before inhalation, after inhalation, or without inhalation
	Too fast inhale	The inhalation is too fast, not suitable for this type of inhaler.
	Absence delays breathing	Exhale immediately after inhalation, without holding for 5-10 seconds
	Exhale into the mouthpiece	Exhale into the device before or during activation
	Incorrect	Strong tilt/rollover, stream not

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	position inhaler	directed into mouth
Powder inhaler	Lack of exhalation before inhalation	There is no calm exhalation before inhaling through the inhaler
	Exhale into the mouthpiece after loading the dose	Exhalation into the device, humidification and loss of powder
	Too slow/ surface inhale	There is no quick and deep breath required to activate the powder
	Incorrect dose charging	Dose not prepared (lever/capsule not activated)
	No breath holding	No breath holding after inhaling through an inhaler
Any inhaler	Inhalation through the nose	The patient inhales through the nose, not through the mouth.
	Loose clasping mouthpiece	Leakage of the medicinal substance due -to loose lip contact
	Usage empty devices	Using the inhaler when the dose remaining is zero (counter = 0)

At inclusion, anamnesis was collected (duration of disease, previous inhalation therapy, number of exacerbations over the past year), comorbidities were recorded, height and body weight were measured, body mass index was calculated, blood pressure and heart rate were measured.

Symptom and quality of life assessment. All patients were assessed at the baseline visit and after 8 weeks: dyspnea severity according to the mMRC scale ; in patients with COPD, the total score on the CAT (COPD Assessment Test) questionnaire; in patients with asthma, the score on the ACT (Asthma Control Test) or ACQ, depending on the scale used in the clinic; subjective fatigue and limitation of daily activity on a 0–10 visual -analogue scale.

Pulmonary function assessment. If spirometry was available, pulmonary function testing was performed before and after the intervention, determining

FEV1 (L and % predicted), FVC, and the FEV1/FVC ratio in accordance with ATS/ERS standards. If spirometry was not available to all patients, it was performed in an accessible subgroup, which was recorded in the protocol.

Inhalation technique assessment. Inhalation technique was assessed using standardized checklists -for each device type (pressurized metered-dose inhaler (PMI), including those with a spacer , and dry powder inhaler (DPI)) based on GOLD/GINA recommendations and the results of systematic reviews on inhalation technique. For each patient, the sequence of key steps was analyzed: device preparation, full exhalation before inhalation, inhalation pattern (slow/deep for PMI, fast/deep for DPI), coordination of inhalation and device activation, breath-holding after inhalation, and exhalation without the inhaler in the mouth. Errors were classified as critical (rendering drug delivery ineffective) and non-critical. The total number of errors and the proportion of patients with ≥1 critical error were calculated before and after the intervention (see Table 1).

Training. All patients underwent structured training in inhalation technique using the "teach-and-repeat" principle: the physician demonstrated the correct technique on the appropriate device, after which the patient repeated all steps step by step until critical errors were completely eliminated, with correction and repeat demonstrations as needed. Patients were given brief written/illustrated instructions on how to use their specific inhaler. Additionally, as indicated and in accordance with GOLD and GINA recommendations, the inhalation therapy regimen was optimized (e.g., switching to a triple combination of LABA/LAMA/ICS in patients with COPD and frequent exacerbations, selecting a more suitable device based on physical and cognitive capabilities). If possible, a brief follow-up visit (in person or by phone) was conducted after 4 weeks to clarify the patient's well-being and, if necessary, repeat the brief training; the main follow-up visit was conducted at -week 8.

Adverse events potentially associated with changes in inhalation therapy or inhalation technique (increased cough, throat irritation, hoarseness, episodes of bronchospasm) were recorded at visits and at interim visits.

Statistical analysis was performed using standard applied statistics packages. Quantitative indicators were described as M±SD for a normal distribution or Me [Q1; Q3] for an abnormal one, categorical indicators were presented as absolute and relative frequencies (n, %). To compare indicators before and after the intervention (mMRC , CAT/ACT, number of critical errors, FEV1, etc.), the paired -Student's t-test or the Wilcoxon test were used depending on the data distribution; for categorical variables, the MacNemar test -or the χ^2 test with corrections were used. Differences were considered statistically significant at $p < 0.05$.

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Study results. The analysis included 38 patients (23 with COPD and 15 with bronchial asthma), the average age was 62±9 years, 55% were men. 71% of patients used pressurized metered-dose inhalers (PDIs), 45% used dry powder inhalers, and 29% used a combination of devices. The average disease duration was 9 [5; 15] years, the median number of exacerbations in the past year was 2 [1; 3].

Basic inhalation technique

• Incorrect inhalation technique (≥1 critical error) was detected in 81.6% of patients; when using DID - in 84%, when using PI - in 68%.

• The average number of critical errors per patient was 2.1±1.4 for DID and 1.5±1.2 for PI.

• The most common critical errors for DID were: too high an inspiratory flow rate (in 47% of patients), failure to hold the breath (29%), and failure to fully exhale before inhalation (27%).

• For PI, the most common reasons were: insufficiently fast/deep inhalation (35%), exhalation into the mouthpiece after loading the dose (22%), and incorrect dose preparation (19%).

Table 2.

Inhalation technique before and after training

	DID: up to	DID: after	PI: to	PI: after	All patients: up to	All patients: after
Proportion of patients with ≥1 critical error, %	84	28	68	25	81.6	26.3
Average number of critical errors per patient	2.1±1.4	0.6±0.9	1.5±1.2	0.4±0.7	–	–

Dynamics of inhalation technique after training

After 8 weeks of the training program, the proportion of patients with ≥1 critical error decreased from 81.6% to 26.3% ($p< 0.001$).

For DID, the proportion of erroneous patients decreased from 84% to 28% ($p< 0.001$), the average number of critical errors decreased from 2.1±1.4 to 0.6±0.9 ($p< 0.001$).

For PI, the proportion of patients with errors decreased from 68% to 25% ($p< 0.001$), the average number of errors decreased from 1.5±1.2 to 0.4±0.7 ($p< 0.001$).

The most significant reduction was observed in errors related to the lack of a full exhalation, synchronization of inhalation and device activation, and breath holding at the height of inhalation.

Changes in symptoms and quality of life

After 8 weeks of structured training, significant improvements in symptom scores and quality of life were observed.

The average score on the mMRC scale decreased from 2.3±0.7 to 1.7±0.6 ($p< 0.01$).

In patients with COPD, the median CAT decreased from 18 [14; 22] to 13 [9; 18] points ($p< 0.001$), while the proportion of patients with CAT< 10 increased from 18% to 39%.

In patients with asthma, the median ACT increased from 17 [14; 19] to 21 [19; 23] points ($p< 0.001$), the proportion of patients with controlled asthma (ACT≥20) increased from 27% to 67%.

Scores on the visual -analogue scale for fatigue and limitation of daily activities decreased by an average of 1.5–2.0 points ($p< 0.01$).

Dynamics of external respiration function

Spirometry was performed in 28 patients (74% of the sample).

FEV1 increased from 1.42±0.39 L to 1.53±0.41 L (approximately from 54±13% to 58±14% of predicted; $p< 0.05$).

The FEV1/FVC ratio did not undergo clinically significant changes, which is consistent with what is expected in stable COPD and asthma with optimized therapy.

The greatest increase in FEV1 was observed in patients who did not show any critical errors in inhalation technique by the end of the observation period.

Exacerbations and safety

During the observation period (8 weeks), 5 mild/moderate exacerbations (13%) and no severe exacerbations requiring hospitalization were recorded; in patients with a high initial exacerbation rate, a trend toward a decrease in their number was noted.

Adverse events were predominantly mild (throat irritation, increased cough, hoarseness) and did not require discontinuation of therapy.

No serious adverse reactions associated with inhalation technique training or device changes have been reported.

Factors associated with error persistence

A small proportion of patients continued to have critical errors despite training. Risk factors included older age, severe cognitive impairment bordering on exclusion criteria, concurrent use of more than one type of inhaler, and low baseline education. This subgroup was more likely to require switching to a simpler device (e.g., switching from a DIP to a DPI or adding a spacer).

Discussion of results.

The presented results generally demonstrate high comparability with data from modern systematic reviews and studies published in reputable journals, while emphasizing the significant potential of structured inhalation technique training in real-world clinical practice. The proportion of patients with at least one critical error at baseline (81.6%) is at the upper limit of the 50–80% range described in multicenter studies and meta-analyses, reflecting the typical prevalence of incorrect inhalation technique in the COPD and asthma population. The pattern of the most common errors (lack of full exhalation, inappropriate inspiratory flow, lack of breath-holding for pressurized metered-dose inhalers, and insufficiently rapid/deep inspiration, as well as dose preparation errors for dry powder inhalers) fully correlates with the profile of critical errors described in comparative studies of DID and PI in patients with asthma and COPD [4,5,6,7].

The magnitude of the effect of the educational intervention deserves special attention: the reduction in the proportion of patients with ≥1 critical error from 81.6% to 26.3% over 8 weeks is comparable to or even slightly exceeds the results of randomized and prospective programs based on the "learn to achieve " approach , including the use of video -materials and multi-stage control. A number of high-quality studies have demonstrated an increase in the proportion of patients with correct technique to 80–90% or more after targeted training, with the average number of critical errors per patient decreasing for all key steps of the maneuver; the transition from 2.1±1.4 to 0.6±0.9 errors for DID and from 1.5±1.2 to 0.4±0.7 for PI demonstrated in the present study is consistent with these trends and indicates the high effectiveness of the implemented training format [8,9,10].

The clinical significance of improved inhalation technique is confirmed by changes in symptoms, quality of life, and lung function. The findings of reduced dyspnea severity (mMRC), decreased CAT scores in COPD patients, and increased ACT/ACQ scores in asthma patients are consistent with the findings of systematic reviews showing an association between a lower frequency of critical errors and better disease control, quality of life, and more favorable clinical outcomes. The observed moderate but statistically significant increase in FEV1, especially in patients who had eliminated critical errors by the end of the follow-up, is also consistent with the results of prospective studies and RCTs, where correction of inhalation technique is accompanied by improved spirometric parameters and a reduced risk of exacerbations. The absence of severe exacerbations and only a limited number of mild/moderate episodes observed in the present study during the 8- -week intervention period reflects the same general trend, although longer

follow-up is required to draw definitive conclusions about the impact on exacerbation rates

An important aspect is the consistency of the obtained results with current international recommendations. GOLD 2023 and GINA emphasize the need for regular assessment of inhalation technique and its adjustment at each visit, considering these measures as a mandatory element of the management of patients with COPD and asthma. It has been shown that inhalation technique deteriorates over time (the so-called inhaler technique Decay), especially in elderly patients, those with cognitive impairment, and those using multiple devices, requires periodic retraining. The factors associated with the persistence of errors identified in this study (old age, cognitive limitations, multiple devices, low educational level) are consistent with the risk factors described in the international literature and highlight the need for individualized inhalation device selection and retraining in high-risk groups [8,10,11].

Thus, the results of this study complement the body of data presented in high-ranking journals, demonstrating that even a relatively brief, structured training program based on the "learn-to --reproduce" principle, combined with optimization of the inhalation therapy regimen, can significantly reduce the frequency of critical errors, improve symptoms, quality of life, and several lung function parameters in real-world clinical settings. These data strengthen the evidence base for the inclusion of regular, targeted inhalation technique training in the standard care of patients with COPD and bronchial asthma in outpatient and inpatient settings.

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