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DEPARMENT: NURSING

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Characteristics of urine

Physical Characteristics

Quantity

Average urine production in adult humans is around 1.4 L of urine per person per day with a normal range of 0.6 to 2.6 L per person per day, produced in around 6 to 8 urinations per day depending on state of hydration, activity level, environmental factors, weight, and the individual's health. Producing too much or too little urine needs medical attention. Polyuria is a condition of excessive production of urine (> 2.5 L/day), oliguria when < 400 mL are produced, and anuria being < 100 mL per day.

Constituents

About 91-96% of urine consists of water. Urine also contains an assortment of inorganic salts and organic compounds, including proteins, hormones, and a wide range of metabolites, varying by what is introduced into the body.

The total solids in urine are on average 59 g per person per day. Organic matter makes up between 65% and 85% of urine dry solids, with volatile solids comprising 75–85% of total solids. Urea is the largest constituent of the solids, constituting more than 50% of the total. On an elemental level, human urine contains 6.87 g/L carbon, 8.12 g/L nitrogen, 8.25 g/L oxygen, and 1.51 g/L hydrogen. The exact proportions vary with individuals and with factors such as diet and health. In healthy persons, urine contains very little protein and an excess is suggestive of illness.

Color

Urine varies in appearance, depending principally upon a body's level of hydration, as well as other factors. Normal urine is a transparent solution ranging from colorless to amber but is usually a pale yellow. In the urine of a healthy individual, the color comes primarily from the presence of urobilin. Urobilin is a final waste product resulting from the breakdown of heme from hemoglobin during the destruction of aging blood cells.

Colorless urine indicates over-hydration, generally preferable to dehydration (though it can remove essential salts from the body). Colorless urine in drug tests can suggest an attempt to avoid detection of illicit drugs in the bloodstream through over-hydration.

- Dark yellow urine is often indicative of dehydration.
- Yellowing/light orange may be caused by removal of excess B vitamins from the bloodstream.
- Certain medications such as rifampin and phenazopyridine can cause orange urine.
- Bloody urine is termed hematuria, a symptom of a wide variety of medical conditions.
- Dark orange to brown urine can be a symptom of jaundice, rhabdomyolysis, or Gilbert's syndrome.
- Black or dark-colored urine is referred to as melanuria and may be caused by a melanoma or non-melanin acute intermittent porphyria.
- Pinkish urine can result from the consumption of beets.
- Greenish urine can result from the consumption of asparagus or foods or beverages with green dyes.
- Reddish or brown urine may be caused by porphyria (not to be confused with the harmless, temporary pink or reddish tint caused by beeturia).
- Blue urine can be caused by the ingestion of methylene blue (e.g., in medications) or foods or beverages with blue dyes.
- Blue urine stains can be caused by blue diaper syndrome.
- Purple urine may be due to purple urine bag syndrome.

Odour

Sometime after leaving the body, urine may acquire a strong "fish-like" odor because of contamination with bacteria that break down urea into ammonia. This odor is not present in fresh urine of healthy individuals; its presence may be a sign of a urinary tract infection.

The odor of normal human urine can reflect what has been consumed or specific diseases. For example, an individual with diabetes mellitus may present a sweetened urine odor. This can be due to kidney diseases as well, such as kidney stones.

Eating asparagus can cause a strong odor reminiscent of the vegetable caused by the body's breakdown of asparagusic acid. Likewise consumption of saffron, alcohol, coffee, tuna fish, and onion can result in telltale scents. Particularly spicy foods can have a similar effect, as their compounds pass through the kidneys without being fully broken down before exiting the body.

Turbidity

Turbid (cloudy) urine may be a symptom of a bacterial infection, but can also be caused by crystallization of salts such as calcium phosphate.

pH

The pH normally is within the range of 5.5 to 7 with an average of 6.2. In persons with hyperuricosuria, acidic urine can contribute to the formation of stones of uric acid in the kidneys, ureters, or bladder. Urine pH can be monitored by a physician or at home.

A diet which is high in protein from meat and dairy, as well as alcohol consumption can reduce urine pH, whilst potassium and organic acids, such as from diets high in fruit and vegetables, can increase the pH and make it more alkaline. Some drugs also can increase urine pH, including acetazolamide, potassium citrate, and sodium bicarbonate.

Cranberries, popularly thought to decrease the pH of urine, have actually been shown not to acidify urine. Drugs that can decrease urine pH include ammonium chloride, chlorothiazide diuretics, and methenamine mandelate.

Density

Human urine has a specific gravity of 1.003–1.035. Any deviations may be associated with urinary disorders.

Hazards

Healthy urine is not toxic. However, it contains compounds eliminated by the body as undesirable, and can be irritating to skin and eyes. With suitable processing, it is possible to extract potable water from urine.

Bacteria and pathogens

Urine is not sterile, not even in the bladder. Earlier studies, with less sophisticated analytical techniques, had found that urine was sterile until it reached the urethra. In the urethra, epithelial cells lining the urethra are colonized by facultatively anaerobicGram-negative rod and cocci bacteria.

Chemical Characteristics of Urine

Normal urine consists of water, urea, salts, and pigments.

Urine is a liquid byproduct of the body secreted by the kidneys through a process called urination and excreted through the urethra. The normal chemical composition of urine is mainly water content, but it also includes nitrogenous molecules, such as urea, as well as creatinine and other metabolic waste components.

Other substances may be excreted in urine due to injury or infection of the glomeruli of the kidneys, which can alter the ability of the nephron to reabsorb or filter the different components of blood plasma.

Urine is an aqueous solution of greater than 95% water, with a minimum of these remaining constituents, in order of decreasing concentration:

- Urea 9.3 g/L.
- Chloride 1.87 g/L.
- Sodium 1.17 g/L.
- Potassium 0.750 g/L.
- Creatinine 0.670 g/L.
- Other dissolved ions, inorganic and organic compounds (proteins, hormones, metabolites).

Urine is sterile until it reaches the urethra, where epithelial cells lining the urethra are colonized by facultatively anaerobic gram-negative rods and cocci. Urea is essentially a processed form of ammonia that is non-toxic to mammals, unlike ammonia, which can be highly toxic. It is processed from ammonia and carbon dioxide in the liver.

Urine Components

Over 99 percent of urinary solutes are composed of only 68 chemicals which have a concentration of 10 mg/L or more. 42 compounds are actually involved. They may be classified as follows:

- Electrolytes such as sodium, potassium, calcium, magnesium and chloride
- Nitrogenous chemicals such as urea and creatinine
- Vitamins
- Hormones
- Organic acids such as uric acid
- Other organic compounds

Total Dissolved Solids

Total dissolved solids in urine constitute between 24.8 to 37.1 g/kg. Urinary solids are primarily made up of organic matter, largely volatile solids. Urine has large amounts of nitrogen, phosphorus, and potassium. Nitrogen content in urine is high, mostly in urea, which makes up more than 50 percent of the total organic acids. This includes urea from protein metabolism, sodium and potassium both of which come from food. Dry solids thus comprise 14-18 percent nitrogen, 13 percent carbon, and 3.7 percent each of potassium and phosphorus. The largest excretion of these substances from the body is through urine.

Normal Constituents of Urine:

A. Urea: Nitrogenous Constituents:

1. Urea is the main end product of catabo-lism of protein in mammals. Its excretion is directly proportional to the protein in-take. It consists of 80-90% of the total uri-nary nitrogen.

2. In fever, diabetes, or excess adrenocorti-cal activity, urea excretion is increased due to increased protein catabolism.

3. Decreased urea excretion is due to de-creased urea production in the last stages of fatal liver disease.

4. In acidosis, there is decreased urea excre-tion.

B. Ammonia:

1. Ammonia is formed by the kidney from glutamine or amino acids in acidosis.

2. There is a high ammonia output in the urine in uncontrolled diabetes mellitus in which renal function is unimpaired.

C. Creatinine and Creatine:

1. Creatine is excreted by children and preg-nant women and much smaller amounts in men. The excretion in men is 6% of the total excretion of creatinine.

2. Creatinine is formed from creatine. It is excreted in relatively constant amounts regardless of diet.

3. The creatinine coefficient is the ratio be-tween the amount of creatinine excreted in 24 hours and the body weight in kg. It is usually 20-26 mg/kg/day in normal men and 14-22 mg/kg/day in normal women.

4. Creatinine excretion is decreased in many pathological conditions.

5. Creatine excretion is also found in patho-logical states such as starvation, hyper-thyroidism, impaired carbohydrate me-tabolism and infections.

6. Creatine excretion is decreased in hy-pothyroidism.

D. Uric Acid:

1. It is the end product of the oxidation of purines in the body. It is not only formed from dietary nucleoprotein but also from the breakdown of cellular nucleoprotein in the body.

2. It is slightly soluble in water and precipi-tates readily from acid urine on standing.

3. Uric acid excretion is increased in leukemia, severe liver disease and vari-ous stages of gout.

4. The concentrated urine on cooling forms a brick-red deposit which is mainly acid urate.

5. Pure uric acid is colourless. Deposits of uric acid and urates are coloured by ab-sorbed urinary pigments, particularly the red uroervthrin.

6. The specificity of the analysis of uric acid is increased by treatment with uricase, the enzyme (from hog kidney) which converts uric acid to allantoin.

E. Amino Acids:

1. About 150-200 mg of amino acid nitro-gen is excreted in the urine of adults in 24 hours.

2. The infant at birth excretes about 3 mg amino acid nitrogen per pound of body weight, and up to the age of 6 months the value reaches to 1 mg/pound which is maintained throughout childhood. Prema-ture infants excrete 10 times amino acid nitrogen than that of full-term infant.

3. The low excretion of amino acid nitrogen is due to its high renal threshold value.

4. Increased amounts of amino acids are ex-creted in liver disease and in certain types of poisoning.

5. In cystinuria, 4 amino acids-arginine, cys-tine, lysine and ornithine are excreted in urine.

F. Allantoin:

1. It is the partial oxidative products of uric acid. Small quantities of the allantoin are excreted in human urine.

2. In other sub-primate mammals, allantoin, the principal end product of purine me-tabolism, is excreted.

G. Sulphates:

The urine sulphur is derived from sulphur contain-ing amino acids such as methionine and cystine and therefore, its output varies with protein intake.

The urine sulphur exists in 3 forms:

I. Inorganic (sulfate) sulfur:

1. This is the completely oxidized sulfur pre-cipitated from urine.

2. It is proportionate to the ingested protein with a ratio of 5 : 1 between urine nitro-gen and inorganic sulfate.

II. Ethereal sulfur (conjugated sulfates):

1. It is about 10% of the total excreted sulfur.

This includes the organic combination of sulfur excreted in the urine.

2. It consists of the sulphuric esters of cer-tain phenols.

3. It forms no precipitate on addition of acidi-fied $BaCl_2$. Some of the phenols are de-rived from putrefaction of protein in the large intestine.

4. Clinically, the ethereal sulfate is that of indoxyl indican which is formed from bac-terial decomposition of tryptophan in the large intestine.

5. Normally, 5-20 mg of indican are excreted and the amount increases in constipation. In cholera, typhus gangrene of lung, suffi-cient indican is excreted. Indoxyl liber-ated from indican is oxidized to indigo blue on exposure to air.

III. Neutral sulfur:

1. These are un-oxidized sulfur and contained in cystine, taurine, thiocyanate or sulfides.

2. They do not vary with the diet.

3. They are mainly the products of endog-enous metabolism.

Other organic compounds:

H. Chlorides:

These are excreted as NaCl and output varies with intake.

I. Phosphates:

1. The urine phosphates consist of sodium and potassium phosphates as well as cal-cium and magnesium phosphates.

2. The greater part of the excreted phos-phates is derived from ingested food which contains organic phosphates, e.g., nucleoprotein, phosphoprotein and phospholipids. Phosphates of food are not completely absorbed. Some phosphate is also derived from cellular breakdown.

3. Phosphate excretion is increased in cer-tain bone diseases such as osteomalacia, wasting diseases of the nervous system and in renal tubular rickets.

4. Marked increase of phosphate excretion is also observed in hyperparathyroidism and decrease in hypoparathyroidism and in infectious diseases.

J. Oxalates:

1. The amount of oxalate in the urine is low (20 mg/day) and found as calcium oxalate crystals in urinary deposits.

2. The excretion of oxalate is increased by ingestion of fruits and vegetables contain-ing high oxalates (spinach).

3. Large quantities of oxalate are excreted in urine in inherited metabolic diseases.

4. The oxalates present in urine are com-posed of partly unchanged ingested acid and partly oxidative products of other compounds.

K. Minerals:

1. The 4 cations of the extracellular fluid— sodium, potassium, calcium and magne sium—are present in the urine.

2. Sodium content varies with intake. Urine potassium increases when the intake is increased or in excessive tissue catabolism. The excretion of potassium is affected by alkalosis. Sodium and potassium excre-tion are also controlled by the activity of the adrenal cortex.

3. Calcium and magnesium are not com-pletely absorbed and their presence in the urine is low. But their presence in the urine varies in certain pathological states, par-ticularly those involving bone metabolism.

L. Enzymes:

1. Traces of many enzymes are excreted in urine including pancreatic amylase, pep-sin, trypsin and lipase.

2. The pancreatic amylase excretion is in-creased in pancreatic disease.

M. Hormones and vitamins:

1. Certain hormones (sex hormones) and vi-tamins (e.g., B, and C) are found in urine.

2. The vitamin needs are assessed by study-ing the urinary output after test doses. The pregnancy test is also performed by the urinary sex hormones.

Abnormal Components of the Urine

A. Proteins:

Proteinuria (albuminuria) is the presence of albu-min and globulin in the urine in abnormal concen-trations. The traces of protein (10-150 mg) present in normal urine cannot be detected by the ordinary simple tests. Pathologically, several proteins, such as serum albumin, serum globulin, hemoglobin, mucus, proteose, Bence-Jones proteins are found in urine.

1. Physiologic proteinuria:

In this condition, less than 0.5% protein is present in urine which occurs after severe exercise, after a high protein meal or as a result of some temporary impairment in renal circulation when a person stands erect. In 30-35% of pregnancy, there is proteinuria.

2. Pathologic proteinuria:

Proteinuria is marked in glomerulonephritis. In neph-rotic syndrome, a marked proteinuria oc-curs. The proteinuria increases with the increasing severity of the renal lesion. Pro-teinuria also results in poisoning of the renal tubules by heavy metals like mer-cury, arsenic or bismuth.

3. Hemoglobin is also present as a result of hematuria due to hemorrhage from the kidneys or urinary tract, clotting may oc-cur due to sufficient fibrinogen on pass-ing of much blood.

4. Mucus is the term for an unidentified pro-tein precipitated by acetic acid in the cold. It is mucin. The mucus is increased in in-fection of the bladder.

5. Proteose may be found which is of little clinical significance.

6. Bence-Jones proteins found in the urine are the peculiar proteins which are light chain fragments of globulins. Most com-monly they occur in multiple myeloma and rarely in leukemia. They are precipi-tated when the urine warmed to 50-60°C and re-dissolved almost completely at 100°C and precipitated again on cooling.

B. Glucose:

Normal individuals excrete not more than 16-300 mg of sugar per day which is diffi-cult to detect by simple test. It is said to be glycosuria when more than this quantity is found in urine. There are different causes of glycosuira.

Transient glycosuria is observed after emotional stress such as exciting atheletic contest. 15% of cases of glycosuria are not due to diabetes glycosuria suggesting dia-betes must be confirmed by blood glucose studies to eliminate the probability of re-nal glycosuria.

The presence of glucose must be tested by Benedict's test. But in case of pregnant women and lactating mother, the Osazone test must be performed for urine glucose to eliminate the lactose present in urine.

C. Other sugars:

1. Fructosuria:

Fructosuria is due to the dis-turbance in fructose metabolism but no other

carbohydrates.

2. Galactosuria and lactosuria:

These may occur occasionally in infants, pregnant women and lactating mother. Galactosuria may occur in inherited diseases due to the non-conversion of galactose to glucose.

3. Pentosuria:

This may occur transiently after intake of food containing large quan tities of pentose's, such as grapes, cherries and plums. It may take place in inherited diseases in which pentose's are not metabo lized. To detect these other sugars in urine it is wise to perform Osazone test.

D. Ketone bodies:

1. Only less than 1 mg of ketone bodies are excreted in urine normally in 24 hours.

2. Increased amount of ketone bodies are ex-creted in urine in starvation, diabetes mellitus, pregnancy, ether anesthesia, and some types of alkalosis.

3. Excess fat metabolism may induce a ketonuria in many animals.

4. Increased amount of ammonia is excreted in acidosis accompanying ketosis.

E. Bilirubin and Bile salts:

1. Bilirubin is found in the urine in cases of obstructive or hepatic jaundice.

2. Bilirubinuria is accompanied by the ex-cretion of bile salts.

3. Bile salts may be excreted in urine with-out bile pigment in certain stages in liver disease.

4. In excessive hemolysis, traces of bilirubin without bile salts are excreted in urine.

F. Blood:

1. In the lesion of the kidney or urinary tract blood is excreted in the urine in addition to its presence in nephritis.

2. Free hemoglobin is also found in urine after quick hemolysis, e.g., in black water fever (a complication of malaria) or after severe burns.

G. Urobilinogen:

1. In excessive hemolysis, e.g., hemolytic jaundice or pernicious anemia, part of the bile pigment formed by breakdown of hemoglobin is excreted in urine as urobilinogen.

2. Urobilin is formed from colourless uro-bilinogen when the urine is exposed to air. This gives the urine an orange colour.

3. In liver disease or temporarily in consti-pation, large amounts of urobilin are found in urine.

4. Urobilinogen excreted in urine normally are 1-3.5 mg/24 hrs.

H. Porphyrins:

1. Coprophyrins excreted in urine normally are 50-250 (µ gm./day.

2. Coproporphyria are excreted more in cer-tain liver diseases.

3. The increased amount of coproporphyrins in the urine is a characteristic of the urine of patients suffering from porphyria.