Spirometry in primary care

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PennineGPLearning

What is spirometry?

- A method of assessing lung function
- Measures volume of air a patient can expel after a full inspiration
- Recorded as flow volume curve/loop or classic spirogram of volume-time graph

Uses of spirometry

- Assesses lung function in a measurable, quantifiable and reproducible way
- Differentiates between Obstructive (e.g. COPD/Asthma) and Restrictive lung diseases (e.g. Pulmonary fibrosis, scoliosis, obesity, lung resection, neuromuscular diseases)
- Used to diagnose COPD and asthma – must be correlated with clinical history
- Used to diagnose severity of COPD and asthma and for monitoring response to treatment as well as disease progression

Spirometry measurements

3 most important measures are:

- **FEV_1** (Forced Expiratory Volume): volume of air that patient is able to exhale in first second of forced exhalation (in litres). A healthy patient will expire between 70 and 90% of the FVC in the first second of the test. This means that he/she takes roughly about 5 seconds to expire the last 10 to 30 % of the FVC.

- **FVC** (Forced Vital Capacity) : total volume of air that patient can forcibly exhale in one breath (in litres)

- **FEV_1/FVC** : ratio of FEV_1 to FVC (can be expressed as a number or percentage)

Spirometry measurements

Can also measure:

- **VC** : slow vital capacity (use if higher than FVC or if patient cannot perform forced full exhalation)
- **FEV_1/VC** : ratio of FEV_1 to VC
- Values of FEV_1 and FVC are expressed as a percentage of predicted normal values for a person of the same age, gender, height and ethnicity

Important variables

These affect the predicted normal values in spirometry parameters:

- Age
- Gender
- Height
- Ethnicity (predicted normal values tend to be lower in Asians and Afro-Carribeans compared to Caucasians)

Absolute contraindications to spirometry

- Active infection e.g. TB till treated for 2 weeks

- Conditions which require avoidance straining/forced exhalation such as:

  - dissecting/unstable aortic aneurysm,
  - current pneumothorax
  - recent surgery

Relative contraindications to spirometry

- Suspected respiratory infection in last 4-6 weeks
- Undiagnosed chest symptoms such as haemoptysis
- Any condition which may be aggravated by forced expiration such as:

  - PMH of pneumothorax
  - Recent MI/PE/vascular event (within 1 month)
  - Uncontrolled hypertension
  - Previous thoracic or eye or abdominal surgery

- Patient too unwell to perform procedure
- Communication problems such as learning disability or confusion

Spirometry procedure – Pre-test advice to patient

Avoid:

- smoking at least 24 hours before the test
- eating a large meal before the test
- vigorous exercise before the test
- wearing tight clothing at time of test

Spirometry procedure –pre-test advice to patient

Investigating/establishing diagnosis requires initial baseline test and if obstructive picture present then post-bronchodilator test/reversibility testing.

Advise patients (before the test) to **STOP** :

- Short acting bronchodilator for 4 hours
- Long acting beta 2 agonist bronchodilator for 8 hours
- Long acting antimuscarinic bronchodilator for 36 hours

CONTINUE – inhaled and oral steroids

Spirometry procedure –pre-test advice to patient

For monitoring existing conditions patients require post-bronchodilator spirometry only:

Before the test **CONTINUE**:

- All usual inhaled therapy

Spirometry procedure

- Seat patient comfortably
- Apply nose clip (for VC but not essential for FVC)
- Patient inhales maximally
- Then for VC slow exhalation through mouthpiece for as long as possible
- For FVC fast and hard exhalation for as long as possible

Spirometry procedure

- Minimum of 3 acceptable manoeuvres for each measurement
- Maximum variability 100ml between each blow meets repeatability criteria

- Ensure patient:
  - breathes in to maximal inspiration
  - doesn't obstruct mouthpiece with their teeth or tongue
  - seals lips around mouthpiece and there are no leaks
  - removes false teeth if they are loose

- Observe for slow starts, early stops and variability in flow within the manoeuvres. This will help with interpreting the spirometry traces.

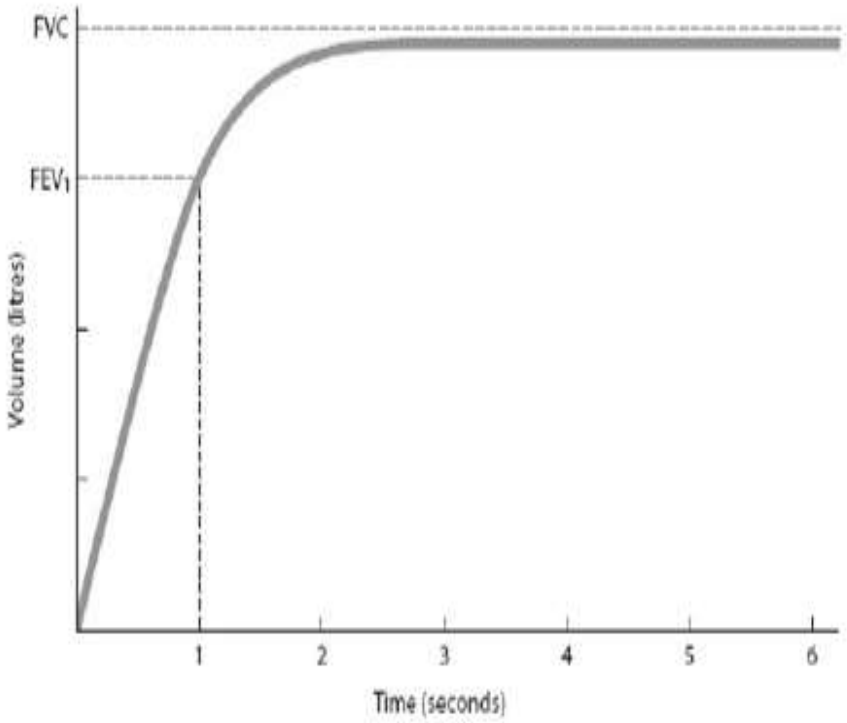
Spirometry procedure

- Do not perform more than 4 VC procedures in 1 session
- Do not perform more than 8 FVC procedures in 1 session – rebook another appointment to perform the procedure again.
- **Post-bronchodilator testing**

  Patient inhales 200-400mcg salbutamol or 500mcg terbutaline via spacer and spirometry repeated after 15-20mins.

Normal spirometry results

- Volume-Time graph



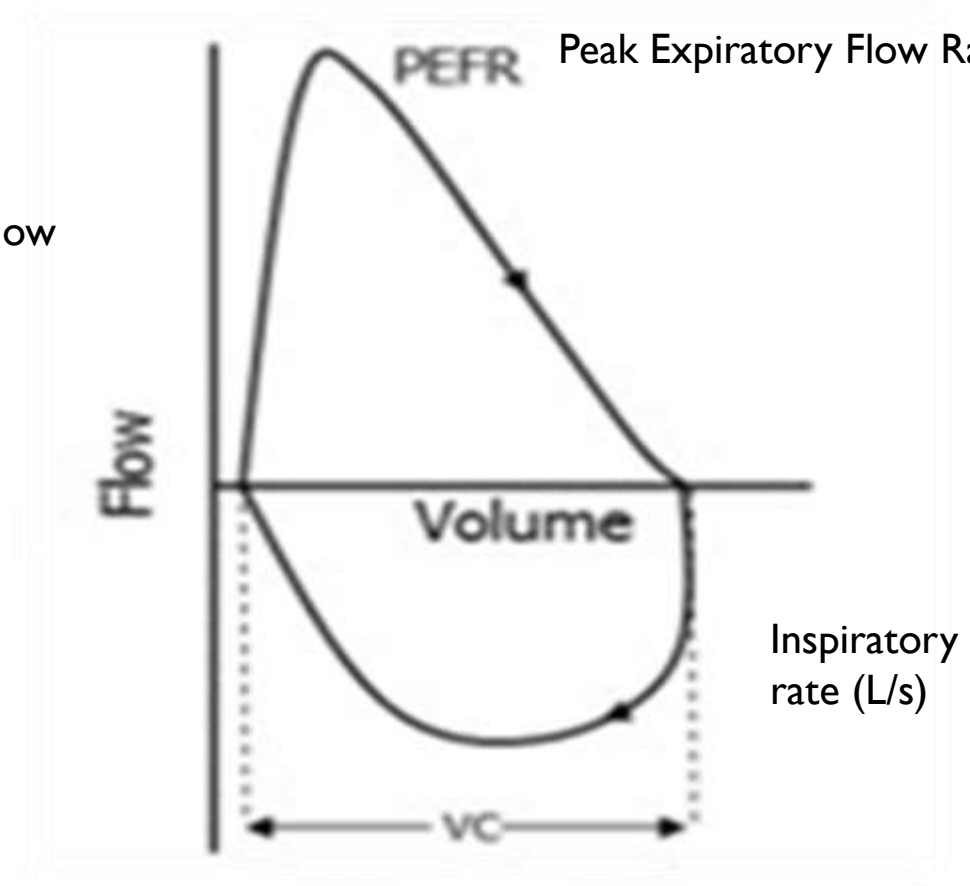
Volume-Time graph explained

- The volume expired in the first second of the FVC test is called $FEV_{1.}$ Healthy patients will expire most of the air in their lungs during this time.

- FVC is the total volume that the patient forcibly exhales in one breath and is usually reached by about 6 seconds in healthy people. This is the highest point reached on the curve.

Normal spirometry results

- Flow-volume loop



Flow-Volume loop explained

- A Flow-Volume loop begins at the intersection of the X-axis (volume) and Y-axis (flow): at the start of the test both flow and volume are equal to zero.

- Directly after this starting point the curve rapidly mounts to a peak: Peak (Expiratory) Flow. In healthy patients, this PEF is attained in less than a second. The PEF measures the air expired from the large upper airways (trachea-bronchi).

- After the PEF the curve descends (i.e. the flow decreases) as more air is expired until the flow reaches zero. This is when the FVC is reached : the patient has blown out as much air as he/she can.

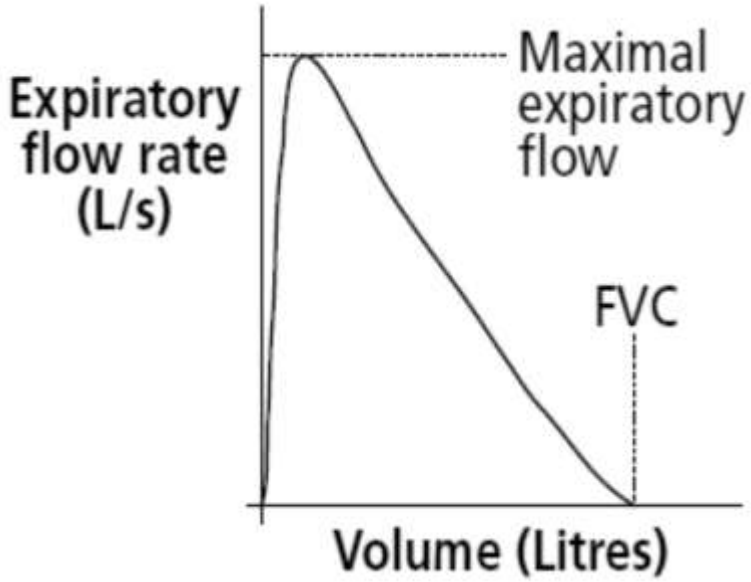
Flow volume loop explained

- Once the FVC is reached the patient performs a forced and complete inspiration which completes the loop below the X-axis.

- This is not absolutely necessary for interpretation of the test and if it is missed you have a flow-volume curve.

Normal spirometry results

- Flow- volume curve



Diagnosis COPD

- FEV_1/FVC < 0.7 or 70% indicating airway obstruction

  AND FEV_1 < 80 % predicted normal value **with or without** symptoms

  or ≥ 80 % predicted normal **with** respiratory symptoms

- FVC can be normal or reduced

- Little or no reversibility demonstrated on post-bronchodilator spirometry

- Expiratory flow volume curve appears concave

Severity of COPD

- Indicated by level of FEV_1 reduction

- According to NICE 2010 and GOLD 2011 guidelines:

  Stage 1 – Mild - FEV_1 ≥ 80 % of predicted normal with respiratory symptoms

  Stage 2 – Moderate – FEV_1 50 - 79 % of predicted normal

  Stage 3 – Severe - FEV_1 30 – 49 % of predicted normal

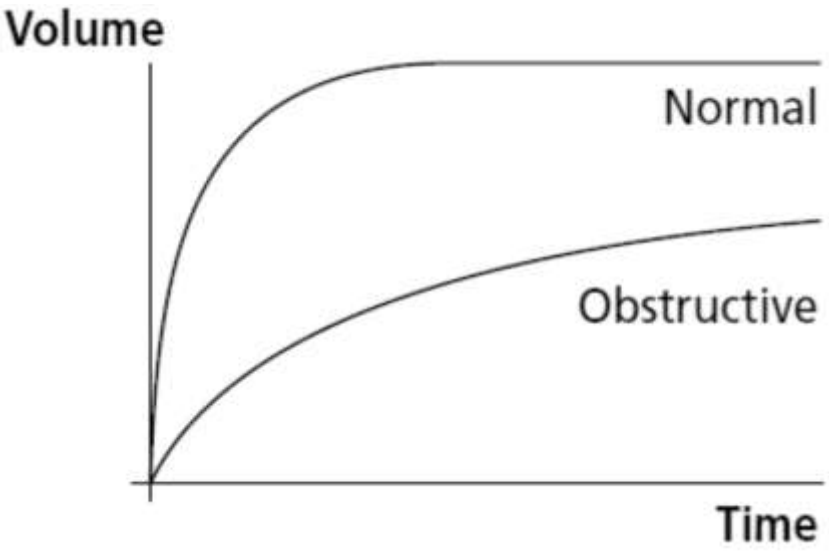
  Stage 4 – Very severe - FEV_1 < 30 % of predicted normal

Diagnosis asthma

- FEV_1/FVC < 0.7 or 70 % indicating airway obstruction.
- Reversibility of FEV_1 > 400ml or 20% with bronchodilators.
- Large increase FEV_1 (>400ml) in response to 30mg daily oral prednisolone for 2 weeks.
- Cannot exclude asthma based on normal spirometry in asymptomatic patient. May need to do serial measurements of home peak flow in AM and PM over 2 weeks – need to see ≥20% diurnal variability on 3 or more days per week to diagnose asthma.
- Consider repeating spirometry at intervals if it is normal.

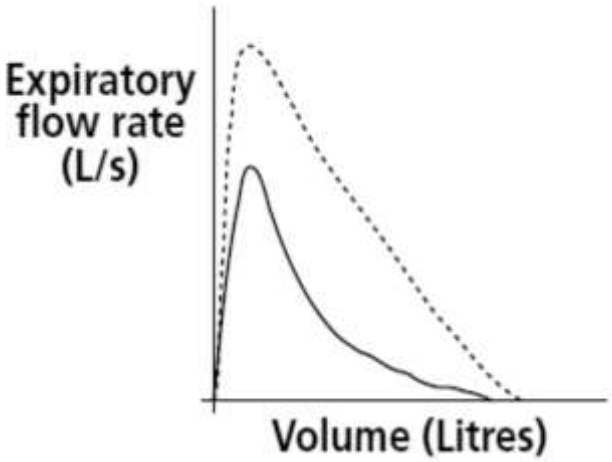
Spirometry indicating obstructive lung disease

- Volume-time graph

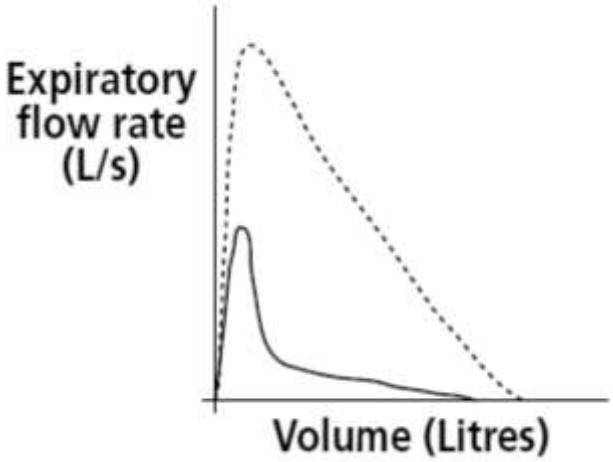


Spirometry indicating obstructive lung disease

- Flow-volume curve



PEF is reduced and reduction in airflow to complete expiration has distinctive dipping.



'Steeple pattern' seen in severe obstructive lung disease

Spirometry indicating obstructive lung disease

- The air in the large airways usually can be expired without problems, so PEF may be normal on the flow-volume curve.
- When all the air is expired from the large airways, air from the smaller airways will be expired.
- With obstructive lung disease, these airways are partially blocked, so the air will come out slower , hence the concave downward slope after the PEF is reached. This can be simulated by blowing through a straw.

Restrictive Lung diseases

- FVC reduced (< 80 % predicted normal) (restrictive lung diseases reduce amount of air patient can breathe in therefore expelled volumes will also be reduced)

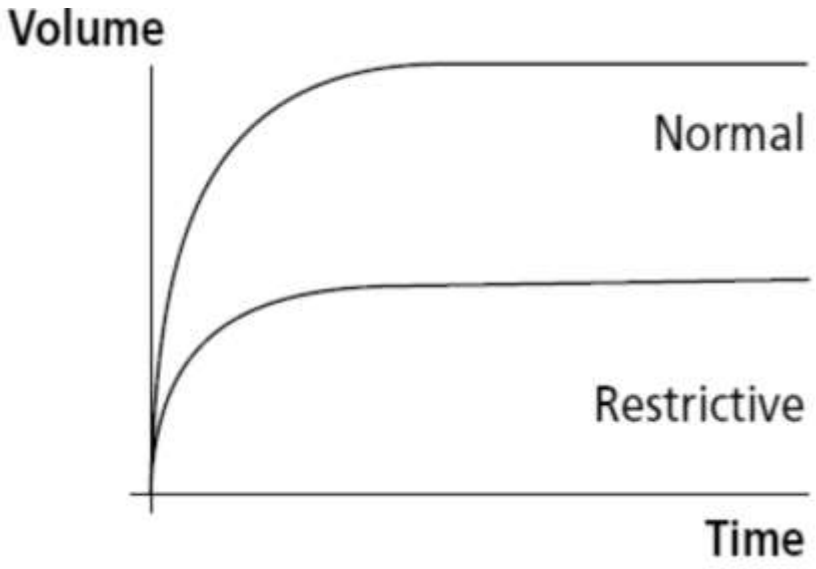
- FEV_1 reduced (< 80 % predicted normal)

- **Normal FEV_1 /FVC ratio** (i.e. >0.7 – this is the main differentiating parameter between obstructive and restrictive diseases)

- Expiratory flow volume curve appears convex

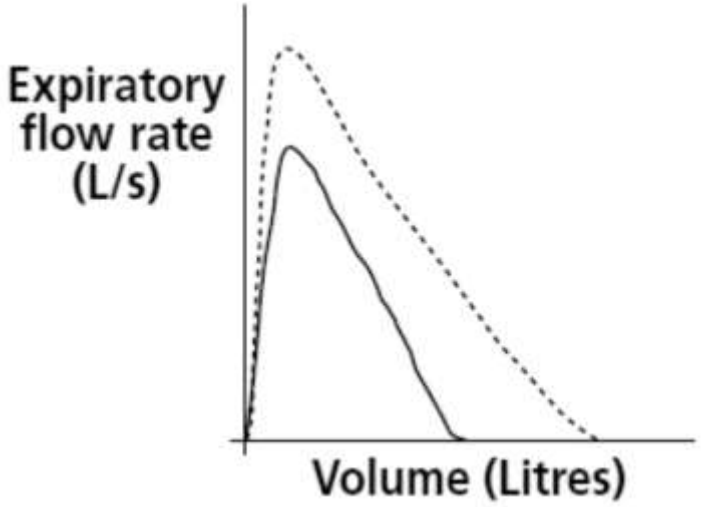
Spirometry indicating restrictive lung disease

- Volume- time graph



Spirometry indicating restrictive lung disease

- Flow- volume curve



The curve has a normal shape but there is an absolute reduction in volume; FVC is reduced.

Spirometry indicating restrictive lung disease

- Since the airways are normal, the flow volume loop will have a normal shape: the curve will descend in a straight line from the PEF (Peak Expiratory Flow) to the X-axis.
- Total lung volume is low, which results in a low FVC.
- PEF can be normal or low.

Mixed Obstructive and Restrictive Lung disease

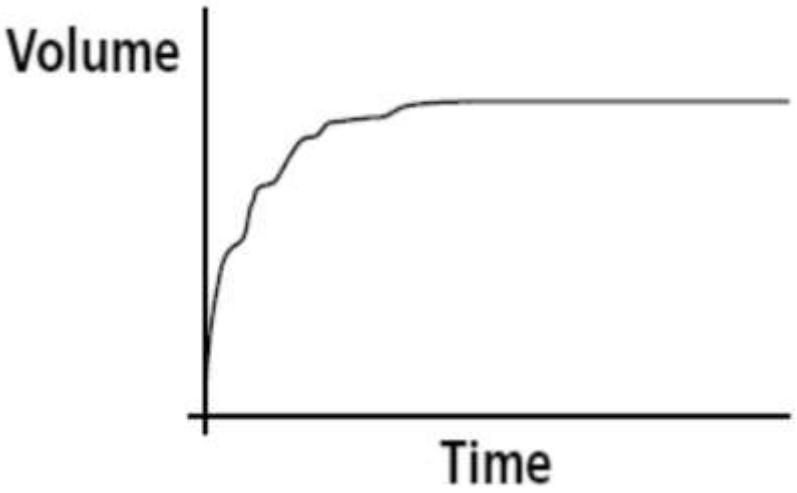
- Some patients will have both obstructive and restrictive lung disease. Spirometry may be more difficult to interpret in these patients but will show changes in keeping with both conditions.

Common errors in performing spirometry

- Inadequate or incomplete inhalation
- Lack of maximal effort during exhalation
- Additional breath taken during manoeuvre
- Lips not tight around mouthpiece
- Slow start to forced exhalation
- Exhalation stops before complete expiration
- Some exhalation through the nose
- Coughing

Errors on spirometry traces

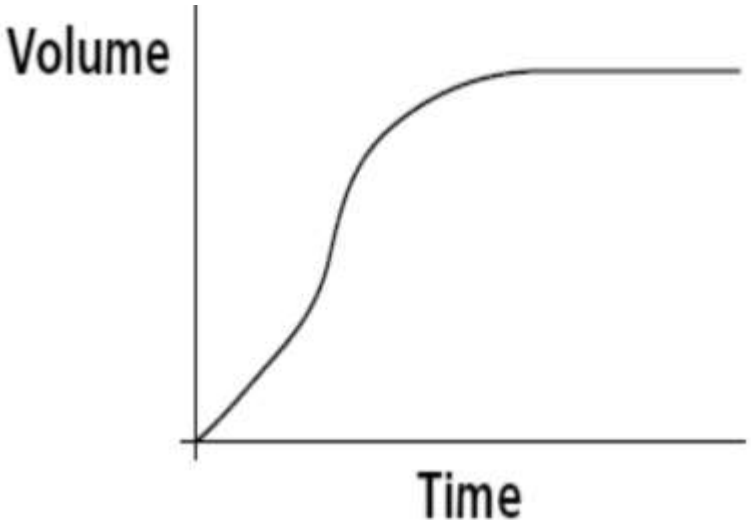
- Cough during exhalation



Irregular pattern on exhalation in keeping with cough

Errors on spirometry traces

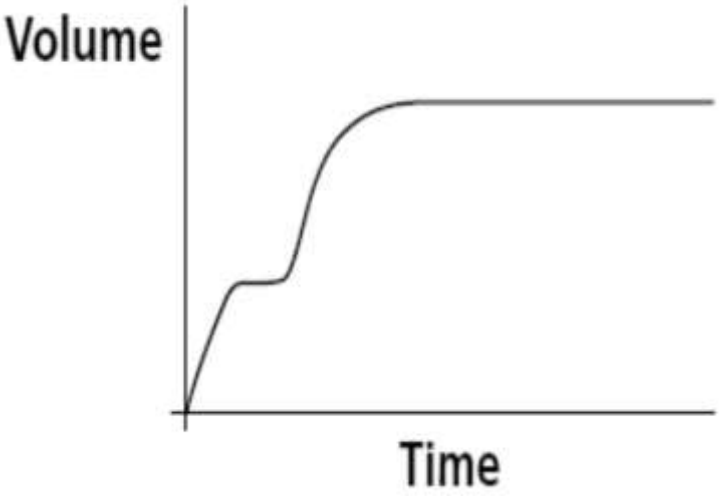
- Slow start to forced exhalation



Marked increase in force of exhalation short time after the start indicated by steep gradient

Errors on spirometry traces

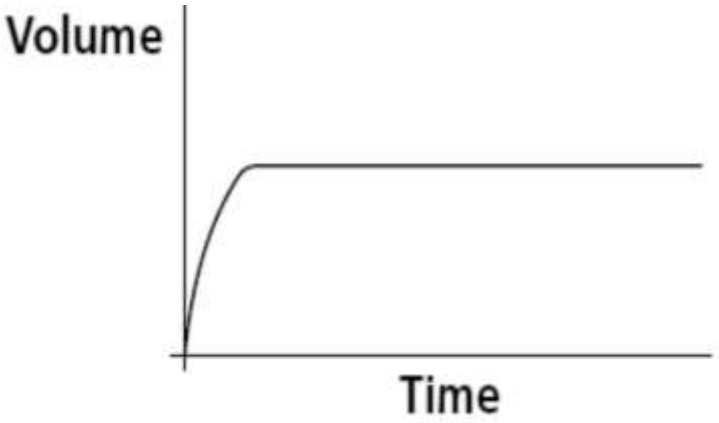
- Extra breath taken during manoeuvre



Extra breath shown by short plateau a short time after start with subsequent full expiration being reached

Errors on spirometry traces

- Early stoppage of manoeuvre



Following a normal start to the procedure the trace reaches an abrupt plateau. Actual FVC is not reached.

Conclusions

- Spirometry is a useful commonly used tool for diagnosis and monitoring of respiratory conditions in General Practice.
- It can be difficult for patients to perform and so practitioners need to be aware of potential inaccuracies on traces.
- Accurate spirometry interpretation is possible with revision of basic physiology, awareness of potential problems in performing the procedure and practice!
- If the spirometry is difficult to interpret then it would be wise to seek a specialist opinion.

References/Sources

- PCC Guide to Quality Assured Spirometry 2013
- BTS Spirometry in practice guideline
- NICE 2010 COPD guideline
- NICE CKS COPD summary
- NICE CKS Asthma summary