Modelling of the vital signs

Simulator of vital signs allows induce all situations (physiological and heart rhythm disturbances), which can the medical student or doctor to see in the operating rooms, anesthesiology and intensive medicine.

1. *Modelling of physiological parameters of the patient on the simulator of vital signs*

Blood pressure:

Mean arterial blood pressure of adult humans is 120/80 mmHg. At a pressure below 100/60 mmHg we are talking about hypotension, at a pressure above 139/89 mmHg we are talking about hypertension.

Body temperature (measured in the axilla):

below 34 °C -   death

34 - 35.9 °C -   hypothermia

36 – 36.9 °C -   normothermia

37 - 38 °C -   subfebrility

38.1 - 40 ° C -   febrility/febris (fever)

40.1 - 42 °C -   hyperpyrexia

above 42 °C -   death

Normal heart and respiratory rate:

	heart rate	*respiratory rate*
newborn	130 - 160/min	50 - 60/min
infant under 1 year	100 - 140/min	35 - 40/min
child to 10 years	okolo 90/min	20/min
adult	70 - 80/min	16 - 20/min

ECG (electrocardiogram)

For the 12-lead ECG physiological sinus rhythm following applies:

- **P wave** is normally upright in all leads except VR. When the QRS complex is predominantly downward in lead VL, the P wave may also be inverted (Fig. 1).

- **PR interval** is constant and the normal range is 120-220 ms (3-5 small squares of ECG paper).

- there is a fairly wide range of normality in the direction of the cardiac axis. In most people the QRS complex is tallest in lead II, but in leads I and III the QRS complex is also predominantly upright (i.e. the R wave is greater than the S wave).

- **QRS complex** should be less than 120 ms in duration (i.e. less than 3 small squares) in all leads.

- **ST segment** (the part of the ECG between the S wave and the T wave) should be horizontal and isoelectric, which means that it should be at the same level as the baseline of the record between the end of the T wave and the next P wave.

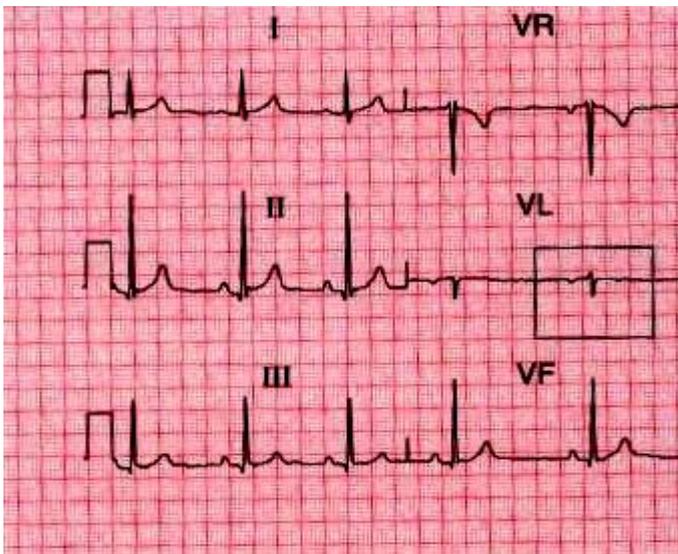- **T wave** is always inverted in lead VR but is usually upright in all the other leads.

Fig. 1 The physiological ECG in sinus rhythm

2. Heart rhythm disturbances

Arrhythmias are heart rhythm disorders of varying etiology and pathogenesis. In a broader sense arrhythmias are conditions that manifest regularity disorder (arrhythmia own, for example atrial fibrillation), heart rate disorder (dysrhythmia, e.g. sinus tachycardia).

2.1. Pathophysiology of heart rhythm disturbances

Cause of arrhythmia is a disorder of impulse formation and conduction, or a combination of both. The source of the arrhythmia may be: hypoxia (lack of oxygen in arterial blood), hypercapnia (increase the carbon dioxide concentration in the blood), acidosis or alkalosis (acid-base disturbances), hypokalemia and hyperkalemia (lack and excess of potassium), electrolyte disturbances, drug intoxication, or other types of intoxication, all forms of acute and chronic ischemic heart diseases, cardiomyopathy (disease affecting the myocardium) and a host of other diseases. Arrhythmia (dysrhythmia) is an abnormal heart rhythm mainly due to the failure of formation or conducting of impulses, or a combination of both mechanisms. Arrhythmia can also cause pain, agitation, anxiety, physical fatigue, but also chest injuries, or certain groups of drugs, including anti-arrhythmic drugs

2.2. Division of heart rhythm disturbances

In terms of hemodynamic arrhythmias divided on fast and slow. Quick arrhythmias by shortening lead to reduced diastolic filling of the ventricles and a decrease in cardiac output. Indicatively be assumed decrease in cardiac output (MOS) using the formula 220 - age in years. Slow arrhythmias partially improve the performance of the chambers during diastole, but the low frequency reduces cardiac output and lead to a reduction in the blood flow of the vital organs.

1. *Bradyarrhytmias (less than 60 beats/min in adults):*
   - sinus bradycardia (slower heart beat than 60/min.)
   - sinoatrial block (impaired conduction of the sinoatrial node to the atrium)
   - atrioventricular block I.- III. degree (Impaired conduction in the atrioventricular node and bundle of His)

2. *Tachycardia with narrow QRS complex - supraventricular (more than 100 beats/min in adults):*
   - sinus tachycardia (fast heart beat of 90 / min.)
   - fibrillation atrial (irregular atrial)

3. *Tachycardia with a wide QRS complex:*
   - ventricular tachycardia (rapid contractions of the ventricles)
   - ventricular fibrillation (irregular chambers)

2.3. Clinical manifestations of heart rhythm disturbances

2.3.1. Anamnesis

The patient is able to inform the doctor that cures for heart disorders, often it can also be specified. Unless the heart rhythm disorder patients experience the first time, waving detectable beginning: subjective perception of „skipping heart" feeling palpitations, fatigue, nausea, shortness of breath, dizziness, chest pain, anamnestic manifestations of serious arrhythmia and transient loss of consciousness - syncope. It arises due to loss of blood supply of the brain and is often associated with collapse. Patients with arrhythmias for the first time feel fear and anxiety. When diagnosing a patient will help any ECG, only with the three of chest electrodes.

2.4. ECG in symptomatic patients

Using a simulator vital signs we can observe abnormal heart rhythm (sinus tachycardia, sinus bradycardia, ventricular fibrillation, asystole, and others).

2.4.1. Sinus tachycardia

Its essence is the increase in the frequency of impulses in the SA node over 90 (100) per minute. Making impulse is thus accelerated, but regular. Periodicity may be impaired breathing (especially deep) - on breathing accelerates, slows down during expiration. This condition can be relatively easily identified even at normal ECG.

For sinus tachycardia (Fig. 2) is true:

• the frequency of the QRS complex of 100/min

• sinus rhythm. Stimuli must be based in the sinus node.

• P waves are converted into the chamber (usually with a constant PR interval).

• the higher the frequency, the more P waves hidden in the preceding T wave.

May then be a big problem different from each sinus tachycardia, atrioventricular nodal reentry tachycardia (AVRN), atrioventricular nodal reentry tachycardia (AVRT) and cardiac arrhythmia, whose origin is abnormal spread of cardiac conduction atrium (atrial flutter).

Fig. 2 Sinus tachycardia-distance between P and T waves are short (FG Yanowitz, 2007)

2.4.2. Sinus bradycardia

Slowing the formation of conduction in the SA node below 60 per minute. Occurs physiologically in healthy well-trained athletes and sleep in healthy people as a sign of saving (economic) activity of the heart (heart rate reduction at current increase in systolic volume reduces the amount of work to required deliver the amount of blood - oxygen to the tissues). Detection of sinus bradycardia in circumstances other may be a sign of damage to the heart or the system that controls the frequency.

For sinus bradycardia (Fig. 3) is true:

• sinus rhythm

• frequency of 45/min

• otherwise physiological ECG

Fig. 3 Sinus bradycardia - distance between T and P is extended (FG Yanowitz, 2007)

2.4.3. Ventricular fibrillation

This is a fatal dysrhythmia caused by the high time and location, a non-coordinated activity of a number of ectopic lesions in the wall and / or in the heart ventricular septum. The result of such electrical activity is uncoordinated contraction (Fig. 4) of individual districts ventricular muscle, of hemodynamic site means stop blood circulation.
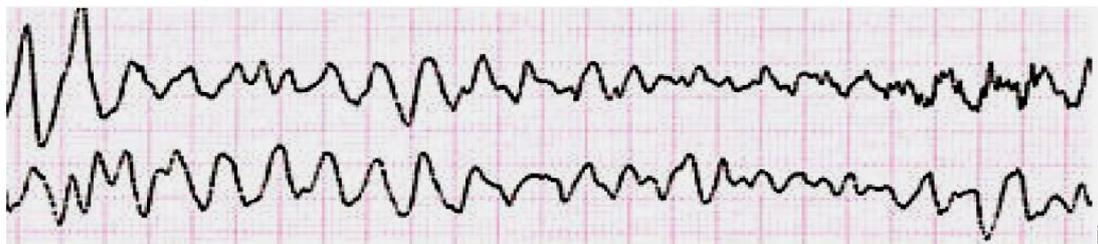

Fig. 4 Ventricular fibrillation

2.4.4. Asystole

The condition where the heart does not show any electrical activity (mechanical activity is dependent on the electrical activity). There is cardiac arrest and if the state is not urgently addressed, also the death of the individual. Condition can be diagnosed using electrocardiography, when the ECG record is a horizontal line (isoelectric line).

Vital signs simulator (ProSim 8)

Vital signs simulator (ProSim 8) is compact, portable simulators, used to measure the performance of patient monitors.

The product is intended to be used to test and verify the basic operation of patient monitoring devices or systems used to monitor various physiological parameters of a patient, including ECG, respiration, invasive blood pressure, non-invasive blood pressure, temperature, cardiac output, and SpO_2.
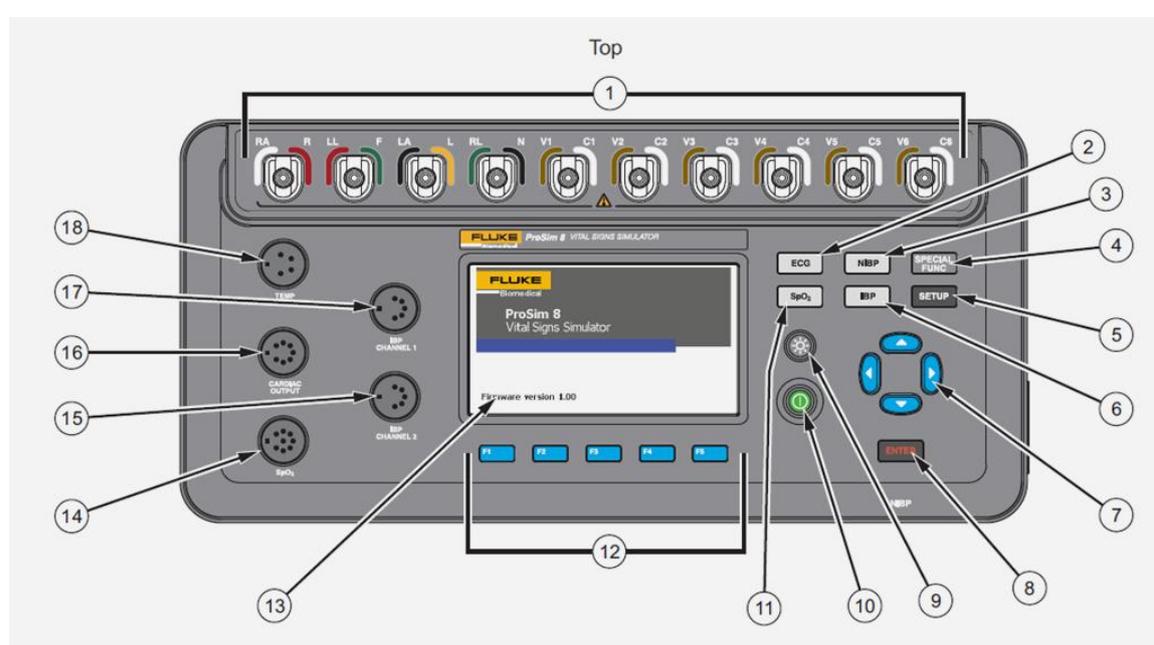

Fig. 5 Vital signs simulator ProSim 8 (Top-Panel Controls and Connections)

1 ECG Posts, **2** ECG Function, **3** NIBP Button, **4** Special Functions. **5** SETUP Button, **6** IBP Button, **7** Navigation Buttons, **8** Enter Button, **9** Backlight Button, **10** Power Button, **11** SpO_2 Button, **12** Function Softkeys, **13** LCD Display, **14** SpO_2 Connector, **15** IBP Channel 1 Connector, **16** Cardiac Output Connector, **17** IBP Channel 2 Connector, **18** Temperature Connector

TASK: Based on the values of heart rate, blood pressure, respiratory rate, ECG and RESP curves identify the simulated conditions: normal, hypertension, hypotension, sinus bradycardia, sinus tachycardia, ventricular fibrillation (heart attack) and asystole. Write down the heart rate, blood pressure, respiratory rate and draw the record of ECG and RESP waveforms

Modelling of the patient conditions

1. Plug the power cord into the socket INPUT of the simulator. The other end of the power cord plug in to the power outlet
2. Press the button ⓞ on the front control panel of the simulator and turn on the simulator of vital functions
   - If the test is complete and no errors appear, the display shows the home view
3. Connect the ECG electrodes to the ECG circuit of the simulator and connect the ECG cable to the ECG connector on the right side of the monitor (Fig. 6)
4. Assemble artificial arm of adult patient (Fig. 7)
5. Prepare apparatus for simulating NIBP as it is shown in Fig. 8
6. By pressing the function keys F1-F5 (Fig. 5) the teacher start the predefined simulated conditions. Press "More" button to see additional simulations. (The screen displays ECG and RESP curve with the corresponding values of heart rate and respiratory rate)
7. Press the NIBP button on the front control panel of the patient monitor. (Device begins simulate NIBP measurement using the arteficial arm). Repeat NIBP measurement for each the predefined simulated patient condition
8. Write the values of heart rate, blood pressure, respiratory rate, which are displayed on the patient monitor for each simulated patient condition to the table
9. Draw an ECG and RESP waveforms of each simulated patient condition
10. Based on the values of heart rate, blood pressure, respiratory rate, ECG and RESP waveforms **students identify** the simulated conditions (condition 1-7)
11. Press the button ⓞ turn off the simulator and monitor of vital functions
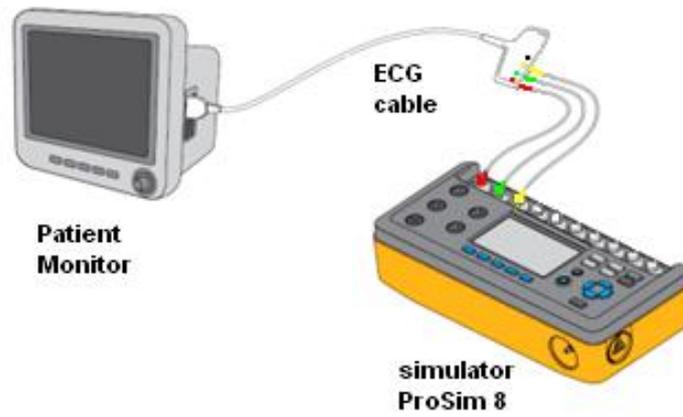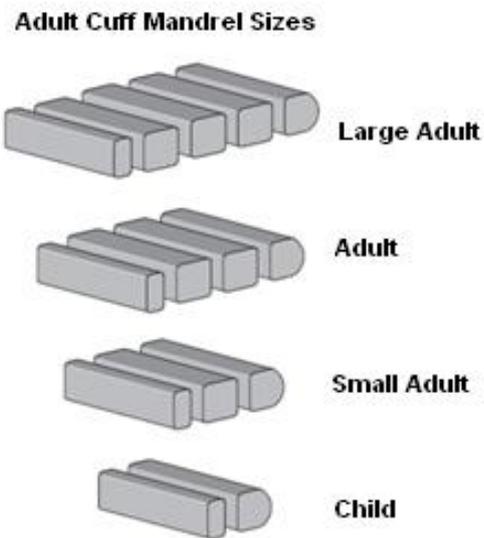
Fig. 6 ECG Connections
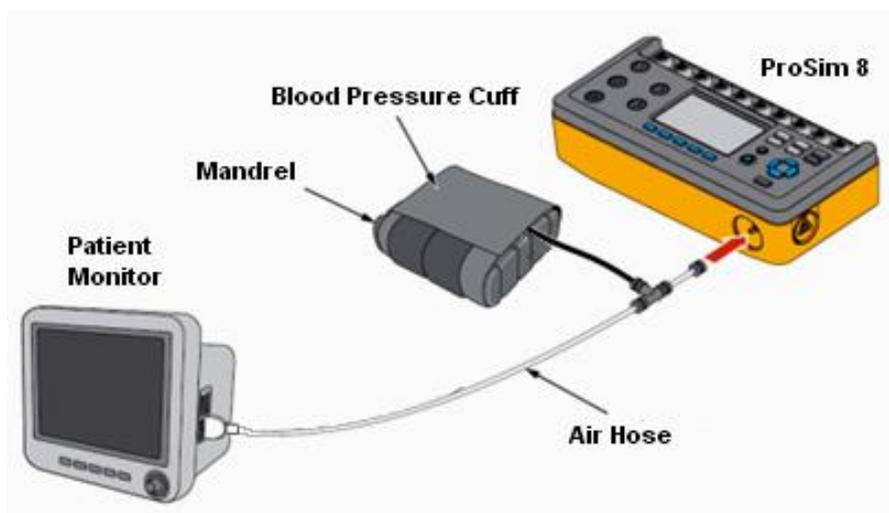

Fig. 7 Adjustments for Adult Blood Pressure Cuff Mandrel

Fig. 8 Non-Invasive Blood Pressure Test Connections