SPIROMETRY GUIDELINES

Spirometry is a method of assessing lung function: primarily the volume and flow of air expired from a position of full inspiration. It is a reliable method of differentiating between obstructive airways disorders and restrictive diseases (BTS, 2005).

Universally at The Noah's Ark Children's Hospital for Wales we use the Viasys Micro Lab Spirometer and this protocol provides instructions for use.

DEFINITIONS:

Peak Expiratory Flow (PEF): The maximum flow achievable from a forced expiration with an open glottis from a position of full inspiration.

Forced Expiratory Volume in 1 Second (FEV1): The maximum volume which can be expired from the lungs in the first second of a forced expiration from a position of full inspiration. This measurement is used to assess the airways in particular in obstructive airway disease such as asthma.

Forced Vital Capacity (FVC): The maximum volume of gas that can be expired from the lungs during a forced and complete expiration from a position of full inspiration. This measurement looks at the total capacity of the lungs during a forced effort.

FEV1/FVC ratio: The amount exhaled during the first second is a constant fraction of FVC irrespective of lung size. FEV1/FVC ratio is generally expressed as a percentage.

Forced Expiratory Flow 25-75% ($FEF_{25-75\%}$): The average expired flow over the middle half of the FVC manoeuvre. This is regarded as a more sensitive measure of small airways narrowing than FEV_1. However $FEF_{25-75\%}$ has a wide range of normality, is less reproducible than FEV_1, and is difficult to interpret if the VC (or FVC) is reduced or increased.

Expired Relaxed Vital Capacity (RVC): The maximum volume of gas that can be expired during relaxed but complete expiration from a position of full inspiration. This measurement is used to assess lung capacity in weaker patients such as a patient with neuromuscular disease.

Spirometry is displayed graphically as either a Flow Volume Loop or a Volume Time Curve, shown below:

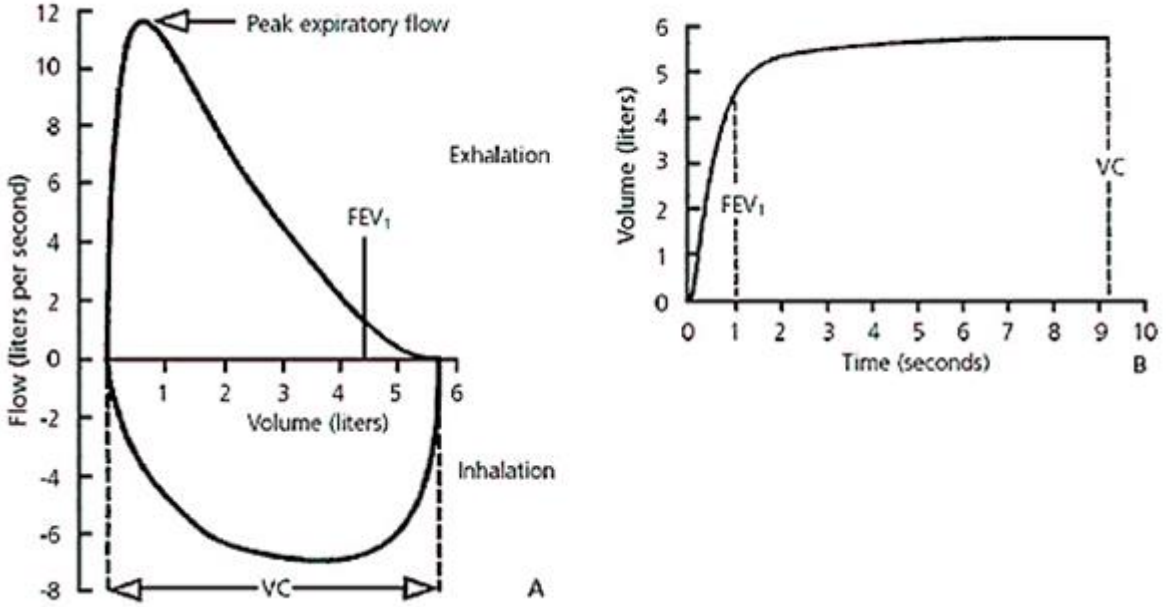

Figure 1: Flow Volume Loop and Volume Time Graphs

CALIBRATION:

Calibration needs to be performed weekly to check accuracy of volume and linearity. Checks should produce a value within 3% of syringe volume. Biological controls should also be performed and recorded. Biological checks should be within 5% of each other.

To perform a calibration on Viasys Micro Lab Spirometer, turn the spirometer on and click:

1. 'Calibration check',
2. 'Spirometry',
3. 'Check calibration',
4. The attach the 3L syringe with filter to the transducer and follow the on screen instructions, pull out and then push in the syringe once to keep within the grey areas, wait and then repeat at a different flow rate on the next page etc.
5. The spirometer will then give you a calibration report, check that each test passed.
6. If they did not pass, try again. If the spirometer continues to fail or an error is reported clinical engineering should be contacted on ext: 5678.

Figure 3: Spirometer set up

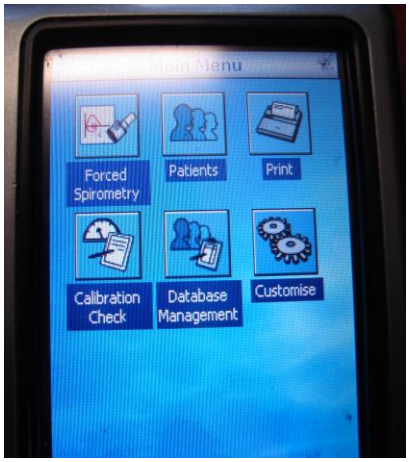

Figure 4: Calibration Check on main menu

Figure 5: Calibration set up with 3L syringe

CONTRAINDICATIONS TO SPIROMETRY:

- Haemoptysis of unknown origin
- Pneumothorax
- Unstable cardiovascular status
- Thoracic, abdominal or cerebral aneurysms
- Recent eye surgery
- Recent thoracic or abdominal surgery
- Acute disorders affecting test performance such as nausea or vomiting

INFECTION CONTROL/MICROBIOLOGICAL GUIDELINES:

- Bacterial-viral filters should be used for all patients and thrown away after use.
- Patients and clinicians should wash hands before performing spirometry.
- Only allow the patient to touch the transducer casing.
- Before every use and between patients, wipe the outer surface of the hand held transducer and spirometry unit with an antibacterial wipe and allow to dry.

At the NACHfW there are a number of spirometers, they each have two transducer flow heads, this is specifically for infection control in cystic fibrosis (CF) patients. When performing spirometry with CF patients please follow the guidelines below:

- Check the patient's microbiological status prior to use
- Patients with certain microbiological status e.g. MRSA, Burkholderia Cepacia or Atypical Mycobacterium should always use their own hand held spirometer or a separate transducer (liaise with the PRU physiotherapist).
- If the patient has isolated pseudomonas (is prescribed nebulised Colystin/Promixin/Tobi) use the transducer marked with a P.
- If there has been a change in a patient's microbiological status or if the incorrect transducer has been used the transducer should be sterilised immediately.
- All transducers should be sterilised weekly according to sterilisation solution information.

PATIENT TECHNIQUE:

FORCED SPIROMETRY:
It is important to note that in order to achieve reliable reproducible results maximal effort is required from the patient.

The patient should be instructed to:

- Breathe in as deeply as possible through the mouth,
- Place the lips and teeth tightly around the mouthpiece,
- Blow out as hard and as fast as possible until no further air can be exhaled.
- For infection control reasons, ask the patient to remove the mouthpiece prior to inspiration. Do not perform inspiration loop.
- The operator should observe the patient to see that the tests were carried out correctly and that the expired air was not lost around the mouthpiece.
- The patient should continue to exhale until the flow of exhaled air has ceased. ATS Guidelines state that the test can end when the volume-time curve shows a change in volume (<0.025L) for >1seconds and the subject has tried to exhale for >3seconds in children aged <10 years and >6 seconds in subject >10years. Some children will have difficulty meeting ATS criteria. There should be a 'Plateau on the volume-time curve or the subject cannot continue further exhalation'.
- The incentive screen used for children aims to achieve a 3 seconds exhalation.

A test is unacceptable if:

- The patient did not fully inspire to start
- There was a leak at the mouth
- The mouth piece was obstructed i.e. with the tongue
- There was a poorly coordinated start
- There was a cough within the first second of expiration
- There was early termination of the blow or closure of the glottis
- The patient gave a sub maximal effort

The Viasys Micro Lab Spirometer will have prompts for some of these faults. Attempts which do not meet acceptability criteria should not be deleted but the quality of results obtained and repeatability must always be commented on.

REPRODUCIBILITY:
After 3 technically acceptable tests have been performed the spirometer will advise whether reproducibility criteria have been met. Currently the spirometers are set for BTS quality criteria requiring 3 attempts which are within 100ml of each other or 5%. This may not always be possible but ensure repeatability and technique are commented on with the results.

RELAXED SPIROMETRY:
The patient is instructed to breathe in as deeply as possible, then to place lips tightly around the mouthpiece, and then to breathe out into the equipment at a sustained and comfortable speed until no further air can be exhaled. The manoeuvre is like a deep sigh and expiration should neither be forced nor held back.

PERFORMING THE TEST:

Before the test is performed it is important to check the date on the spirometer and patient details such as date of birth, height, weight, gender and ethnicity, these are needed to calculate reference values. If the patient is unable to stand to have their height measured, arm span can be used as an estimate.
It is important to document any medication which may affect spirometry performance and the time it was last taken e.g. bronchodilators or cholinesterase inhibitors.
Check contraindications and infection control parameters.
Ensure the patient is in a reproducible position either standing or sitting (if unable to stand or at risk of syncope). Document position to ensure consistent technique at each measure.
If it is the childs first spirometry it may be useful to practice just on the mouthpiece before it is connected to the transducer.
In patients who do not have lip closure use filter and facemask (without exhalation port).

To perform spirometry on the Viasys Micro Lab Spirometer , click:

1. 'Patients'
2. Then either search for a patient who has been before and ensure height and weight are up to date

OR

1. 'Add' a new patient's details
2. 'Ok'
3. Select 'Forced' or 'relaxed' Spirometry
4. Instruct the patient how to perform the test (see patient technique section).
5. Use the arrows at the top of the screen to scroll through different views, the cartoon incentive can be used for younger children.
6. Give verbal encouragement to obtain best effort and good technique.
7. Click 'again' to repeat the test until you have obtained 3 technically acceptable tests. The spirometer gives prompts after each test and will state if the criteria have been met when you end the session.
8. Click 'view results' or 'done'
9. Select the best test and click 'set best'
10. Click 'Done'
11. 'Print' – the spirometer will either print the automated best result or the test the operator has set as best, this will depend on the set up of your spirometer.

Figure 6: Incentive Screen

REVERSIBILITY TESTING

- Perform technically acceptable baseline spirometry, as described above.
- Administer 600mcg salbutamol vai MDI and spacer (check dose with referring physician).
- Allow 15 minutes rest for maximum bronchodilation to occur.
- Perform technically acceptable spirometry post bronchodilator using the 'post 1' mode in order to get both pre and post results on the same print out. This mode can also be used for drug trials.

ERS reversibility guidelines:
Significant improvement - >12% and 200ml increase in FEV1 OR FVC

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