Bodyplethysmography

Functional examination of the lungs is a set of non-invasive examination methods, which also includes body plethysmography. Body plethysmography is an important method for diagnosing lung diseases in the field pneumologie (https://www.wikiskripta.eu/w/Port%C3%A1l:Pneumologie). While the method Spirometry works with vital capacity of the lungs (https://www.wikiskripta.eu/w/Plicn%C3%AD_objemy) (what the patient exhales maximally after a maximum inhalation), in body plethysmography it is possible to assess the lung disorders, it is necessary to know the total lung capacity (that is vital lung capacity (https://www.wikiskripta.eu/w/Plicn%C3%AD_objemy) and residual volume). The examination method is carried out using a bodyplethysmograph device, which includes a closable airtight cabin.

Method Principle

The principle of this device is based on Boyle-Maryott's law, which states that the product of pressure and volume is constant, under conditions of the same temperature (p.V= constant, T = constant). We can therefore transfer the measurement of the volume of air in the lungs to the measurement of pressure deviations inside the cabin (box), which are caused by the breathing cycle (inhale - exhale), the movement of the chest. Body plethysmography can be used to determine so-called indirectly measurable ventilation parameters, which include - intrathoracic gas volume (TGV), resistance to air flowing in the airways (Raw). Furthermore, functional residual lung capacity, residual volume and total lung capacity (https://www.wikiskripta.eu/w/Plicn%C3%AD_objemy) can also be measured.

ITGV measurement principle

ITGV/TGV'(intrathoracic gas volume, intrathoracic volume) *is the pulmonary (https://www.wikiskripta.eu/w/Pl%C3%ADce) volume at which the valve is closed, the so-called intrathoracic gas volume. It is the total volume of compressible gas found in the thorax and includes the compressible air found in the zaludeku (https://www.wikiskripta.eu/w/%C5%BDaludek) and abdominal cavity. Under normal circumstances, the patient's functional residual capacity is slightly higher than the true functional residual capacity (https://www.wikiskripta.eu/w/Plicn%C3%AD_objemy).*

After a normal exhalation (exhalation), the pressure in the lungs, in the oral cavity (https://www.wikiskripta.eu/w/Dutina_%C3%BAstn%C3%AD) and in the box is equal to the barometric (atmospheric) pressure $\mathbf{P_B}$. The corresponding lung volume (https://www.wikiskripta.eu/w/Plicn%C3%AD_objemy) is denoted $\mathbf{V_L}$. If the valve is closed and dech (https://www.wikiskripta.eu/w/D%C3%BDch%C3%A1n%C3%AD_a_jeho_poruchy) is performed, the volume in the lungs will increase (*ΔV*), while the pressure decreases (**ΔP**). The **Boyle-Mariott** law states that for a constant temperature (https://www.wikiskripta.eu/w/T%C4%9Blesn%C3%A1_temperature) for an unchanging amount of air $P * V = const$.

The following therefore applies:

$$P_B * V_L = (P_B - \Delta P) * (V_L + \Delta V)$$

$$P_B * V_L = P_B * V_L + P_B * \Delta V - \Delta P * V_L - \Delta P * \Delta V$$

Since **ΔV** and **ΔP** is very much compared to $\mathbf{P_B}$ **'**and $\mathbf{V_L}$ small, their product can be neglected in the previous equation, and after subsequent modification we arrive at the form:

$$V_L = P_B * \frac{\Delta V}{\Delta P}$$

This expression allows the calculation of the lung volume ($\mathbf{V_L}$) at which the valve is closed. **ΔP** represents the change in alveolar (https://www.wikiskripta.eu/w/Pl%C3%ADce,_stavba_a_funkce#Alveoli) pressure ($\mathbf{\Delta P_{alv}}$ ***') when exhaling against the valve. Since there is no airflow leading to differential pressures between the bronchi (https://www.wikiskripta.eu/w/Larynx,_trachea_a_bronchy_-_stavba_a_funkce#Pr.C5.AFdu.C5.A1ky_.28bronchi.29), it gives assume that the change in alveolar pressure is equal to the change in pressure in the oral cavity (*** ΔP_D ***). Hence*** $\Delta P = \Delta P_{alv} = \Delta P_D$. ***The change in volume*** ΔV ***in this case is equal to the change in total volume in the lungs (due to the movement of the chest wall), or*** $\Delta V = \Delta V_L$.*'*

The **ITGV** can therefore be measured by calculating it as the product of the barometric pressure and the quotient of the change in lung volume and the change in pressure in the [1] (https://www.wikiskripta.eu/w/Dutina_%C3%BAstn%C3%AD) oral cavity.

$$V_L = P_B * \frac{\Delta V_L}{\Delta P_D}$$

Plethysmographic Box Role

The next step is to find **ΔV_L** using the box. For this purpose, the **Boyle-Mariott'** law related to the volume of the box is used again.

$$V_{boxu} = P_B * \frac{\Delta V_{boxu}}{\Delta P_{boxu}}$$

If we consider the tissue as incompressible, the volume change in the lungs can be related to the volume change in the box with the opposite sign (**ΔV_{boxu}= - ΔV_L**).

$$\Delta V_L = -\Delta P_{boxu} * \frac{V_{boxu}}{P_B}$$

If we substitute the previous equation into the equation for calculating **ITGV**, we get the following form:

$$V_L = -V_{boxu} * \frac{\Delta P_{boxu}}{\Delta P_D}$$

Intrathoracic lung volume ***can therefore be estimated based on measurable values, which are pressure changes in the oral cavity (https://www.wikiskripta.eu/w/Dutina_%C3%BAstn%C3%AD) and pressure change in the box. This volume can be considered as functional residual capacity (https://www.wikiskripta.eu/w/Plicn%C3%AD_objemy#Statick.C3.A9_kapacity). Another calculation can be derived from the relationship (ΔV_{boxu}= - ΔV_L***) and the calibration factor **Kv can be introduced** to stand in for barometric pressure.

$$FRC = K_V * \frac{\Delta V_{boxu}}{\Delta P_D}(K_V = P_B)$$

The calibration factor is the volume of babinyox, which is known after subtracting the patient's body volume. A motor-driven pump is also used for precise calibration.

Measurement of lung resistance

Resistance (*sRaw*) or resistance belongs to the mechanical properties of the lungs. Airway resistance is defined by the ratio of the pressure drop between the alveoli and the airflow through the airways (from areas of higher pressure to areas of lower pressure). The flow rate can be defined from the pressure drop and resistance given by the flow. We measure resistance in KPa.l-1. By this method measurement, we will also determine the volume of gas in the chest (TGV).

This examination is performed to determine the patency of the airways, to measure dynamic changes in resistance during bronchomotor tests.

The examination takes place in the so-called bodyplethysmographic cabin. Patient's breathing is measured at a normal breathing rate or shallow rapid breathing ("panting"). With this, we will measure the dependence of airway flow on the change intraalveolar pressure.

$$sRaw = P_{boxu} * \frac{\Delta V_{boxu}}{V}$$

Examination progress

The investigation involves several actions. At the beginning, the patient needs to be weighed and measured so that the device can be properly calibrated. After placing the patient on the seat inside the glass airtight cabin, the door is closed. After the next 0.5-2 min. the air in the cabin is heated by the patient's body heat. As a result of the increased air temperature, the gas expands and thus pressure changes occur. These are subsequently equalized by pumping out excess air through a valve inside the cabin. After reaching equilibrium, the Boyle-Mariott law can be applied in calculations. The probe is placed in the patient's mouth to prevent air escaping through the nose, a clip is used. We make sure that everything is tight and ask the patient to place the palms of both hands on his face. The actual examination begins with calm breathing. We measure the values while breathing calmly, then ask the patient to take as deep a breath as possible, followed by a deep breath, and then breathe normally. This process is repeated 3 times to make the measured results reliable. Subsequently, the lung resistance is checked, during which the patient breathes shallowly and quickly (the so-called train). The result is evaluated by a computer program that clearly displays the individual lung volumes in the form of graphs and in a table.

Links

References

- Criée C. P. et al.: *Body plethysmography – Its principles and clinical use.* February 28, 2011
- Hughes J.M.B, Pride, N.B. Lung function tests. Edinburgh: W.B. Sounders, 2000.H