National Asthma Council AUSTRALIA

Spirometry quick reference guide

A guide to performing high-quality spirometry

This quick reference guide contains practical information on how to do spirometry. Spirometry is an objective physiological test of lung function. A spirometer measures how much, and how quickly, air can be exhaled in a single blow from full lungs. Some spirometers also measure airflow during inspiration.

The spirometer must meet ATS/ERS performance criteria and be calibrated, cleaned and maintained according to the manufacturer's recommendations.

Abbreviations

BTPS	Body temperature and ambient pressure saturated with water vapour
COPD	Chronic obstructive pulmonary disease
FET	Forced expiratory time
FEV_1	Forced expiratory volume in 1 second
FVC	Forced vital capacity
GLI	Global Lung Function Initiative
LLN	Lower limit of normal for demographic group
PEF	Peak expiratory flow

Pre-appointment instructions for patients

- Ask patient to bring own inhaler and spacer.
- For a diagnostic test, withhold bronchodilators (Table on page 3).
- Advise patient to wear etc.

For more information, refer to the National Asthma Council Australia's Spirometry handbook for primary care available at www.nationalasthma.org.au.

Recommended bronchodilator withholding times

Short-acting beta$_2$ agonists (SABAs) Salbutamol (e.g. *Asmol*, *Ventolin*) Terbutaline (e.g. *Bricanyl*)	4 hours
Short-acting muscarinic antagonists (SAMAs) Ipratropium (e.g. *Atrovent*)	12 hours
Long-acting beta$_2$ agonists (LABAs) **with twice-daily dosing** Formoterol (e.g. *DuoResp Spiromax*, *Flutiform*, *Oxis*, *Symbicort*) Salmeterol (e.g. *Fluticasone and salmeterol Cipla*, *Serevent*, *Seretide*)	24 hours
Long-acting beta$_2$ agonists (LABAs) **with once-daily dosing** Indacaterol (e.g. *Onbrez*, *Ultibro*) Olodaterol (e.g. *Spiolto*) Vilanterol (e.g. *Anoro*, *Breo*, *Trelegy*)	36 hours
Long-acting muscarinic antagonists (LAMAs) Aclidinium (e.g. *Bretaris*, *Brimica*) Glycopyrronium (e.g. *Seebri*, *Ultibro*) Tiotropium (e.g. *Braltus*, *Spiriva*, *Spiolto*) Umeclidinium (e.g. *Anoro*, *Incruse*, *Trelegy*)	

NOTE: For combination therapies containing more than one listed medicine, use the longer withholding time

Preparing the spirometer

Use GLI-2012 reference equations validated in multiple ethnic groups and age groups.

Prepare the spirometer by following the manufacturer's instructions:

- Check spirometer is correctly set up – ensure LLN enabled and correct reference values selected.
- Determine zero flow level (if required for the spirometer) and perform calibration/verification check.
- Attach disposable filters/mouthpiece.
- Enter room temperature and barometric pressure (if not automatically measured and recorded).
- **Enter patient information:**
  - height without shoes†
  - weight without shoes†#
  - date of birth
  - sex at birth
  - ethnicity (ask patient to identify)
  - smoking status.

If the patient has used an inhaled bronchodilator on the day of the test (or within recommended bronchodilator withholding times), record the dose and time last taken.

† Measure before the test – do not rely on the patient's report.
# Not essential for predicted values but can be useful for interpretation.

Preparing the patient

Check for contraindications or any conditions likely to make the test unreliable.

Explain to the patient:

- **what the test measures**
  The aim of this lung function test is to measure how much air you can blow out with one breath, and also how fast you can blow that air out.
- **what they will need to do**
  To do the test properly you will need to breathe in the biggest breath you can until your lungs are completely full, and then blow out very hard and very fast into the mouthpiece, until your lungs are completely empty. You will have to keep trying to breathe out for a few seconds longer than feels comfortable.
- **how many times they will need to do it.**
  You will need to do the test at least three times (but probably more) to make sure we get reliable results.

Demonstrate correct posture and the amount of force needed when exhaling.

Give simple, clear instructions during the test.

Advise the patient that doing the test properly (maximal effort) is hard work and they may become light-headed while blowing out, but they will be given a chance to rest between attempts. They should stop if they become excessively dizzy or if they have significant pain.

NOTE: The use of a nose clip is recommended for forced manoeuvres, but is not essential.

Performing the test

Wash your hands before and after the test and wear gloves as necessary.

Coach the person to make maximal effort and exhale completely – verbal encouragement is essential for best results.

Keep going, you're doing well, keep going

Closed-circuit method
(measuring expiratory and inspiratory flow)

The patient should:

1. sit upright with their legs uncrossed and their feet flat on the floor, without leaning forward
2. place the mouthpiece in their mouth and close their lips to form a tight seal
3. breathe normally for 2–3 breaths
4. breathe in rapidly and deeply until their lungs are completely full
5. without pausing for more than 2 seconds, blast air out as hard and fast as possible and for as long as possible, until their lungs are completely empty or they cannot possibly blow out any longer
6. keeping a tight seal on the mouthpiece, breathe in again as forcefully and fully as possible
7. remove the mouthpiece and breathe normally.

Open-circuit method
(measuring expiratory flow only)

The patient should:

1. sit upright with their legs uncrossed and their feet flat on the floor, without leaning forward
2. breathe in rapidly and deeply until their lungs are completely full
3. immediately place the mouthpiece in their mouth and close their lips to form a tight seal
4. without pausing for more than 2 seconds, blast air out as hard and fast as possible and for as long as possible, until their lungs are completely empty or they cannot possibly blow out any longer
5. remove the mouthpiece and breathe normally.

Acceptability criteria for a single blow

A blow is acceptable if:

- it meets criteria for the start of forced expiration
- it meets criteria for the end of forced expiration
- the operator observed that the patient achieved maximal inhalation and made maximal expiratory effort
- there is no evidence of other faults.

Criteria for start of forced expiration

Blow must achieve **both** of 2 conditions:

1. Back-extrapolated volume is less than 5% of FVC or less than 0.100 L, whichever is greater

   AND

2. Hesitation time is less than 2 seconds.

PEF should be achieved with a sharp rise and close to the start of expiration (time zero) on the displayed flow–volume curve.

Criteria for end of forced expiration

Blow must show smooth continuous exhalation with maximal effort until lungs empty.

Blow must achieve **one** of 3 conditions:

1. A definite plateau at the end of time–volume curve (<0.025 L change in volume for at least 1 second)

   OR

2. FET ≥ 15 seconds (applies only if no plateau reached)

   OR

3. FVC is greater than (or within repeatability limits of) their highest FVC value for the testing set (applies only if patient cannot expire long enough to achieve plateau).

Repeatability criteria for multiple blows

FEV_1

The two largest values for FEV_1 from acceptable manoeuvres should be within 150 mL of each other.

FVC

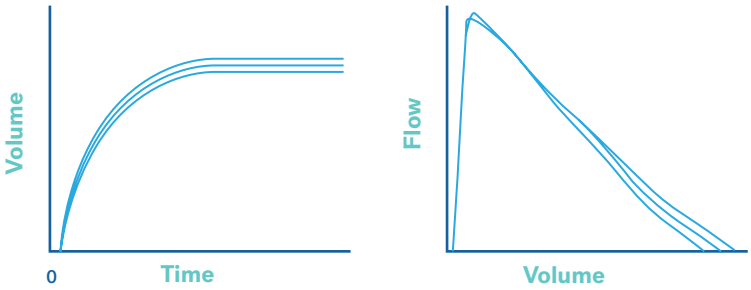
The two largest values for FVC from acceptable manoeuvres should be within 150 mL of each other.

For a complete test

Obtain at least 3 acceptable blows (for adults, usually no more than 8 blows in total should be attempted).

Check repeatability.

Testing is complete when acceptability and repeatability criteria are achieved, or a maximum of 8 trials has been attempted.



Criteria apply to adults and children older than 6 years.

Superimposing curves helps determine repeatability.

Newer spirometers automatically calculate highest FEV_1 and FVC values from three acceptable blows.

Assessing bronchodilator responsiveness ('reversibility')

Performing baseline and post-bronchodilator spirometry

1. Perform baseline spirometry (meeting acceptability and repeatability criteria).
2. Administer bronchodilator (e.g. 4 separate puffs salbutamol (*Ventolin/Asmol)* 100 micrograms per puff via a pressurised metered-dose inhaler and spacer).
3. Wait 10–15 minutes.
4. Repeat spirometry.

Calculate percentage and absolute increase in FEV_1

$$\textbf{FEV}_1\textbf{ \% response} = 100 \times \frac{FEV_1\text{ (post bronchodilator)} - FEV_1\text{ (baseline)}}{FEV_1\text{ (baseline)}}$$

Absolute change in FEV_1 = *post-bronchodilator FEV_1 – baseline FEV_1*

Definition of positive bronchodilator response

Adults and adolescents ≥12 years: increase in FEV_1 (or FVC) of ≥12% **and** an absolute increase in FEV_1 (or FVC) of ≥200 mL

Children: an increase in FEV1 (or FVC) of ≥12%

NOTE: pre-and post-bronchodilator readings must be made and recorded for Medical Benefits Schedule reimbursement (refer to www.mbsonline.gov.au).

Identifying abnormal ventilatory patterns

1. Is the shape of the flow–volume curve normal?

2. Is FEV_1/FVC ratio normal?

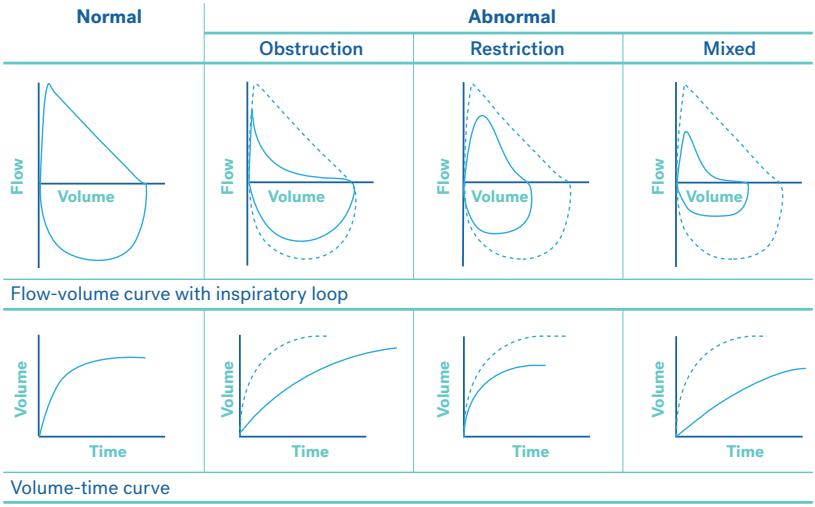
FEV_1/FVC ratio < LLN identifies expiratory airflow obstruction.

Use FEV_1% predicted to assess severity.

3. Is FVC normal?

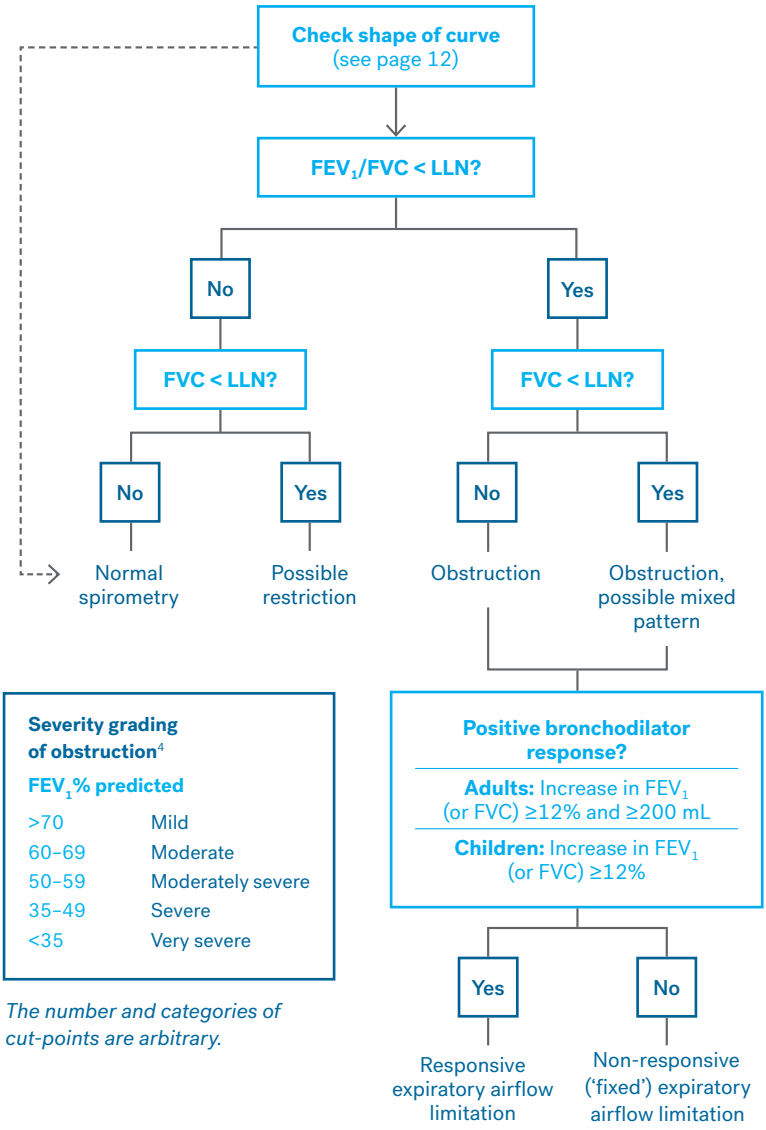
FVC < LLN identifies potential restriction.

Recognising abnormal ventilatory patterns on spirometry curves



Obstructive	Restrictive	Mixed
Pattern		
Expiratory airflow limitation: unable to blow out quickly (e.g. asthma, COPD, asthma–COPD overlap)	Small lungs (e.g. pulmonary fibrosis, interstitial lung disease, pleural/chest wall disease, weak inspiratory muscles, rib deformity, obesity)	Small lungs and unable to blow out quickly (e.g. cystic fibrosis)
Spirometry findings		
Low FEV_1/FVC (<LLN) Concave flow–volume curve	Low FVC (<LLN) FEV_1/FVC ratio normal or high Flow–volume curve shows small volume	Low FEV_1/FVC ratio (<LLN) Low FVC (<LLN) Reduced FEV_1 predicted Concave flow–volume curve with small volume

Interpreting spirometry results



Severity grading of obstruction[4]

FEV$_1$% predicted	
>70	Mild
60–69	Moderate
50–59	Moderately severe
35–49	Severe
<35	Very severe

The number and categories of cut-points are arbitrary.

Adapted with permission from Queensland Health Spirometry Training Program

Obtaining reliable results

Correct spirometry technique is crucial to obtaining reliable results for making a diagnosis or monitoring management of respiratory conditions.

Operators must have completed training that meets TSANZ standard** and be able to:

- use, maintain and validate the spirometer
- identify whether tests have been done correctly
- resolve common problems.

The test requires effort by the patient, so there must be cooperation between the operator and the patient, and continual coaching by the operator during the test.

It is essential to meet acceptability and repeatability criteria.

More information

Graham BL, Steenbruggen I, Miller MR *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: e70-e88.

NAC how-to video: https://www.nationalasthma.org.au/living-with-asthma/how-to-videos/performing-spirometry-in-primary-care

Australian asthma handbook (asthmahandbook.org.au)

The COPD-X plan (available at https://copdx.org.au)

National Asthma Council Australia (nationalasthma.org.au)

List of accredited respiratory laboratories maintained by TSANZ: https://www.thoracic.org.au/respiratorylaboratoryaccreditation/australia

Notes

* The 2019 joint official statement on the standardisation of spirometry by the American Thoracic Society (ATS) and European Respiratory Society (ERS) introduced new requirements for the manufacture of spirometers. These performance standards apply to new spirometers, but are not met by all spirometers in use in Australia. During this transition, all spirometers used in clinical practice must meet the ATS/ ERS 2005 standard (Miller et al 1999) or the ATS/ERS 2019 standard (Graham et al 2019).

** Thoracic Society of Australia and New Zealand. Standards for spirometry training courses. Companion document to Standards for the delivery of spirometry to spirometry for coal miners. Sydney: TSANZ; 2017.

This Spirometry quick reference guide is based on the Spirometry Handbook for primary care.

Sources

Brazzale D, Hall G, Swanney MP. Reference values for spirometry and their use in test interpretation: A position statement from the Australian and New Zealand Society of Respiratory Science. *Respirology* 2016; 21: 1201-9.

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Pellegrino R, Viegi G, Brusasco V *et al*. Interpretive strategies for lung function tests. *Eur Respir J* 2005; 26: 948-68.

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Thoracic Society of Australia and New Zealand. Standards for spirometry training courses. Companion document to *Standards for the delivery of spirometry to spirometry for coal miners.* Sydney: TSANZ; 2017.

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