

DISORDERS AND EXAMINATION OF PULMONARY VENTILATION



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Pulmonary ventilation

- provides change of air between atmosphere and lung alveoli
- depends on airways patency, lung volume, lung and thoracic wall elasticity, respiratory centre activity and motor innervation of respiratory muscles

Static lung volumes

- **Tidal volume (V_T) = 0.5 l** – amount of air inhaled or exhaled with each breath during quiet respiration
- **Inspiratory reserve volume (IRV) = 3 l** – amount of air that can be forcefully inhaled after a normal tidal volume inhalation
- **expiratory reserve volume (ERV) = 1.1 l** – amount of air that can be forcefully exhaled after a normal tidal volume exhalation
- **residual volume (RV) = 1.2 l** – amount of air left in the lungs after a forced exhalation (it can not be exhaled)
- **dead space (V_D) =** the volume of air in the conducting airways
(it can not be measured directly with classical spirometry)
 - **anatomical dead space (150-200 ml)** – physiological, airways to terminal bronchioli
 - **total (functional) dead space** – anatomical death space + pathologically changed parts of lung, which are ventilated but in which change of respiratory gasses is restricted (decrease of perfusion of diffusion across the alveolo-capillary membrane)

Static lung capacities

- **Vital capacity (VC):** volume of air, which can be expired with maximal effort after a maximal inspiration

$$VC = V_T + IRV + ERV$$

calculation of normal value of vital capacity in ml:

man: $VC = [27.63 - (0.112 \times \text{age (years)})] \times \text{height (cm)}$

woman: $VC = [21.78 - (0.101 \times \text{age (years)})] \times \text{height (cm)}$

- **total lung capacity (TLC):** amount of air contained in the lungs after a maximal inspiration

$$TLC = V_T + IRV + ERV + RV$$

- **functional residual capacity (FRC):** volume of air, remaining in the lungs after a normal tidal volume expiration

$$FRC = ERV + RV$$

Dynamic lung volumes

- **forced expiratory volume (FEV1):** volume of air that can be exhaled during the first second of a forced expiration after a maximal inspiration
- **FEV1% (Tiffeneau's index):** FEV1 expressed as the ratio in percentage terms

$$\text{FEV1\%} = (\text{FEV1} / \text{VC}) \times 100 \% \quad \text{normal value: } 80 \%$$

- **minute lung ventilation = 8 l:** volume of air expired during 1 minute of quiet breathing
- **minute alveolar ventilation:** minute ventilation minus minute ventilation of the deadspace
- **maximal minute ventilation (MVV):** maximal amount of air expired during 1 minute of forced breathing

$$\text{indirect calculation: } \text{MVV} = \text{FEV1} \times 30 \text{ breath/min}$$

calculation of normal values in l:

$$\text{man: } \text{MVV} = [86.5 - (0.522 \times \text{age (years)})] \times \text{body surface area(m}^2\text{)}$$

$$\text{woman: } \text{MVV} = [71.3 - (0.474 \times \text{age (years)})] \times \text{body surface area(m}^2\text{)}$$

Examination of respiratory functions

spirometers

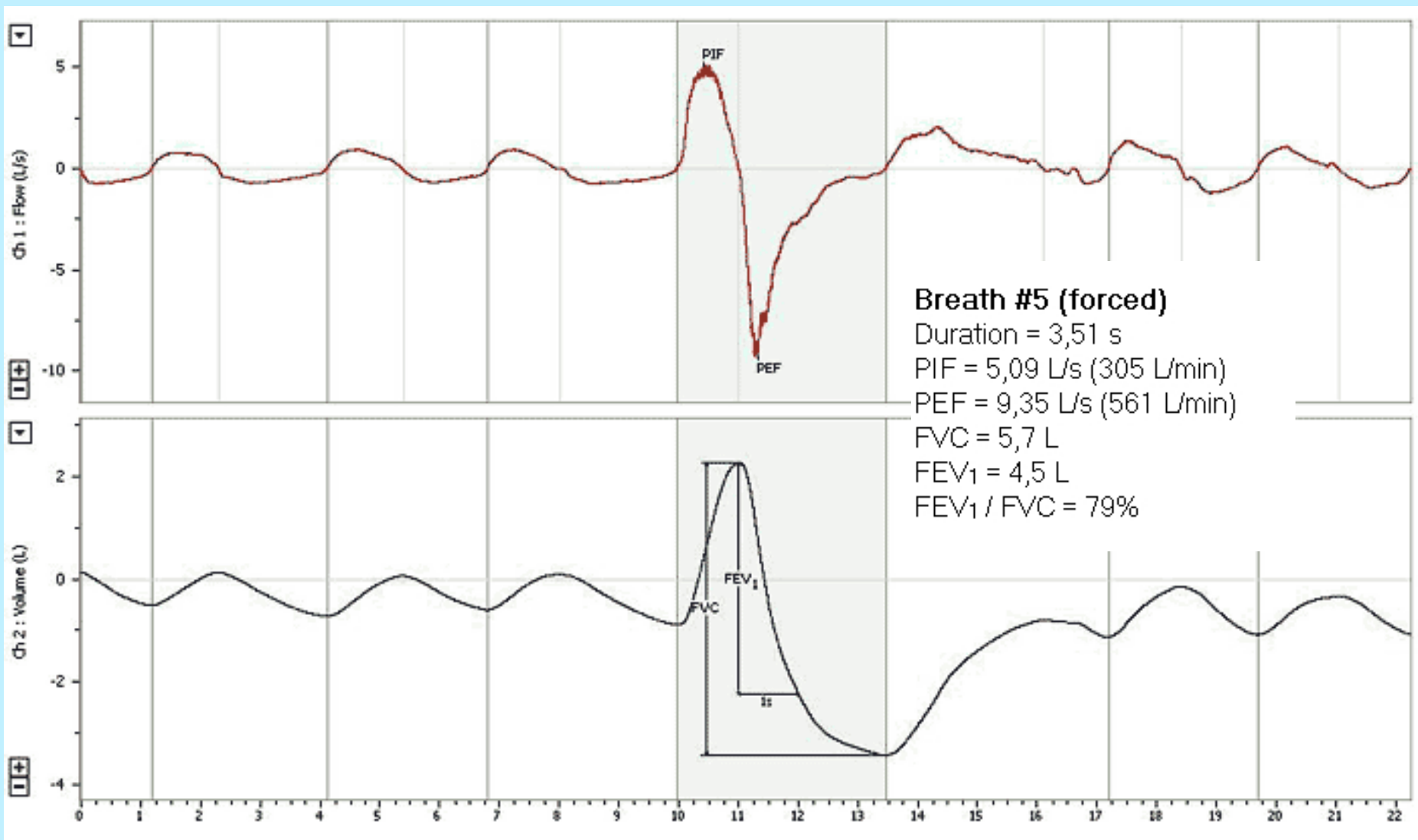
- devices measuring primarily volumes
e.g. EUTEST



- devices measuring primarily air flow
e.g. PowerLab

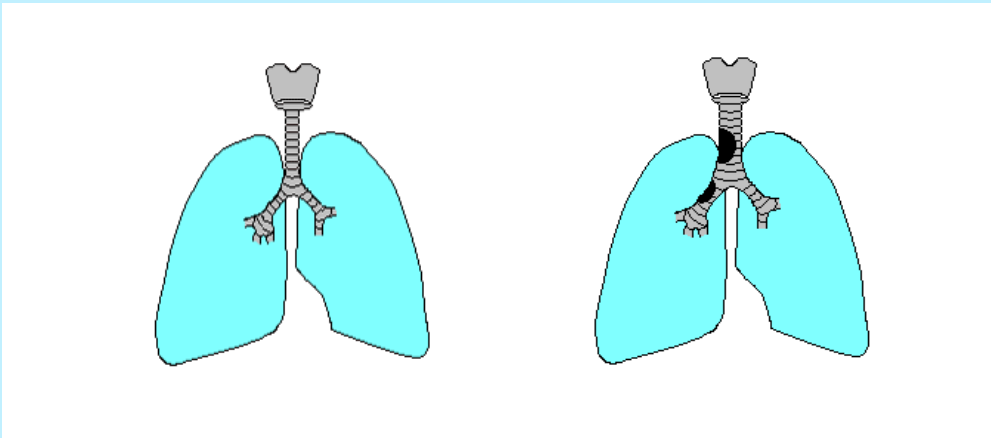


Examination of respiratory functions – physiological recording

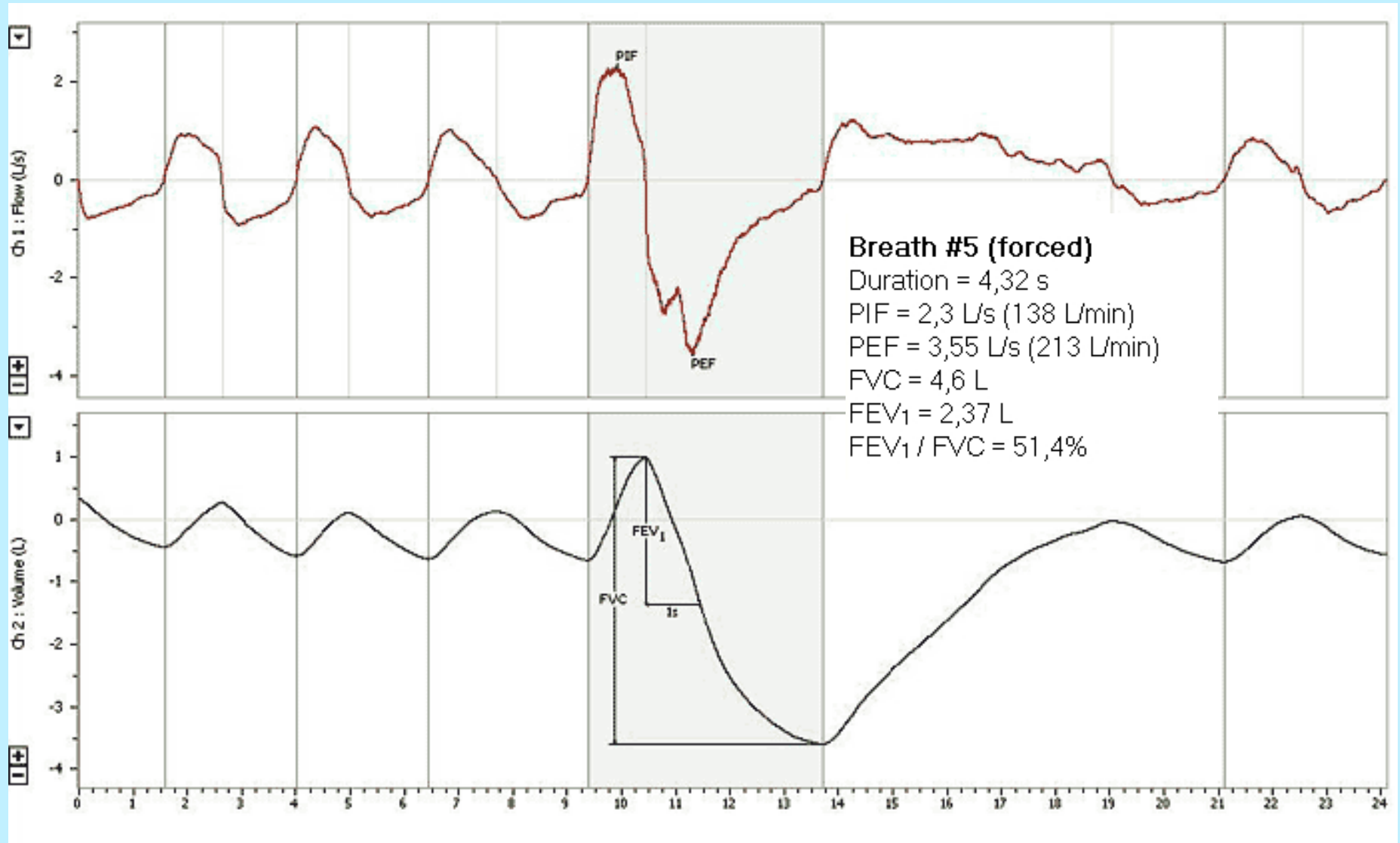


Obstructive disorders of pulmonary ventilation

- reduction of patency of airways
- constriction of upper airways – inspiratory dyspnoea
- constriction of lower airways – expiratory dyspnoea
- diagnosis according to spirometry:
normal VC , decreased FEV1 → FEV1% < 80 %
- examples:
asthma bronchial, bronchitis, corpus alien in the airways,
partial obstruction or compression of bronchial tubes by
tumours, goitre etc.



Obstructive disorders of pulmonary ventilation

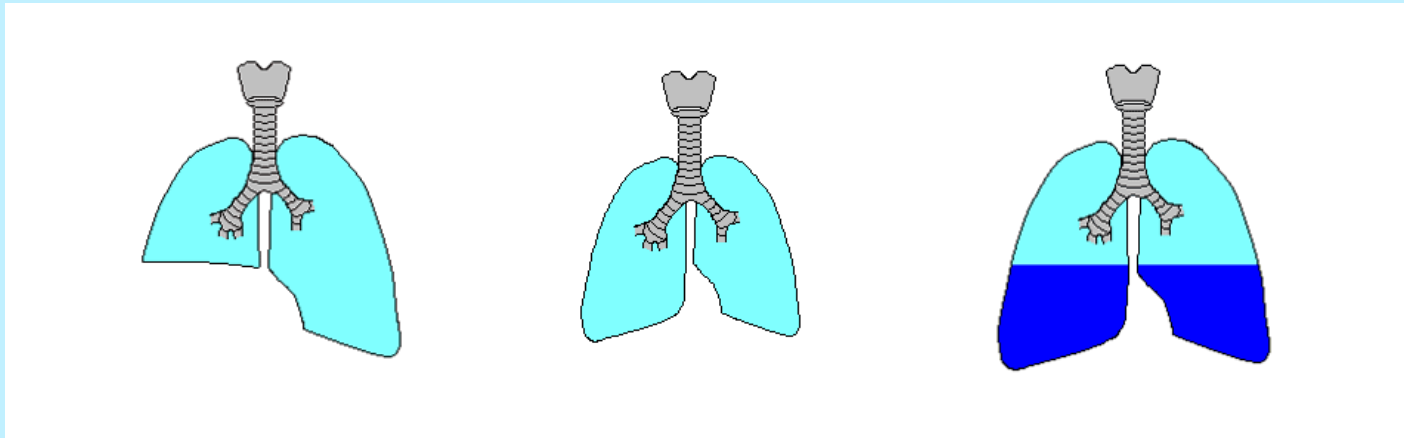


Restrictive disorders of pulmonary ventilation

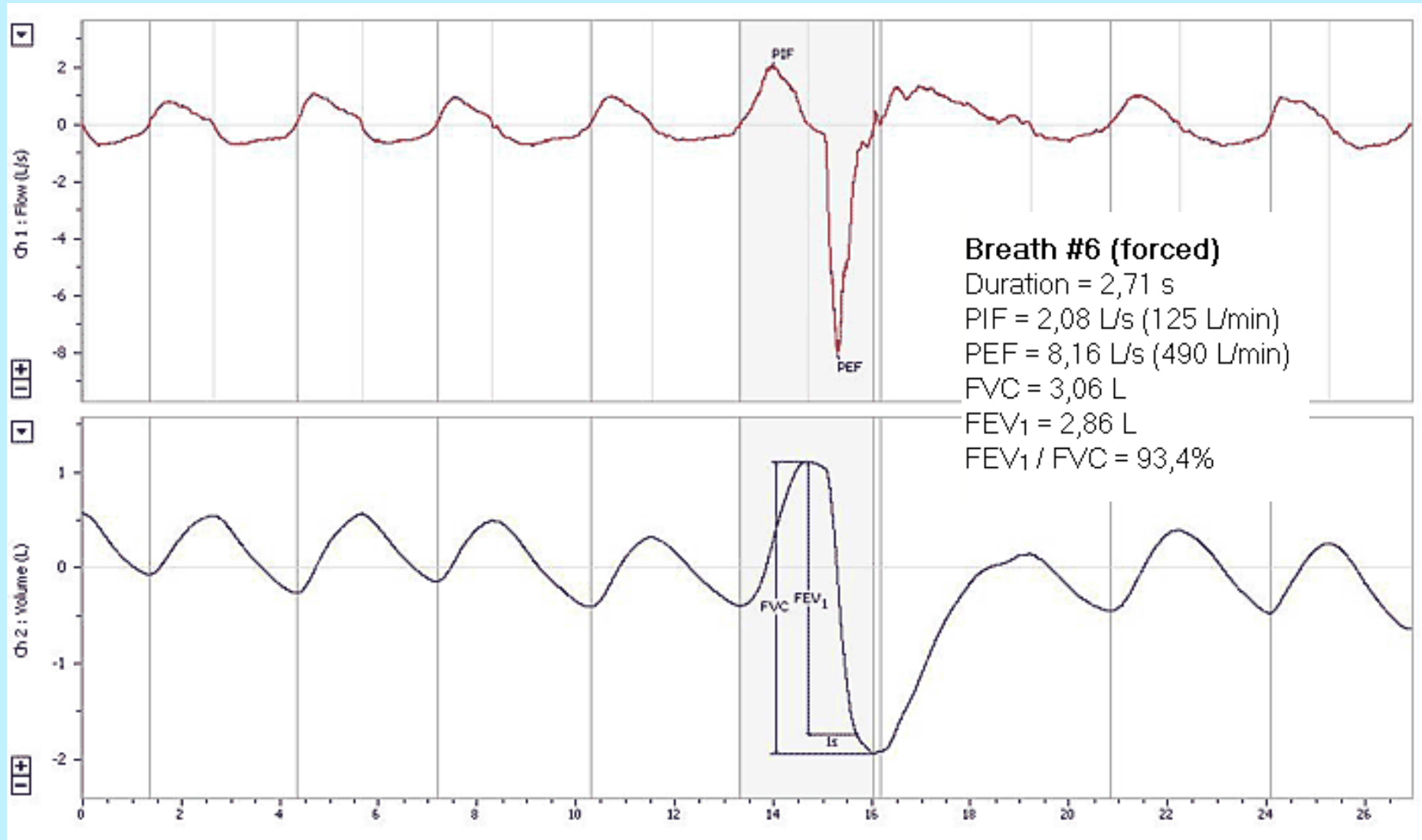
- restriction of lung capacity
- diagnosis according to spirometry:
 - decreased VC (pathological is the decrease under 80 % of normal value), FEV1% often > 80 %

examples:

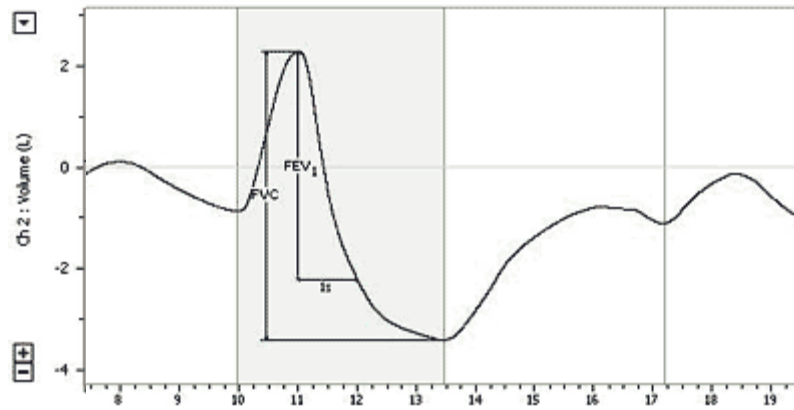
state after lung resection, lung atelectasis, lung oedema, pneumonia, pneumothorax, hydrothorax, lung fibrosis, thoracic deformities, disorders of respiratory muscles (their innervation or neuromuscular junction)



Restrictive disorders of pulmonary ventilation



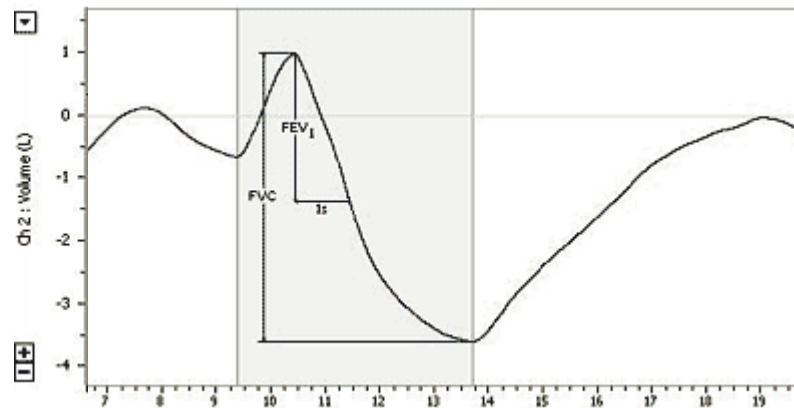
**normal
state**



Breath #5 (forced)

Duration = 3,51 s
PIF = 5,09 L/s (305 L/min)
PEF = 9,35 L/s (561 L/min)
FVC = 5,7 L
FEV₁ = 4,5 L
FEV₁ / FVC = 79%

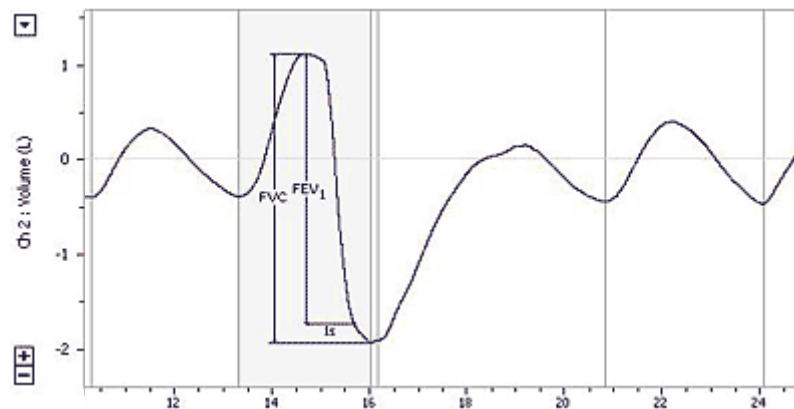
**obstructive
disorder**



Breath #5 (forced)

Duration = 4,32 s
PIF = 2,3 L/s (138 L/min)
PEF = 3,55 L/s (213 L/min)
FVC = 4,6 L
FEV₁ = 2,37 L
FEV₁ / FVC = 51,4%

**restrictive
disorder**



Breath #6 (forced)

Duration = 2,71 s
PIF = 2,08 L/s (125 L/min)
PEF = 8,16 L/s (490 L/min)
FVC = 3,06 L
FEV₁ = 2,86 L
FEV₁ / FVC = 93,4%

Assessment of the disorder severity

- according to FEV1 – in obstructive disorder decreased primarily
 - in restrictive disorder decreased secondarily (due to decrease of vital capacity)

Decrease of FEV1 under 80 % of the normal value is considered as pathological.

FEV1 60-80 % of the normal value = moderate disorder

FEV1 40-60 % of the normal value = middle disorder

FEV1 < 40 % of the normal value = severe disorder

THE END