Phys Lab Protocols

Spirometry

physiology.lf1.cuni.cz

Labs aim: Explore biology in context through brain and hands

Spirometry comprises noninvasive tests that measure how well your lungs are functioning. It is used to diagnose asthma, chronic obstructive pulmonary disease (COPD), chronic bronchitis, emphysema, pulmonary fibrosis, and other conditions which affect breathing. Spirometry is commonly used periodically to assess whether a treatment for a chronic lung condition is having desired effects on your breathing. Nowadays, spirometry tests work mainly by measuring airflows into and out of your lungs during standardized ventilatory maneuvers. Air flows at specific moments during the spirometry maneuvers or averaged over given time intervals give us the **dynamic lung parameters**. E.g., the forced expiratory volume in 1 second **(FEF1**) represents an average expiratory airflow during the first second of forceful expiration. Or, the peak expiratory flow (**PEF**) is the maximal expiratory airflow during the whole forceful expiration (reached roughly 100 ms after the start of forceful expiration). The corresponding lung volumes (**static lung parameters**) are obtained by time integration of airflow data over specific time intervals. E.g., the vital capacity (**VC**) is obtained by integrating the airflow over a time interval needed to exhale all air inhaled after the maximal inspiration – in principle, that breathing could be quiet or forceful since volumes of air exhaled would be equal if that maneuver starts with maximally inflated lungs and end up fully exhaled). Another static parameter, the tidal volume (**TV**) is obtained by measuring the volume of air exhaled or inhaled during one breathing cycle of normal quiet resting breathing (assessed TV is an average of measured TVs over more consecutive breathing cycles). See the following picture depicting the most important static lung parameters.

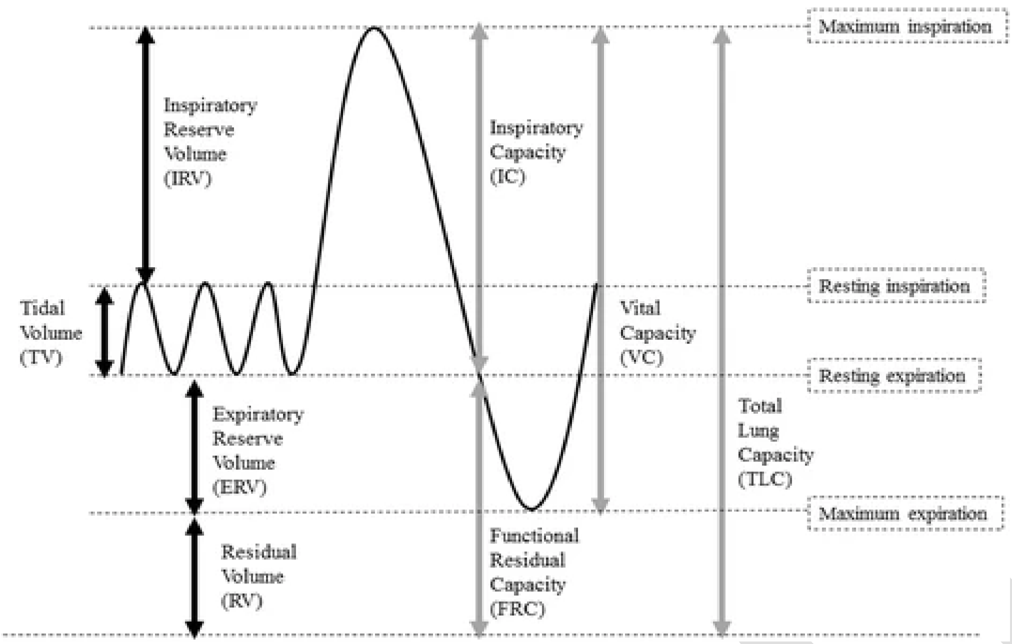

Fig. 1. **Static lung parameters (volumes)**

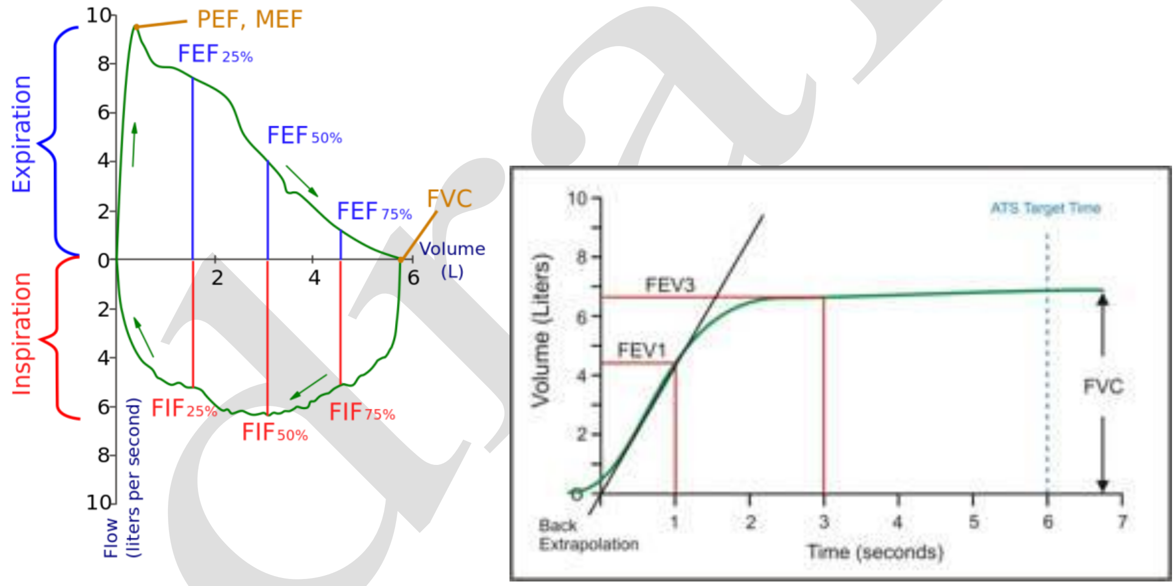

Fig. 2. Physiological **flow-volume loop** during the forceful expiration (blue curve) and inspiration (green curve; flow is in [L/sec]), with the forceful expiration detailed on volume-time graph (right graph).

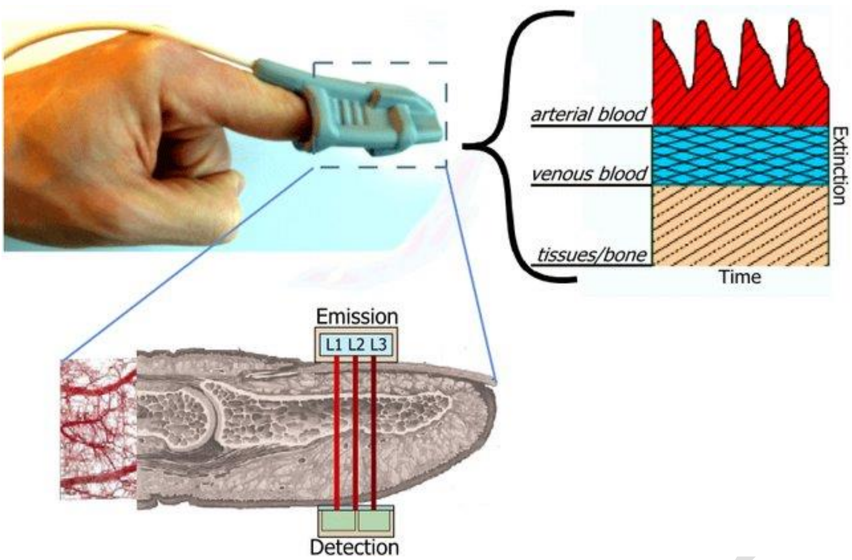

Fig. 3. **Pulse oximetry** measures the saturation of Hb in arterial portion of finger's capillary using the transmission/ reflection of the light on the sensor site. It is based on two physical principles: (1) the presence of a pulsatile signal generated by arterial blood (which is relatively independent of non-pulsatile arterial blood; and (2) on the fact that oxyhemoglobin (O_2Hb) and deoxyhemoglobin (Hb) have different absorption spectra.

AIMS OF THE LAB

- to assess how well your lungs work by measuring how much air you inhale or exhale during various breathing maneuvers, i.e., to estimate what is your TV (tidal volume), VT (vital capacity), IRV (inspiratory reserve volume), ERV (expiratory reserve volume) – i.e., the measurement of **static** lung paraments
- to see how quickly and how much you exhale/inhale at rest or at maximal breathing effort - i.e., to assess the parameters of **dynamic** spirometry dealing with air flows: maximal minute ventilation, resting minute ventilation, PEF (peak expiratory flow), FEV1 (forced expiratory volume in 1 second) and FEV1 to FVC ratio and other dynamic lung parameters
- to obtain the flow-volume loop and to interpret it in terms of dynamic and static spirometry and with respect to possible obstructive, restrictive and mixed lung pathology
- to see how breathing pattern, namely the decrease of ventilation caused by free apnea, could affect the oxygenation of hemoglobin in lungs measured by pulse oximeter (SpO_2), and to discuss how blood CO_2 levels or exercising would affect the time interval of free apnea

REQUIRED KNOWLEDGE

- Ventilation cycle: muscles involved, change in pressure within thorax, transpulmonary pressure, alveolar pressure
- Work of breathing: airway resistance, tissue elasticity (elastic work), surfactants, Laplace law (alveoli)
- Air composition: partial pressure outside the body, in alveoli, in blood, in dead space, in blood (venous vs. arterial), in tissues

- Respiratory quotient, gas exchange, diffusion of gases through alveolo-capillary barrier
- Properties of gas: solubility of gases, cross-sectional area for gas diffusion
- Lung perfusion, Fick's Law, Haldane and Bohr effect, effect of ventilation on pH (pH on ventilation)
- Dead space: types (anatomical, physiological), function of dead space, implications
- Lung volumes and capacities (dynamic and static parameters), spirometry
- Restrictive disorders, obstructive disorders, meaning of FEV1/FVC

List of tasks:

SPIROMETRY

1. perform FVC and FEV1 measurement, compare to norm. (everyone, if personal spirometer is available or allowed to be used)

2. estimate PEF (if personal peakflowmeter is available), compare to norm (everyone)

3. perform thorough spirometry examination using computerized spirometry system (2-3 students should examined if possible)

   a. static spirometry (VT, IRV, ERV and other parameters)

   b. dynamic spirometry (flow-volume curve, maximal MV, resting MV)

4. perform the measurement of SpO_2 during free apnea (measure the SpO_2 by pulse oximeter before, during and after the apnea, discuss the collected results)

5. perform physical examination of lungs (if the time allows)

   a. apsection

   b. palpation

   c. percussion

   d. auscultation