

Conducting pre- and post-bronchodilator spirometry for the diagnosis of suspected chronic obstructive pulmonary disease

Developed in collaboration with an advisory committee of Quebec clinicians from various specialties and areas of expertise.

- !** *This protocol supplements the protocol on initiating a pre-/post-bronchodilator spirometry test (No. 888052), which includes information on the short-acting bronchodilators needed to conduct the test.*
- !** *All healthcare professionals who perform pre- and post-bronchodilator (pre/post-BD) spirometry must have the necessary skills to conduct the test and to analyze spirometry results (e.g., training and supervised practicum, maintenance of competence).*

CLINICAL SITUATION OR TARGET POPULATION

Adult suspected of having chronic obstructive pulmonary disease (COPD) and whose respiratory symptoms and risk factors had been objectively assessed by the healthcare professional who [ordered](#) the pre-/post-BD spirometry test.

INDICATIONS TO THE APPLICATION OF THIS PROTOCOL

Adult referred for pre-/post-bronchodilator spirometry test for the diagnosis of suspected COPD.

CONTRAINDICATIONS TO THE APPLICATION OF THIS PROTOCOL

Contraindications to performing pre/post-BD spirometry identified after initiating (ordering) the test, namely:

- An unstable¹ or decompensated² cardiovascular or lung condition
- An active respiratory infection
- Eye surgery (within the past week)
- Poorly controlled glaucoma
- Abdominal or thoracic surgery (within the past 4 weeks)
- A diagnosed aortic aneurysm
- A technical functional constraint (e.g., a tracheotomy)
- Care objective D³
- Difficulty understanding the instructions or cooperating with the medical staff for the purpose of conducting the test
- Any other condition that could cause harm to the individual
- Non-compliant equipment that would compromise the person's safety or the reliability of the results
- Contraindications to all short-acting bronchodilators (SABDs)

¹ In the presence of an **unstable** heart or lung condition, immediate care takes precedence over confirming COPD by means of spirometry (e.g., a myocardial infarction, a pulmonary embolism, a thoracic, abdominal or cerebral aneurysm, or severe heart failure that has not been sufficiently stabilized).

² In the presence of a **decompensated** heart or lung condition, appropriate management is required before conducting a spirometry test.

³ Care Objective D: Provide comfort only, without aiming to prolong life. There is no clinical justification for administering a spirometry test to confirm COPD.

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 [Click here](#) for additional clinical tools on this topic.

INSTRUCTIONS

LIST OF ITEMS VERIFIED AT THE TIME OF ORDERING THE TEST

- Any contraindications to performing a spirometry test for diagnostic purposes
- The current use of inhaled medication
- The care objectives
- Considerations regarding the SABD to be administered during the test

1. STEPS TO BE TAKEN BEFORE CONDUCTING THE TEST FOR DIAGNOSING COPD

► When scheduling the appointment:

- Give the person the pre-test instructions in accordance with the local procedure.
(e.g., pausing the current bronchodilators⁴, no alcohol or tobacco use for 8 hours before the test, and no strenuous exercise or heavy meals for 1 hour before the test).
- Depending on the local setup, remind the person to purchase the short-acting bronchodilator prescribed for the test.

► A few days before the test:

- Check that there are no [contraindications](#) that could preclude the test from being carried out. If there are any, reschedule the appointment.
- Inquire about any history of severe reactions to salbutamol (e.g., transient tremor, transient palpitations or paradoxical bronchospasm) and consider an alternative option if necessary.
- Regarding medications, check if the person is currently using:
 - Medications that could interfere with the bronchodilator to be administered during the test (e.g., a non-selective beta-blocker);
 - An inhaled corticosteroid or a bronchodilator. In this regard, check the [withholding period](#) for the bronchodilator (longer for a long-acting bronchodilator) and inform the person of the required medication withholding period before the test.
- Confirm the care objectives;
- Review the pre-test instructions that were provided when the appointment was scheduled.

► On the day of the test, make sure that you have:

- A spirometer that meets the current standards and uses the latest calculation methods employed at the healthcare facility;
- A spirometer calibrated⁵ according to the manufacturer's instructions and local procedures;
- A single-use mouthpiece with a filter, a nose clip, and a valved holding chamber for administering the bronchodilator.

⁴ Before spirometry testing, it is not necessary to discontinue inhaled corticosteroids or leukotriene modifiers. Leukotriene modifiers are oral medications used to treat asthma. They may be added to inhaled corticosteroids (ICS) or other therapies, particularly in patients with asthma who have a leukotriene-mediated inflammatory component; however, they are not a first-line treatment for COPD alone.

⁵ Quality control procedures (calibration verification) must be repeated and documented following any modification and before conducting further tests (e.g., equipment repairs, software updates, equipment replacement or relocation, or whenever calibration verification fails).

- Equipment and a protocol for cardiopulmonary resuscitation (defibrillator) and the necessary medication in the event of severe bronchospasm;
- Salbutamol for the test or an alternative option, if needed⁶, depending on the individual's specific circumstances, e.g., a history of paradoxical bronchospasm or severe to very severe allergic reaction to salbutamol (rare).

2. PERFORMING PRE/POST-BRONCHODILATOR SPIROMETRY

► When conducting the test, ensure that:

- Review any specific information or instructions provided by the prescriber (e.g., continue with current inhaled medication, mild neurocognitive disorder⁷);
- Suggest to the person empty their bladder and remove any oral prostheses that could move before the test;
- Check:
 - Compliance with the pre-test instructions provided when the appointment was scheduled;
 - That there are no contraindications to applying this protocol.
- Record:
 - Any deviation from the pre-test instructions (e.g., type and dosage of any inhaled, oral or injected medication that could affect lung function, and the date and time of the last dose);
 - The information needed by the spirometer software to determine the reference values: weight, height, age, biological sex at birth, and ethnic origin (depending on the calculation model used)⁸;
 - The presence of excess weight (abdominal obesity⁹) that could compromise the spirometry test results and their interpretation;
 - The availability of a sufficient salbutamol¹⁰ doses for conducting the test.
- Provide the person information about:
 - The purpose of the spirometry test;
 - The possible adverse effects of the test (e.g., shortness of breath, dizziness, coughing, temporary incontinence, and increased intraocular, intracranial, intrathoracic or intra-abdominal pressure);
 - The possible adverse effects of the short-acting bronchodilator to be administered during the test (e.g., transient tremor that might be accompanied by palpitations).
- Assess the person's overall condition and check their vital signs, if deemed necessary. If need be, refer the person to a qualified professional for lung or heart auscultation.

⁶ Alternative options to salbutamol may include ipratropium bromide (≥ 20 kg: 80 mcg per treatment) or terbutaline (two inhalations of 0.5 mg each). For further information, consult the product monographs ([ipratropium bromide](#); [terbutaline](#)). The use of terbutaline (dry powder inhaler) as an alternative to salbutamol requires ensuring that the entire administered dose reaches the lungs, particularly through clinical observation of inhalation technique and inspiratory effort.

⁷ Instructions may be adapted and support provided for individuals with intellectual or cognitive limitations, or language barriers. Refer to spirometry-specific care procedures or specialized resources, as needed.

⁸ It is important to use the same reference equation set for predicted values as that used by local pulmonary function laboratories. When GLI 2012 reference equations or another ethnicity-specific reference equation set is used, the patient's ethnicity must be entered into the spirometer software prior to spirometry testing. When the GLI Global (GLI Race-Neutral) reference equations are used, ethnicity does not need to be entered.

⁹ In individuals with abdominal obesity, a non-parenchymal (non-specific) restrictive pattern may be identified during pre- and post-bronchodilator spirometry.

¹⁰ In persons receiving a non-selective beta-blocker, salbutamol may be partially effective or ineffective. In this situation, ipratropium bromide, a short-acting bronchodilator, may be used as an alternative, with a longer waiting period (approximately 30 to 45 minutes) before post-bronchodilator testing.

2.1 Conducting the test

! If a respiratory infection is suspected, reschedule the appointment or adjust the protective measures for the health professional who will be conducting the test, this in accordance with the local procedure and in collaboration with the infection prevention and control team.

► Before starting:

➤ Explain the procedure and the number of maneuvers¹¹ to be repeated, namely:

1. Pre-bronchodilator spirometry to obtain three valid and repeatable FEV₁ and FVC measurements (maximum of 8 attempts);
2. The administration of a short-acting inhaled bronchodilator (400 mcg of salbutamol¹² or the equivalent, with a valved holding chamber if a metered-dose inhaler is used) (wait 10 to 15 minutes¹³ to achieve the maximum response during post-bronchodilator maneuvers);
3. Post-bronchodilator spirometry to obtain three additional valid and repeatable FEV₁ and FVC measurements (maximum of 8 attempts).

➤ Demonstrate:

- The proper technique for performing respiratory maneuvers, emphasizing that maximum effort is required to obtain reliable results;
- The technique for administering an inhaled bronchodilator, stressing the importance of following the inhalation technique correctly in order to obtain reliable results.

► Take into account any constraints or circumstances indicated by the prescriber to facilitate the test and to determine whether to proceed with it.

► Make sure that the person understands the instructions¹⁴ and is cooperative so that valid maneuvers can be achieved. If not, reschedule the appointment or notify the prescriber.

2.2 Procedure (details in [Appendix II](#))

► Obtain at least three valid and repeatable curves during a maximum of eight attempts at breathing maneuvers (before and after the bronchodilator is administered)¹⁵.

- Allow sufficient time between breathing maneuvers so that the person can recover sufficiently and be willing to perform another optimal maneuver.

► During each breathing maneuver:

- Ensure that the person has the correct posture and that the nose clip is securely in place;
- Make sure that the lips are tightly sealed around the mouthpiece and that it is not obstructed by the tongue or teeth;
- Encourage the person throughout the procedure, remain vigilant for any signs of severe discomfort (e.g., signs of imminent fainting) and, if necessary, stop the test;

¹¹ A spirometry manoeuvre is a sequence of breathing movements consisting of a maximal deep inspiration followed by an expiration that is as forceful and rapid as possible. This manoeuvre is used to measure the forced expiratory volume in one second (FEV₁) and the forced vital capacity (FVC).

¹² The salbutamol dose may be reduced to 200 mcg in individuals with a history of tremor or tachycardia following administration of this bronchodilator.

¹³ If an anticholinergic agent is used (e.g., ipratropium bromide), allow a waiting period of 30 to 45 minutes before proceeding with the post-bronchodilator (post-BD) portion of the spirometry test.

¹⁴ Instructions may be adapted and support provided for individuals with intellectual or cognitive limitations, or language barriers. Refer to spirometry-specific care procedures or specialized resources, if necessary.

¹⁵ If three acceptable respiratory manoeuvres cannot be obtained during the pre-bronchodilator (pre-BD) phase, the post-bronchodilator (post-BD) phase is generally not clinically relevant.

- Make sure that the person has achieved maximum inspiration and maximum expiratory effort (ideally lasting 6 to 12 seconds with a 1-second plateau) with a rapid initiation of the breathing maneuver (with no hesitation or delay at the start of exhalation);
 - Visually inspect the performance of each maneuver before moving on to the next one in order to identify any:
 - Slow starts;
 - Early stops;
 - Flow rate variability;
 - Hesitation or delay at the start of exhalation (which artificially alters the FEV₁ value); or
 - Incomplete exhalations.
- Monitoring the person for and managing peri-test adverse effects.
- Continuously monitor for adverse effects associated with the spirometry test that could compromise the person's safety when returning home.
 - Monitor for warning signs that would require the test to be stopped, namely, signs of:
 - An unstable or decompensated cardiovascular or lung condition;
 - Bronchospasm;
 - Imminent fainting.
 - Administer emergency treatment as needed in the event of bronchospasm or an anaphylactic reaction (rare).

2.3 Analysis of the results for the report to the prescriber

- Assess the validity AND repeatability¹⁶ of the breathing maneuvers using volume-time curves and flow-volume loops ([Annexe III](#)).
- To help the prescriber interpret the results:
- Reject any maneuvers that do not meet the validity and repeatability criteria;
 - Record the reasons that can justify utilizing spirometric parameters derived from an invalid breathing maneuver but that are usable¹⁷;
 - Display only the lines of the spirometer report needed for interpretation (the FVC, FEV₁ and FEV₁/FVC ratio) or clearly identify them;
 - Select, from among the three valid breathing maneuvers, the best FEV₁ and FVC values and their ratio, and provide these choices, with comments, to the prescriber. These best values can come from different maneuvers.
- Indicate the plausible respiratory function profile based on the spirometry results and include it in the report ([Appendix IV](#)).

¹⁶ Of all respiratory manoeuvres performed, at least three should meet the acceptability and repeatability criteria (repeatability defined as a maximum difference of 150 mL between the two highest values).

¹⁷ For example, FEV₁ remains acceptable if a cough or premature termination of exhalation occurs after the first second. FVC remains acceptable even in the absence of an end-expiratory plateau, provided that the highest FVC values obtained are highly consistent.

3. INFORMATION TO BE PROVIDED TO THE PERSON

- ▶ Upon receiving the pre-/post-BD spirometry test results, the prescriber will determine if ordering additional tests is relevant.
- ▶ The pre-/post-BD spirometry test **may need to be repeated** if the validity and repeatability criteria for the breathing maneuvers were only partially met or if the result is close to the cutoff value.
- ▶ Remind the patient to continue using the prescribed inhaled medication until the next follow-up appointment.
- ▶ Inform the person that without a follow-up by the prescriber, primary care physician or specialized nurse practitioner (SNP), they should check with their clinic or family medicine group or the entity with which they are affiliated to confirm receipt of the results and, if necessary, request a follow-up.

4. FOLLOW-UP WITH THE PRESCRIBER

- ▶ Send to the prescriber the spirometry test results (best values for the FEV₁, FVC and FEV₁/FVC ratio), the conclusions of the analysis, and information relevant to the clinical interpretation for diagnostic purposes:
 - Any deviation from the pre-test instructions
 - The presence of an acute condition that could interfere with the test result or its interpretation
 - A lack of clinical stability at the time of the appointment
 - The date and time of the last dose of bronchodilator medication
- ▶ In accordance with the local procedure, ensure continuity of care by checking that the person has been registered and that the results will be interpreted by a physician or an SNP.

5. SITUATIONS REQUIRING SPECIAL ATTENTION, A REASSESSMENT OR FURTHER INVESTIGATION

Consult the prescriber in the following situations:

- A history of severe reaction to salbutamol, which may require the use of an alternative option for performing post-bronchodilator spirometry, or the individual refuses to use this medication again because of significant adverse effects experienced during previous use (e.g., tremor or tachycardia).
- No prescription for a short-acting bronchodilator for the purpose performing the post-BD phase of the spirometry test, if such a prescription is required by the local procedure.

Inform the prescriber in the following situations:

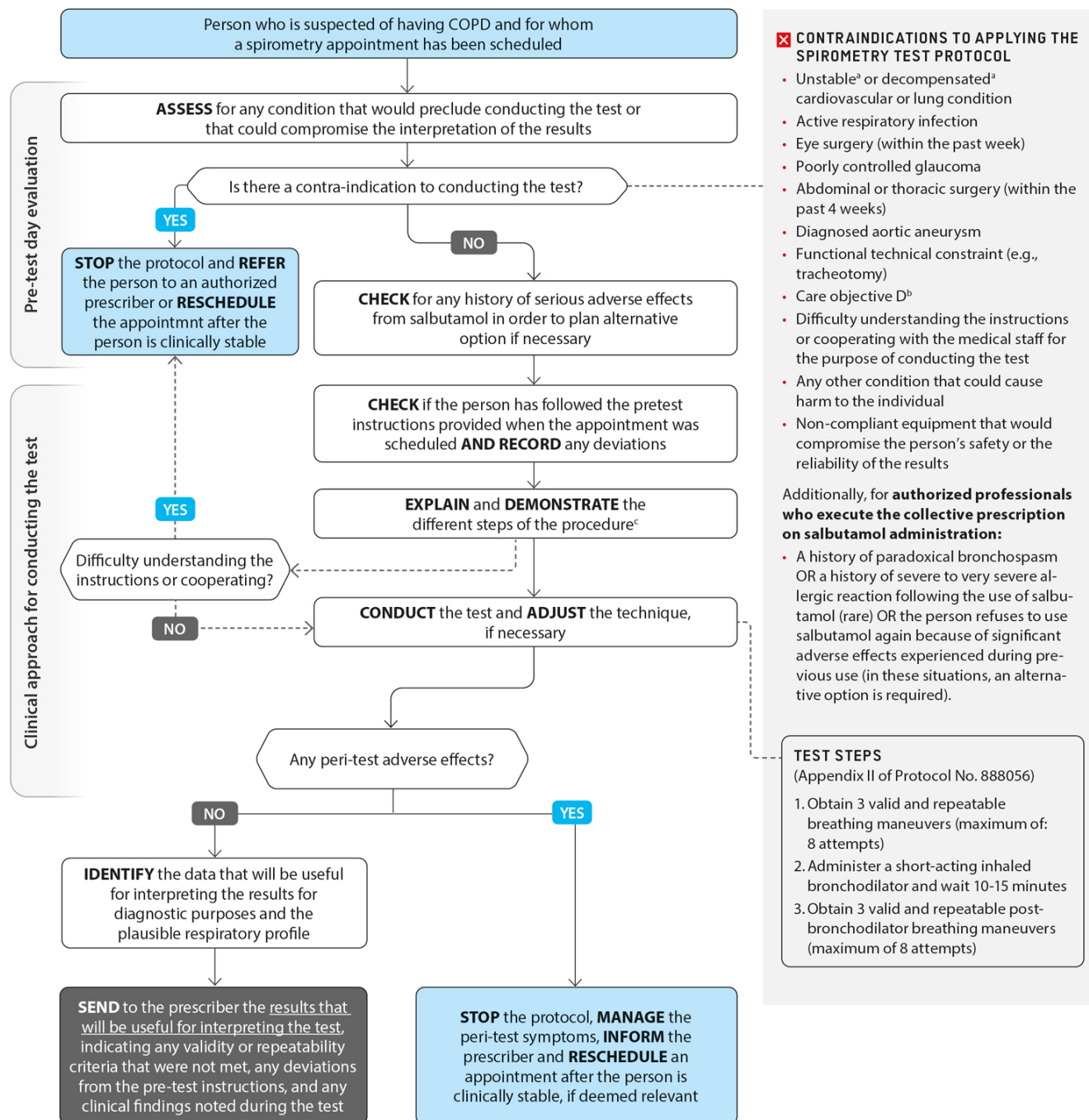
- The inability to obtain three valid breathing maneuvers during a maximum of eight attempts (pre- or post-bronchodilator¹⁸).
- Severe adverse effects or any signs of severe discomfort occurring during the test or in response to the short-acting bronchodilator.
- An FEV₁/FVC ratio close to the cutoff value of 0.7 in the presence of symptoms strongly suggestive of COPD.

Refer the individual to a healthcare professional qualified to perform lung or heart auscultation, based on their overall condition and vital signs at test time.

¹⁸ Communicate the acceptable results to the ordering clinician, together with any information relevant to their interpretation.

6. DECISION-MAKING ALGORITHM

- **All healthcare professionals who conduct pre/post-bronchodilator spirometry tests must have the necessary skills to do so and to analyze spirometry results (e.g., training and a supervised practicum, maintenance of competence)**
- Make sure that you have a spirometer that is calibrated according to the manufacturer's instructions AND complies with the current standards (including the latest calculation models used at the healthcare facility)



a. **Unstable** – A condition requiring immediate acute care rather than spirometry (e.g., a myocardial infarction [occurring less than a week ago], a pulmonary embolism, a thoracic, abdominal or cerebral aneurysm, or severe heart failure that has not been adequately stabilized).

Decompensated – A situation that requires appropriate care before the spirometry test is conducted.

b. Objective D: Provide comfort only, without aiming to prolong life. There is no clinical justification for administering a spirometry test to confirm COPD.

c. You can adjust the instructions and provide support to individuals with intellectual or cognitive limitations, or a language issue. Refer to specialized spirometry care methods or resources, if necessary.

REFERENCES

This protocol is based on the latest scientific data and best practice recommendations, enriched with contextual information and the perspectives of Quebec clinicians. For details on the protocol development process and to consult the references, see the [supporting report](#).

APPENDIX I – LENGTH OF BRONCHODILATOR WITHHOLDING PERIOD

INHALED BRONCHODILATOR	LENGTH OF WITHHOLDING PERIOD
SABA (e.g., salbutamol and terbutaline ¹⁹)	4 to 6 h
SAMA (e.g., ipratropium bromide)	12 h
LABA (e.g., formoterol or salmeterol)	24 h
Ultra-LABA (e.g., indacaterol, vilanterol or olodaterol)	36 h
LAMA (e.g., tiotropium, umeclidinium, aclidinium or glycopyrronium)	36 to 48 h

LABA: long-acting beta₂-agonist; LAMA: long-acting muscarinic antagonist; SABA: short-acting beta₂-agonist; SAMA: short-acting muscarinic antagonist...

¹⁹ Terbutaline: dry powder inhaler.

► **Procedure for pre-/post-bronchodilator spirometry test:**

1. Explain and demonstrate the test
2. Enter the data to determine the reference (predicted) value: weight, height, age and biological sex at birth
3. Check that the person is in the correct posture and that the nose clip is securely in place
4. Proceed to the maneuver:
 - Have the person place the mouthpiece (with antibacterial filter) in their mouth and check there is no leakage or blockage
 - The person inhales to total lung capacity (TLC)
 - Maximum exhalation (6 to 12 seconds with a 1-second plateau) with a peak at the start (with no hesitation or delay at the start of the exhalation)
5. Repeat this maneuver until 3 valid and repeatable curves are obtained
 - Variation of ≤ 150 mL for the FVC and FEV₁
 - **Maximum of 8 attempts**
6. Determine the bronchodilator response
 - **Administer a short-acting bronchodilator** using a valved holding chamber if a metered-dose inhaler is used (e.g., 4 inhalations of salbutamol 100 mcg/inh)
 - Wait for 10 to 15 minutes
 - Repeat the procedure set out in step 4 to obtain 3 additional valid and repeatable curves
 - **Maximum of 8 attempts**

APPENDIX III – VALIDITY AND REPEATABILITY CRITERIA

VALIDITY	Proper start - Maximal exhalation (6 to 12 seconds with a 1-second plateau) with a peak at the start (with no hesitation or delay at the start of the exhalation) - Back-extrapolated volume $\leq$ 5% of the FVC (or 100 mL), whichever is greater
	Flow-volume curve - Peak expiratory flow is reached quickly and occurs near the start of exhalation - A steady, continuous downward trend: no coughing, no glottal closure (premature termination) during the first second of exhalation, no leakage around the mouthpiece, no blockage of the mouthpiece, and no additional inhalations.
	Proper performance of the maneuver - Meeting at least one of the following three forced end-expiratory criteria: - Reaching an expiratory plateau (a volume change $\leq$ 25 mL lasting at least one second) OR - Having a forced expiratory time of 6 to 12 seconds, even if a plateau has not been reached OR - If no expiratory plateau, an FVC greater than (or within the repeatability range of) the highest FVC observed in the series of maneuvers¹. - If the peak inspiratory volume after the end of a forced expiration is greater than the FVC, then the FIVC–FVC difference must be less than or equal to 5% (or 100 mL) of the FVC, whichever is greater².
REPEATABILITY	The difference between the two highest FVC values and the two highest FEV ₁ values must be less than or equal to 150 mL ³ .

FEV₁: forced expiratory volume in one second; FIVC: forced inspiratory vital capacity; FIVC–FVC: difference between the volume inhaled and the volume exhaled during a complete maneuver; FVC: forced vital capacity.

¹ Occurs when the person cannot exhale long enough to reach a plateau (e.g., individuals with restrictive lung disease) or when they inhale or remove the mouthpiece before reaching a plateau.

² Although performing a maximum forced inspiration is strongly recommended, not doing this does not preclude a maneuver from being deemed acceptable, unless a specific search is being done for an extrathoracic obstruction.

³ The two highest FVC values and the two highest FEV₁ values may come from different breathing maneuvers. To assess repeatability, it is preferable to look at the FEV₁ rather than the FVC, since the latter varies according to the forced exhalation time. This assessment is performed for pre- and post-bronchodilator maneuvers.

Partially valid breathing maneuvers may sometimes be useful, for example:

- The FEV₁ is valid if a cough or premature termination of the breath occurs after the first second.
- The FVC is valid even if a plateau is not reached at the end of a forced expiration, provided the highest FVC values obtained are very similar.

APPENDIX IV – RESPIRATORY FUNCTION PROFILES

SPIROMETRIC PARAMETERS FOR DISTINGUISHING RESPIRATORY PROFILE TYPES USING THE FIXED RATIO OR LLN METHOD						
PARAMETER ¹	Obstructive Profile		Restrictive Pattern Profile		Mixed Profile (restrictive and obstructive pattern)	
	Fixed ratio	LLN	Fixed ratio	LLN	Fixed ratio	LLN
FEV₁/FVC ratio (based on the best post-BD FEV ₁ and FVC values)	< 0.7	< LLN	≥ 0.7	≥ LLN	< 0.7	< LLN
FVC (best post-BD values; % of the predicted value)	≥ 80%	≥ LLN	< 80%	< LLN	< 80%	< LLN
FEV₁ (best post-BD values; % of the predicted value)	Normal OR ↓	Normal OR ↓	↓	↓	↓	↓
Notes	N/A		% of the predicted. Post-BD FEV ₁ and FVC synchronously reduced.		% of the predicted. Post-BD FEV ₁ reduced to a greater degree than that of the post-BD FVC.	
Flow-volume loop	Concave		Convex or resembles the predicted loop but is smaller		Concave with low volume	

¹. The values reported for the ratio, FVC and FEV₁ are those obtained from the best measurements from three valid and repeatable post-BD breathing maneuvers.

- ▶ Both methods (fixed ratio and LLN) can be used to interpret the results, but they have certain limitations, especially in cases of mild COPD.
 - When the fixed FEV₁/FVC ratio method is used, extreme ages – that is, over 80 or under 50 – are associated with a risk of overdiagnosis or underdiagnosis, respectively, of COPD.
- ▶ Using the lower limit of normal (LLN) method to calculate the reference values (predicted values) requires appropriate reference equations for the calculations to be accurate (e.g., equations from the Global Lung Function Initiative, GLI). The new GLI Global equations (also known as GLI 2022), which include theoretical values based on age, sex and height derived from healthy population databases, are aimed at providing a racially neutral approach, although they still have certain limitations.
- ▶ Variations in the interpretation of spirometry results are possible if a different method for calculating the reference values is used. **To simplify the interpretation of results in primary case, the fixed ratio is proposed.**
- ▶ If the ratio is close to the cutoff value of 0.7 and there are symptoms strongly suggestive of COPD, consultation with a respirologist is favoured.
- ▶ For individuals with mild obstructive disease, the FEV₁ is normal (≥ 80% of the predicted value), but the FEV₁/FVC ratio is reduced.