Measurement of the vital capacity of lung

Introduction:

An examination of ventilation function of lungs is necessary for evaluation of functional properties of human respiratory system. It used either for estimation of defects in respiratory system or consideration of fitness load in sport medicine.

During the examination of ventilation function we measure following parameters (fig. 1):

- **Vital capacity** (VC) – the volume of gas that can be expelled from the lungs from a position of full inspiration, with no limit to duration of inspiration; equal to inspiratory capacity plus expiratory reserve volume. Higher values can be obtained for chronic obstructive diseases. Total air volume in human respiratory system after maximal inspiration depends on the age and sex of the investigated person (from 4000 to 5500 ml)
- **Inspiratory reserve volume** (IRV) – the maximal amount of additional air that can be drawn into the lungs by determined effort after normal inspiration (usually up to 2500 ml)
- **Inspiratory capacity** (IC) – the summation of TV and IRV
- **Expiratory reserve volume** (ERV) – the additional amount of air that can be expired from the lungs by determined effort after normal expiration (up to 1000 ml)
- **Tidal volume** (TV) - normal volume of air displaced between normal inhalation and exhalation when extra effort is not applied.
- **Respiratory rate** – the number of breaths per minute.
- **Minute ventilation** (MV) - the total volume of gas in liters exhaled from the lungs per minute.
- **Maximal minute ventilation** (MMV) - maximal amount of air expired during 1 minute of forced breathing.
• **Breathing reserve** (BR) - The difference between the volumes of air breathed under ordinary resting conditions and the maximum breathing capacity.

• **Residual volume** (RV) - the volume of air still remaining in the lungs after the most forcible expiration possible and amounting usually from 1000 to 1500 ml. It can be measured only by special equipment.

• **Functional residual capacity** (FRC) - the amount of air remaining at the end of normal quiet respiration; the summation of ERV and RV.

![Expiratory flow curve.](image)

The spirometer in this task measures air volume expired by investigated person automatically and evaluates following parameters:

- **VC** – vital capacity;
- **FVC** - forced (maximal) vital capacity (vital capacity measured when the patient is exhaling with maximal speed and effort.). FVC can be sometimes lower that VC, because forced expiration causes increase of intrapleural pressure and premature closure of peripheral airways.
- **FEV₁** - forced expiratory volume in 1 second. The volume exhaled during the first second of a forced expiratory maneuver started from the level of total lung capacity. A lowered value pointing on obstructive diseases.
- **FEV₁ / FVC** – a ratio FEV₁ and FVC.

- **FEV₁ / VC** - a ratio FEV₁ and VC. Used to distinguish between restrictive and obstructive diseases. **Tiffeneau index** – the ratio of (FEV₁) and (VC). FEV₁% = (FEV₁ / VC) x 100 %. For healthy people approx 80 % (0,8).
- **PEF** – Peak expiratory flow is the maximum flow generated during expiration performed with maximal force and started after a full inspiration (maximal air flow for 10 ms). It appears at the beginning of exhalation (curve in Fig. 2).
- **FEF₂₅₋₇₅** – forced midexpiratory flow is the average rate of airflow measured between exhaled volumes of 25 and 75 per cent of the vital capacity during a forced exhalation. It is a sensitive parameter to obstructive diseases.
The spirometer will print out all measured values in table and two graphs. The result of examination is included. NORMAL SPIROMETRY – normal respiratory functions. In the case of diseases, it can evaluate obstructive, restrictive or combined diseases. Characterization of each disease is shown on boards in practical room B.

**Equipment:**

1) Spirometer SpiroUSB
The spirometer is working with PC and is connected via USB port.

![Fig. 3. Spirometer](image)

**Task:**
Measure vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in 1 sec. (FEV₁), and forced midexpiratory flow (FEF₂₅₋₇₅) of lungs. Compare the values with expected ones.
Execution:

ATTENTION:

Please be careful when handling the device – especially protect it against falling and impact.

1. Click on the icon SPIROMETRY PC on the screen.
2. Choose - New patient.
   A. Data input
   Input the data: items marked by * are obligatory.
   ID – input your birth date in the format DDMMXX
   First name
   Surname
   DOB – Date of birth
   Gender
   Height
   Weight
   Ethnic Origin
   Smoking
   Do not fill other items.
   After the input press Save+Close
   Save + New will allow you to input new patients.

B. Mean spirometer measurement

Attention: If the window with the requirement of the spirometer calibration will appear, please click on: NO X

1. Select investigated person – New examination for X ..Y...
2. Put mouthpiece in the spirometer (each student will take new mouthpiece and uses it for all measurements. After all measurements each student will trash it.)
3. Mark the Relaxed Base (vital capacity measurement).
4. For the measurement start EXHALE NOW! Writing will appear. Eventually click on New exam
5. Put the mouthpiece into your mouth and the clamp on your nose. Breathe in deeply and breathe out maximally.
6. If the test failed press Reject and repeat the test. If the test was successful, press Accept+Next.
   Repeat the successful tests three times.
7. If you want to proceed on the next test, press Accept+Done and Continue exam.
8. Select Forced Base (FVC – forced vital capacity).
9. The text Start Breathing! will appear on the screen. Put the mouthpiece into your mouth and the clamp on your nose. Breathe in deeply and breathe out as fast as you can.
10. If the test failed press Reject and repeat the test. Reject the test if the following messages will appear
11. If the test was successful press **Accept+Next**. Repeat the tests three times.
12. If you want to finish the spirometer measurements press **Accept+Done**.
13. Export the results via PRINT and EXCEL and send them via email to your email address.
14. Close print menu and select **NEW** and input new student as described in this manual.
An example of spirometer results.