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Urine Search in Three Components or Examinations: Physical, Chemical and Microscopical

Naval Kishor Lodha[1*], Biramchand Mewara[2], Krishna Murari[3], Pankaj Soni[4], Saba Paraveen[5], Narendra Swami[5] and Gopal Sharma[6]

[1]*Department of Clinical Microbiology, Consultant Microbiologist, Jhalawar, Rajasthan, India*
[2]*General Surgery, Jhalawar Medical College, Jhalawar, Rajasthan, India*
[3]*Department of Biochemistry, Jhalawar Medical College, Jhalawar, Rajasthan, India*
[4]*Department of Orthopedic, Jhalawar Medical College, Jhalawar, Rajasthan, India*
[5]*Department of Obstetrics and gynaecology, Jhalawar Medical College, Jhalawar, Rajasthan, India*
[6]*Department of Clinical Microbiology, Jaipur, Rajasthan, India*

**Corresponding author*

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A B S T R A C T

Urinalysisa portmanteau of the words urine and analysis, (McPherson and Pincus, 2017) a urinalysis is a test of urine. It's used to detect and manage a wide range of disorders, such as urinary tract infections, kidney disease and diabetes. A urinalysis involves checking the appearance, concentration and content of urine. Medical tests that includes physical (macroscopic) examination of the urine, chemical evaluation using urine test strips, and microscopic examination. Macroscopic examination targets parameters such as color, clarity, and specific gravity; urine test strips measure chemical properties such as pH, glucose concentration, and protein levels; and microscopy is performed to identify elements such as cells, urinary casts, crystals, and organisms.

Introduction

Human kidneys play a major role in the process of excretion. Constituents of normal human urine include 95% water and 5% solid wastes. It is produced in the nephron, which is the structural and functional unit of the kidney. Urine formation in our body is mainly carried out in three phases namely glomerular filtration, reabsorption and secretion. The glomerulus and Bowman's capsule together form the renal corpuscle. A healthy glomerulus allows many solutes in the blood to pass through, but does not permit the passage of cells or high-molecular weight substances such as most proteins. The filtrate from the glomerulus enters the capsule and proceeds to the renal tubules, which reabsorb water and solutes from the filtrate into the circulation and secrete substances from the blood into the urine in order to maintain homeostasis (Ovalle and Nahirney, 2021).

The first destination is the proximal convoluted tubule. The filtrate proceeds into the loop of Henle, then flows through the distal convoluted tubule to the collecting duct. The collecting ducts ultimately drain into the renal calyces, which lead to the renal pelvis and the ureter. Urine flows through the ureters into the bladder and exits the body through the urethra. (Turgeon, 2016) Besides excreting waste products, the process of urine formation helps to maintain fluid, electrolyte and acid-base balance in the body. The composition of urine reflects not only the functioning of the kidneys, but numerous other aspects of the body's homeostatic processes. The ease with which a urine sample can be obtained makes it a practical choice for diagnostic testing.

Medical tests

It's used to detect and manage a wide range of disorders, such as urinary tract infections, kidney disease and diabetes. A urinalysis involves checking the physical properties of urine, such as color and clarity; chemical analysis using urine test strips; and microscopic examination. Test strips contain pads impregnated with chemical compounds that change color when they interact with specific elements in the sample, such as glucose, protein and blood, (McPherson and Pincus, 2017) and microscopic examination permits the counting and classification of solid elements of the urine, such as cells, crystals, and bacteria. Urinalysis is one of the most commonly performed medical laboratory tests. It is frequently used to help diagnose urinary tract infections and to investigate other issues with the urinary system, such as incontinence. It may be used to screen for diseases as part of a medical assessment. The results can suggest the presence of conditions such as kidney disease, liver disease and diabetes. In emergency medicine urinalysis is used to investigate numerous symptoms, including abdominal and pelvic pain, fever, and confusion. During pregnancy, it may be performed to screen for protein in the urine (proteinuria), which can be a sign of pre-eclampsia, and bacteria in the urine, which is associated with pregnancy complications. The analysis of urine is invaluable in the diagnosis and management of kidney diseases.

Sample collection

To collect a urine sample you should: label a sterile, screw-top container with your name, age and the date. Wash your hands. Start to pee and collect a sample of urine "mid-stream" in the container. Samples for urinalysis are collected into a clean (sterile) container. The sample can be collected at any time of the day, but the first urine of the morning is preferred because it is more concentrated. (McPherson and Pincus, 2017) To prevent contamination, a "midstream clean-catch" technique is recommended, in which the genital area is cleaned before urinating and the sample is collected partway through the urination. Samples can also be collected from a urinary catheter or by inserting a needle through the abdomen and into the bladder. In infants and young children, urine may be collected into a bag attached to the genital region, but this is associated with a high risk of contamination. If the sample is not tested promptly, inaccurate results can occur because bacteria in the urine will multiply and elements such as cells and casts will degrade. It is recommended that urinalysis is performed within two hours of sample collection if the urine is not refrigerated (McPherson and Pincus, 2017).

Macroscopic (Physical) Examination

Normal urine has a yellow hue, which is primarily caused by the pigment urochrome. The color can range from pale yellow to amber based on the individual's hydration status. Urine can develop a variety of abnormal colors, which may suggest disease in some cases (McPherson and Pincus, 2017). A total lack of color indicates that the urine is extremely dilute, which may be caused by excessive fluid intake, diabetes insipidus, or diabetes mellitus. Dark yellow-brown to green urine may suggest a high concentration of bilirubin, a state known as bilirubinuria (McPherson and Pincus, 2017). Red urine often indicates the presence of red blood cells or hemoglobin, but can also be caused by some medications and the consumption of foods containing red pigments (McPherson and Pincus, 2017) such as beets. Myoglobin, a product of muscle breakdown, can give urine a red to reddish-brown color. Dark brown or black urine can occur in a genetic disorder called alkaptonuria and in people with melanoma (Kang *et al.*, 2011). Purple urine occurs in purple urine bag syndrome (Brunzel, 2018).

A spectrum of abnormal colors can result from the intake of drugs. An unusually bright yellow color can occur after consumption of B vitamin supplements, while phenazopyridine, used to treat urinary tract-related pain, can turn the urine orange. Methylene blue may turn it blue to bluish-green. Phenolphthalein, a stimulant laxative previously found in Ex-Lax, can produce colors ranging from red to purple, and levodopa, used to treat Parkinson's disease, may result in "cola-colored" urine. The clarity of urine is also recorded during urinalysis. Urine is typically clear; materials such as crystals, cells, bacteria, and mucus can impart a cloudy appearance (McPherson and Pincus, 2017). A milky appearance can be caused by a very high concentration of white blood cells or fats, or by chyluria (the presence of lymphatic fluid in the urine) (Mundt and Shanahan, 2016).

Urine Test Strips

A standard urine test strip may comprise up to 10 different chemical pads or reagents which react (change color) when immersed in, and then removed from, a urine sample. The test can often be read in as little as 30 to 120 seconds after dipping, although certain tests require longer. Routine testing of the urine with multiparameter strips is the first step in the diagnosis of a wide range of diseases. The analysis includes testing for the presence Physical and Chemical characteristics pH Color Specific gravity Blood Glucose Ketones Albumin Protein Bilirubin Urobilinogen Leukocyte esterase HCG or to test for infection by different pathogens (Wilson, 2005).

pH

Urine pH is a vital piece of information and provides insight into tubular function. Normally, urine is slightly acidic because of metabolic activity. A urinary pH greater than 5.5 in the presence of systemic acidemia (serum pH less than 7.35) suggests renal dysfunction related to an inability to excrete hydrogen ions. On the contrary, the most common cause of alkaline urine is a stale urine sample due to the growth of bacteria and the breakdown of urea releasing ammonia.

Determination of urinary pH is helpful for the diagnosis and management of urinary tract infections and crystals/calculi formation (Echeverry *et al.*, 2010).

Normal: 4.5 to 8

Diagnosis

High Values (alkaline): Stale/old urine specimens (most common), hyperventilation, presence of urease-producing bacteria, renal tubular acidosis, vegetarian diet, vomiting.

Low Values (acid): Cranberry juice, dehydration, diabetes mellitus, diabetic ketoacidosis, diarrhea, emphysema, high protein diet, starvation, potassium depletion, medications (methionine, mandelic acid, etc.), and a possible predisposition to the formation of renal or bladder calculi (Wilson, 2005).

Color

Normal urine has a yellow hue, which is primarily caused by the pigment urochrome. The color can range from pale yellow to amber based on the individual's hydration status. Urine can develop a variety of abnormal colors, which may suggest disease in some cases.

Normal: Yellow (light/pale to dark/deep amber).

Diagnosis

Amber: Bile pigments

Brown/Black (Tea-colored): Bile pigments, cascara, chloroquine, fava beans, homogentisic acid (alkaptonuria), levodopa, melanin or oxidized melanogen, methemoglobin, methyldopa, metronidazole, myoglobin, nitrofurantoin, primaquine, rhubarb, riboflavin, senna

Dark Yellow: Concentrated specimen (dehydration, exercise)

Green/Blue: Amitriptyline, asparagus, biliverdin, cimetidine, clorets (breath mint), indicans, indigo carmine, indomethacin, methocarbamol, methylene blue, promethazine, propofol, pseudomonal UTI, triamterene

Orange: Bile pigments, carrots, coumadin, nitrofurantoin, phenothiazines, phenazopyridine, rifampin, vitamin C.

Pink/Red: Beets, blackberries, chlorpromazine, food dyes, hematuria, hemoglobinuria, menstrual contamination, myoglobinuria, phenolphthalein, porphyrins, rifampin, rhubarb, senna, thioridazine, uric acid crystals (Simerville *et al.*, 2005). A urine sample that turns red on standing suggests the presence of porphobilinogen, which is increased in acute porphyrias.

Specific gravity

Specific gravity is a measure of the concentration of the urine, which provides information about hydration status and kidney function. It normally ranges from 1.003 to 1.035; lower values indicate that the urine is dilute, while higher ones mean that it is concentrated. A urine specific gravity that consistently remains around 1.010 (isosthenuria) can indicate kidney damage, as it suggests that the kidneys have lost the ability to control urine concentration (Brunzel, 2018). It is not possible for the kidneys to produce urine with a specific gravity greater than 1.040 but such readings can occur in urine that contains high-molecular weight substances, such as contrast dyes used in radiographic imaging. Specific gravity is commonly measured with urine test strips, but refractometers may also be used and give more accurate results.

Normal: 1.002-1.035

Variations according to the patient's diet, health, hydration status, and physical activity.

Diagnosis

High Values: Contrast media, dehydration, decreased renal blood flow (shock, heart failure, renal artery stenosis), diarrhea, emesis, excessive sweating, glycosuria, hepatic failure, syndrome of inappropriate antidiuretic hormone (SIADH).

Low Values: Acute tubular necrosis, acute adrenal insufficiency, aldosteronism, diuretic use, diabetes insipidus, excessive fluid intake (psychogenic polydipsia), impaired renal function, interstitial nephritis, hypercalcemia, hypokalaemia, pyelonephritis.

False Elevation: Dextran solutions, intravenous (IV) radiopaque contrast media, proteinuria

False Depression: Alkaline urine. (Patel, 2006)

Blood

Blood Reagent pads for blood change color in the presence of heme groups, which catalyze the reaction of hydrogen peroxide with the color indicator in the test strip. Heme groups are found in hemoglobin, but also in myoglobin (a product of muscle breakdown). Thus, a positive result for blood can represent the presence of red blood cells (hematuria), free hemoglobin (hemoglobinuria), or myoglobin (myoglobinuria) (Mundt and Shanahan, 2016). Red blood cells can sometimes be distinguished from free hemoglobin or myoglobin as the former causes a speckled pattern on the test pad while the latter results in a uniform color change.

Dipstick test for blood detects primarily the peroxidase activity of erythrocytes, but myoglobin and hemoglobin can also catalyze this reaction. Thus, a positive test result indicates hematuria, myoglobinuria, or hemoglobinuria.

Normal: Negative (usually) or less than or equal to 5 RBCs per mL (lab-dependent value)

Diagnosis

Hematuria

Renal calculi, glomerulonephritis, pyelonephritis, tumors, trauma, anticoagulants, strenuous exercise, exposure to toxic chemicals

Hemoglobinuria

Hemolytic anemias, RBC trauma, strenuous exercise, transfusion reactions, severe burns, infections (i.e., malaria)

Myoglobinuria

Muscle trauma eg, rhabdomyolysis, prolonged coma, convulsions, drug abuse, extensive exertion, alcoholism/overdose, muscle wasting diseases

False-positive: Dehydration, exercise, hemoglobinuria, menstrual blood, myoglobinuria

False-negative: Captopril, elevated specific gravity, acid urine, proteinuria, vitamin C (Wilson, 2005).

Glucose Test

Glucose Test strips for glucose contain the enzyme glucose oxidase, which breaks down glucose and forms hydrogen peroxide as a byproduct. In the presence of a peroxidase enzyme, hydrogen peroxide reacts with a chromogen to induce a color change (Mundt and Shanahan, 2016). The presence of glucose in the urine is known as glycosuria. In people with normal blood sugar levels, the amount of glucose in the urine should be negligible as it is reabsorbed by the renal tubules (Rakel and Rakel, 2016). High blood sugar levels (hyperglycemia) cause excess glucose to spill over into the urine and result in a positive reading. This characteristically occurs in diabetes mellitus (although it is not part of the formal diagnostic criteria). Glycosuria may occur in people with normal blood sugar levels during pregnancy or due to dysfunction of the renal tubules (termed renal glycosuria).

Glycosuria occurs when the filtered load of glucose exceeds the tubular cells' ability to reabsorb it, which normally happens at a glucose serum concentration of around 180 mg per dL. Furthermore, nitrites are not normally found in urine, and it is highly specific for urinary tract infection. However, due to its low sensitivity, a negative result does not rule out infection (Simerville *et al.*, 2005).

Normal: Negative

Diagnosis

Diabetes mellitus, Cushing syndrome, Fanconi syndrome, glucose infusion, pregnancy.

Glucosuria with normal plasma glucose without other features of Fanconi syndrome is due to a benign condition referred to as renal glycosuria and is due to a mutation in the sodium-glucose linked transporter 2.

False-positive: Ketones, levodopa

False-negative: Elevated specific gravity, uric acid, vitamin C (Echeverry *et al.*, 2010).

Ketone Bodies

Ketone bodies are products of fat breakdown. When the body relies on fats, rather than carbohydrates, as its main energy source, increased levels of ketones occur in the blood and urine. The presence of detectable levels of ketones in the urine is called ketonuria. Ketones occur in three forms in the body: beta-hydroxybutyrate (BHB), acetone and acetoacetate. Test strips use sodium nitroprusside to detect acetoacetate, and those with a glycine additive can detect acetone; however, none detect BHB. The reaction of ketones with sodium nitroprusside in an alkaline medium turns the test pad purple (Sharp, 2020).

Ketonuria occurs in uncontrolled type 1 diabetes and in diabetic ketoacidosis. Ketonuria can also occur when the body's demand for carbohydrates outpaces dietary intake, such as in people following a ketogenic diet, people experiencing severe vomiting or diarrhea, and during starvation or after strenuous exercise. Mild ketonuria can be normal during pregnancy. Some medications, such as levodopa or methyldopa, can cause a false positive result.

Products of body fat metabolism

Normal: Negative

Diagnosis

Uncontrolled diabetes mellitus (diabetic ketoacidosis), pregnancy, carbohydrate-free diets, starvation, febrile illness.

False-positive: Acid urine, elevated specific gravity, mesna, phenolphthalein, some drug metabolites (e.g., levodopa, captopril)

False-negative: Stale/old urine specimens.

Remember: Reagent strips do not detect beta-hydroxy-butyric acid, only acetoacetic acid and acetone (Simerville *et al.,* 2005).

Proteins

Test strips estimate urine protein levels by exploiting the ability of protein to interfere with pH indicators. The reagent pad contains an indicator that is buffered to a pH of 3, which changes from yellow to green in the presence of protein. Trace levels of protein in the urine can be normal, but high levels (proteinuria) can indicate kidney disease. Most cases of proteinuria are caused by increased levels of albumin, which test strips can detect relatively well; but they are markedly less sensitive to other proteins, such as Bence-Jones protein, (Bain, 2015) which may occur in multiple myeloma. Because the test pad reaction is dependent on pH, false positive results can occur if the urine is highly alkaline. Conventional test strips are not sensitive enough to reliably detect microalbuminuria, a condition in which urine albumin levels are slightly elevated, although dipsticks specialized for this measurement exist (Bain, 2015).

Normal: Proteinuria less than or equal to 150 mg/day (typically albuminuria less than 30 mg/day) or 10 mg/dL.

Diagnosis

Albuminuria of 30 mg/day to 300 mg/day is an indicator of early renal disease, glomerular injury, and risk of progression of renal disease

Other Associations

Multiple myeloma, congestive heart failure, Fanconi syndrome, Wilson disease, pyelonephritis, and physiological conditions (strenuous exercise, fever, hypothermia, emotional distress, orthostatic proteinuria, and dehydration)

False-positive: Alkaline or concentrated urine, phenazopyridine, quaternary ammonia compounds

False-negative: Acid or dilute urine, primary protein is not albumin (Brunzel, 2018).

Bilirubin

Bilirubin is a waste product formed from the breakdown of hemoglobin. Cells of the mononuclear phagocyte system digest aged red blood cells and release unconjugated bilirubin into the bloodstream, which is converted to water-soluble conjugated bilirubin by the liver. Conjugated bilirubin is normally stored in the gallbladder as a constituent of bile and is excreted through the intestines; it does not occur at detectable levels in the urine (Sharp, 2020).

The presence of bilirubin in the urine (termed bilirubinuria) occurs as a consequence of high blood levels of conjugated bilirubin in liver disease or bile duct obstruction. Bilirubin is detected by means of reaction with a diazonium salt that forms a colored complex. With prolonged light exposure, bilirubin converts to biliverdin and becomes undetectable by reagent strips.

Normal: There is no bilirubin in normal urine

Diagnosis

Liver dysfunction, biliary obstruction, congenital hyperbilirubinemia, viral or drug-induced hepatitis, cirrhosis

False-positive: medications such as phenazopyridine that have a similar color at the low pH of the reagent pad

False-negative: stale/old urine specimens, chlorpromazine, selenium. (Patel, 2006)

Urobilinogen

Urobilinogen refers to a group of compounds produced from bilirubin by the intestinal flora. Under normal conditions, most of the urobilinogen produced is absorbed into the bloodstream and secreted into the bile by the liver, or excreted in the feces as stercobilin and other compounds. A small fraction is excreted in the urine.

Urine urobilinogen is increased in liver disease and hemolytic jaundice (jaundice due to increased destruction of red blood cells); in the latter case, urine bilirubin is typically negative. In bile duct obstruction, urine bilirubin increases but urobilinogen is normal or decreased, as bilirubin cannot reach the intestines to be converted to urobilinogen. Testing methods are based on the Ehrlich reaction of urobilinogen with para-dimethylaminobenzaldehyde, or interaction with a diazonium compound to produce a colored product. Test strips that use Ehrlich's reagent can give false positive results in the presence of porphobilinogen and numerous drugs (Brunzel, 2018). Decreased levels of urobilinogen cannot be detected by the dipstick method. Like bilirubin, urobilinogen is sensitive to light.

The degradation product of bilirubin metabolism from bacteria in the intestine

Normal: 0.1 mg/dL to 1 mg/dL in random samples or up to 4 mg/daily

Diagnosis

Elevation: Hemolysis, liver disease (cirrhosis, hepatitis), sickle cell disease, thalassemia

Decrease: Antibiotic use, bile duct obstruction

False-positive: Elevated nitrite levels, phenazopyridine, porphobilinogen, sulfonamides, and aminosalicylic acid

False-negative: Prolonged exposition to daylight, formaldehyde, high levels of nitrites (Echeverry *et al.,* 2010).

Nitrites

Some bacteria that cause UTIs can reduce urinary nitrates to nitrites. The presence of nitrites, which causes a pink color on the reagent strip pad, therefore acts as an indicator of urinary tract infection (Mundt and Shanahan, 2016). The nitrite test is quite specific (meaning that someone is likely to have a UTI if it is positive) but not sensitive (a negative result does not reliably indicate that the subject does not have a UTI) (McPherson and Pincus, 2017). Not all bacteria that cause UTIs produce nitrite, and because it takes time for the chemical reaction to occur, the test is best performed on urine that has been in the bladder overnight. A diet low in vegetables can lead to low nitrate levels in the urine, meaning that nitrites cannot be produced. False positive results can occur in samples that are contaminated or stored improperly, allowing bacteria to multiply.

Products originating from the reduction of urinary nitrates

Normal: Negative

Diagnosis

Urinary tract infection (UTI) from a nitrate reductase-positive bacteria (*E. coli*, *Proteus*, *Enterobacter*, *Klebsiella*, *Streptococcus faecalis* and *Staphylococcus aureus*)

False-positive: Contamination, exposure of dipstick to air, pigmented materials, phenazopyridine

False-negative: elevated specific gravity, elevated urobilinogen levels, nitrate reductase-negative bacteria, acid urine, vitamin C, urine with less than 4 hours of bladder resting, absent dietary nitrates

Remember: A negative result does not rule out UTI (Simerville *et al.,* 2005).

Leukocyte esterase

Leukocyte esterase, an enzyme found in granulocytes, is measured to estimate the concentration of white blood cells. The action of the enzyme on chemicals in the test pad ends in the creation of a purple azo dye. False positive results can occur if the sample is contaminated with vaginal secretions; false negatives can occur in very concentrated samples or those containing high levels of glucose and protein. Elevated white blood cell counts in urine generally indicate infection or inflammation. People with a low level of neutrophils in the blood (neutropenia) may not have enough white blood cells in their urine to produce a positive reaction. (Takhar and Moran, 2014)

An enzyme present in certain WBCs (except lymphocytes)

Normal: Negative

Diagnosis

Inflammation of the urinary tract, sterile pyuria (balanitis, urethritis, tuberculosis, bladder tumors, nephrolithiasis, foreign bodies, exercise, glomerulonephritis, corticosteroids, and cyclophosphamide), fever, glomerulonephritis, pelvic inflammation

False-positive: Contamination, highly pigmented urine, strong oxidizing agents, Trichomonas

False-negative: Elevated specific gravity, glycosuria, ketonuria, proteinuria, some oxidizing drugs (cephalexin, nitrofurantoin, tetracycline, gentamicin), vitamin C (Patel, 2006).

Microscopic Examination

Microscopic characteristics RBCs cells WBCs cells Epithelial cells RBC castWBC cast Hyaline cast Granular cast Waxy cast Uric acid, Calcium Oxalate, Triple Phosphate *Trichomonas vaginalis* Yeast cell Microbial flora.

Red Blood Cell

Under the microscope, normal red blood cells (RBCs) appear as small concave discs. Their numbers are reported per high-power field. In highly concentrated urine they may shrivel and develop a spiky shape, which is termed crenation, while in dilute urine they can swell and lose their hemoglobin, creating a faint outline known as a ghost cell. A small quantity of red blood cells (0–2 or 3/hpf) in the urine is considered normal

(Hitzeman *et al.,* 2022). An increased level of RBCs is termed hematuria. Microscopic hematuria is sometimes observed in healthy people after exercise (Wilson, 2005) or as a consequence of contamination of the sample with menstrual blood (Hitzeman *et al.,* 2022). Pathologic causes of hematuria are diverse and include trauma to the urinary tract, kidney stones, urinary tract infections, drug toxicity, genitourinary cancers, and a variety of other renal and systemic diseases. Abnormally shaped red blood cells with blob-like protrusions of the cell membrane, called dysmorphic RBCs, are thought to represent damage to the glomerulus. Normal: 0-5 cells/high-power field, Diagnosis: UTI, inflammation (Simerville *et al.,* 2005).

White Blood Cell

Typically, most white blood cells (WBCs) in urine are neutrophils. They are round, larger than RBCs, possess a cell nucleus, and have a granular appearance. A few white blood cells can normally be found in the urine of healthy individuals. An increased number of WBCs is termed pyuria or leukocyturia and is associated with infection or inflammation of the urinary tract. WBCs can also appear in the urine following exercise or fever. (Brunzel, 2018) An increased number of eosinophils (eosinophiluria) can occur in acute interstitial nephritis and chronic UTIs. Cytocentrifugation and staining of the urine sample is necessary to reliably distinguish eosinophils from neutrophils.

Epithelial cell

Epithelial cells form the lining of the urinary tract. Three types may occur in urine: squamous epithelial cells, transitional epithelial cells and renal tubular epithelial cells. Some laboratories do not distinguish between the three types of cells and simply report "epithelial cells" in general. Squamous epithelial cells line the urethra, as well as the vagina and the outer layer of the skin. They are very large, flat, and thin, with irregular borders and a single, small nucleus. They may fold into various shapes. They are not considered clinically significant, but if they are seen in large numbers they can indicate contamination of the sample by vaginal secretions or the skin of the urogenital area.

Transitional epithelial cells, also known as urothelial cells, line the urinary tract from the renal pelvis through the ureters and bladder and, in males, the upper (proximal) portion of the urethra. They are smaller than squamous cells and their shape varies based on the layer of epithelium from which they are derived, but they are most commonly round or pear-shaped. (Brunzel, 2018) They may have one or two nuclei. Small numbers of these cells are found in normal urine; larger numbers can be seen after invasive procedures like catheterization or cystoscopy or in conditions that irritate the urinary tract, such as urinary tract infections. In the absence of recent trauma to the urinary tract, clusters and sheets of transitional cells in the urine may indicate malignancy, requiring further investigation.

Casts

Casts are a coagulum composed of the trapped contents of tubule lumen and Tamm-Horsfallmucoprotein. They originate in the lumen the distal convoluted tubule or collecting duct with pH alterations or long periods of urinary concentration or stasis. The casts preserve the cylindrical shape of the tubule in which they were formed. Only a few hyaline or finely granular casts may be seen under normal physiological conditions. Cellular casts can dissolve within 30 to 10 minutes depending on the pH of the urine sample, thus promptly testing is mandatory for appropriate testing.

Red Blood Cell Casts

Red blood cell casts mean there is a microscopic amount of bleeding from the kidney. They are seen in many kidney diseases. Renal tubular epithelial cell casts reflect damage to tubule cells in the kidney.

Normal: Absent

Diagnosis

Glomerulonephritis, vasculitis, intrinsic renal disease (tubulointerstitial nephritis, acute tubular injury/necrosis), strenuous exercise (see image attached) (Patel, 2006).

White Blood Cell Casts

Urinary casts are tiny tube-shaped particles that can be found when urine is examined under the microscope during a test called urinalysis. Urinary casts may be made up of white blood cells, red blood cells, kidney cells, or substances such as protein or fat.

Normal: Absent

Diagnosis

Pyelonephritis, interstitial nephritis, glomerulo-nephritis, renal inflammatory processes (see image attached) (Echeverry *et al.*, 2010).

Epithelial Cell Casts

Renal tubular epithelial cell casts reflect damage to tubule cells in the kidney. These casts are seen in conditions such as renal tubular necrosis, viral disease (such as cytomegalovirus (CMV) nephritis), and kidney transplant rejection.

Normal: Absent

Diagnosis

Acute tubular injury/necrosis, interstitial nephritis, glomerulonephritis, eclampsia, nephritic syndrome, transplant rejection, heavy metal ingestion, renal disease (Patel, 2006).

Granular Casts

Granular casts are a sign of many types of kidney diseases. Red blood cell casts mean there is a microscopic amount of bleeding from the kidney.

They are seen in many kidney diseases. Renal tubular epithelial cell casts reflect damage to tubule cells in the kidney.

Normal: Absent

Diagnosis

Glomerular or tubular disease, pyelonephritis, advanced renal disease, viral infections, stress/exercise, non-specific (Echeverry *et al.*, 2010).

Waxy (broad) Casts

Waxy casts can be found in people with advanced kidney disease and long-term (chronic) kidney failure. White blood cell (WBC) casts are common with acute kidney infections and interstitial nephritis.

Normal: Absent

Diagnosis

Advanced renal failure (dilated tubules with decreased flow) (Patel, 2006).

Table.1

Urine substances to be checked	Normal values	Collection timings	Significance
pH	4.7 to 7.7 Average = acidic 6.0	A random and fresh sample	Urine pH never reaches 8 > Test blood glucoseInform the physician
Color	Variable, pale-yellow to dark amber	A random sample	Red color urine, check for hemoglobin
Specific gravity	1.000to 1.030	A Random sample	Specific gravity is the measurement of the kidneys' ability to concentrate urine.
Blood	Negative	A random sample	It is seen in various conditions of the urinary tract
Glucose	Qualitative = nil 50 to 100 mg/L	A random sample	Urine glucose >1000mg/dL (>55 mmol/L) Test blood glucoseInform the physician
Ketones	Negative	A random sample	Ketonuria indicates diabetic crises It may be seen in starvation
Albumin	Adult = 7.5 to 15 mg/L	A random sample	Adult = Proteinuria >2000 mg.
Protein	Qualitative =nil	A random sample	Indicate renal disease
Bilirubin	Negative May find 0 to 0.02 mg/dL	A random sample (Check within one hour)	Urine bilirubin is negative in hemolytic disease. It appears in the urine before other S/S of liver disease
Urobilinogen	Random sample = <1 mg/Dl	1. A random sample	It rapidly decomposed at room temperature Also, when exposed to light
Nitrite	Negative	A random sample (Fasting sample is better)	A negative test does not rule out bacteria in the urine
Leukocyte esterase	Negative	A random sample	The positive test needs a urine culture
HCG	Pregnant = positive Nonpregnant = Negative	A random urine sample	It is advised in pregnancy and follow-up of tumors

Table.2

Urine substances to be checked	Normal values	Collection	Significance
RBCs cells	Absent	A random sample	The persistent presence of RBCs in the urine needs thorough investigations
WBCs cells	1. Absent 2. Female = slightly more	A random sample	Urine culture should be done when increased WBCs are found
Epithelial cells	1. Renal tubular cells= 0 to 3/HPF 2. Squamous cells = Commonly seen	A random sample	urinary tract infection, kidney disease, or other serious medical condition
RBC cast	0/HPF(Absent)	A random sample	Indicates hemorrhage in the nephron
WBC cast	Negative	A random urine sample	Seen in renal inflammatory diseases
Hyaline cast	Occasional 0 to 2/HPF	A random sample	Usually seen when there is damage to the glomerular capillary membrane
Granular cast	Occasional 0 to 2/HPF	A random sample	These indicate renal disease
Waxy cast	Negative	A random sample	In renal failure (severe renal disease)
Fatty cast	Negative	A random urine sample	Seen in diabetic nephropathy
Uric acid	Absent	A random urine sample	Acid urine, hyperuricosuria, uric acid nephropathy, normal
Calcium Oxalate	Absent	A random urine sample	Ethylene glycol poisoning, acid urine, hyperoxaluria, normal
Triple Phosphate	Absent	A random urine sample	Alkaline urine, decreased urine volume, UTI from urease-producing bacteria
Trichomonasvaginalis	Absent	A random urine sample	UTI due to Trichomonasvaginalis
Yeast cell	Absent	A random urine sample	Genitourinary infection
Microbial flora	Occasional 0 to 2/HPF	A random urine sample	Microbial flora of the introitus, vagina and urethra in women with a normal genitourinary tract but who are prone to suffer recurrent urinary infections. Urine culture should be done when increased Microbial flora are found

Fig.1

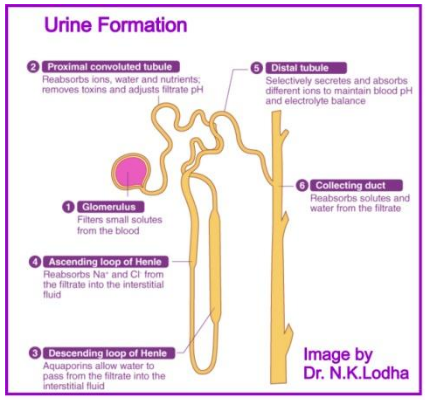


Fig.2

Fig.3

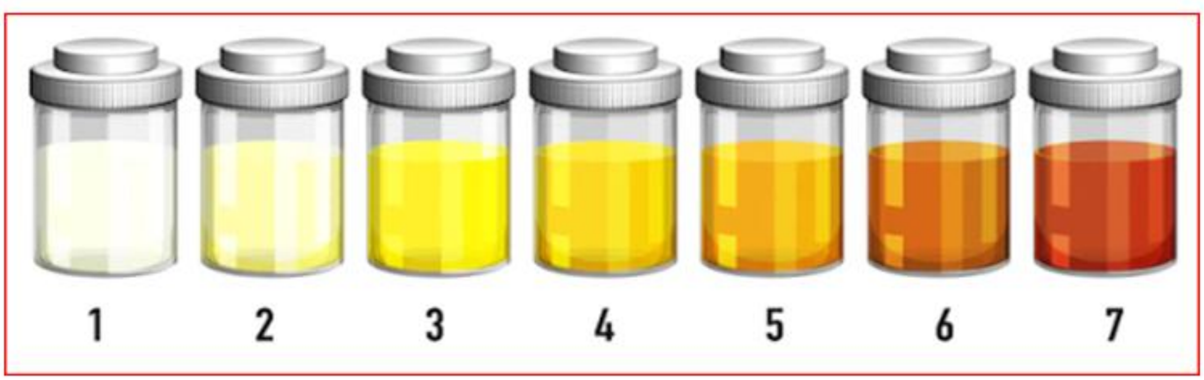


Fig.4

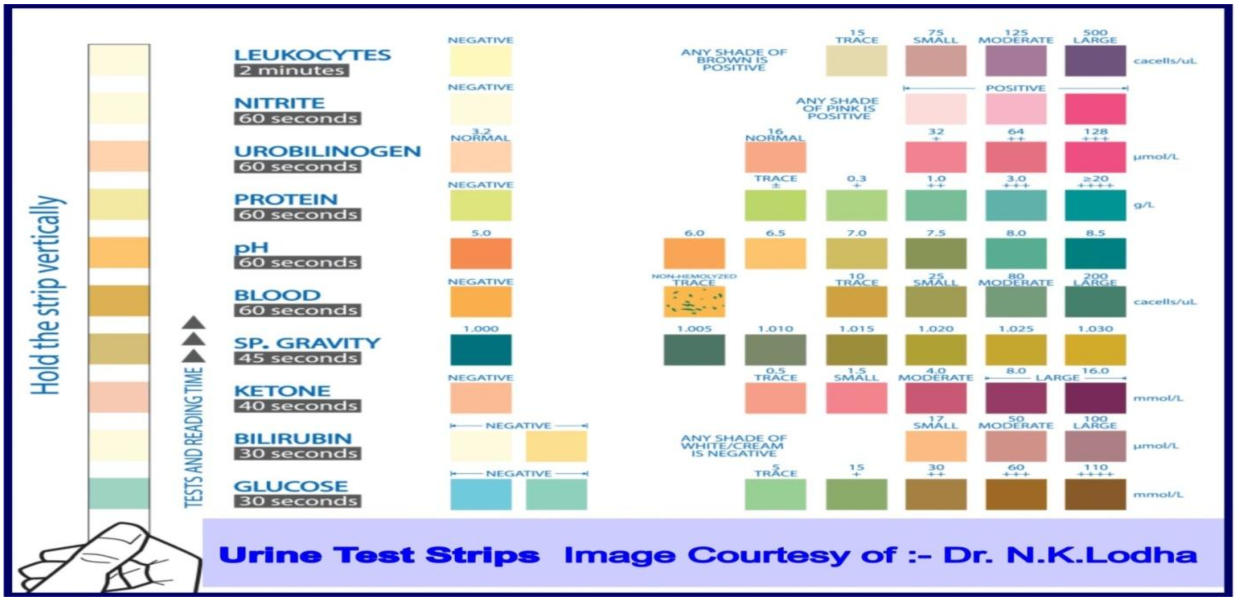

Hold the strip vertically
TESTS AND READING TIME
LEUKOCYTES 2 minutes
NITRITE 60 seconds
UROBILINOGEN 60 seconds
PROTEIN 60 seconds
pH 60 seconds
BLOOD 60 seconds
SP. GRAVITY 45 seconds
KETONE 40 seconds
BILIRUBIN 30 seconds
GLUCOSE 30 seconds
NEGATIVE
ANY SHADE OF BROWN IS POSITIVE
15 TRACE
75 SMALL
125 MODERATE
500 LARGE
cacells/uL
NEGATIVE
ANY SHADE OF PINK IS POSITIVE
POSITIVE
3.2 NORMAL
16 NORMAL
32 +
64 ++
128 +++
µmol/L
NEGATIVE
TRACE ±
0.3 +
1.0 ++
3.0 +++
≥20 ++++
g/L
5.0
6.0
6.5
7.0
7.5
8.0
8.5
NEGATIVE
NON-HEMOLYZED TRACE
10 TRACE
25 SMALL
80 MODERATE
200 LARGE
cacells/uL
1.000
1.005
1.010
1.015
1.020
1.025
1.030
NEGATIVE
0.5 TRACE
1.5 SMALL
4.0 MODERATE
8.0
LARGE
16.0
mmol/L
NEGATIVE
ANY SHADE OF WHITE/CREAM IS NEGATIVE
17 SMALL
50 MODERATE
100 LARGE
µmol/L
NEGATIVE
5 TRACE
15 +
30 ++
60 +++
110 ++++
mmol/L
Urine Test Strips Image Courtesy of :- Dr. N.K.Lodha

Fig.5


High Values (alkaline)pH: renal tubular acidosis
Low Values (acid) pH:bladder calculi

Fig.6

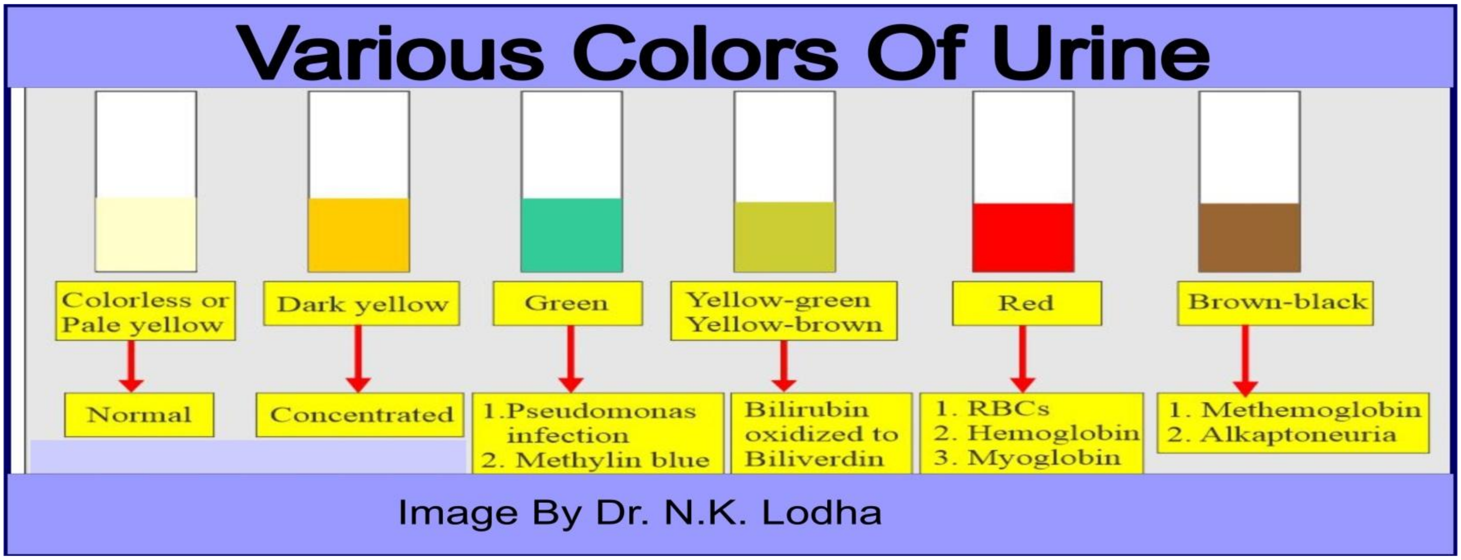

Various Colors Of Urine
Colorless or Pale yellow
Dark yellow
Green
Yellow-green Yellow-brown
Red
Brown-black
Normal
Concentrated
1.Pseudomonas infection
2. Methylin blue
Bilirubin oxidized to Biliverdin
1. RBCs
2. Hemoglobin
3. Myoglobin
1. Methemoglobin
2. Alkaptoneuria
Image By Dr. N.K. Lodha

Fig.7

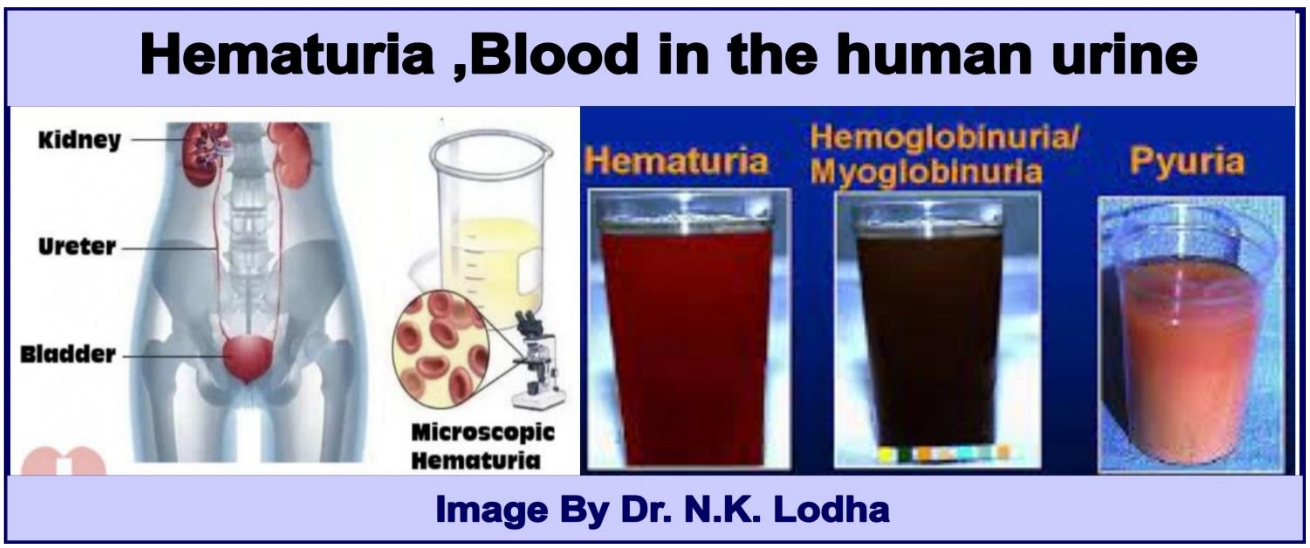
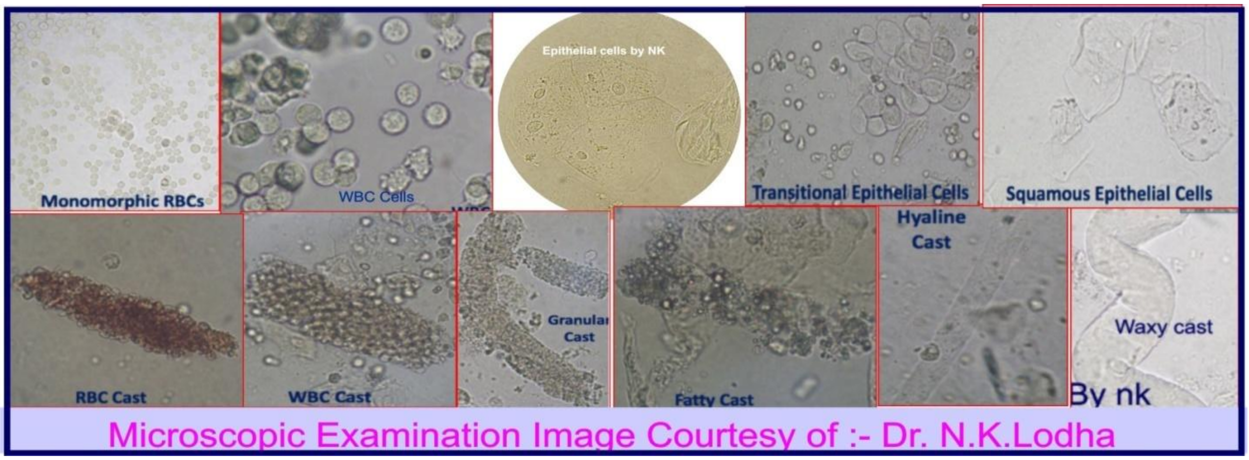

Hematuria ,Blood in the human urine
Kidney
Ureter
Bladder
Microscopic Hematuria
Hematuria
Hemoglobinuria/ Myoglobinuria
Pyuria
Image By Dr. N.K. Lodha

Fig.8



Hyaline Casts

Hyaline casts can be identified in both healthy individuals and those with certain pathological conditions.

In most cases, they indicate a decreased or sluggish urine flow, which can be caused by dehydration from strenuous exercise, diuretic medications, or severe vomiting, or by decreased blood flow to the kidneys.

Normal: Up to 5 casts/low-power field

Diagnosis

Normal finding in concentrated urine, fever, exercise, diuretics, pyelonephritis, chronic renal disease (Simerville *et al.,* 2005).

Fatty Casts

Fatty casts are seen in people who have lipids in urine. This is most often a complication of nephroticsyndrome.

Granular casts are a sign of many types of kidney diseases. Red blood cell casts mean there is a microscopic amount of bleeding from the kidney.

Normal: Absent

Diagnosis

Heavy proteinuria (nephrotic syndrome), renal disease, hypothyroidism, acute tubular necrosis, diabetes mellitus, severe crush injuries (Echeverry *et al.,* 2010).

Crystals

End products of metabolism are found highly concentrated in the urine and can precipitate in the form of crystals. The presence of crystals is not necessarily associated with pathological states, although several types of crystals are associated with certain diseases.

For example, cholesterol crystals are seen in polycystic renal disease and nephrotic syndrome and polycystic renal disease; leucine and tyrosine crystals are associated with severe liver disease (Simerville *et al.,* 2005).

Uric Acid

Uric acid is a chemical created when the body breaks down substances called purines. Most uric acid dissolves in blood and travels to the kidneys, where it passes out in urine. If your body produces too much uric acid or does not remove enough of it, you may get sick.

Yellow to orange-brown, diamond- or barrel-shaped crystals

Normal: Absent

Diagnosis

Acid urine, hyperuricosuria, uric acid nephropathy, normal (see image attached) (Echeverry *et al.,* 2010).

Calcium Oxalate

These crystals may stick together and form a solid mass (a kidney stone). Oxalate is one type of substance that can form crystals in the urine. This can happen if there is too much oxalate, too little liquid, and the oxalate "sticks" to calcium while urine is being made by the kidneys.

Most commonly encountered crystal in human urine

Refractile square "envelope" shape

Normal: Absent

Diagnosis

Ethylene glycol poisoning, acid urine, hyperoxaluria, normal (see image attached) (Simerville *et al.,* 2005).

Triple Phosphate (Struvite)

Triple phosphate crystals, also known as magnesium ammonium phosphate crystals, are found in alkaline urine (pH greater than 7).

"Coffin lid" appearance crystals

Normal: Absent

Diagnosis

Alkaline urine, decreased urine volume, UTI from urease-producing bacteria (*Proteus, Klebsiella*) (Echeverry *et al.,* 2010).

Interpretation

Example of reference values for dipstick urinalysis (Takhar and Moran, 2014) hide Blood-Negative, Leukocytes-Negative, Nitrite-Negative, Protein-Negative to trace, pH-5–7, Specific gravity-1.000–1.035, Glucose-Negative, Ketones-Negative, Bilirubin-Negative, Urobilinogen-<1 mg/dL

The interpretation of urinalysis takes into account the results of physical, chemical and microscopic examination and the person's overall condition. Urine test results should always be interpreted using the reference range provided by the laboratory that performed the test, or using information provided by the test strip/device manufacturer. Not all abnormal results signify disease, and false positive results are common. For this reason, the use of urinalysis for screening in the general population has been discouraged, but it remains a common practice (Chu and Lowder, 2018).

Urinalysis is commonly used to help diagnose urinary tract infections, but the significance of the results depends on the broader clinical situation. In the setting of UTI symptoms, positive dipstick results for nitrite and leukocyte esterase are strongly suggestive of a UTI, (Gupta *et al.,* 2017) but negative results do not rule it out if there is a high degree of suspicion. When the dipstick test is positive, microscopy is used to confirm and count WBCs, RBCs and bacteria and assess for possible contamination (signified by a high number of squamous epithelial cells in the sample) (Gupta *et al.,* 2017). If UTI is suspected, particularly in complicated cases or when urinalysis results are inconclusive, a urine culture may be performed to identify microorganisms if present, obtain a colony count, and carry out antibiotic sensitivity testing. The colony count helps to distinguish between contamination and infection. If a significant quantity of bacteria is present in the urine but there are no symptoms of a UTI, the condition is called asymptomatic bacteriuria. Asymptomatic bacteriuria is common in elderly people and in those with long-term urinary catheters, and in most cases does not require treatment. Exceptions include pregnant women, in whom bacteriuria is associated with poorer pregnancy outcomes, and people undergoing some invasive urology procedures. A positive dipstick result for blood could signify the presence of red blood cells, hemoglobin, or myoglobin, and therefore requires microscopic analysis for confirmation.

Intact red blood cells will normally be observed under the microscope if present, but they may lyse in dilute or alkaline samples (Hitzeman *et al.,* 2022). Hemoglobinuria, if unaccompanied by a high quantity of RBCs, can signify intravascular hemolysis (destruction of red blood cells inside the body). Myoglobinuria occurs in rhabdomyolysis and other conditions that cause breakdown of muscle tissue.If red blood cells are present, the interpretation takes into account whether the urine is visibly bloody (termed macroscopic hematuria) or if RBCs are only seen on microscopy (microscopic hematuria). Contamination of the sample with blood from a non-urinary source, such as from menstruation or rectal bleeding, can mimic hematuria, and microscopic hematuria is sometimes observed in healthy people after exercise. Other causes of microscopic hematuria include UTI, kidney stones, benign prostatic hyperplasia, and trauma to the urinary tract. Kidney diseases that affect the glomerulus can cause microscopic hematuria, in which case it is referred to as glomerular hematuria. On urine microscopy, the presence of abnormally shaped ("dysmorphic") red blood cells and RBC casts is associated with glomerular hematuria. Proteinuria and elevated blood creatinine alongside hematuria suggests kidney dysfunction. In people at risk, persistent microscopic hematuria can be a sign of urinary tract cancer and may require further testing, such as urinary tract imaging and cystoscopy. Sometimes no cause can be identified, and the condition is managed with regular monitoring. The causes of macroscopic hematuria are similar, but in the absence of an obvious explanation such as trauma or UTI, it is more strongly associated with malignancy and requires further investigation.

These specific urine tests will be included in a new article to come

Odor, Volume, Bicarbonate, Chloride (as NaCl), Creatinine, Creatine, Cystine, Lysozyme, Urea, Uric acid, Calcium, Magnesium, Sodium, Potassium, Phosphate, Oxalate, Sulfates, Ammonia, Hemoglobin, Myoglobin, 5-hydroxy indoleacetic acid (5-HIAA), Vanilylmandelic acid (VMA), Catecholamines, Porphyrins, Porphobilinogen, Amylase, Phenylketonuria,

References

Bain, 2015, they are markedly less sensitive to other proteins, such as Bence-Jones protein,p. 470.

Brunzel, 2018, as it suggests that the kidneys have lost the ability to control urine concentration. p. 78.

Brunzel, 2018, Purple urine occurs in purple urine bag syndrome.p. 70.

Brunzel, 2018, the presence of porphobilinogen and numerous drugs.pp. 114–6.

Brunzel, 2018, they are most commonly round or pear-shaped.p. 45.

Brunzel, 2018, WBCs can also appear in the urine following exercise or fever. p. 141.

Chu, C. M.; Lowder, J. L. (2018). Jump up to:[a b]. *"Diagnosis and treatment of urinary tract infections across age groups". American Journal of Obstetrics and Gynecology. 219 (1): 40–51. doi:10.1016/j.ajog.2017.12.231. PMID 29305250. S2CID 23789220.*

Echeverry G, Hortin G L, Rai A J. Introduction to urinalysis: historical perspectives and clinical application. Methods Mol Biol. 2010;641:1-12.

Gupta, K.; Grigoryan, L.; Trautner, B. (2017). Jump up to:[a b]. *"Urinary Tract Infection". Annals of Internal Medicine. 167 (7): ITC49–ITC64. doi:10.7326/AITC201710030. PMID 28973215. S2CID 31963042.*

Hitzeman, N.; Greer, D.; Carpio, E. (2022) Jump up to:[a b c d]. *"Office-Based Urinalysis: A Comprehensive Review". American Family Physician. 106 (1): 27–35B. PMID*

35839369.

Kang, K. H.; Jeong, K. H.; Baik, S. K.; Huh, W. Y.; Lee, T. W.; Ihm, C. G.; *et al.*, (2011). "Purple urine bag syndrome: case report and literature review". *Clinical Nephrology*. 75 (6): 557–559. doi:10.5414/cn106615. PMID 21612761.

McPherson and Pincus, 2017, Test strips contain pads impregnated with chemical compounds that change color when they interact with specific elements in the sample, such as glucose, protein and blood, p. 460.

McPherson and Pincus, 2017, that urinalysis is performed within two hours of sample collection if the urine is not refrigerated. p. 443.

McPherson and Pincus, 2017, the words urine and analysis pp. 441–3.

McPherson and Pincus, 2017. Jump up to:[a] [b], Dark yellow-brown to green urine may suggest a high concentration of bilirubin, a state known as bilirubinuria. p. 444.

McPherson and Pincus, 2017. Jump up to:[a] [b], pp. 457–8.

Mundt and Shanahan, 2016, A milky appearance can be caused by a very high concentration of white blood cells or fats, or by chyluria (the presence of lymphatic fluid in the urine). p. 76.

Mundt and Shanahan, 2016, Thus, a positive result for blood can represent the presence of red blood cells (hematuria), free hemoglobin (hemoglobinuria), or myoglobin (myoglobinuria).p. 98.

Ovalle and Nahirney 2021, microscopy is performed to identify elements such as cells, urinary casts, crystals, and organisms. pp. 383–9.

Ovalle and Nahirney 2021, the blood into the urine in order to maintain homeostasis.pp. 393–8.

Patel H P. The abnormal urinalysis. PediatrClin North Am. 2006 Jun;53(3):325-37, v.

Rakel and Rakel 2016, the amount of glucose in the urine should be negligible as it is reabsorbed by the renal tubules. p. 970.

Sharp *et al.*, 2020, the gallbladder as a constituent of bile and is excreted through the intestines; it does not occur at detectable levels in the urine. pp. 136–7.

Sharp *et al.*, 2020, The reaction of ketones with sodium nitroprusside in an alkaline medium turns the test pad purple. pp. 124–6.

Simerville J A, Maxted W C, Pahira J J. Urinalysis: a comprehensive review. Am Fam Physician. 2005 Mar 15;71(6):1153-62.

Takhar, S. S.; Moran, G. J. (2014). "Diagnosis and Management of Urinary Tract Infection in the Emergency Department and Outpatient Settings". Infectious Disease Clinics of North America. 28 (1): 33–48. doi:10.1016/j.idc.2013.10.003. PMID 24484573.

Turgeon 2016, Urine flows through the ureters into the bladder and exits the body through the urethra. pp. 387–90.

Wilson L A. Urinalysis. Nurs Stand. 2005 May 11-17;19(35):51-4.

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