Training Manual on Diagnostic Spirometry

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Spirometry is one of the very important tools for the diagnosis, monitor, assessment and prediction of different lung conditions. Its access is increasing in our country. Quality of test and interpretation is as important as it's availability. A well-structured training program is essential part of performing quality spirometry and it's interpretation. Here two experts need to be involved- ‘Coach’ or ‘Driver’, who will perform the test and ‘Provider’ who will interpret and use in clinical setting. A ‘Coach’ or ‘Driver’ usually comes from health technologists- Respiratory Technologists, which is completely absent in our country. In resource poor setting an expert physician is suffice to do all the things alone. The spirometry course should be at least 3-month full time course. Unfortunately, we have no such courses yet in our country, even one-day course. Money, infrastructure, experts and priority are the main barriers to set up such a training center at present.

Bangladesh Primary Care Respiratory Society (BPCRS) are very keen to improve the Lung Health in Bangladesh. BPCRS have organized and completed 6-months spirometry training from University of Washington for its two Community Respiratory Centers (Khulna and Feni). The UW CoMotion Program provided funding and International Primary Care Respiratory Group (IPCRG) granted this bursary through its E-Quality project.

Strong determination, active participation and subsequent self-paced learning by practice are the key of success to do and interpret spirometry.

We wish a very successful learning on Spirometry from this Manual.

Dr GM Monsur Habib
President, BPCRS

Dr. SM Rowshan Alam
Secretary General, BPCRS
At the very outset, I must take the privilege to express my heartfelt gratitude to the Almighty Allah to give us all the opportunities for publishing “Manual for Workshop on Diagnostic Spirometry”. I am grateful to respectable Dr. GM Monsur Habib, Dr. SM Rowshan Alam and other members of BPCRS to contribute a lot for preparing this manual. We all the board members tried our level best to make this manual more informative, easier, simplified, analytic and palatable. Performing spirometry test has increased dramatically. This increase is largely due to a global awareness of spirometry as an essential tool for assessing and monitoring respiratory disease, in particular asthma and COPD. The latest information will help the participants (qualified health professionals) with the technical, practical and clinical skills to perform spirometry more accurately.

I, on behalf of Bangladesh Primary Care Respiratory Society, express my deepest gratitude to all those who came forward to bring out this manual timely. I also acknowledge the contribution of other non-medical experts and technical hands in this regard.

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Spirometry is a breathing maneuver in which a patient breathe in as deeply and then blows all the air out of their lungs as forcefully and as completely as possible, in one breath(1). This is called Forced Vital Capacity test or FVC maneuver(2). It measures the volume & the flow of air. Volume means how much air is exhaled & Flow means how fast air is exhaled. This is the gold standard test for COPD diagnosis(3,4). Under-use of spirometry leads to inaccurate COPD diagnosis(5), monitoring and overall management of Chronic Respiratory Diseases. It also helps to assess the fitness of people (healthy or patient) for any intervention(6, 7).

Most common spirometry test in primary care focuses on expiratory measurements, not inspiratory.

Widespread uptake has been limited by(8):

- Concerns over technical performance of operators(9)
- Difficulty with interpretation of results(10)
- Lack of approved local training courses (11,12)
- Lack of evidence showing clear benefit when spirometry is incorporated into management(13)
In case of reversibility testing spirometry is more reliable than Peak Flow measurement (14, 15). In case of demonstrating variability like serial peak flow in occupational asthma (16), allergic alveolitis (17) patients undergoing upper abdominal surgery (18). Peak flow measurement is more useful than spirometry.

Spirometry must be performed to an approved standard and usually possible from about 8 years of age and even earlier (19).

However, there are two caveats are shown –

Normal spirometry, when not symptomatic, does not exclude the diagnosis of asthma.

Repeated measurements of lung function are often more informative than a single measurement.
Why to perform spirometry?

**Spirometry performs -**

1. Diagnosis, severity assess & follow-up of Asthma & COPD
2. Detect restrictive lung condition
3. Perform Pre-operative assessment

**Additional uses –**

- Make a diagnosis and assess severity in a range of other respiratory conditions
- Distinguish between obstruction and restriction as causes of breathlessness
- Screen workforces in occupational environments
- Assess fitness to dive
- Perform pre-employment screening in certain professions
- Lung age can be measured which can work as a strong motivation to stop smoking
Restrictive vs. Obstructive lung disease

Restrictive lung disease -
There is stiffness inside the lung tissue or chest wall cavity causes restrict the amount of air going in & out of the lungs that means difficulty in taking air inside the lung(20). If the lungs cannot inflate properly, then less air comes out during exhale. So reduction of lung volume occurs. Interstitial lung disease like fibrosis, sarcoidosis(20), Extrinsic disorders such as kyphoscoliosis(21) and ankylosing spondylitis(22) and neuromuscular cause as well as marked obesity causes restriction(23).

Obstructive lung disease –
Asthma, COPD, Emphysema, Bronchiectasis obstruct the flow of air being exhaled. The air will remain inside the lung after full expiration(24,25). When the airways are inflamed, constricted or filled with mucous, the airflow is obstructed that causes reduction of air flow.
Calibration of Spirometer

Calibration / Biological Calibration

Regular calibration checks are an important step for reducing probability of instrument error, increasing confidence in the results & confirm the accuracy & documents its stability(26). Calibration checks should be regularly planned events.

The measurement of volume can be affected by temp and pressure. It should be based on:

- How often the spirometer is used
- Where it is used
- Stability characteristics of the spirometer
- The recommendation of the manufacturer

Calibration should be performed by using a special 3 liters syringe following the manufacturer’s recommended procedures. 3 L should be accurate to within 3%. Calibrated volume measurement should be between 2.91 & 3.09 L. If a spirometer fails a calibration check, it should not be used until it is serviced or repaired.

Calibration should be verified –
- Before every clinic session or
- After every 10th patient

A calibration log should be maintained
Preparation begins at the appointment time is made. Ask the patient to bring existing inhaler to the appointment. Check if any contraindication and ensure patient has prescription for bronchodilator.

**Good spirometry results require –**

1. Consistent technique for preparing the patient
2. Teaching and coaching the maneuver and making successful corrections during the session
3. Good effort from patient

**Avoid cross-contamination**

- A new spirette is needed for each patient
- Not all spirometry bands make spirettes that have filters to protect against spread of airborne infection to coach

**Brief explanation of purpose of test-**

- Simple & clear
- Lung measurement- How fast they can blow air out of their lungs
- Test doesn’t hurt
- Requires patient effort & co-operation
- Duration of test
Patients preparation

Key patient information –
1. Patient name or medical record number
2. Age or date of birth
3. Height & weight – height measured without shoes. If unable to measure height, use arm span instead
4. Gender
5. Race

Important information to record -
1. Posture
2. Nose clips- Patient who are unable to avoid nasal breathing during maneuver should be use nose clips. Some expert encourages all patients to use nose clips. Use of nose clip should be recoded.
3. Restrictive clothing
4. Loose dentures
5. Medications- in last 24 hrs, Date & time of their last dose
Type of spirometric test required –

1. Base-line spirometry:  
   Follow up of disease condition
2. Baseline spirometry with Reversibility testing:  
   Most commonly used

Equipment requirements - 
1. A spirometer, meets the ISO standard 267823  
2. One-way disposable mouthpieces and nose clips  
3. Bacterial and viral filters  
4. Calibrated height measure and weighing scales  
5. Non-electrostatic valve holding spacer  
6. Short acting bronchodilators as per guidelines

Ten steps of performing Spirometry

Step 1: Assess the patient for contra-indications –

Absolute
- Current respiratory distress
- Active infection e.g. AFB positive TB until treated for 2 weeks
- Condition that may be cause serious consequence if aggravated by forced expiration
  1. Dissecting / unstable aortic aneurysm  
  2. Current pneumothorax  
  3. Recent surgery including ophthalmic, thoracic, abdominal or neurosurgery.
Relative
- Suspected respiratory infection in the last 4-6 weeks
- Undiagnosed chest symptoms e.g. Hemoptysis
- Any condition which may be aggravated by forced expiration
  1. H/O- prior pneumothorax
  2. Unstable vascular status such as recent (within 1 month) MI
  3. Uncontrolled HTN
  4. Pulmonary embolism
  5. H/O- hemorrhagic event (stroke)
  6. Previous thoracic, abdominal or eye surgery
- If the patient is too unwell to perform forced expiration
- Communication problems such as learning disability
- Perforated ear drum
- Acute disorder- Nausea, vomiting

Common challenging patients-

- Cognitively impaired
- Patients with significant shortness of breath
- Testing through a translator

Young children  Teenagers  Physically disabled

Seniors
Working with young patient (19, 27) (4-6yrs old)

1. First confirm they can follow multiple step commands
2. Make it a game
3. Use a party whistles/tooter, pin wheels
4. Practice first with just a spirette
5. Use eye contact and praise, body language

Working with Teens

1. Respect the need for privacy
2. Engage in the gadget
3. Use meaningful explanations
4. Encourage a personal best
5. Show them print out

Working with Older Adults-

1. Be mindful of the potential for fainting
2. Sitting, not standing, is the norm for testing
3. Be cautious with clinically unstable patient- seek medical clearance when in doubt
4. Stop if the patient is tired, light-headed or indicates discomfort

Step 2: Measure the patient’s height and weight.

Step 3: Explain and demonstrate the procedure to the patient.
### Step 4: Prepare patient and equipment to perform the SVC

- Insert spirette in correct place into spirometer
- Patient is sitting comfortably
- Apply nose clip
- Verbally encourage patient to continue to exhale
- Observe both patient and the volume-time curve as each VC is performed to ensure they:
  1. Breathe in to maximal inspiration
  2. Do not obstruct the mouthpiece with their teeth or tongue
  3. There are no leaks from the mouthpiece
  4. Remove false teeth if loose
- Minimum three acceptable VC maneuvers must be obtained
- Usually this will be achieved within eighth maneuvers
- Repeatability criteria are met
- If the patient is unable to achieve the quality criteria, record why this has not been possible
- Another appointment may be required or refer for specialist assessment

### Step 5: Prepare the patient and the equipment for FVC

- Insert spirette in correct place into spirometer
- Position:
  1. Standing may be easier for children
  2. Sitting may be better for seniors
  3. Good posture, don’t tilt chin down
- Nose clip is not essential
- Observe the patient throughout entire maneuver, look for
  1. Forced expiratory maneuver
  2. A strong sustained effort throughout blow
  3. Watch for air leaks
  4. Squeeze all the air out
- Do not perform >8 maneuvers in one session
- Minimum three acceptable maneuvers must be obtained
- Repeatability criteria are met
- If the patient is unable to achieve the quality criteria, record why this has not been possible
Performing Spirometry

**Step 6: Record baseline spirometry results**
- In electronic or paper templates
- Using the largest FEV1 and FVC or VC to determine FEV1/FVC

**Step 7: Post-bronchodilator testing**
- Should be performed if baseline spirometry reveals an obstructive picture
- Administer bronchodilator: (usually 4 x 100mcg salbutamol as separate puffs via spacer or 2.5mg via nebulizer)
- Perform spirometry after 15 minutes

**Step 8: Record post-bronchodilator spirometry results**
- In electronic or paper template
- Using the largest post-bronchodilator FEV1 and largest VC or FVC to determine the FEV1/VC ratio

**Step 9:**
- Arrange interpretation of the spirometric results by a competent interpreter

**Step 10:**

Ensure patient has a follow up appointment arranged for the results to be explained & to arrange on-going management.
During spirometry session-
• If necessary, up to eight forced blows can be performed in a single session.
• Obviously, if a patient is frail and becoming exhausted, brought back on another day
• A further problem that may be encountered is 'spirometry induced bronchospasm' where each successive blow will produce increasing airflow obstruction and progressively lower FEV1
• For obvious reasons, if this occurs, testing should be abandoned on this occasion - the patient may also need to be given a bronchodilator and allowed to rest and recover.

Possible side-effect during spirometry-
Forced expiratory maneuver will require the patient to take a very deep breath in and then use maximal effort to exhale all of the air out from their lungs. Maximal means to use as much effort as possible. During test, the patient will be asked to perform the maneuver at least 3 times. During each maneuver, it is important that the patient exerts a maximal effort.

**Giving best effort each time**

1. Reduces variation  
2. Increases reproducibility  
3. Makes the results more reliable

Coaching is essential to help the patient to do the maneuver correctly
Identify FET, FVC & FEV1 on VT curve. “How much air” is exhaled during maneuver over a period of time?
1. Time is measured on the horizontal axis in second
2. Volume of exhaled air is measured on the vertical axis in liters.
Quick rise from Zero indicates that patient exhaled hard & fast without hesitating. As the patient continues to exhale, the curve levels off to a plateau. This leveling off of the curve indicates that the volume is no longer increasing. This means that the patient has given a full expiration.

Curve should be smooth without any noticeable bumps.
Volume – time curve

Stopping before curve plateaus is early termination & is unacceptable. Flat shape in last second indicates that patient made a good effort to give a full & complete expiration. After full expiration, they had less & less air left in their lungs.

**Common normal parameter in clinical practice are as-**

- **Relaxed vital capacity (RVC) Slow vital capacity (SVC) Vital capacity (VC)**

  Volume of air that can be exhaled in a relaxed blow from a position of maximum inhalation to maximum exhalation

- **Forced vital capacity (FVC)** -

  Volume of air that can be exhaled forcibly from a position of maximum inhalation to maximum exhalation by using maximum effort

- **Forced expired volume in one second (FEV1)** -

  Volume of air exhaled in the first second of a force exhalation from a position of maximum inhalation to maximum exhalation which is 80 – 90% of FVC.

**The ratio of FEV1 to FVC (FEV1 / FVC or FEV1%)**

- Normal in adult : > 0.75 - 0.80
- Normal in child : > 0.90
- If below <70% in adult indicate pathology
- If below <80% in child indicate pathology
Volume – time curve

- **Forced expiratory time (FET) - length of blow**

Recommended duration of the maneuver is 6 seconds. Longer maneuver is acceptable. Shorter maneuver may be acceptable if the volume of air is no longer increasing for at least one second.

**ATS guideline for length of effort by age-**
- 10 yrs of age & above is at or above 6 seconds
- 7 - 9 yrs of age is at or above 3 seconds
- 6 yrs of age or below is at or above 2 seconds

**Parameter of Volume – time curve**
- SVC or RVC or VC
- FVC
- FEV1
- FEV1 / FVC
- FET : Forced expiratory time
Flow/Volume loop

Identify FVC, PEF & FEF 25-75. Volume is measured on the horizontal axis in liters and flow is measured on the vertical axis in liters/S. Flow represents how fast the patient is able to exhale.

Curve rises quickly to a peak indicates that patient exhaled hard & fast without any hesitation and good starting. Peak must be as pyramid, not blunt/rounded. Rounded peak may indicate the patient didn’t blow hard enough. If blow can’t reach up to peak is Sub-maximal effort. From peak the curve heads downwards & gradually tapers off at the end as the flow reaches zero which indicates that patient achieved a full expiration.
Volume – time curve

Parameter of Flow/ Volume curve

a. FVC
b. PEF – maximum expiratory flow (10 L/S)
c. PEFT – duration of peak time which is < 0.15 S
d. Mid flow / FEF 25 – 75 / Maximum mid expiratory flow(MMEF) – mean flow from 25% to 75% of the FVC: L/S

Basic parameter of Spirometry

i. Relaxed vital capacity (RVC) or
ii. Slow vital capacity (SVC) or Vital capacity (VC)
iii. FVC
iv. FEV1
v. FEV1/ FVC
Interpretation of Spirograms

Interpret spirogram

Demographics

Diagnosis by Flow chart

Reproducibility (Quality grading)

F-V curve

Acceptability

V-T curve

Demographics  Acceptability  Reproducibility

Diagnosis by Flow chart
V-T Curve & F-V curve is accepted by

1. Good starting-
2. Not early termination
3. Sharp rise
4. Sharp peak
5. Length of blow – according to ATS guideline
6. Absence of artifact/error

Summary of Acceptability
Acceptability of FVC maneuver

**Back Extrapolated Volume**

- A spirometric trial with an excessive hesitating start is defined as having a ratio of volume of air calculated at time zero using the back-extrapolation method.
- Back extrapolation is performed using the steepest part of the slope on the V-T curve.
- This will minimize inaccuracies in FEV1 due to hesitation at the start of Exhalation.

Back extrapolated volume (EV, BEV) should be less than 150 ml or 5% of FVC, whichever is greater.
Reproducibility is a measure of the consistency of efforts. Because spirometry is an effort-dependent test, reproducible FVC and FEV1 will occur if the patient is trying as hard as possible.

### Table: Reproducibility of FVC Maneuver

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Best</th>
<th>Trial 2</th>
<th>Trial 1</th>
<th>Trial 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (L)</td>
<td>2.97</td>
<td>2.96</td>
<td>2.97</td>
<td>2.78</td>
</tr>
<tr>
<td>FEV1 (L)</td>
<td>2.56</td>
<td>2.56</td>
<td>2.49</td>
<td>2.45</td>
</tr>
<tr>
<td>FEV1 + FVC</td>
<td>5.52</td>
<td>5.46</td>
<td>5.23</td>
<td></td>
</tr>
</tbody>
</table>

All 3 trials meet acceptability criteria.

**Selected the best parameter/Trial**

- Take minimum 3 best trials
- Find highest values of FEV1 & FVC for best parameter
- Best 1, Best 2 & Best 3 trial are obtained from highest value of Summation of FEV1 & FVC

### Selecting Maximum Variance

- Take minimum 3 best blows
- Find the 2 highest values for FEV1 & FVC
- Subtract the second highest from the highest value
- This result is called the FVC or FEV1 variance
- The largest variance from FVC or FEV1 variance is called Maximum variance

**Maximum variance/ Vari-Max = 150 ml**

FVC var = 2.97 – 2.82 = 0.15 L = 150 ml
FEV1 var = 2.59 – 2.45 = 0.14 L = 140 ml
Reproducibility of FVC maneuver

<table>
<thead>
<tr>
<th>Grade</th>
<th>Age 7 yrs or Older</th>
<th>Age 6 yrs or Younger</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Vari-max Within 150 ml</td>
<td>Within 100 ml</td>
</tr>
<tr>
<td>B</td>
<td>Vari-max Within 150 ml</td>
<td>Within 100 ml</td>
</tr>
<tr>
<td>C</td>
<td>Vari-max 151 – 200 ml</td>
<td>101 - 150 ml</td>
</tr>
<tr>
<td>D</td>
<td>Vari-max 201 - 250 ml</td>
<td>151 - 200 ml</td>
</tr>
<tr>
<td>E</td>
<td>1 acceptable tests</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>No acceptable tests</td>
<td></td>
</tr>
</tbody>
</table>

Spirometry quality grading system

---

**Exercise**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC(L)</td>
<td>1.74, 1.67, 1.64, 3.67, 48</td>
<td>1.98, 1.94, 1.68, 54</td>
</tr>
<tr>
<td>FEV1(L)</td>
<td>0.67, 0.65, 0.67, 2.89, 23</td>
<td>0.78, 0.71, 0.61, 27</td>
</tr>
<tr>
<td>FVC Var</td>
<td>1.74-1.67, 0.07 L, 70 ml</td>
<td>1.98-1.94, 0.04 L, 40 ml</td>
</tr>
<tr>
<td>FEV1 Var</td>
<td>0.67-0.67, 0.00 L, 00 ml</td>
<td>0.78-0.71, 0.07 L, 70 ml</td>
</tr>
</tbody>
</table>

All 3 trials meet acceptability criteria

Maximum variance = 70 ml

Session Quality - ???
The ATS Algorithm—Summary of FVC maneuver

1. Perform Maneuver
   - Curves Ok?
     - Yes: Sufficient Plateau
     - No: Minimum FET?
       - No: Discard maneuver
       - Yes: Enough maneuvers
         - Yes: Reproducible Test?
           - Yes: Save & Interpret
           - No: Perform another maneuver
         - No: Discard maneuver
   - Check both the VT & FV curves visually for common errors
   - Was the VT plateau at least one second?
   - Are there at least 3 acceptable maneuvers?
   - Are there best Quality grading

Training Manual on Diagnostic Spirometry
Bronchodilator reversibility tests

- **Materials need for test:** PFM/Spirometry, Short acting BD, Non-electrostatic valve holding Spacer
- **Test may be lost during severe exacerbation/Viral infection**
- **Method:**
  - **Stop BD prior to test as following:**
    - SABA > 4hrs
    - LABA > 15hrs
    - Ipratropium-4hrs
    - Tiotropium-36 hours
  - **Measure Baseline PEFR or FEV₁ (PEF is less reliable than spirometry)**
  - **Give BD by large volume spacer**
    - 400 mcg Inhaled Salbutamol
      - 4 divided dose,
      - 30 S. interval
  - **Wait for 15 minutes**
  - **Re-measure PEFR or FEV₁, (depends on baseline device)**

**Interpretation**

**PEFR**
- **By %:** Adult, Child > 20%
- **By Vol:** Adult, Child At least 60 L/M

**FEV₁**
- **By %:** Adult > 12%
- **By Vol:** Adult At least 200 mL/S

- **Highest - Lowest**
- **By percentage:** \[ \times 100 \]
- **By Volume:** \[(\text{Highest} - \text{Lowest})\]
Consider patient history in all interpretation decision making.

Flow chart for Diagnosis:

Severity grading:

<table>
<thead>
<tr>
<th>Severity</th>
<th>Asthma grading</th>
<th>COPD grading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>Post-test FEV1 (%) Pred.</td>
<td>At or &gt; 80% of PV</td>
</tr>
<tr>
<td>Moderate</td>
<td>61 – 79% of PV</td>
<td>50% to 79% of PV</td>
</tr>
<tr>
<td>Severe</td>
<td>At or &lt; 60% of PV</td>
<td>30% to 49% of PV</td>
</tr>
<tr>
<td>Very Severe</td>
<td>&lt;30% of PV</td>
<td>&lt;30% of PV</td>
</tr>
</tbody>
</table>

Consistent with Obstruction < 0.70
Baseline Spirometry
FEV1/FVC Ratio ≥ 0.70
Post-BD Reversibility test
FEV1/FVC Ratio ≥ 0.70
Post-BD Reversibility test
FVC ≥80% of predicted
<80% of predicted

Reversible? 
+ve
ACO/Asthma/COPD
COPD
Methacholine challenge test
Normal Spirogram
Suspect Asthma
Consistent Full PFT

Consider patient history in all interpretation decision making.
Common errors - Identification & Solution

Error # 01 - Sub-maximal inhalation
Solution - Taking the deepest possible

Error-2: Hesitation, Large extrapolated volume
Solution - Blast air out faster & harder
Common errors - Identification & Solution

Error-3: Sub-maximal blast
Solution - Blast air out harder

Error-4: Cough in 1st Second
Solution - Keep blowing until to stop
Common errors- Identification & Solution

Error-05: Early termination
Solution- Keep blowing until to stop

Error-06: Cessation of Airflow-Glottis closure or Breath holding
Solution-
Glottis closure - may be involuntary and should be documented
Breath holding - to blow UNTIL TOLD TO STOP
Common errors- Identification & Solution

Error-07: Partially Obstructed
Solution- unblocked

Curve- wobbles

Peak- reduced
Curve- wobbles

Error-08: Leak
Solution- unblocked,
Check equipment & connection

"back-track" toward zero
volume at the end of the
maneuver

Curve drops down
Common errors - Identification & Solution

Error-9: Extra breath
Solution - Use nose-clip, Lips tightly sealed around the mouthpiece

Error-10: Poor initial
Solution - Blast air out faster & harder
Spirometry patterns for different respiratory problems

- Extra thoracic UAO
- Intra thoracic UAO
- Fixed UAO

- Mild obstructive: e.g., asthma, COPD
- Moderate/severe obstructive: e.g., asthma, COPD
- Severe obstructive: e.g., COPD, emphysema
- Restrictive: e.g., pulmonary fibrosis
It is also called the maximal breathing capacity (MBC). It is the maximum volume of air which can be moved into & out of the Lungs in one minute by deepest & fastest breathing.

**Maximum voluntary Ventilation (MVV)**

Significant –
1. Index of respiratory efficiency & physical fitness.
2. Respiratory muscle assessment.
3. Pre-operative assessment.

**Measured by**-
1. **Indirect method – FEV1 x 40**
2. **Direct method – Breathing deeply & rapidly for 12 second and then multiply by 5**

$\frac{\text{Direct method}}{\text{Indirect method}} = < 0.80$

Indicate that MVV is low relative to the FEV1 means-

1. Major airway obstruction
2. Neuromuscular disease: MG, Polymyositis, Amyotrophic lateral sclerosis
3. Poor patient’s performance
4. The subject is massively obese? The MVV tends to decrease before the FEV1
Parameters for adequate pre-operative lung function

Q.1: Can the patient’s lungs get sufficient O2 into the body to Oxygenate the blood?
Ans: Yes- Provided SpO2 > 92%

Q.2: Can the patient’s lungs eliminate sufficient CO2 from the body to prevent CO2 accumulation?
Ans: Yes- Provided the
VC > 1700ml and/or
FEV1 > 600ml and/or
FEV1/VC ratio > 32%

Q.3: Can the patient generate a cough sufficiently to prevent mucous accumulation?
Ans: Yes- Provided the
PEFR > 150 L/min

Q.4: Can the patient increase their respiratory minute volume sufficiently to compensate for factors such as –
1. Elevated post-operative metabolic rate
2. Elevated body temperature
Ans: Yes- Provided the
FEV1 > 1200ml and/or
MBC > 40 L/min
Reference


7. Pierce R. Spirometry: an essential clinical measurement. (0300-8495 (Print)).

8. Desjardins A, Boulay ME, Gagne MA-Ohoo, Simon M, Boulet LP. Family medicine physician teachers and residents’ intentions to prescribe and interpret spirometry: a descriptive cross-sectional study. (1532-4303 (Electronic)).

9. Petty TL. Benefits of and barriers to the widespread use of spirometry. (1070-5287 (Print)).

10. Shiraiishi T. [Routine pulmonary function tests--contributing factors of various spirogram and flow-volume parameters and their value in the diagnosis of small airway disease]. (0047-1860 (Print)).

11. Morin C, Buffel C, Lorenzo A. [Need for the training of GPs to perform spirometry: a study of French GP trainees]. (1776-2588 (Electronic)).

12. Bunge L, Baruch D, Plantier L, Mazars T, Roche N, Izadifar A. [Study of the feasibility of spirometry in general practice]. (1776-2588 (Electronic)).


14. Sim YS, Lee JH, Lee WY, Suh DI, Oh YM, Yoon JS, et al. Spirometry and Bronchodilator Test. (1738-3536 (Print)).

15. Saglani S, Menzie-Gow AN. Approaches to Asthma Diagnosis in Children and Adults. (2296-2360 (Print)).
17. Barber Cm Fau - Wiggans RE, Wiggans Re Fau - Bradshaw LM, Bradshaw Lm Fau - Fishwick D, Fishwick D. Serial peak flow measurements in allergic alveolitis. (1471-8405 (Electronic)).
19. Jat KR. Spirometry in children. (1475-1534 (Electronic)).
26. Madsen F. Validation of spirometer calibration syringes. (1502-7686 (Electronic)).
27. Ayuk AC, Uwaezuoke SN, Ndukwu CI, Ndu IK, Iloh KK, Okoli CV. Spirometry in Asthma Care: A Review of the Trends and Challenges in Pediatric Practice. (1179-5565 (Print)).

Further reading:
1. Spirometry fundamental – A basic guide to Lung function testing
2. A Guide to performing Quality Assured Diagnostic Spirometry
3. Spirometry 360 TM – University of Washington
4. Primary care asthma program - Spirometry manual