**Refractometric Analysis of Urine**

**Relevant for: Hospitals, clinics and sports institutes**

Refractometric analysis of the urine of patients and athletes quickly shows vital human health parameters such as urine specific gravity, urine total solids and urine osmotic pressure.

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1 **Refractometric analysis of urine saves life**

Acute dehydration is a significant health risk and can lead to heat stroke and death. Some athletes in weight-regulated sports such as boxing, wrestling and martial arts did not drink sufficient fluids before matches in order to reduce their body weight to qualify for certain events. In 1997, for example, three collegiate wrestlers died because they wanted to reduce their weight by dehydration.

Because of these health risks dehydration status should quickly be determined, not only in weight-regulated sports but also in hospitals if for example small babies do not drink enough milk. Indicators of the dehydration status are the specific gravity and the osmotic pressure of urine. Both parameters can easily be obtained via refractive index measurement. Moreover, the content of total dissolved solids of human urine can also be analyzed.

**Urine specific gravity**

Specific gravity is also referred to as relative density. The urine specific gravity is a measure of the ratio of the density of urine compared to the density of water, both at the same temperature. At 20 °C it should be between 1.002 and 1.028. An increased specific gravity can indicate dehydration, drug use or renal arterial stenosis. Renal failure and diabetes often accompany decreased urine specific gravity. Besides the refractometric determination, the urine specific gravity could also be determined with a reagent strip. This method is not recommended as with a refractometer the urine specific gravity values are consistently more accurate (Chadha et al, 2000).

**Urine osmolality**

The urine osmolality corresponds to the osmotic pressure of urine expressed in osmols or milliosmols per kilogram of water. In healthy human, it is usually greater than the osmolality of serum. The osmolality is a colligative property of the urine which depends on the number of dissolved particles. As electrolytes in solution ionize to yield more particles per mol than non-electrolytes, the colligative properties of urine are changed more per mol than unionized solutes. In healthy individuals with restricted fluid intake, urine osmolality should be greater than 800 mOsm/kg. Moreover, healthy kidneys are able to concentrate urine to an osmolality four times greater than serum and dilute it to an osmolality four times smaller than that serum (Curria et al, 2011).

**Urine total solids**

There exists a correlation between total solids of urine and its refracture. Determining the urine total solids by refractometry is simple, accurate and fast. On top of that, it is a well-established method as already in 1918 Blohm showed for human urine that the refractometer reading is proportional to its dissolved total solids. Moreover, he
determined a refractometric coefficient of proportionality. (Rubini and Wolf, 1957) An alternative method to characterize urine total solids is the drying procedure, which often takes too long until a result concerning the human health is got. Moreover, urine appears to be more labile during drying than serum (Wolf, 1966).

Table 1 summarizes maintained urine values according to the state of renal function.

<table>
<thead>
<tr>
<th>State of renal function</th>
<th>Refractive index</th>
<th>Total solids (g/100 g)</th>
<th>Specific gravity (20/20)</th>
<th>Osmolality (Os/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>1.3415 – 1.3464</td>
<td>5.4 - 8.5</td>
<td>1.022 – 1.035</td>
<td>0.80 – 1.30</td>
</tr>
<tr>
<td>Moderate disease</td>
<td>1.3374 – 1.3396</td>
<td>2.8 - 4.2</td>
<td>1.011 – 1.017</td>
<td>0.40 – 0.60</td>
</tr>
<tr>
<td>Severe disease</td>
<td>&lt; 1.3374</td>
<td>&lt; 2.8</td>
<td>&lt; 1.011</td>
<td>&lt; 0.40</td>
</tr>
<tr>
<td>Above normal</td>
<td>1.3464 - 1.3489</td>
<td>8.5 - 10</td>
<td>1.035 – 1.040*</td>
<td>1.30 – 1.45</td>
</tr>
</tbody>
</table>

* Specific gravities of 1.060 may occur when abnormal solutes such as glucose are present in sufficient amounts, but with no corresponding elevation in osmotic pressure.

2.3 Abbemat Refractometer from Anton Paar

According to the needs of the hospital/clinic, an Abbemat refractometer of the Economy, Performance, Performance Plus or Heavy Duty line can be used. All Anton Paar refractometers have the predefined methods "Urine specific gravity", "Urine osmotic pressure" and "Urine total solids" showing you directly the urine-specific values, temperature and other important parameters.

As the refractive index and therefore the urine-specific parameters are dependent on the temperature of the urine sample, all Abbemats have a Peltier thermostat included.

2.4 Measurement Procedure

The measurement procedure of vital human urine parameters is described here using the urine-specific gravity scale.

Choose the predefined method "Urine specific gravity". The Urine specific gravity scale is valid for a sample temperature of 20 °C and covers a specific gravity range from 0.9982 g/ml (the density of distilled water), up to 1.0400 g/ml. The maximum resolution of this method is 0.00001 g/ml. Urine osmotic pressure and urine total solids are as well determined at 20 °C and have a maximum resolution of 0.1 mOsm/L and 0.001 %Vol.. When selecting the temperature, the internal Peltier thermostat of the Abbemat refractometer is automatically set to 20.00 °C.
operating temperature. If there are lots of samples an automatic sample changer and a flow-through cell can be taken.

2.5 Refractometric Measurement of Urine

Clean the prism with distilled water and a soft cloth. Pipette around 1 mL to 2 mL urine sample onto the prism. Press "Start" and the measurement begins. The data is automatically saved in the refractometer. After the measurement, the data can easily be exported via USB or printed as an MS-Excel-file. Except when using the Abbemat 200, export of the data is also possible as pdf.

If further data security is needed, depending on the chosen Abbemat instrument, varied degrees of safety precautions can be set by the user. These include electronic signature, password rules and audit trail. Moreover, a clear passed/failed - result can be chosen for analysis of samples when time is short.

3 References


Scudiero, L. (2006), Molecular Weight Determination of Sucrose Using an Osmometer, Washington State University

