Temperature measurement

Thermometry determines **temperature** - an objective measure of the thermal state of a substance. According to SI, the basic quantity is **thermodynamic temperature**, the unit of which is **Kelvin**.

The following temperature scales have been or are being used to measure temperature:

- thermodynamic temperature scale;
- Celsius temperature scale;
- Fahrenheit temperature scale;
- Réaumur temperature scale;
- Rankine temperature scale.

Central body temperature (BT) is measured intracavitally, most often **per rectum**.

We measure **peripheral BT** most often on the **dorsum of the foot** and further evaluate the temperature difference.

Difference between central and peripheral BT > 2 °C indicates hypovolemia or increased α-mimetic activity, difference > 8 °C indicates shock circulation, severe hypovolemia.

Indications for continuous BT measurement are::

- intracranial hypertension;
- thiopental coma;
- patients with hemodynamic instability;
- patients with a complex ventilation settings;
- patients with malignant hyperthermia.

Method of measurement

Temperature can only be measured indirectly on the basis of known physical phenomena at different temperatures. **Thermometry** is therefore performed in several ways, based mostly on the volumetric expansion of liquids or the **longitudinal expansion of solids at different temperatures**. The most accurate is **intracavitary measurements**, ie **rectally, vaginally, orally** (auricular measurements cannot be considered accurate).

From a practical point of view, measuring a higher axillary temperature with a high probability predicts a higher rectal value, but a normal axillary temperature does not exclude a higher rectal temperature. When in doubt about **axillary temperature**, the patient should be re-measured **rectally**.

Liquid thermometers

These are the most widely used thermometers ever. The most common are **mercury thermometers**, although they are gradually expelled due to the toxicity of **mercury**. They consist of a **mercury tank with a capillary and a scale**. With increasing temperature, mercury changes its volume and climbs in capillaries. Two basic modifications are used:

- **maximum thermometer** - records the highest measured value. Due to the narrowing of the capillary above the reservoir, the mercury remains at the maximum point after use and must be "shaken down" into the reservoir. The settling time of the final temperature is several minutes.

Thermometers

Another type of liquid thermometer is the **alcohol thermometer**, measuring in the range from −110 °C do 70 °C.

The sensitivity of these thermometers increases with the volume of the reservoir and the smaller radius of the capillary. These thermometers measure to the nearest tenth of a degree.

Non-contact infrared thermometers

According to Stefan-Boltzmann's law|, every body with a certain temperature emits thermal radiation. **The infrared non-contact thermometer, sometimes also a pyrometer, is based on the principle of measuring the amount of energy radiated in this way in the infrared spectrum**. Because Stefan-Boltzmann's law applies to black bodies, the emissivity quantity is introduced for real bodies. **Emissivity is the ratio between the radiation of a real body and a black body at the same temperature.** In addition, for real bodies, their transprarency and reflectivity must be taken into account. For transparent materials, accuracy is achieved by spectral filtration, eg glass behaves opaque for a wavelenght of 5 μm. Reflective materials measure not only their own but also reflected radiation.

The design consists of optical systems (lenses, optical fibers, spectral filters), which determines the diameter of the measured area at the prescribed distance. For aiming the measured area with light or laser sights. The beams are concentrated in a **detector**, which is usually a photovoltaic cell or photoresistor. This creates an electrical signal that is amplified and displayed in various ways.

The advantage is **contactlessness**, the possibility of measuring at greater distances, **fast response** and negligible influence on the measured object.

Resistance thermometers

This thermometer is based on a change in the electrical resistance of a metal with a change in temperature. This dependence can be expressed by the relation:

$R_t = R_0 \cdot (1 + \alpha \cdot t)$,

where R_t is the resistance at temperature t, R_0 is the resistance at zero temperature and α (K^{-1}) is the temperature coefficient of resistance

The advantage of this type of thermometer is **the linearity of measurements over a wide range of temperatures and easy evaluation**. The most commonly used is the platium thermometer, which measures the temperature in the range from -100 °C to 440 °C, while measuring with an accuracy of thousands of degrees. This type of thermometer is used at least in technical practice and is often part of more complex measuring devices (eg as a sensor for measuring the reference temperature of thermocouple probes).

Thermocouple

Thermoelectric cells measure temperature based on a **thermoelectric effect**. It works on the principle that in a closed electrical circuit of two conductors of different metals, each having a different temperature, an electric current flows. If we disconnect this circuit, we are able to measure the values of **thermal voltage**, which are given by the temperature difference between the connections. For practical use of the thermocouple, one wire is placed in the environment with the **reference temperature** (in practice room temperature, approx. 25 ° C) and the other is placed in the environment where we want to measure the temperature. The voltmeter then measures the value of the thermal voltage between the connections, to the nearest hundredth of a degree Celsius.

Said **thermal voltage** is a quadratic function of temperature. In the case of its use in medicine, where the temperature range is only from 20 °C to 50 °C, we can express the given linear dependence using the relation:

$U_{AB} = k \cdot (t_A - t_B)$

where U_{AB} is the thermal voltage between the reference and measuring point of the thermocouple, t_A and t_B are the temperatures of these points; k is the calibration constant depending on the thermocouple type. In medical applications, the most commonly used are thermocouples **copper-constantan** (calibration constant 40 μV/K) or **manganese-constantan**. The accuracy of thermocouple temperature measurement depends on the sensitivity of the thermal voltage voltmeter and the accuracy of the thermocouple cold end temperature measurement.

The advantage of thermocouples is **miniaturization**, so they are used in medicine as invasive temperature meters, eg for **hyperthermia**.

Thermistor

Thermistor temperature measurement is based on the measurement of **electrical resistance**, where the density of free electrons in a semiconductor rises sharply with increasing temperature. This reduces the electrical resistance.

The given dependence can be expressed by the equation:

$T = B \cdot (\ln R - \ln A)$

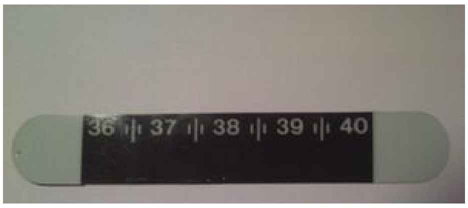
where B and A are the material constants, R is the resistance and T is the absolute temperature of the semiconductor.

The measurement is very accurate, in the order of mK. Sensors for thermistors are usually invasive needles, with the thermistor itself at the tip of the needle.

Phosphor thermometry

Phosphor thermometry is used to measure the temperature of surfaces covered with a layer of phosphor. Phosphor emits light after excitation due to luminescence. Its brightness, color and decay time are temperature dependent. The dependence of the **decay time** after excitation on the **temperature** is most often used. It is used in **fiber invasive thermometers**.

LC thermometers



LC thermometer

LC (liquid crystal) thermometers work on the basis of liquid crystals, which change color depending on the temperature. The resolution can be up to 0.1 ° C. In the form of **disposable temperature strips**, they can be used to measure body temperature on the forehead.

Links

Related articles

- Článek o měření teploty v Katalogu metod v biofyzice
- Sledování fyziologických funkcí
- Termografie
- Měření a hodnocení tělesné teploty
- Chyby měření fyzikálních veličin, relativní chyba

External links

- Phosphor thermometry (https://en.wikipedia.org/wiki/Phosphor_thermometry)
- Liquid crystal thermometer (https://en.wikipedia.org/wiki/Liquid_crystal_thermometer)

References

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