

SPIROMETRY

Safety

| Contraindications. | Precautions. |
|--------------------------------------------------------------------------------------|-----------------|
| Unstable cardiovascular status i.e. angina, MI or CVA past 3/12, Severe Hypertension | Pregnancy |
| Haemoptysis of unknown origin | Chest Infection |
| Pneumothorax | Ear Infection |
| Thoracic, Abdominal or cerebral aneurysm | |
| Recent eye surgery / cataracts / glaucoma | |
| Recent thoracic / abdominal surgery | |

Technique – Slow Vital Capacity

- **Perform prior to forced manoeuvre**
- Ensure spirometer calibrated / serviced / cleaned
- Check contra-indications and blood pressure
- Record height, age, sex, ethnic origin (remember to change factor if required)
- **Pre bronchodilator / Post bronchodilator – depending on assessment ensure patient has or has not taken medication prior to manoeuvre**
- Sit upright
- Wearing a nose clip
- Inhale completely
- Place mouthpiece in mouth and close lips around the mouthpiece to get a good seal
- Exhale with a relatively constant flow, and not unduly slowly, until no more air can be expelled whilst maintaining an upright position
- Repeat for a maximum of four manoeuvres
- Check quality and repeatability criteria have been met (Required 3 good quality blows with at least two within 5% variability)

Technique – Forced manoeuvres

- ❖ Performing an FVC manoeuvre
 - Ensure spirometer calibrated
 - Check contra-indications and blood pressure
 - Record height, age, sex, ethnic origin (remember to change factor if required)
 - **Pre bronchodilator / Post bronchodilator – depending on assessment**
 - Sit upright
 - Inhale completely and rapidly with a pause of <1sec at TLC
 - Place mouthpiece in mouth and close lips around the mouthpiece
 - Exhale maximally, “blast the air” until no more air can be expelled whilst maintaining an upright position
 - Repeat instructions as necessary, coaching vigorously
 - Repeat for a minimum of three manoeuvres, up to a maximum of eight

- Check repeatability

No more than eight manoeuvres in one sitting. – **BTS 1997.**

Acceptability

- ❖ In order for a test to be acceptable it must meet the following criteria:
 - At the start of test there should be no hesitation and no coughing
 - The subject should be encouraged to achieve maximal effort throughout
 - Full expiration should be achieved. This can be >15 seconds required in obstructed patients and can be seen by a plateau of the volume/time curve
 - Without a glottis closure / leak / an obstructed mouthpiece

Repeatability

- ❖ An adequate test requires a minimum of three acceptable FVC manoeuvres
- ❖ Acceptable repeatability occurs when
 - The difference between the largest and next largest FVC is $\leq 0.150\text{L}$ and the difference between the largest and next largest FEV1 is $\leq 0.150\text{L}$ (**ATS, 2005**)
 - The difference between the largest and next largest FVC is $\leq 0.100\text{L}$ or 5% and the difference between the largest and next largest FEV1 is $\leq 0.100\text{L}$ or 5% (**BTS, 2005**)

Infection Control

- ❖ Adhere to your local guidance, which may include use of one-way mouthpieces (BTS, 2005) or viral/bacterial filters.
- ❖ Maintain a record of cleaning, disinfection and sterilisation

Verification

- ❖ Verification is the process by which you check if the spirometer is measuring within an acceptable level of variability. It is measured via a 3 litre syringe at a variety of flow rates
- ❖ Maintain a record of verification, as well as any repairs, alterations, software updates and relocation of equipment (ATS, 2005)

Calibration

- ❖ Calibration is the adjustment of the spirometer when a difference is noted between the known and measured value inputted via the verification procedure

Common problems encountered during spirometry testing

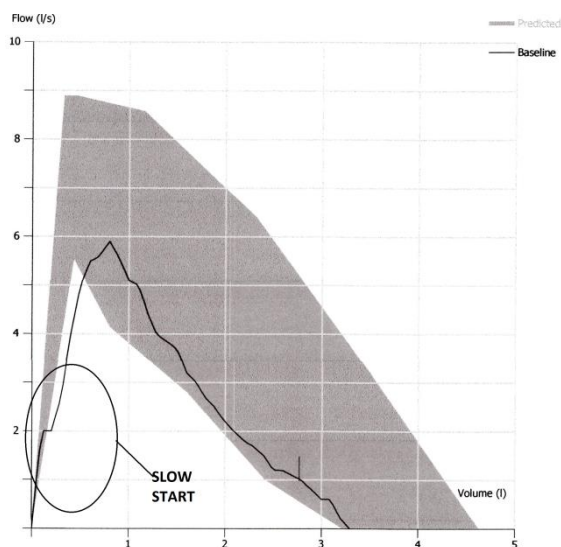
1. Patient technique - Slow Start:

Identifying the problem:

Identified by the lag behind the predicted line on the volume/time graph and on the flow/volume graph. Remember the top of the flow volume curve (peak flow) should look like a peak, not a curve a curve would suggest a slow start.

Overcoming the problem:

- Ensure patient is full aware of necessary technique.
- Utilising the phrase “blast the air out” may help, along with vigorous coaching and encouragement.
- Ensure there is no leak around the mouthpiece or nose clip and that the mouthpiece is not obstructed by tongue, teeth or dentures.
- Demonstration of good start technique.



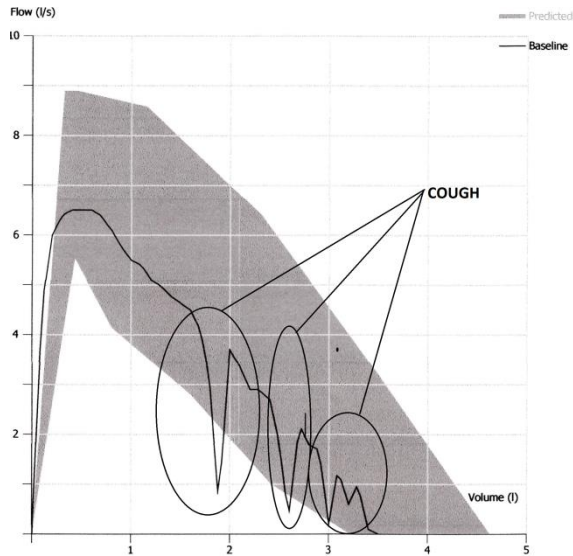
2. Patient technique - Cough:

Identifying the problem:

Identified via the rapidly changing inspiratory and expiratory flow rates on the flow/volume graph.

Overcoming the problem:

- Ensure the testing environment is suitable i.e. no allergens (dust, pets, smoke, perfumes etc.),
- Ensure sufficient rests between tests,
- May have to consider utilising VC resu



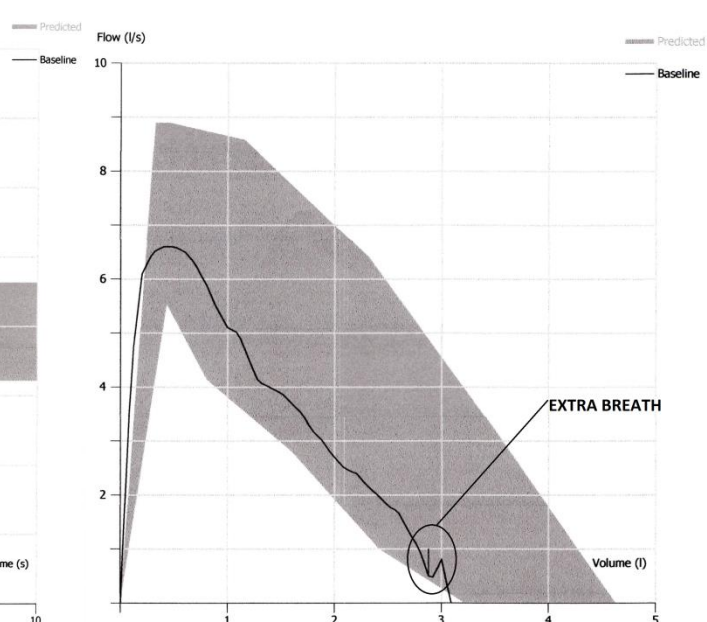
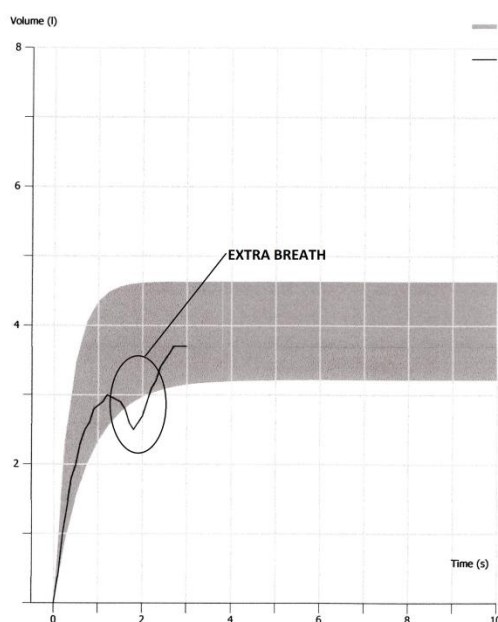
3. Patient technique - Extra breath taken:

Identifying the problem:

Identified by the small reduction in volume (or a dip) in the volume time graph, or as a small reduction in the flow in the flow/volume graph. If the patient takes another full breath in and out a second flow volume loop will be seen at the end of the original curve.

Overcoming the problem:

- Ensure the patient is aware that the test does not require a second breath to be taken.
- Close monitoring of patient, along with vigorous coaching and encouragement may also help.
- Demonstration of good technique.



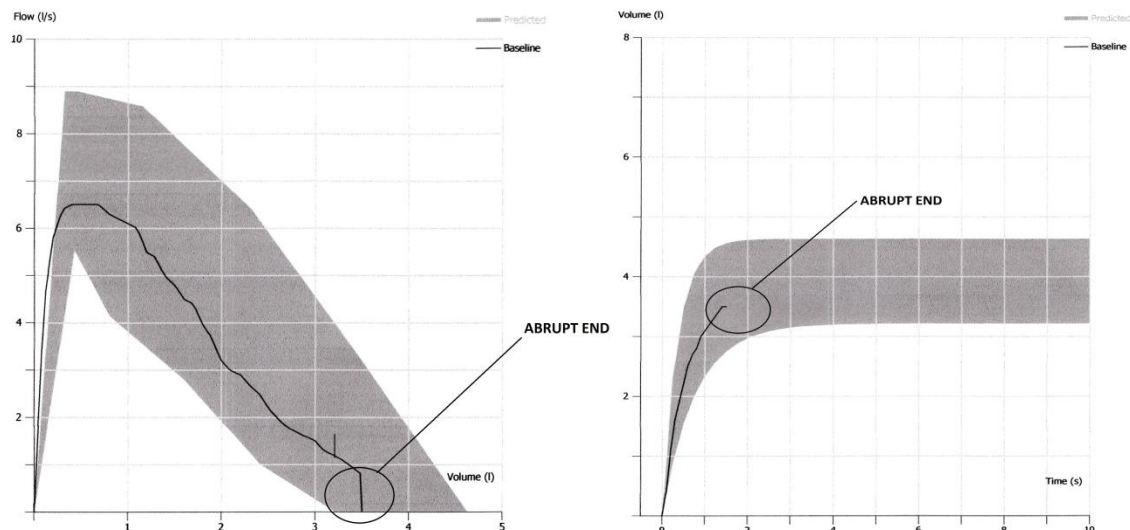
4. Patient technique - Abrupt end:

Identifying the problem:

Identified via the short expiratory time on the volume / time graph and the sharp decrease in flow at the end of the flow/volume graph – usually takes approximately four seconds for a “normal” to completely exhale.

Overcoming the problem:

- Ensure patient is aware they need to completely empty their lungs.
- Utilisation of the phrase “squeeze all of the air out of the lungs” may help.
- Vigorous coaching and encouragement all the way to the end of the test.
- Demonstration of good technique.



5. Patient technique - Short blow:

Identifying the problem:

Identified by the fact the blow is complete within 1 second on the volume/time graph. By looking at the results you can see the FEV1/FVC ration is 100% - this means all of the air was blown out in the first second. This graph looks more like a peak flow measurement than a spirometry measurement.

It takes on average 6 seconds to complete a full FVC manoeuvre. If a patient does not exhale for 6 seconds this result could then give a false impression of a restrictive ventilatory defect.

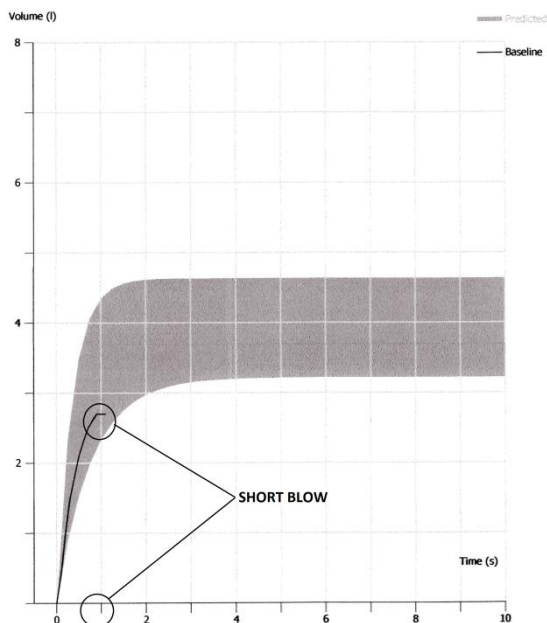
Overcoming the problem:

- Ensure the patient is aware how spirometry differs from a peak flow and explain that they need to completely empty their lungs.
- Demonstration of good technique.

- Utilisation of the phrase “squeeze all of the air out of the lungs” may help.
- Vigorous coaching and encouragement all the way to the end of the test.

Summary of All forced tests

| | FEV1 | FVC | PEF | FEV1/FVC |
|--------------|-------------|-------------|------------|-----------------|
| Base | 2.77 | 2.78 | 379 | 100% |
| Base+ | 2.77 | 2.78 | 379 | 100% |



INTERPRETATION OF SPIROMETRY

Indices:

- ❖ Forced expiratory volume in 1 second (FEV1)
 - The FEV1 is the maximal volume of air in litres forcibly exhaled in the first second of an FVC manoeuvre.
- ❖ Forced Vital Capacity (FVC)
 - The FVC is the maximal volume of air in litres maximally exhaled following a maximal inspiration.
- ❖ Vital Capacity (VC)
 - The VC is the maximal volume of air in litres steadily exhaled following a maximal inspiration e.g. as FVC but without force, sometimes described as a slow VC.
 - Can exceed FVC by >200ml indicating air trapping.
- ❖ Ratio
 - The ratio of FEV1/FVC expressed as a fraction. (may be written as FER, or FEV1/FVC)

- ❖ Forced Expiratory Flow (FEF) can be defined as what fraction remains of the forced vital capacity (FVC) and as such FEF 25 – 75% and FEF 25-50% are more sensitive to changes in the smaller airways than FEV1, and therefore may be useful in detecting early signs of airflow obstruction.

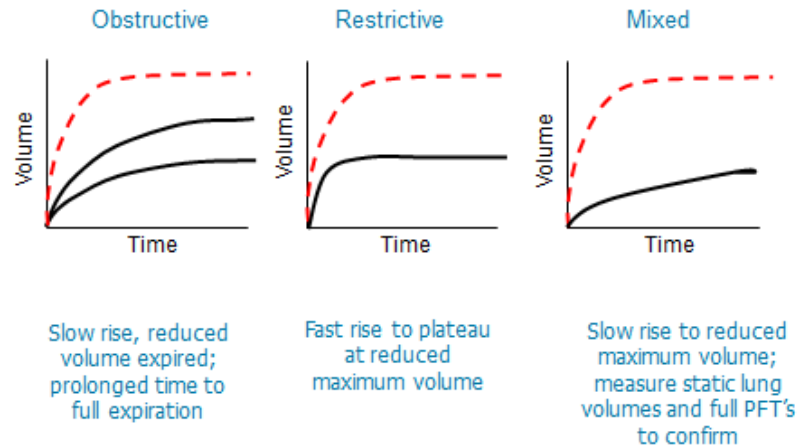
Patterns of spirometry results:

| | FEV1 | FVC or VC (VC max) | RATIO |
|-------------------------------------------------------|-----------------|---------------------------|-------------------------|
| NORMAL | ↑ 80% predicted | ↑ 80% predicted | ↑ Lower limit of normal |
| OBSTRUCTIVE (Moderate, Severe, Very Severe) | ↓ 80% predicted | ↑ 80% predicted | ↓ lower limit of normal |
| OBSTRUCTIVE (Mild) | ↑ 80% predicted | ↑ 80% predicted | ↓ lower limit of normal |
| RESTRICTIVE | ↓ 80% predicted | ↓ 80% predicted | ↑ lower limit of normal |
| COMBINED | ↓ 80% predicted | ↓ 80% predicted | ↓ lower limit of normal |

Classification of COPD Severity: NICE Guidelines 101 Chronic Obstructive Pulmonary Disease. Management of COPD in adults in primary and secondary care. **(2018)**

| Post bronchodilator FEV1/FVC | FEV1 % predicted | Severity classification |
|------------------------------|-------------------------|--------------------------------|
| <0.7 | 80% | Stage 1 (mild) |
| <0.7 | 50 – 79% | Stage 2 (moderate) |
| <0.7 | 30 – 49% | Stage 3 (severe) |
| <0.7 | < 30% | Stage 4 (very severe) |

Volume Time Curves



Reversibility

ASTHMA: GOLD, Global Strategy for Asthma Management and Prevention, 2010

- ❖ Spirometry is the preferred method of measuring airflow limitation and its reversibility to establish a diagnosis of asthma. An increase in FEV1 of $\geq 20\%$ and 400ml after an administration of a bronchodilator indicates reversible airflow limitation consistent with asthma.

Useful references:

- ❖ PCRS : <https://www.pcrs-uk.org/spirometry>
- ❖ <https://www.brit-thoracic.org.uk/standards-of-care/quality-improvement/copd-and-spirometry/>
- ❖ **PCC Spirometry:** 2013
- ❖ **ATS / ERS Task force:** Standardisation of Spirometry 2005
- ❖ **BTS COPD Consortium.** Spirometry in Practice: A practical guide to using spirometry in primary care 2nd edition 2005
- ❖ **Global Initiative for COPD:** Spirometry for Health Care Providers 2016
- ❖ **NICE Clinical Guideline 101, 2010** Management of COPD in adults in primary and secondary care.