Interpretation of Urine Chemistry and Electrolyte Analysis

張哲銘 醫師

高雄市立小港醫院內科
高雄醫學大學附設中和紀念醫院腎臟內科

Urine chemistry

The examination of urine is still indispensable first step for most clinicians in approaching patients with suspected kidney disease. Modern urinalysis depends heavily on the chemical/enzymatic reaction built in small blocks on a urine dipstick. Therefore, it's important to understand how these reactions are completed and also the pitfalls which accompany these tests.

- **Specific gravity (SG)**

  The SG pad contains a polyionic polymer which binds H^+ and causes a change of a pH indicator dye. The measurement of urine SG depends on ionic concentrations which correlate linearly with urine osmolality. Urine SG reaction can be falsely elevated at urine pH less than 6 and falsely lowered by urine pH greater that 7.

- **Urine pH**

  The urine acidity reflects the usual obligate excretion of acidic metabolic wastes. The pH pad contains two indicators: methyl red and bromthymol blue. If a accurate measurement of urine pH is necessary, the urine has to be sealed to prevent CO_2 from evaporation and measure by a pH electrode. The urine usually becomes more alkaline if left at room temperature for longer than 30~60 min because of the breakdown of urea.

- **Urine glucose**

  The dipstick detects glucose by a reaction of glucose oxidase which does not cross-reacts with other sugars. Detection range is between 50 and 1000 mg/dl.

Ascorbic acid in the urine gives false-negative result and hydrogen peroxide gives false-positive result.

- **Urine ketone**

  Acetoactate acid and acetone react with nitroprusside on the stick, but β-hydroxybutyrate does not. Urine ketones are seen in uncontrolled diabetes and also in starvation.

- **Urine urobilinogen**

  Urobilinogen is produced from conjugated bilirubin by intestinal bacteria, and appears in blood stream during resorption. The dipstick test is based on Ehrlich's reagent. Small amount of urobilinogen appears in normal urine. Larger amount of this substance appears in icteric hepatic diseases except obstructive jaundice.

- **Urine bilirubin**

  The pad in the dipstick for bilirubin contains aniline dye that detects conjugated bilirubin. Therefore, the dipstick bilirubin pad should be negative in normal individual because there's only minute amount of conjugated bilirubin in normal plasma.

- **Urine nitrite and leukocyte esterase**

  The nitrite pad detects nitrites (normally not present) converted from nitrates by bacteria. It's as sensitive as to detect 10~15 organisms per ml. However, it also takes 3~4 hrs for bacteria to convert the reaction and will be negative in a less retained urine sample. The leukocyte esterase test detects the released esterase from the lysed leukocyte and therefore, the test can be positive even if no leukocyte can be seen in the urine. Contamination of urine by vaginal secretion can give false-positive result. Either nitrite or esterase reaction alone gives variable sensitivity and specificity. The negative predictive value is high (as high as 97.5%) if both tests are negative.

- **Urine protein**

  The normal urinary composition is approximately 40% albumin, 40% Tamm-Horsfall protein, 15% Tamm-Horsfall protein and 5% others. The dipstick pad contains the pH-sensitive tetrabromophenol in a citric acid buffer. A trace（±）reaction corresponds to 15~30 mg/dl, and a 4+ indicates greater than 2000 mg/dl. The test is most sensitive to negatively charged proteins but not positively charged proteins.

  Urinary protein is a generally accepted sign of kidney diseases.

  Well-characterized assessment is widely used in the screening of proteinuric kidney diseases, especially using the albumin/creatinine ratio (ACR). An ACR greater than 30 mg/g usually is recognized as significant for excessive protein excretion. Increased urinary protein excretion is also noted to be highly predictive of worse outcome in several medical situations, such as diabetes and hypertension. It can even predict a worse respiratory condition in medical intensive unit. Therefore, increased urinary protein excretion does not just represent the renal disease, but also shows an early worse sign in some systemic illness.

Urinary electrolytes

- **Urine osmolality**

  Urinary osmolality usually corresponds well with urine SG in the absence of certain constiturnts, such as glucose, proteins, and radiocontrast agents. Urine osmolality reflects the degree of urinary concentration determined by the systemic hydration status and the antidiuretic hormone level.

- **Urine sodium**

  In the absence of profuse sweating and gastrointestinal fluid loss, urinary sodium

is a reliable indicator of dietary sodium intake. Normal kidney takes 5~7 days to respond fully to the changes of dietary sodium intake by adjusting urinary sodium excretion. A diseased kidney can still reflect such a change, but may take longer time than 5~7 days. In the evaluation of plasma sodium disorders, especially hyponatremia, urinary sodium is frequently measured to assist the diagnosis. A urine sodium level greater than 20 mEq/L usually referred to an increased sodium loss from kidney in the evaluation of hyponatremia. There is, however, a common pitfall. An increased urine sodium level in the presence of significant body fluid loss (> 5%) and the consequent urine concentration does not really represent a renal sodium loss.

- **Urine potassium**

  The urinary potassium level is less accurate than sodium to reflect the body store. In the evaluation of clinical potassium disorders, a simple urine potassium measurement is not as valuable as 24-hour collection and calculation of transtubular potassium gradient (TTKG). TTKG represents the potassium excreted by distal nephron driven by aldosterone. This estimation is rather accurate as long as the urine is not dilute and the urine sodium is above 25 mEq/L.

- **Urine calcium, magnesium**

  Urine calcium and magnesium do not directly represent total body store because they both have a much greater storage site (bone and teeth for calcium, bone and muscle for magnesium). In recent years, urine calcium and magnesium are more frequently used to evaluate the possible involved distal nephron channellopathy, chiefly manifested by familiar hypokalemia.