

Urine osmolality

Urine osmolality depends on the **amount of osmotically active particles** excreted in the urine, regardless of their weight, size or electric charge. Osmolality is expressed in mmol/kg. It is only approximately dependent on urine density. Its measurement is more accurate compared to density, has a greater informative value and is preferred.

If we compare the two quantities, the osmolality reflects **the total mass concentration of all solutes**, while the density reflects their total mass concentration. Therefore, we can simply say that osmolality will be more affected by changes in the concentration of low molecular weight substances (in practice, especially sodium, glucose and urea), while density will be more significantly affected by the presence of protein in the urine.

Normal osmolality values at normal fluid intake are 300-900 mmol / kg. Urine osmolality depends on the dilution and concentration of the kidneys. The extreme values of osmolality at maximum dilution or maximum concentration are in the range of 50-1200 mmol / kg. If the osmolality of the urine is approximately the same as the osmolality of the blood, it is **isoosmolar** urine. **Hypoosmolar** urine has a lower osmolality than blood, i.e. less than about 290 mmol/kg. **Hyperosmolar** urine is urine with a higher osmolality than blood.

Theoretically, we can imagine that definitive urine arises from isoosmolar glomerular filtrate, to which pure, so-called solvent-free water is added or resorbed in the renal tubules.

The transport of solute-free water expresses its clearance. We will explain what this quantity means using the following considerations: First, let us define the **clearance of osmotically active substances**. It is a quantity analogous to the commonly used clearance of endogenous creatinine: the clearance of osmotically active substances represents the theoretical volume of blood plasma, which is completely deprived of all osmotically active particles in the kidneys per unit time. The following will apply (derivation is similar to endogenous creatinine clearance):

$$Cl_{osm} = \frac{U_{osm} \cdot V}{P_{osm}},$$

where Cl_{osm} is the osmolar clearance in ml/s,
 V is diuresis in ml/s
 U_{osm} is the osmolar urine concentration in mmol/kg of water,
 P_{osm} is the osmolar plasma concentration in mmol/kg of water.

If the primitive urine has the same osmolality as the plasma and we neglect the contribution of proteins to the total osmolality of the plasma, the volume of filtered primitive urine must be the same as the clearance of the osmotically active Cl particles .

Solvent-free water clearance is the difference between the actual volume of definitive urine excreted per unit time and osmolar clearance:

$$Cl_{H_2O} = V - Cl_{osm}$$

where Cl_{H_2O} is the clearance of solute-free water in ml/s,
 Cl_{osm} is the osmolar clearance in ml/s,
 V is diuresis in ml/s.

If the clearance of solute-free water is **negative**, it means that part of the solute-free water has been resorbed from the primitive urine, so that the definitive urine is more osmotically concentrated. Conversely, if the clearance of solute-free water were **positive**, hypoosmolar urine would form, against blood plasma diluted with solute-free water. Physiological values range between ,00.027 and ,000.007 ml / s.

The kidneys are able to excrete large amounts of solute-free water to prevent hyponatremia. Conversely, in the absence of water, its excretion is limited and particles are excreted in a smaller volume of water.

Determination of the urine osmolality

With osmometer

Osmometers are used to accurately determine osmolality. They take advantage of the fact that dissolved particles affect some properties of the solution:

- they reduce the freezing point of the solution (**cryoscopic** principle);
- they increase the boiling point of the solution (**ebulioscopic** principle);
- they reduce the solvent vapor pressure above the solution.

The magnitude of the change in the above quantities depends on the concentration of osmotically active substances in the measured solution, and osmometers record these changes with great accuracy. A lowering of the freezing point is usually detected. It is true that 1 mol of particles of a substance dissolved in 1 kg of water lowers its freezing point by 1.86 °C.

Roughly by calculation based on the substance concentration values of Na⁺, K⁺, NH₄⁺ and urea in urine

$$\text{Urine osmolality} = 2([\text{Na}^+] + [\text{K}^+] + [\text{NH}_4^+]) + [\text{urea}]$$

This calculation fails if the urine contains a high concentration of other substances, which are physiologically present in orders of magnitude lower amounts - for example, with significant glycosuria or ketonuria.

Roughly calculated from the relative density value

If the urine does not contain protein or sugar

we multiply the last two digits of the relative density value by a factor of 33.

$$\text{Relative density of urine} = 1,019 \rightarrow \text{Estimation of osmolalit: } 19 \cdot 33 = 627 \text{ mmol/kg.}$$

If the urine contains protein or sugar

we must first correct the relative density value

- in the presence of protein, we subtract 0.003 from the relative density value for every 10 g/l;
- in the presence of glucose, we subtract 0.004 from the relative density value for every 10 g/l.

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