Urinalysis in the diagnosis of kidney disease

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INTRODUCTION

The urinalysis is an informative and noninvasive diagnostic tool that is readily accessible to the clinician in both the ambulatory and hospital settings. In conjunction with the history, physical examination, and laboratory testing, the urinalysis plays a central role in evaluating acute and chronic kidney disease. In addition, abnormal findings on a routine urinalysis, even in an otherwise asymptomatic patient, may be the first evidence of underlying kidney disease. The urinalysis can also be used in some patients to monitor the course of established kidney disease.

Interpretation of the urinalysis in patients with established or suspected kidney disease will be presented in this topic. Assessment of kidney function, a general approach to the patient with kidney disease, an overview of the indications for kidney biopsy, and the differential diagnosis and evaluation of glomerular disease are discussed separately:

- (See "Assessment of kidney function".)
- (See "Diagnostic approach to adult patients with subacute kidney injury in an outpatient setting".)
- (See "The kidney biopsy".)
- (See "Glomerular disease: Evaluation and differential diagnosis in adults".)

GENERAL PRINCIPLES

Components of the urinalysis — A complete urinalysis consists of three components:

- Gross assessment of the urine (see 'Gross assessment of the urine' below)
- Urine dipstick analysis (see 'Urine dipstick analysis' below)
- Microscopic examination of the urinary sediment (see 'Examination of the urine sediment' below)

Indications for testing

When to perform a urinalysis — A urinalysis may provide diagnostic insight in the following settings:

- In a patient with an acute or chronic reduction in the glomerular filtration rate or unexplained albuminuria.
- In a patient with suspected kidney disease. Kidney disease may be suspected on the basis of clinical findings (eg, edema) or because of a concurrent illness or condition that is commonly associated with kidney disease (eg, systemic lupus erythematosus, small-vessel vasculitis, newly identified hypertension).

When to examine the urine sediment — Microscopic examination of the urine sediment **should be performed** in the following settings:

- In all patients with acute kidney injury (AKI), with the possible exception of those with ultrasonographically proven kidney obstruction
- In the initial workup of most patients with undifferentiated chronic kidney disease (CKD)
- In an otherwise asymptomatic patient in order to clarify the significance of findings noted on urine dipstick analyses (eg, microscopic hematuria) when the dipstick was part of a workup for another condition (eg, hypertension, diabetes mellitus, connective tissue disease)

Microscopic examination of the urine may be helpful in the following settings:

- The serial follow-up of acute and chronic kidney diseases
- The initial evaluation of patients with kidney stones (see "Kidney stones in adults: Evaluation of the patient with established stone disease", section on 'Urinalysis')

Microscopic examination of the urine may **not** be needed in the following settings:

- In patients with mildly to moderately impaired kidney function (estimated glomerular filtration rate 30 to 59 mL/min/1.73 m^2) and no abnormalities on urine dipstick (eg, hematuria, albuminuria)
- In patients with diabetes who have reduced kidney function and albuminuria but no other abnormalities on urine dipstick (eg, hematuria)
- In patients with symptoms suggestive of urinary tract infection and concomitant positive testing for leukocyte esterase and/or nitrite on urine dipstick

Specimen collection — The urine specimen must be properly collected in order to reliably interpret the findings and therefore maximize diagnostic utility. The following technique should be followed whenever feasible [1]:

- The specimen should be collected into a clean, dry container.
- Patients should be asked to clean the external genitalia and provide a midstream specimen for analysis.
- In patients with indwelling urinary catheters, a sample should be obtained directly from the catheter tubing, rather than from the urometer or drainage bag. This will ensure that the sample represents recently produced urine and avoids contamination by debris in the collection bag.
- The specimen should be examined at room temperature within two hours of retrieval. If this is not feasible, the sample should be refrigerated at 2 to 8°C and then re-warmed to room temperature prior to assessment. Clinicians should be aware that this approach may lead to the detection of crystals that precipitate at cooler temperatures but do not dissolve in solution upon re-warming.

GROSS ASSESSMENT OF THE URINE

Normal urine is clear and light yellow in color. Urine turbidity and color may be altered in a number of settings.

Urine color — The typical yellow color of urine is lighter when urine is dilute and darker when concentrated, such as after an overnight water restriction. The urine may also have a variety of other colors.

Red to brown urine — The excretion of red to brown urine is observed in a variety of settings [2]. The initial step in the evaluation of this abnormality is centrifugation of the urine to see whether the red color is in the urine sediment or the supernatant (algorithm 1).

- If the red color is seen only in the sediment (and the supernatant is not red), the patient likely has hematuria. (See 'Heme' below.)
- If, on the other hand, the supernatant is red, then the supernatant should be tested for heme (frequently labeled as "blood") with a urine dipstick:
  - If a urine dipstick of the red supernatant is positive for heme, the patient has either hemoglobinuria or myoglobinuria. (See 'Hemoglobinuria and myoglobinuria' below.)
  - If a urine dipstick of the red supernatant is negative for heme, one of the following conditions should be considered:
    - Use of certain medications such as rifampin, phenytoin, or hydroxycobalamin
    - Consumption of food dyes
    - Ingestion of beets (beeturia), rhubarb, or senna
    - Acute intermittent porphyria

Hemoglobinuria and myoglobinuria — Hemoglobinuria is the presence of free hemoglobin (which is normally only present inside intact red blood cells [RBCs]) in the urine. This may occur during episodes of intravascular hemolysis or lysis of RBCs in the urine. Myoglobinuria is the presence of free myoglobin (which is normally only present in intact muscle cells) in the urine. This may occur during rhabdomyolysis (eg, due to crush injury of muscle). Both hemoglobinuria and myoglobinuria can produce a red or red to brown urine:

- Hemoglobin is relatively poorly filtered due both to its large size (molecular weight 69,000 of the tetramer and 34,000 of the dimer) and protein binding to haptoglobin. Only the unbound dimer is filtered. Hemoglobinuria will not occur until haptoglobin is fully saturated and the filtered load of free hemoglobin exceeds proximal reabsorptive capacity.

  Hemoglobinuria is often associated with red urine. However, the combination of prolonged transit time through the nephron with glomerular bleeding and an acid urine pH may result in the formation of methemoglobin, which has a smoky brown or "Coca cola" color [3]. (See "Etiology and evaluation of hematuria in adults", section on 'Glomerular versus nonglomerular bleeding'.)

- Myoglobin, by comparison, is a monomer (molecular weight 17,000) and is not protein bound. As a result, it is rapidly filtered and excreted, thereby allowing the plasma to retain

its normal color unless kidney failure limits its excretion. The source of the excess myoglobin is skeletal muscle breakdown (rhabdomyolysis), which is also associated with a marked elevation in the serum creatine kinase concentration.

- (See "Clinical manifestations and diagnosis of rhabdomyolysis", section on 'Urine findings and myoglobinuria'.)
- (See "Clinical features and diagnosis of heme pigment-induced acute kidney injury", section on 'Urinalysis'.)

Other urine colors — Rarely, the urine has other colors, including:

- White urine, which may be due to phosphate crystals, chyluria [4,5], or propofol [6].
- Pink urine, presumably due to uric acid crystals, which may occur following propofol administration [7-9].
- Green urine, which may be due to the administration of methylene blue [10], propofol [11-15], amitriptyline, or rarely, from urinary tract infection caused by *Pseudomonas aeruginosa* [16,17].
- Black urine, which may be due to hemoglobinuria [18,19], myoglobulinuria, melanuria in the context of metastatic melanoma [20], or ochronosis. The black urine in ochronosis, which usually results from alkaptonuria (also called "black urine disease"), is caused by the urinary excretion of homogentisic acid. The black color may only be apparent after the urine stands for some time, permitting the oxidation of homogentisic acid. (See "Disorders of tyrosine metabolism", section on 'Alkaptonuria'.)
- Purple urine, which may be due to bacteriuria in patients with urinary catheters [21,22], or coadministration of methylene blue and hydroxycobalamin [23]. (See "Catheter-associated urinary tract infection in adults", section on 'Pathogenesis'.)

Turbidity — Normal urine is usually clear. Turbid urine may be seen in the setting of infection, or as a result of precipitated crystals or chyluria [24]. Contamination caused by genital secretions may also cause turbid urine.

Urine odor — An abnormal pungent odor of the urine is most frequently caused by the production of ammonia by bacteria. The presence of ketones in the urine may cause the urine to have a sweet or fruity odor. Certain rare disorders are associated with specific odors to the urine:

- Maple syrup urine disease, which can confer a maple syrup odor to the urine (see "Overview of maple syrup urine disease")
- Phenylketonuria, which can confer a musty or mousy odor to the urine (see "Overview of phenylketonuria")
- Isovaleric acidemia, which can confer a sweaty feet odor to the urine (see "Organic acidemias: An overview and specific defects", section on 'Isovaleric acidemia')
- Hypermethioninemia, which can confer a rancid butter or fishy odor to the urine

URINE DIPSTICK ANALYSIS

The urine dipstick provides a rapid semiquantitative assessment of urinary characteristics on a series of colorimetric pads embedded on a test strip. Most urine dipsticks permit the analysis of the following core parameters: specific gravity, pH, heme, leukocyte esterase, nitrite, albumin, and glucose. Some dipsticks include test pads for additional parameters including urobilinogen and ketones, although these are generally not used in the diagnosis of kidney disease. Users should be familiar with the specific characteristics of the reagent strips they are using and adhere to manufacturer instructions regarding the amount of urine required and the time that needs to elapse before interpreting the color on any given test pad.

Specific gravity — The osmolality of the urine can be inferred by measuring the urine specific gravity, which is defined as the weight of the solution compared with the weight of an equal volume of distilled water. The urine specific gravity generally varies with the osmolality, rising by approximately 0.001 for every 35 to 40 mosmol/kg increase in urine osmolality (figure 1). Thus, a urine osmolality of 280 mosmol/kg (which is isosmotic to normal plasma, or "isosthenuric") is usually associated with a urine specific gravity of 1.008 or 1.009.

However, there is an important difference between these measures: The urine osmolality is determined by the number of particles in the urine (eg, urea, sodium, potassium), while the specific gravity is determined by both the number and size of the particles in the urine. This becomes important clinically when there are large molecules in the urine, such as glucose or radiocontrast media. In these settings, the specific gravity can exceed 1.030 (suggesting a highly concentrated urine) despite a urine osmolality that may be isosmotic or dilute relative to plasma.

By contrast, there are no causes of a falsely low urine specific gravity. A specific gravity ≤1.003 is indicative of a maximally dilute urine (≤100 mosmol/kg).

pH — The urine hydrogen ion concentration, expressed as the pH, reflects the degree of acidification of the urine. The physiologic urine pH ranges from 4.5 to 8, depending upon the systemic acid-base balance. The urine pH is most often used clinically in patients with metabolic acidosis. The appropriate kidney response to acidemia is to increase urinary acid excretion, with the urine pH falling below 5. A higher value suggests the presence of renal tubular acidosis. A discussion of the urine pH in the diagnosis of renal tubular acidosis is presented elsewhere. (See "Overview and pathophysiology of renal tubular acidosis and the effect on potassium balance".)

In some settings, the urine pH is not indicative of acid excretion by the kidneys. As an example, infection with any pathogen that produces urease, such as *Proteus mirabilis*, can result in a urine pH above 8, even if urinary acidification is normal.

Heme — Heme acts as a pseudoperoxidase, and when heme-containing urine is exposed to peroxide and a chromogen on the test pad, a color change takes place [25]. However, a positive dipstick for heme may result not only from urinary red blood cells (RBCs) but also from free hemoglobin or free myoglobin. In addition, the dipstick may be falsely positive if there is semen present in the urine [26]. Thus, a positive dipstick does not establish the presence of RBCs in the urine, and the diagnosis of hematuria requires confirmation with microscopy [27]. (See 'Hemoglobinuria and myoglobinuria' above and "Etiology and evaluation of hematuria in adults".)

The detection of heme by urine dipstick is thought of as a highly sensitive test for the presence of RBCs equivalent to 1 to 2 RBCs per high-powered field [28]. False-negative results are said to be unusual, and as a result, a dipstick that is negative for heme theoretically excludes the presence of RBCs [29,30]. In theory, however, urinary ascorbic acid can interfere with the peroxidase reaction, thereby yielding false-negative results [31]. Given the prevalence of vitamin C ingestion, this may limit the value of the urine dipstick as a screening test for hematuria. Dipstick manufacturers have attempted to allay such concerns through the production of dipsticks that oxidize ascorbic acid, thereby minimizing the risk of false negatives [32].

Leukocyte esterase — Leukocyte esterase released by lysed neutrophils and macrophages is a marker for the presence of white blood cells (WBCs). However, a concentrated urine may impede cell lysis and therefore produce a false-negative result. Proteinuria and glucosuria may also lead to a false-negative test for leukocyte esterase [25].

Nitrite — Many *Enterobacteriaceae* species, the most common microorganisms causing urinary tract infections, elaborate the enzyme nitrate reductase, which converts urinary nitrate to nitrite. Thus, nitrite-positive urine may indicate underlying bacteriuria. By contrast, urinary

infections with enterococcal species, which express low levels of nitrate reductase, may test negative for nitrites [24].

Protein — The urine dipstick test for protein is most sensitive to albumin and provides a semiquantitative means of assessing albuminuria. The dipstick is **insensitive** to non-albumin proteins, most notably immunoglobulin light chains.

- **Albuminuria** – There are several important limitations of dipstick testing for albuminuria:
  - Moderately increased albuminuria in the range of 30 to 300 mg/day (formerly called "microalbuminuria") may be below the limit of detection of the urine dipstick, particularly if the urine is dilute. (See "Assessment of urinary protein excretion and evaluation of isolated non-nephrotic proteinuria in adults", section on 'Amounts of proteinuria'.)
  - Severely increased albuminuria (more than 300 mg/day, formerly called "macroalbuminuria") may be undetectable or underestimated if the urine is very dilute.
  - The semiquantitative categories of albuminuria that are reported (eg, trace, 1+, 2+, and 3+) may be misleading. A dilute urine, for example, will underestimate the degree of albuminuria. By contrast, a concentrated urine may register as 3+ but may **not** indicate high-grade albuminuria.
  - Recent exposure to iodinated radiocontrast agents can induce transient albuminuria [33]. However, this may not be observed with newer non-ionic contrast agents [34].

  A patient with a persistently positive dipstick test for protein should have albuminuria quantified with assessment of the albumin-to-creatinine ratio on a random (spot) urine sample or with a 24-hour urine collection. (See "Patient education: Collection of a 24-hour urine specimen (Beyond the Basics)" and "Assessment of urinary protein excretion and evaluation of isolated non-nephrotic proteinuria in adults".)

- **Non-albumin proteinuria** – The dipstick is not sensitive to non-albumin proteins, such as immunoglobulin light chains. A screen for the presence of such proteins may be performed with the sulfosalicylic acid (SSA) test.

  SSA detects all proteins in urine and may be useful in patients with acute kidney injury (AKI) of unclear etiology and a urine dipstick that is negative for protein. A positive SSA test in conjunction with a negative dipstick usually indicates the presence of non-albumin proteins in the urine, most often immunoglobulin light chains. (See "Kidney disease in multiple myeloma and other monoclonal gammopathies: Etiology and evaluation".)

The SSA test is performed by mixing 1 part urine supernatant with 3 parts 3 percent SSA and assessing whether the urine becomes turbid, which suggests the presence of proteinuria. The SSA test is described in detail elsewhere. (See "Assessment of urinary protein excretion and evaluation of isolated non-nephrotic proteinuria in adults", section on 'Sulfosalicylic acid test'.)

The clinical significance of dipstick proteinuria has been demonstrated in multiple settings [35,36], and the presence and degree of proteinuria have become a fundamental part of chronic kidney disease (CKD) staging [37] and the prognostication of progression [38,39]. This issue is discussed in detail elsewhere:

- (See "Assessment of urinary protein excretion and evaluation of isolated non-nephrotic proteinuria in adults".)
- (See "Definition and staging of chronic kidney disease in adults".)
- (See "Chronic kidney disease and coronary heart disease".)

Glucose — When present in the urine, glucose triggers the production of peroxide, which in turn leads to the oxidation of a chromogen in a reaction catalyzed by peroxidase [24]. As is the case with the dipstick test for heme, ascorbic acid can produce a false-negative test for glycosuria [31]. Glycosuria may be due to either the inability of the kidney to reabsorb filtered glucose in the proximal tubule despite normal plasma glucose concentration or an overflow scenario related to high plasma glucose concentrations overwhelming the capacity of the renal tubules to reabsorb glucose. In patients with normal kidney function, significant glycosuria does not generally occur until the plasma glucose concentration exceeds 180 mg/dL (10 mmol/L).

When glycosuria occurs with a normal plasma glucose, a primary defect of proximal tubule reabsorption needs to be considered. In this setting, glycosuria may coexist with additional manifestations of proximal tubular dysfunction, including phosphaturia (leading to hypophosphatemia), uricosuria, renal tubular acidosis, and aminoaciduria. This constellation is called the Fanconi syndrome and may result from a variety of disorders, including multiple myeloma, heavy metal exposure, and treatment with certain medications including tenofovir, lamivudine, cisplatin, valproic acid, and aminoglycosides [40]. Glycosuria with normal plasma glucose will also be evident in patients receiving sodium-glucose cotransporter 2 inhibitors.

- (See "Kidney disease in multiple myeloma and other monoclonal gammopathies: Etiology and evaluation", section on 'Light chain proximal tubulopathy'.)
- (See "Etiology and diagnosis of distal (type 1) and proximal (type 2) renal tubular acidosis".)

- (See "Sodium-glucose co-transporter 2 inhibitors for the treatment of hyperglycemia in type 2 diabetes mellitus".)

EXAMINATION OF THE URINE SEDIMENT

Microscopic examination of the urine sediment may provide valuable data that complement clinical findings, laboratory tests, and urine dipstick results. In the correct clinical context, the presence or absence of certain urinary findings under microscopy may help refine the differential diagnosis. (See 'When to examine the urine sediment' above.)

Urine sediment technique — Ideally 10 to 15 mL of urine is centrifuged for five minutes at 400 x g, which corresponds to >1500 rpm on most commercial centrifuges. Most of the supernatant is then poured out, and the pellet is resuspended with gentle shaking of the tube. A pipette can then be used to place approximately 50 microL (or a small drop) of resuspended sediment on a glass slide, followed by application of a coverslip [41]. An alternative approach is to tilt the test tube and insert the corner of the coverslip into the tube to extrude a single drop of resuspended sediment; the coverslip is then laid onto the slide, thereby allowing a thin film of sediment to become interposed between the coverslip and the slide.

Brightfield microscopy is generally adequate for review of the urine sediment. Addition of a Sternheimer-Malbin stain to the specimen may enhance the identification of key structures [1]. The light intensity should be subdued because some structures may be missed if the light is excessively bright. As the specimen is reviewed, the fine adjustment on the microscope should be manipulated to appreciate structures in different levels of depth within the sample [24]. The entire specimen is initially scanned at low power using a 10x objective (100x magnification) with particular attention to the edges of the coverslip where casts tend to migrate. High power using a 40x objective (400x magnification) should then be used to better characterize structures that were identified at lower power. Polarized light may be used to search for lipid-laden elements or crystals, as warranted by the clinical context. Phase contrast, if available, may sharpen the definition to structures in the urine sediment.

The urine sediment examination should be performed by a clinician trained in urine microscopy because the diagnostic yield may be substantially greater compared with a urinalysis performed by laboratory staff [42]. Although automated microscopic platforms have been developed to identify cells and particles in urine, they have not been shown to be as reliable as trained clinicians to diagnosis various kidney diseases such as acute tubular necrosis (ATN), glomerulonephritis, vasculitis, or crystal-induced kidney disease [42-45].

Cells — Cellular elements that may be found in the urinary sediment include red blood cells (RBCs), white blood cells (WBCs), and epithelial cells from all levels of the urinary tract.

Red blood cells — Hematuria can be benign or reflect serious underlying disease (figure 2). The evaluation of patients with hematuria is discussed in detail separately, but some of the major issues will be briefly reviewed here. (See "Etiology and evaluation of hematuria in adults".)

Hematuria may be grossly visible or microscopic. Microscopic hematuria is commonly defined as the presence of 2 or more RBCs per high-powered field in a spun urine sediment (picture 1) [28,46]. The urine color change in gross hematuria does not necessarily reflect a large degree of blood loss, since as little as 1 mL of blood per liter of urine can induce a visible color change. As previously mentioned, red to brown urine can be observed in patients without actual hematuria [27]. (See 'Red to brown urine' above.)

Hematuria may be transient or persistent. Transient hematuria is relatively common and may occur following exercise or sexual intercourse [28]. Menstruation may confound the evaluation of hematuria, and the urinalysis should be repeated when the patient is not menstruating. However, even transient hematuria can represent underlying malignancy, especially in patients over the age of 50 years. Transient hematuria can also occur with urinary tract infection (eg, cystitis or prostatitis). This is typically accompanied by pyuria and bacteriuria, and patients may often complain of dysuria. (See "Etiology and evaluation of hematuria in adults".)

Persistent hematuria should always be evaluated. Among the more common pathologic causes are kidney stones, malignancy, and glomerular disease. A study of Israeli army recruits showed that, even in asymptomatic individuals, those with isolated persistent hematuria were 18 times more likely to develop end-stage kidney disease (ESKD) over a follow-up period that exceeded 20 years [47].

Distinguishing between glomerular and nonglomerular causes is the first key step in the evaluation of unexplained hematuria. Isomorphic RBCs have an appearance similar to erythrocytes in the circulation (small, anucleated cells shaped as biconcave discs) and can be seen with any cause of hematuria. By contrast, dysmorphic RBCs (which have an altered morphology) are suggestive of glomerular disease [48]. There are no uniform criteria for defining dysmorphic RBCs, and designating a certain proportion of RBCs as dysmorphic as the threshold for clinical relevance is debatable; thus, the practical utility of describing dysmorphic RBCs in the diagnosis of glomerular disease has been questioned [49]. However, RBCs that have membrane protrusions (ie, acanthocytes) are a readily definable subset of dysmorphic RBCs (picture 2A-B) that have a sensitivity of 52 percent and specificity of 98 percent for the diagnosis of glomerulonephritis [50]. The concomitant presence of RBC casts and/or

albuminuria in a patient with hematuria increases the likelihood that the observed hematuria is of a glomerular origin [51]. (See "Etiology and evaluation of hematuria in adults", section on 'Glomerular versus nonglomerular bleeding' and 'Red blood cell casts' below.)

Less commonly, urinary RBCs with unique morphologies may suggest underlying systemic illness. This includes sickled RBCs in patients with underlying sickle cell trait/anemia and elliptocytes in patients with hemolysis [52]. (See "Overview of the clinical manifestations of sickle cell disease" and "Hereditary elliptocytosis and related disorders".)

White blood cells — Although the entire spectrum of WBCs may be seen in the urine, neutrophils and eosinophils are the cell types of greatest practical interest to the clinician-microscopist. Neutrophils are intermediate in size compared with RBCs and renal tubular epithelial cells and can be identified by their characteristic granular cytoplasm and multilobed nuclei (picture 3). Urinary neutrophils are commonly associated with bacteriuria. However, if the corresponding urine culture is negative (ie, sterile pyuria), interstitial nephritis, renal tuberculosis, and nephrolithiasis should be considered [53]. (See "Sampling and evaluation of voided urine in the diagnosis of urinary tract infection in adults" and "Clinical manifestations and diagnosis of acute interstitial nephritis", section on 'Clinical features'.)

Urine eosinophils can be detected by applying Wright or Hansel stain to the urine sediment [54]. The presence of eosinophiluria has traditionally been considered a marker of acute interstitial nephritis. However, in a case series of adults with biopsy-proven acute interstitial nephritis, only 34 percent of patients had eosinophiluria [55]. Thus, testing for eosinophiluria should **not** be used to establish or exclude a diagnosis of acute interstitial nephritis [56,57]. (See "Clinical manifestations and diagnosis of acute interstitial nephritis", section on 'Laboratory and radiographic findings'.)

Epithelial cells — Epithelial cells may appear in the urine after being shed from anywhere within the genitourinary tract. Renal tubular cells are 1.5 to 3 times larger than white cells and are further distinguished by a round, large, centrally located nucleus (picture 4). Transitional epithelial cells originate anywhere from the renal pelvis to the proximal urethra and are slightly larger than renal tubular epithelial cells. They may have a pear-like or oval appearance (picture 5). Squamous epithelial cells are derived from the distal urethra or external genitalia. They are large and irregular in shape with a small central nucleus, and their presence represents contamination by genital secretions (picture 6).

Casts — Casts are cylindrical structures that are formed in the tubular lumen; several factors favor cast formation: urine stasis, low pH, and greater urinary concentration [24]. Casts will assume the shape and size of the renal tubule in which they are formed. All casts have a matrix

composed primarily of Tamm-Horsfall mucoprotein (uromodulin), which comprises the basic architecture of any cast. Casts are defined by the nature of the cells or other elements that are embedded in the cast matrix.

Red blood cell casts — The finding of RBC casts suggests an underlying proliferative glomerulonephritis, for which numerous etiologies exist (picture 2C). However, due to their limited sensitivity, the absence of RBC casts, particularly in a patient with hematuria and a high pre-test probability, does not rule out a proliferative glomerulonephritis [50]. RBC casts are not exclusive to the setting of proliferative glomerulonephritis. In one study, nearly 30 percent of patients with biopsy-proven acute interstitial nephritis had RBC casts in the urine [58]. This implies that RBCs that extrude into the renal tubules from an inflamed interstitium can also lead to cast formation.

- (See "Etiology and evaluation of hematuria in adults", section on 'Glomerular versus nonglomerular bleeding'.)
- (See "Clinical manifestations and diagnosis of acute interstitial nephritis", section on 'Clinical features'.)

White blood cell casts — WBC casts are indicative of interstitial or, less classically, glomerular inflammation (picture 7A-B). In a biopsy series of patients with confirmed acute interstitial nephritis, only 3 percent of patients had WBC casts in their urine sediment [55]. This highlights that, in the presence of a reasonable clinical suspicion for acute interstitial nephritis, the absence of WBC casts should not diminish consideration of this important diagnosis.

Renal tubular epithelial cell casts — These may be observed in any setting where there is desquamation of the tubular epithelium, including ATN, acute interstitial nephritis, and proliferative glomerulonephritis (picture 19B).

Granular casts — Granular casts represent degenerated cellular casts or the aggregation of proteins within a cast matrix (picture 8) [24]. Granular casts may be coarse or fine in nature, although the clinical significance of this distinction is unclear. Coarse, deeply pigmented granular casts (ie, "muddy brown" or heme-granular casts) are considered characteristic of ATN, the leading cause of acute kidney injury (AKI) in hospitalized patients [59].

In patients with ischemic or toxic injury to the tubular epithelial cells, cell sloughing into the tubular lumen, due either to cell death or to defective cell-to-cell or cell-to-basement membrane adhesion, may lead to the formation of granular and/or epithelial cell casts. (See "Pathogenesis and etiology of ischemic acute tubular necrosis", section on 'Epithelial cell injury and dysfunction'.)

Hyaline casts — Hyaline casts are only slightly more refractile than water and have a transparent, empty appearance (picture 9). Hyaline casts may be observed with small volumes of concentrated urine or diuretic therapy and are generally nonspecific.

Waxy casts — Waxy casts are thought to be the last stage in the degeneration of a granular cast. They are homogeneous in appearance and are characterized by sharp indentations and darker edges that are more distinct (picture 10). Waxy casts are nonspecific and may be observed in a variety of acute and chronic kidney diseases.

Broad casts — Broad casts are wider than other casts, a characteristic believed to be due to their formation in large, dilated tubules with little flow (picture 11). The presence of broad casts is typically associated with advanced chronic kidney disease (CKD).

Crystals — The presence of crystals in the urine depends upon a variety of factors, including the degree of concentration of constituent molecules, the urine pH, and the presence of inhibitors of crystallization. Many different forms may be observed in normal patients and in those with defined disorders (figure 3):

- **Calcium oxalate or calcium phosphate crystals** – Calcium oxalate crystals, which are not dependent upon the urine pH, may appear in the monohydrate form as rods or with a characteristic "dumbbell" appearance or in the dihydrate form as an envelope-like structure (picture 12 and picture 13A-B).

  Calcium phosphate crystals form in alkaline urine and have a variety of shapes including prisms that may coalesce into a rosette-like appearance. (See "Kidney stones in adults: Epidemiology and risk factors".)

- **Magnesium ammonium phosphate crystals** – Magnesium ammonium phosphate (struvite) and calcium carbonate-apatite are the constituents of struvite stones (picture 14). Normal urine is undersaturated with ammonium phosphate. Struvite stone formation occurs only when ammonia production is increased and the urine pH is elevated, which decreases the solubility of phosphate. Both increased ammonia production and increased urine pH occur only in the setting of a urinary tract infection with a urease-producing organism, such as *Proteus* or *Klebsiella*. (See "Kidney stones in adults: Struvite (infection) stones".)

- **Uric acid crystals** – Uric acid crystals as well as amorphous urates are observed in acidic urine, a milieu that favors the conversion of the relatively soluble urate salt into the insoluble uric acid (picture 15 and picture 20B). (See "Uric acid kidney diseases".)

- **Cystine crystals** – Cystine crystals, with their characteristic hexagonal shape, are diagnostic of cystinuria (picture 16). (See "Cystinuria and cystine stones".)

- **Other crystals** – The consumption of certain medications may yield urinary crystals. Though some of these medications may cause tubular injury and/or obstruction, the presence of such crystals in the urine does not necessarily imply nephrotoxicity. Commonly used medications with a propensity for crystal formation include acyclovir, sulfonamides, atazanavir, and methotrexate (picture 17). (See "Crystal-induced acute kidney injury".)

The observation of crystals in the urine is useful in patients with known or suspected kidney stones and is a risk factor for recurrent calcium oxalate [60] or cystine [61] stone formation. In addition, crystalluria may have diagnostic utility in other settings:

- The presence of magnesium ammonium phosphate crystals, which only occur in the setting of an infection with urease-producing bacteria (see "Kidney stones in adults: Struvite (infection) stones")

- The combination of AKI and calcium oxalate crystals, which may suggest ethylene glycol ingestion (see "Methanol and ethylene glycol poisoning: Pharmacology, clinical manifestations, and diagnosis", section on 'Clinical features of overdose')

- The presence of uric acid crystals occurring in association with AKI, which may suggest tumor lysis syndrome (see "Tumor lysis syndrome: Pathogenesis, clinical manifestations, definition, etiology and risk factors" and "Tumor lysis syndrome: Pathogenesis, clinical manifestations, definition, etiology and risk factors", section on 'Clinical manifestations')

Microorganisms — Bacteria are often seen in the urine, although the clinical significance of bacteriuria is generally guided by patient symptoms (picture 18). Fungi (yeast) are also frequently present (picture 18). (See "Asymptomatic bacteriuria in adults".)

Urinary lipids — Lipid droplets, composed primarily of cholesterol esters and, to a lesser degree, cholesterol, are commonly seen on urinalysis in patients with conditions that are associated with the nephrotic syndrome [62,63]. These fat droplets may be free within sloughed tubular cells (called oval fat bodies) or within casts (called fatty casts) (picture 2D). Fat droplets have a characteristic "Maltese cross" appearance under polarized light (picture 2E).

Fat droplets are round and may be confused with red cells. They can be differentiated from red cells under routine light microscopy by their variable size (ranging from larger to much smaller than red cells), their dark outline, and the "Maltese cross" appearance under polarized light.

The origin of urinary lipid is not well understood [63]. The initial step is the filtration of lipoprotein-bound cholesterol, particularly high-density lipoprotein (HDL) cholesterol. Filtration of lipoproteins is minimal in healthy individuals but is markedly enhanced when glomerular permeability to macromolecules is increased in the nephrotic syndrome. Some of the filtered lipoprotein is taken up by the proximal tubular cells. The cholesterol will be seen in the urine sediment as an oval fat body when the cell is desquamated and/or as free droplets or in fatty casts if the lipid is extruded from the cells.

Because of the apparent requirement for increased glomerular permeability, lipiduria is almost always diagnostic of some form of glomerular disease (see "Glomerular disease: Evaluation and differential diagnosis in adults"). One exception is autosomal dominant polycystic kidney disease [64,65]. In one report, urinary oval fat bodies were observed in 21 of 35 patients with autosomal dominant polycystic kidney disease whose average proteinuria on dipstick was only 1+ [64]. Oval fat bodies were also seen in fluid directly aspirated from kidney cysts, and lipid droplets were observed in the epithelial cells lining the cyst wall. Lipiduria may occasionally be seen in other nonglomerular diseases, such as acute or chronic interstitial nephritis or even prerenal azotemia [65].

COMMON PATTERNS OF ABNORMAL URINARY FINDINGS

Various patterns of urinary findings may suggest specific categories of kidney disease. As with all diagnostic tests, these urinary findings must be interpreted in the context of the history, physical examination, and available laboratory data (table 1). Patterns of urinary findings and the diagnoses to which they point are discussed below.

Hematuria with dysmorphic RBCs, RBC casts, and proteinuria — This constellation of findings (eg, dysmorphic red blood cells [RBCs], RBC casts, and proteinuria) is suggestive of a proliferative glomerular disease, which in the setting of rapidly declining kidney function, constitutes a nephrologic emergency (picture 2A-E). (See "Glomerular disease: Evaluation and differential diagnosis in adults".)

Heavy proteinuria with absent or minimal hematuria — Heavy proteinuria with oval fat bodies, lipid-laden casts, and absent or minimal hematuria is indicative of nonproliferative glomerular diseases including severe diabetic nephropathy. In addition, this pattern may be seen with membranous nephropathy, focal segmental glomerulosclerosis, minimal change disease, and amyloidosis, each of which has both primary and secondary forms. (See "Overview of heavy proteinuria and the nephrotic syndrome".)

Granular or epithelial cell casts and renal tubular epithelial cells — In a patient with acute kidney injury (AKI), the presence of granular and/or epithelial cell casts with or without free renal tubular epithelial cells is strongly suggestive of acute tubular necrosis (ATN) (picture 19A-B) [66]. However, a diagnosis of ATN is still possible even if the urinalysis has no granular casts or tubular epithelial cells [66]. The number of observed granular or renal tubular casts may also have prognostic significance; in a study of patients with ATN who were diagnosed based upon clinical criteria, a semiquantitative assessment of the burden of granular or renal tubular epithelial cell casts on low-powered fields was associated with an increased risk of death or the subsequent need for kidney replacement therapy [67].

The presence of granular casts and tubular epithelial cells in the urine is also associated with progression of AKI in the hospital [68]. Patients whose urinalyses revealed 6 or more granular casts per low-powered field (without tubular epithelial cells), 6 or more tubular epithelial cells per high-powered field (without granular casts), or any number of granular casts and tubular epithelial cells present in the same specimen had a significantly greater likelihood of developing worse kidney function, initiation of dialysis, or death compared with patients who had no granular casts or tubular epithelial cells (54 to 67 percent versus 9 percent). In the setting of unresolving AKI, serial review of the urine sediment may provide novel insights into the patient's diagnosis [69].

Isolated pyuria — Isolated pyuria is usually indicative of bacterial urinary tract infection. The differential diagnosis is broad if a concurrent urine culture is negative and includes a partially or recently treated urinary tract infection, non-bacterial infections (including tuberculosis), prostatitis, interstitial nephritis, and nephrolithiasis [53].

Normal or near-normal urinalysis and abnormal kidney function — In patients with abnormal kidney function, a relatively normal urinalysis (few cells with little or no proteinuria and no casts other than hyaline casts) is of important diagnostic value and may indicate one of the following conditions:

- Prerenal AKI due to either volume contraction or an effective decrease in circulating volume (eg, heart failure, liver disease)
- Hypercalcemia
- Cast nephropathy in multiple myeloma
- Tumor lysis syndrome
- Acute phosphate nephropathy
- Vascular disease that produces glomerular ischemia but not infarction (eg, hypertensive emergency, scleroderma, thrombotic microangiopathies) or that affects extraglomerular vessels (eg, cholesterol atheroemboli, polyarteritis nodosa)

- Urinary tract obstruction

INFORMATION FOR PATIENTS

UpToDate offers two types of patient education materials, "The Basics" and "Beyond the Basics." The Basics patient education pieces are written in plain language, at the 5th to 6th grade reading level, and they answer the four or five key questions a patient might have about a given condition. These articles are best for patients who want a general overview and who prefer short, easy-to-read materials. Beyond the Basics patient education pieces are longer, more sophisticated, and more detailed. These articles are written at the 10th to 12th grade reading level and are best for patients who want in-depth information and are comfortable with some medical jargon.

Here are the patient education articles that are relevant to this topic. We encourage you to print or e-mail these topics to your patients. (You can also locate patient education articles on a variety of subjects by searching on "patient info" and the keyword(s) of interest.)

- Basics topic (see "Patient education: Blood in the urine (hematuria) in adults (The Basics)")
- Beyond the Basics topics (see "Patient education: Blood in the urine (hematuria) in adults (Beyond the Basics)" and "Patient education: Glomerular disease (Beyond the Basics)")

SUMMARY

- **General principles** – In conjunction with the history, physical examination, and laboratory testing, the urinalysis plays a central role in evaluating acute and chronic kidney disease. A complete urinalysis consists of three components: gross evaluation, dipstick analysis, and microscopic examination of the urine sediment. The urine specimen must be properly collected in order to reliably interpret the findings and therefore maximize diagnostic utility. (See 'Components of the urinalysis' above and 'Indications for testing' above and 'Specimen collection' above.)
- **Gross assessment** – Normal urine is clear and light yellow in color. Urine turbidity and color may be altered in a number of settings. (See 'Gross assessment of the urine' above.)
- **Urine dipstick analysis** – The urine dipstick provides a rapid semiquantitative assessment of urinary characteristics on a series of test pads embedded on a reagent strip. Most dipsticks permit the analysis of the following core urine parameters: specific gravity, pH,

heme, leukocyte esterase, nitrite, albumin, and glucose. (See 'Urine dipstick analysis' above.)

- **Examination of the urine sediment** – Microscopic examination of the urine sediment can provide additional diagnostic insights by complementing the clinical data, laboratory tests, and urine dipstick findings. The following diagnostically useful structures may be identified with microscopic examination (see 'Examination of the urine sediment' above):

  - **Cells** – Cellular elements that may be found in the urinary sediment include red blood cells (RBCs) (picture 1), white blood cells (WBCs) (picture 3), and epithelial cells from all levels of the urinary tract (picture 4 and picture 5 and picture 6). (See 'Cells' above.)

  - **Casts** – Casts are cylindrical structures that are formed in the tubular lumen. They are defined by the nature of the cells or other elements that are embedded in the cell matrix. Casts that can be found in the urinary sediment include RBC casts (picture 2C), WBC casts (picture 7A-B), renal tubular epithelial cell casts (picture 19B), granular casts (picture 8), and hyaline casts (picture 9). (See 'Casts' above.)

  - **Crystals** – Crystals in the urine sediment can include calcium phosphate or calcium oxalate crystals (picture 13A-B), magnesium ammonium phosphate crystals (picture 14), uric acid crystals (picture 20A-B), cystine crystals (picture 16), and others. (See 'Crystals' above.)

  - **Urinary lipids** – Lipid droplets, composed primarily of cholesterol esters and, to a lesser degree, cholesterol, are commonly seen on urinalysis in patients with conditions that are associated with the nephrotic syndrome. (See 'Urinary lipids' above.)

- **Clinical correlation** – Various patterns of urinary findings may suggest specific categories of kidney disease. As with all diagnostic tests, these urinary findings must be interpreted in the context of the history, physical examination, and available laboratory data (table 1). (See 'Common patterns of abnormal urinary findings' above.)

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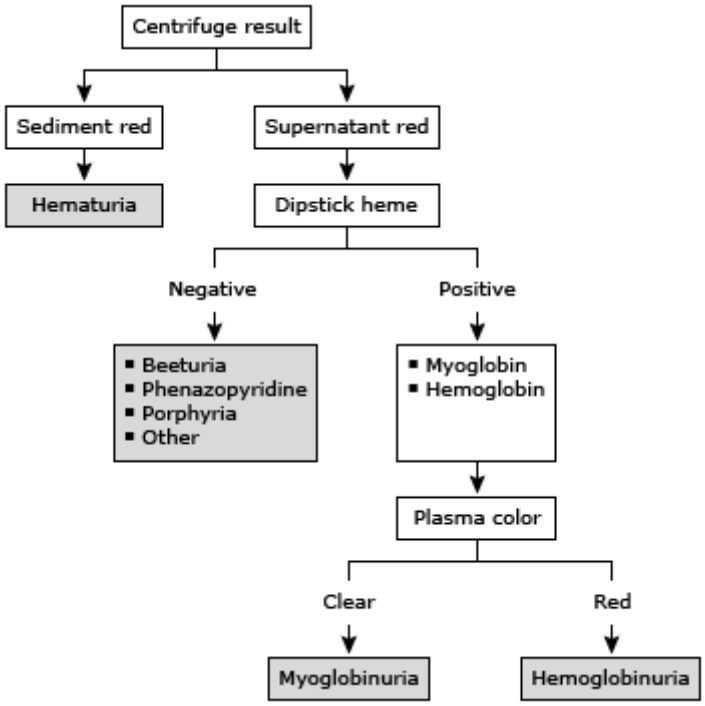
Topic 7196 Version 42.0

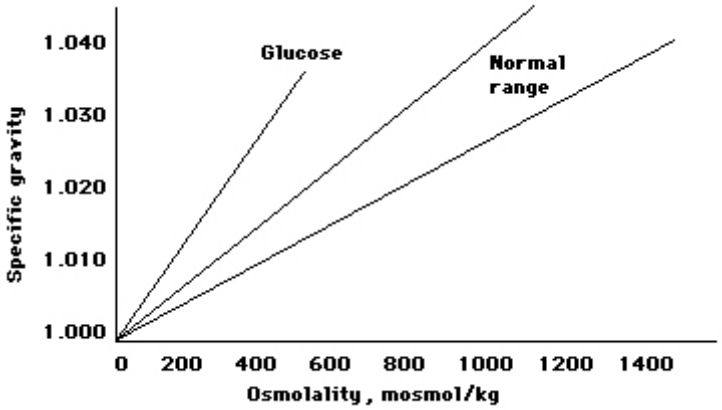
GRAPHICS

Approach to the patient with red or brown urine



Graphic 55923 Version 5.0

Urine osmolality versus specific gravity

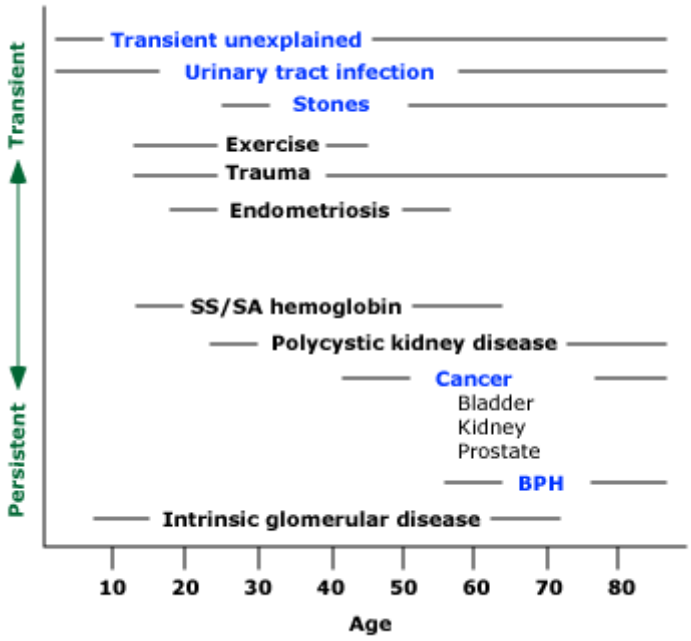


Relationship between the specific gravity and osmolality of the urine from normal subjects who have neither glucose nor protein in the urine. For comparison, the relationship between the specific gravity and osmolality for glucose solutions is included. Glucose is larger than the main solutes in normal urine such as sodium, potassium, ammonium, and urea; as a result, a glucose solution has a higher specific gravity at a given osmolality than normal urine.

Data from Miles B, Paton A, deWardener H, Br Med J 1954; 2:904.

Graphic 75070 Version 2.0

Major causes of hematuria by age and duration

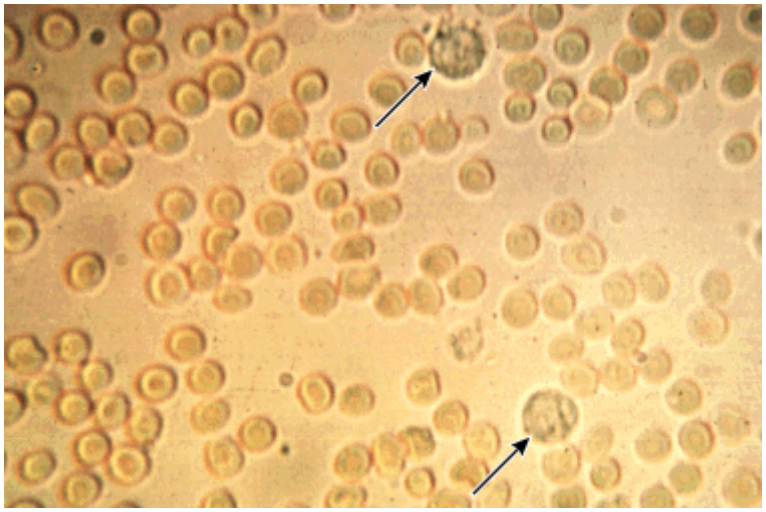


Schematic representation of the major causes of hematuria in relation to the age at which they usually occur (horizontal axis), transience or persistence (vertical axis), and frequency (blue implies more frequent).

BPH: benign prostatic hyperplasia.

Graphic 61296 Version 1.0

Phase-contrast micrograph showing monomorphic red cells in urine sediment

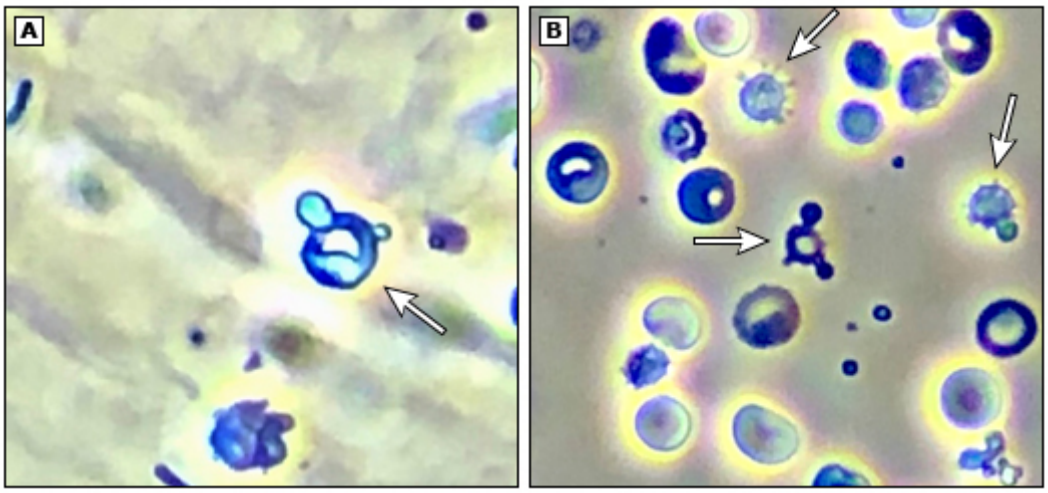


Urine sediment viewed by phase-contrast microscopy showing many red cells and an occasional larger white cell with a granular cytoplasm (arrows). The red cells have a uniform size and shape, suggesting that they are of nonglomerular origin.

Courtesy of Harvard Medical School.

Graphic 80282 Version 4.0

Phase-contrast micrograph showing dysmorphic RBCs in urine sediment

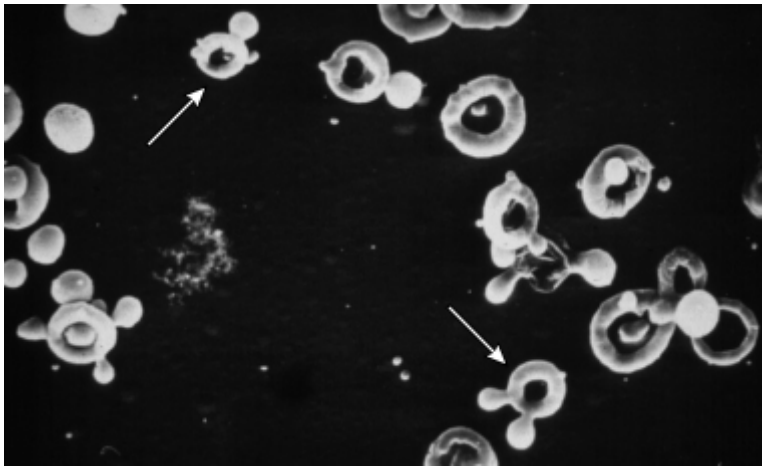


Phase-contrast microscopy showing dysmorphic red blood cells (RBCs) and acanthocytes in the urinary sediment of a patient with glomerular hematuria. Acanthocytes (arrows) can be recognized as ring forms with vesicle-shaped protrusions.

Courtesy of Juan Carlos Q Velez, MD.

Graphic 130438 Version 1.0

Scanning electron micrograph showing dysmorphic red cells in urine sediment

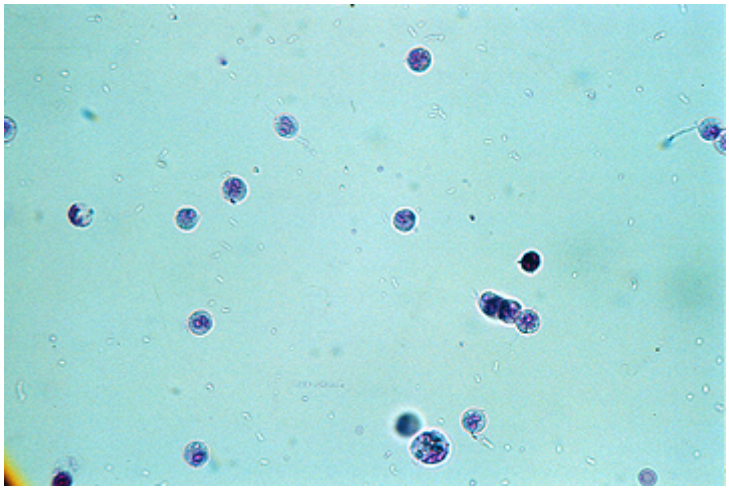


Scanning microscopy showing dysmorphic red cells in a patient with glomerular bleeding. Acanthocytes can be recognized as ring forms with vesicle-shaped protrusions (arrows).

Courtesy of Hans Köhler, MD.

Graphic 62064 Version 3.0

Photomicrograph of urine sediment with white blood cells

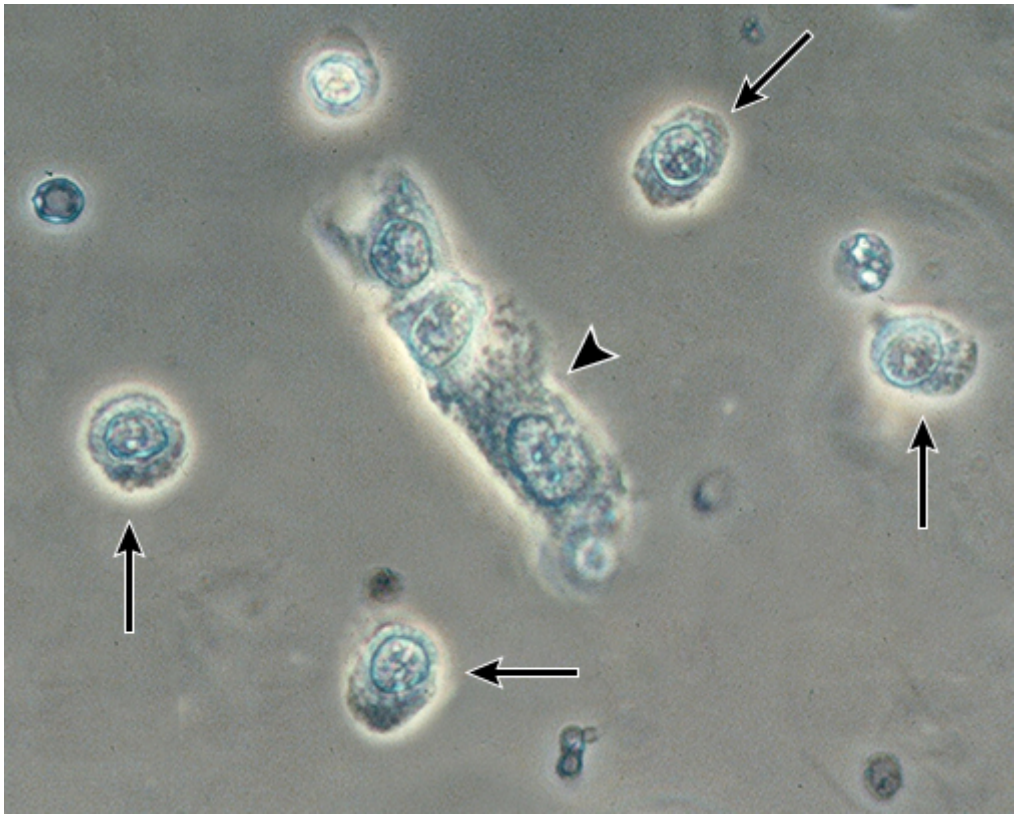


White blood cells in the urine sediment with nuclei and granular cytoplasm.

Courtesy of Frances Andrus, BA, Victoria Hospital, London, Ontario.

Graphic 75211 Version 2.0

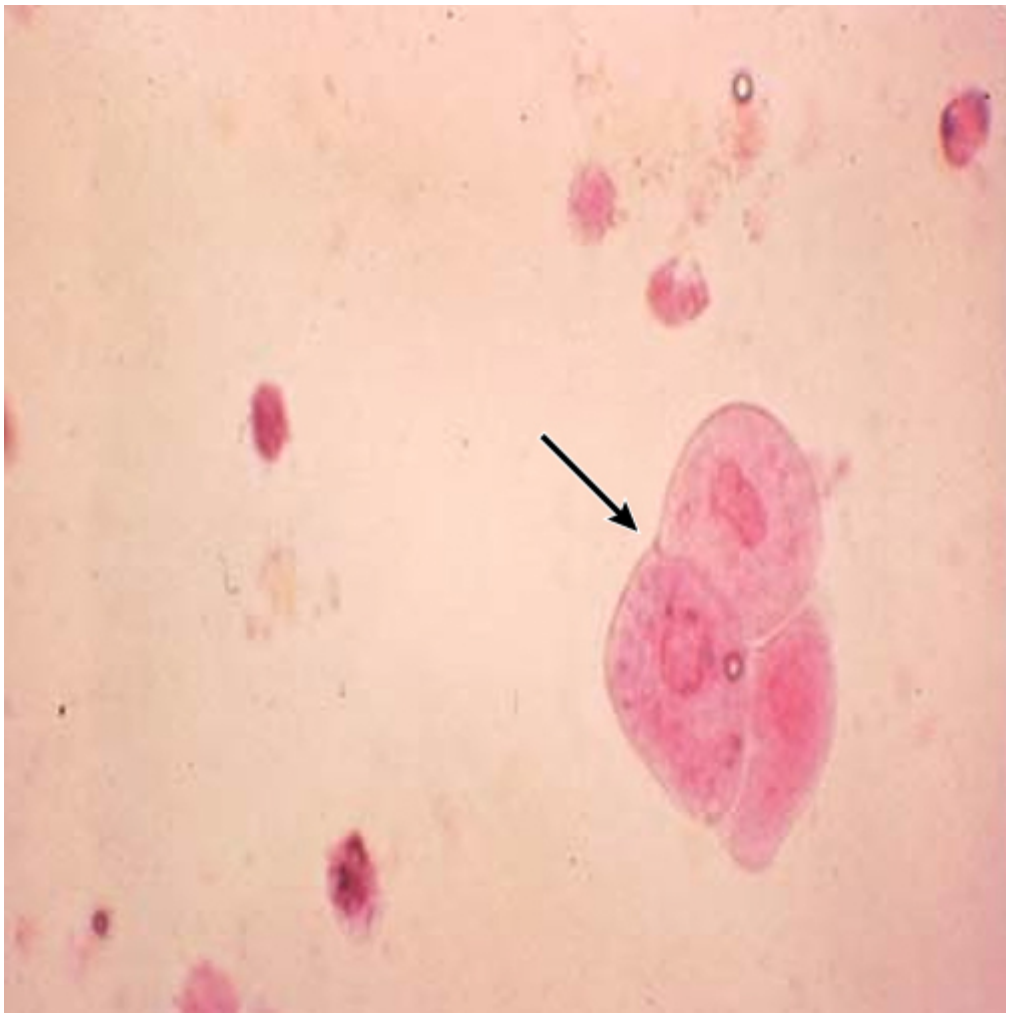
Urine sediment showing renal tubular epithelial cells and a fragmented epithelial cell cast



This slide shows renal tubular cells (arrows) found in the urine, together with a fragment of a tubular epithelial cell cast (arrowhead). The tubular cells are characterized by one central nucleus and many cytoplasmic granules.

Graphic 86348 Version 1.0

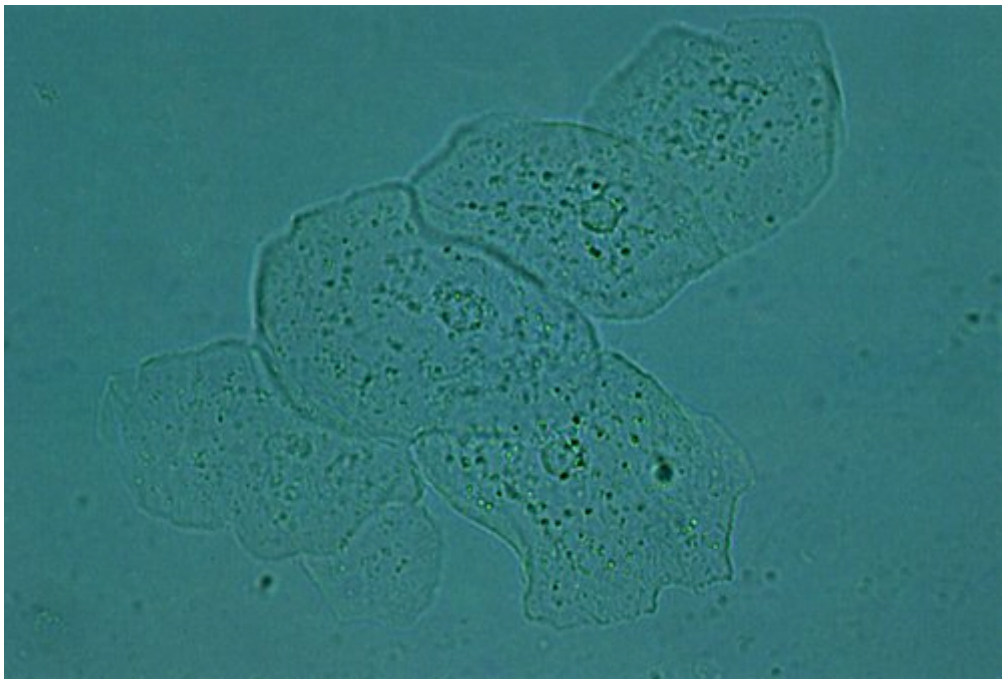
Urine sediment showing a transitional epithelial cell



Reproduced with permission from: Bradley M. Urine crystals: Identification and significance. Lab Med 1982; 13:348.

Graphic 83886 Version 1.0

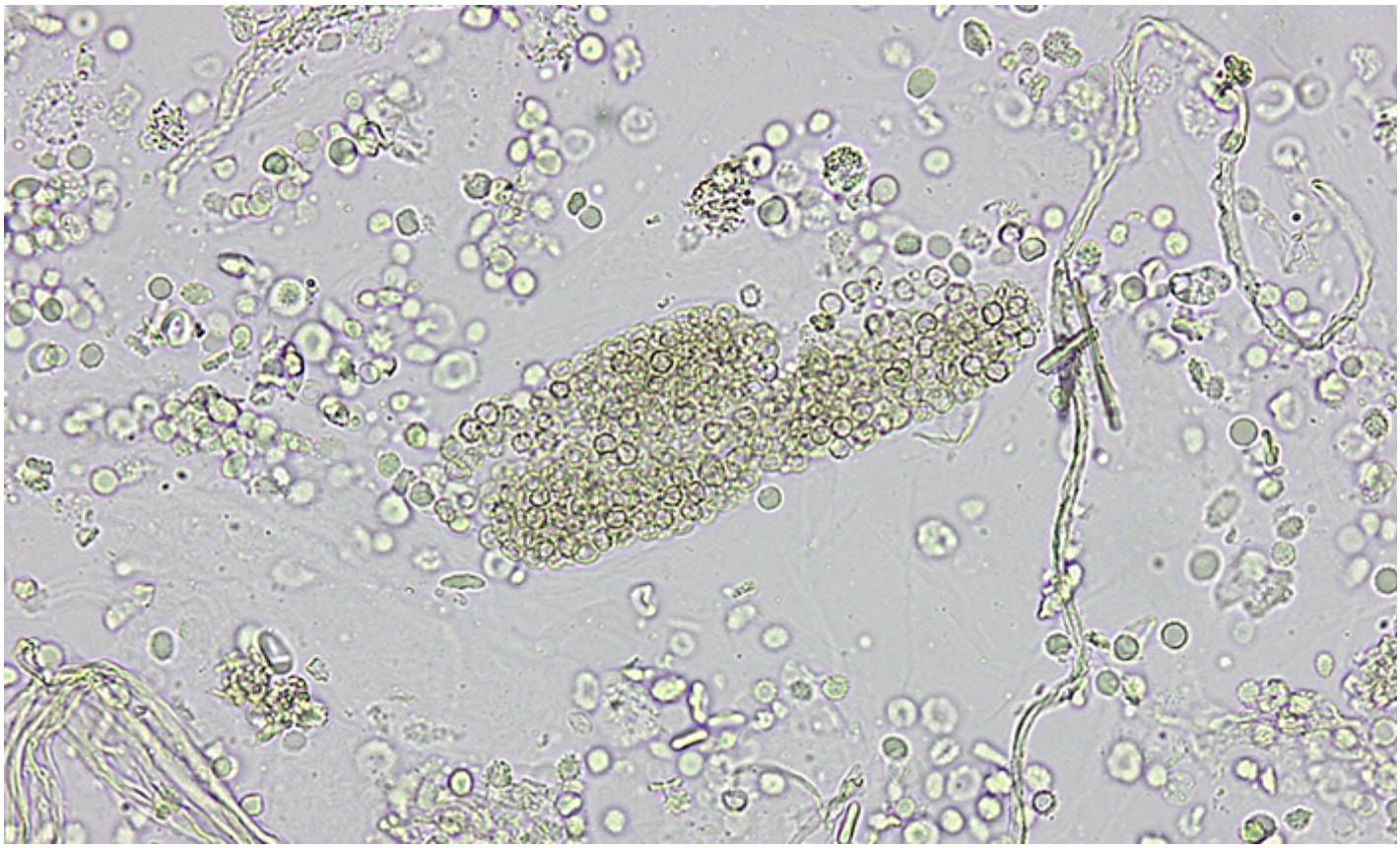
Urine sediment showing squamous epithelial cells



A group of squamous epithelial cells in urine. The cells are large and flat and have some granules in their cytoplasm. The central nucleus is approximately the size of a large lymphocyte. (Bright-field microscopy, 3160.)

Graphic 83632 Version 1.0

Photomicrograph of urine sediment with a red cell cast

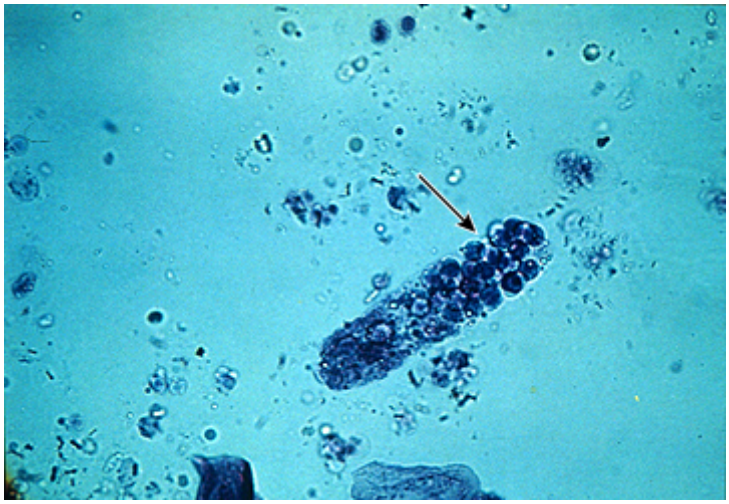


Urine sediment showing free red cells and a red cell cast that is tightly packed with red cells. It is more comr for red cell casts to have fewer red cells trapped within a hyaline or granular cast. Red cell casts are virtually diagnostic of glomerulonephritis or vasculitis.

Courtesy of James F Simon, MD.

Graphic 55778 Version 4.0

Photomicrograph of urine sediment with white blood cell cast (I)

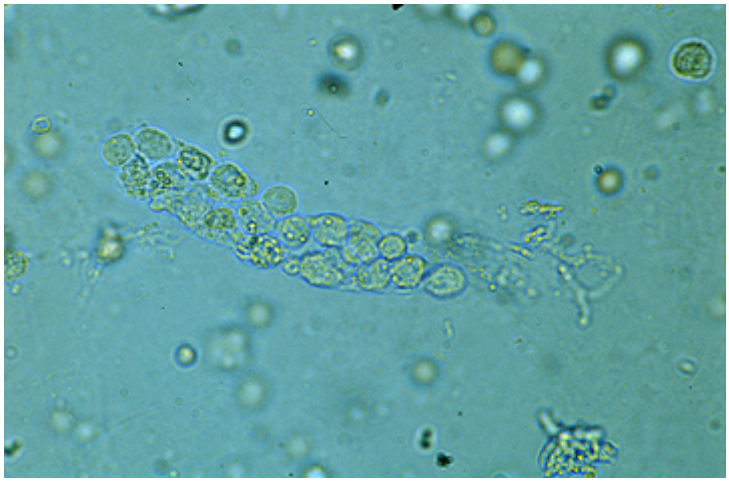


White cell cast in which blue stained white cells (arrow) are contained within a granular cast.

Courtesy of Frances Andrus, BA, Victoria Hospital, London, Ontario.

Graphic 54319 Version 3.0

Photomicrograph of urine sediment with white blood cell cast (II)

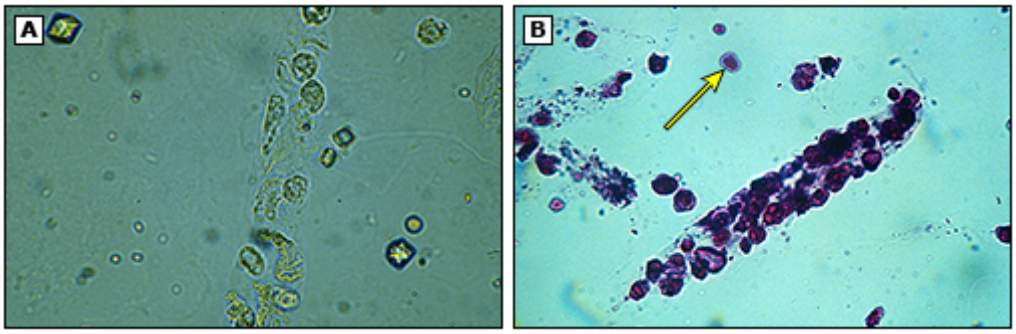


A white blood cell cast, three-quarters of which is filled with leukocytes.

Courtesy of Frances Andrus, BA, Victoria Hospital, London, Ontario.

Graphic 68147 Version 2.0

Photomicrograph showing tubular epithelial cell casts



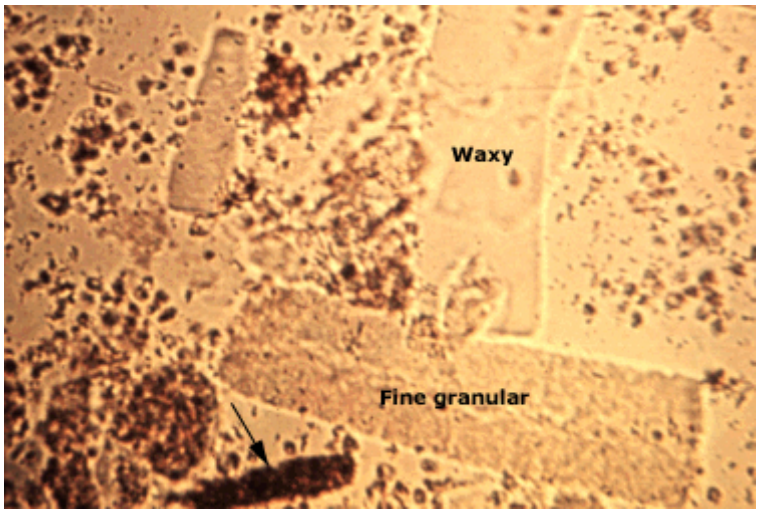
(A) Epithelial cell cast containing cells that are larger than white cells.

(B) Epithelial cell cast with free epithelial cells (arrow) in the urine sediment. Renal tubular epithelial cells are larger than white cells and have a single, large central nucleus.

Courtesy of Frances Andrus, BA, Victoria Hospital, London, Ontario.

Graphic 65729 Version 6.0

Granular and waxy casts

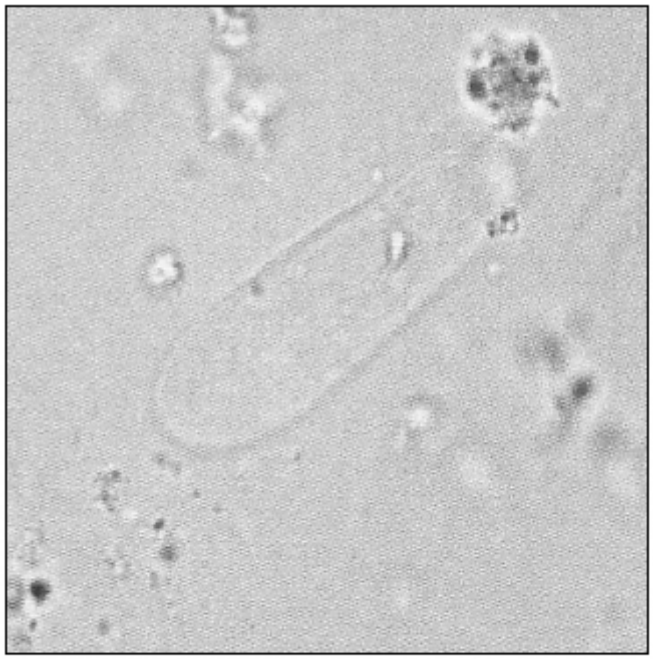


Urine sediment showing waxy and fine and coarse (arrow) granular casts. The broader casts are thought to form when there is stasis (due to advanced kidney failure) in the wider collecting tubules into which many nephrons drain.

Courtesy of Harvard Medical School.

Graphic 59811 Version 2.0

Urine sediment showing a hyaline cast

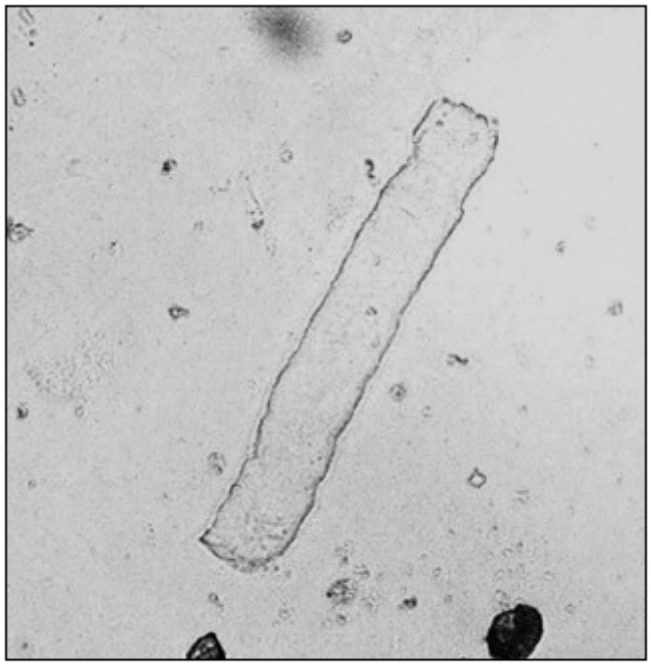


Hyaline cast

Representative photomicrographs of unstained elements in urine.

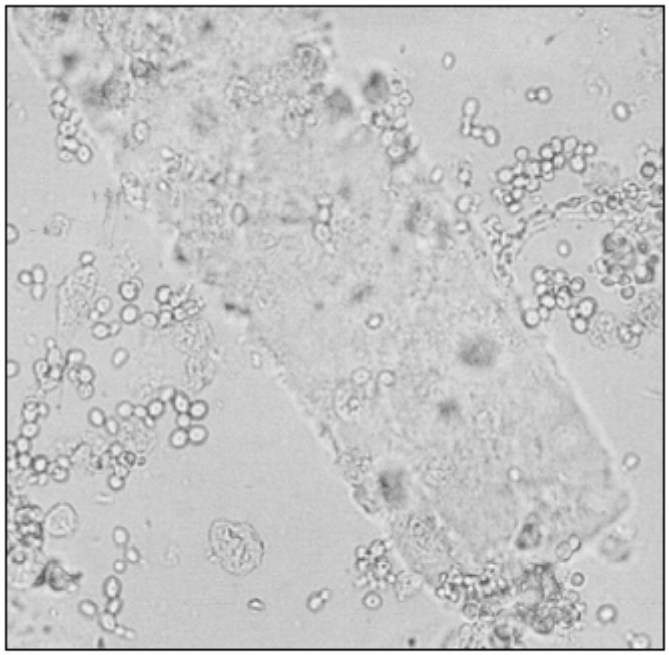
Graphic 86339 Version 1.0

Urine sediment showing a waxy cast



Graphic 83885 Version 1.0

Urine sediment showing a broad cast



Broad waxy cast

Graphic 86555 Version 1.0

Urinary crystals

Crystal type	Appearance	Presence under routine conditions	
Calcium oxalate	**Monohydrate** – Ovoid or dumbbell shaped	Yes	Nephro excessi
	Dihydrate – Envelope shaped		
Calcium phosphate	Long prisms, sometimes arranged as rosettes or stars	Yes	Nephro urine a
Magnesium ammonium phosphate ("triple phosphate")	Coffin lid	No	Infecti
Uric acid	Rhomboid, oval	Yes	Nephro
Cystine	Hexagonal	No	Cystinu

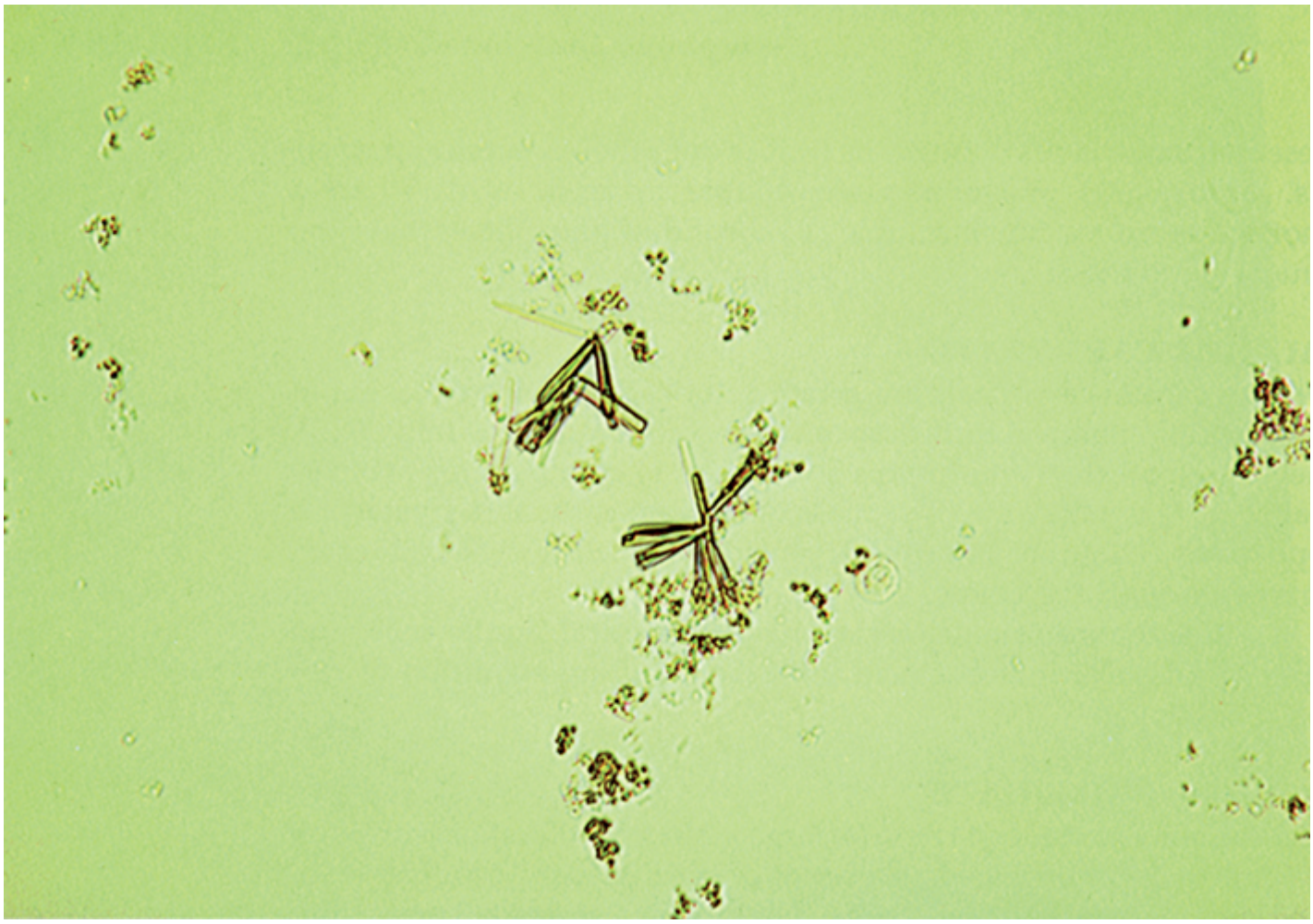
(A,D,E) Reproduced with permission from Jay Seltzer, MD (@jrseltzer).

(B) From: Graff L. Handbook of Routine Urinalysis, Lippincott Williams & Wilkins 1983. Copyright © 1983. Reproduced with permission material is prohibited.

(C) Courtesy of Harvard Medical School.

Graphic 134707 Version 1.0

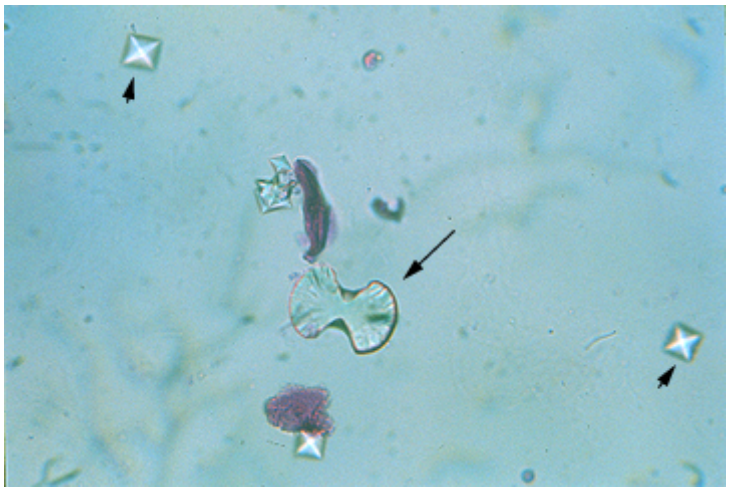
Calcium phosphate crystals in the urine



Urine sediment showing calcium phosphate crystals. Calcium phosphate crystals form in alkaline urine and have a variety of shapes including prisms that may coalesce into a rosette-like appearance.

Graphic 134705 Version 1.0

Calcium oxalate crystals in the urine

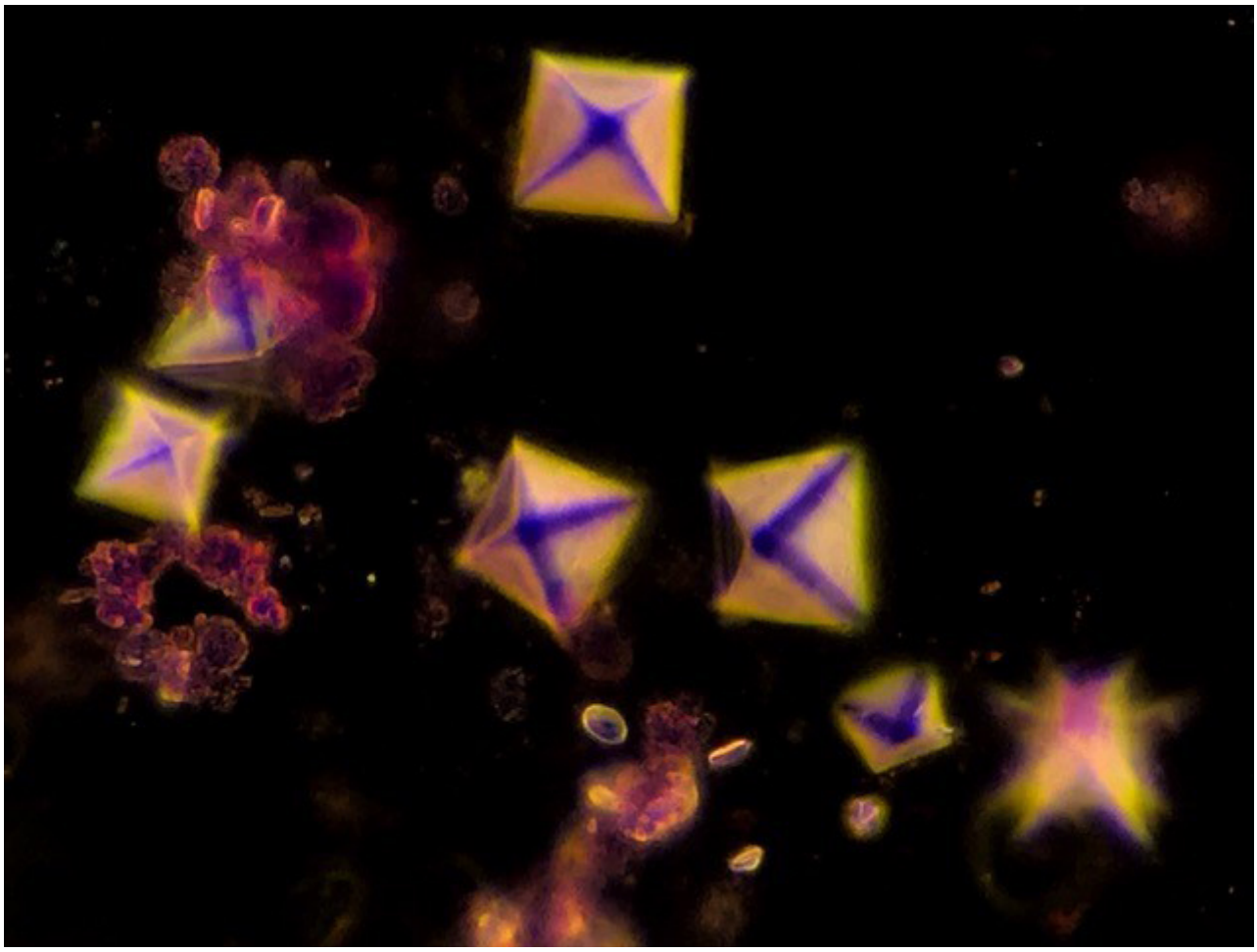


Urine sediment showing both dumbbell-shaped calcium oxalate monohydrate (long arrow) and envelope-shaped calcium oxalate dihydrate (short arrows) crystals. Although not shown, the monohydrate crystals may also have a needle-shaped appearance. The formation of calcium oxalate crystals is independent of the urine pH.

Courtesy of Frances Andrus, BA, Victoria Hospital, London, Ontario.

Graphic 65169 Version 2.0

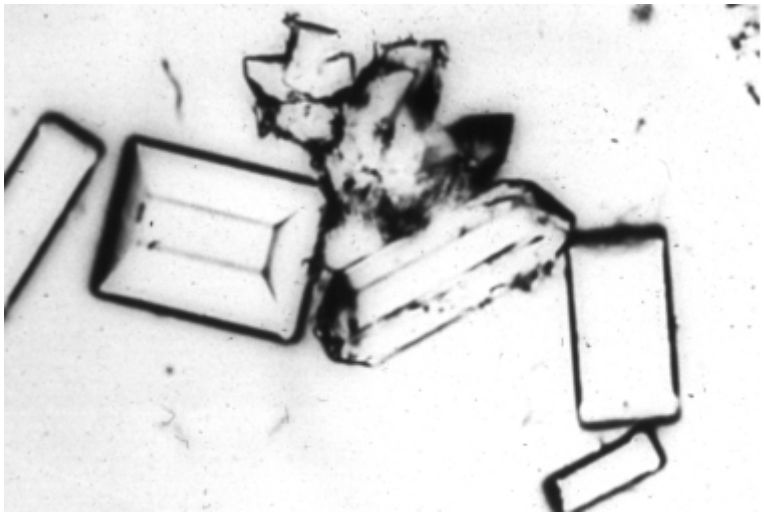
Urinary calcium oxalate dihydrate crystals under polarized light



Urine sediment viewed under polarized light showing envelope-shaped calcium oxalate dihydrate crystals.

Graphic 67694 Version 3.0

Urine sediment showing struvite (magnesium ammonium phosphate) crystals

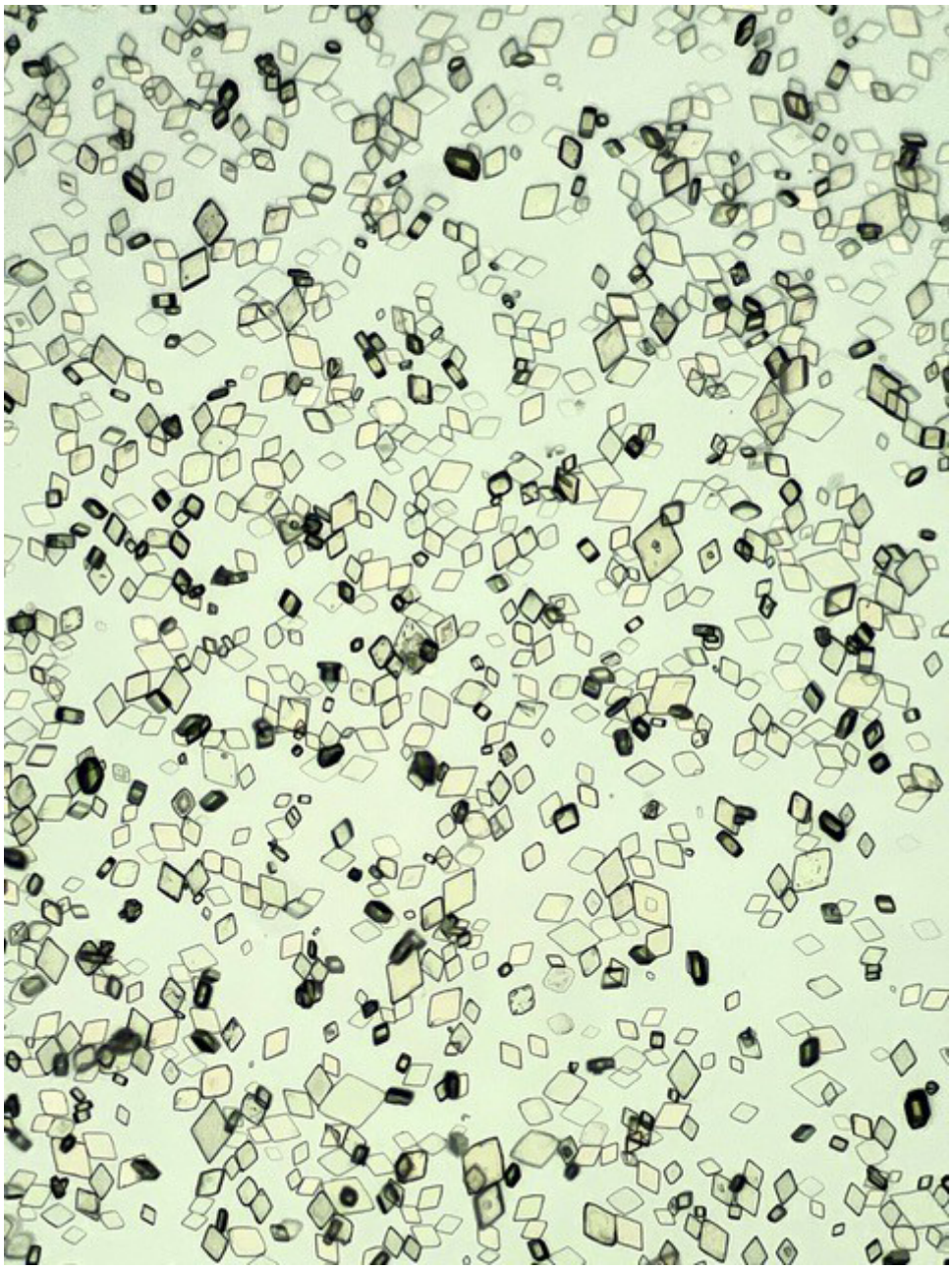


Urine sediment showing multiple "coffin lid" magnesium ammonium phosphate crystals (struvite) that form only in an alkaline urine (pH usually above 7.0) caused by an upper urinary tract infection with a urease-producing bacteria.

Courtesy of Harvard Medical School.

Graphic 54594 Version 6.0

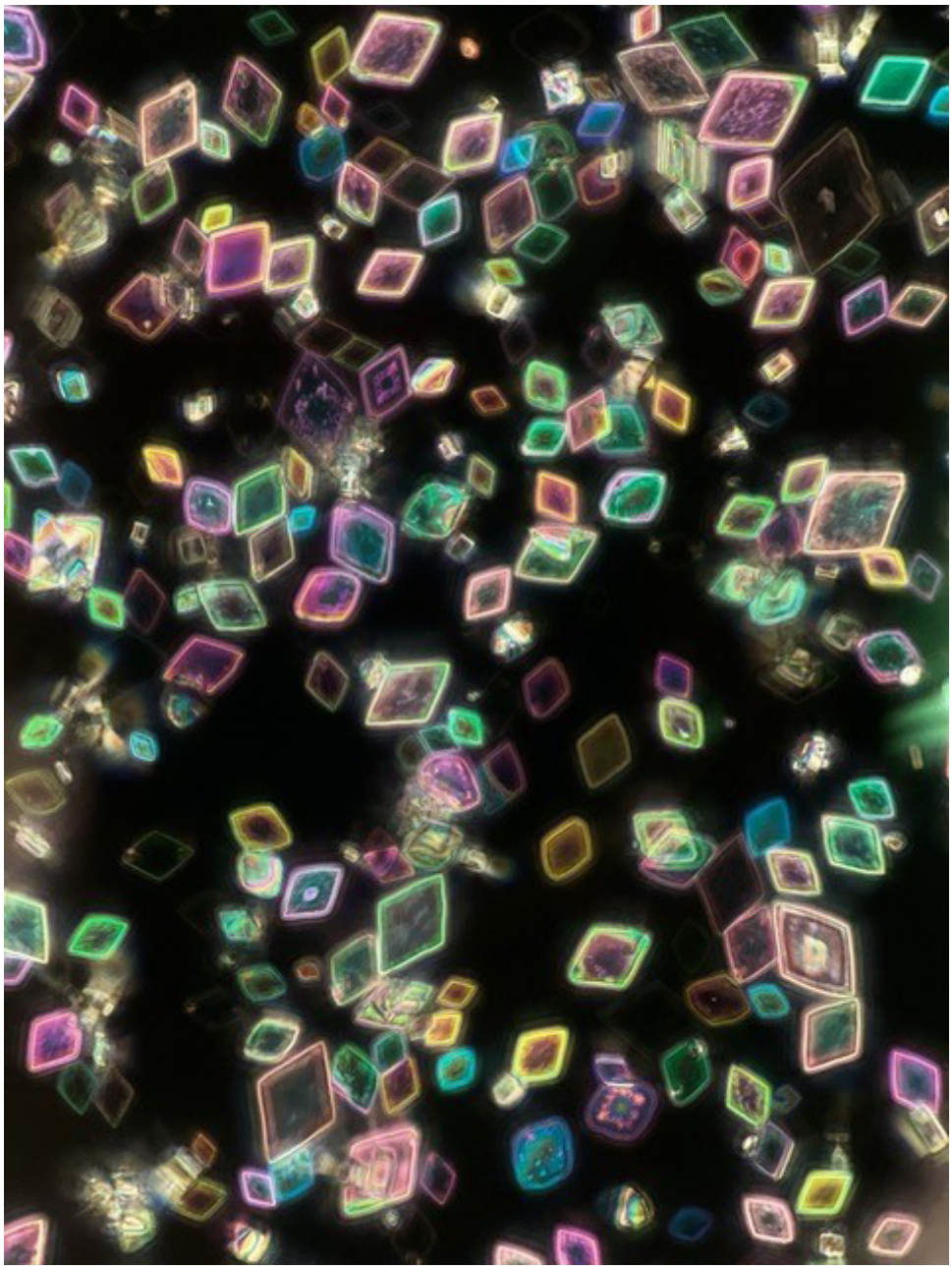
Urine sediment showing uric acid crystals



These crystals are pleomorphic, most often appearing as rhombic plates or rosettes. They are yellow or reddish-brown and form only in an acid urine (pH 5.5 or less).

Graphic 134706 Version 1.0

Uric acid crystals under polarized light

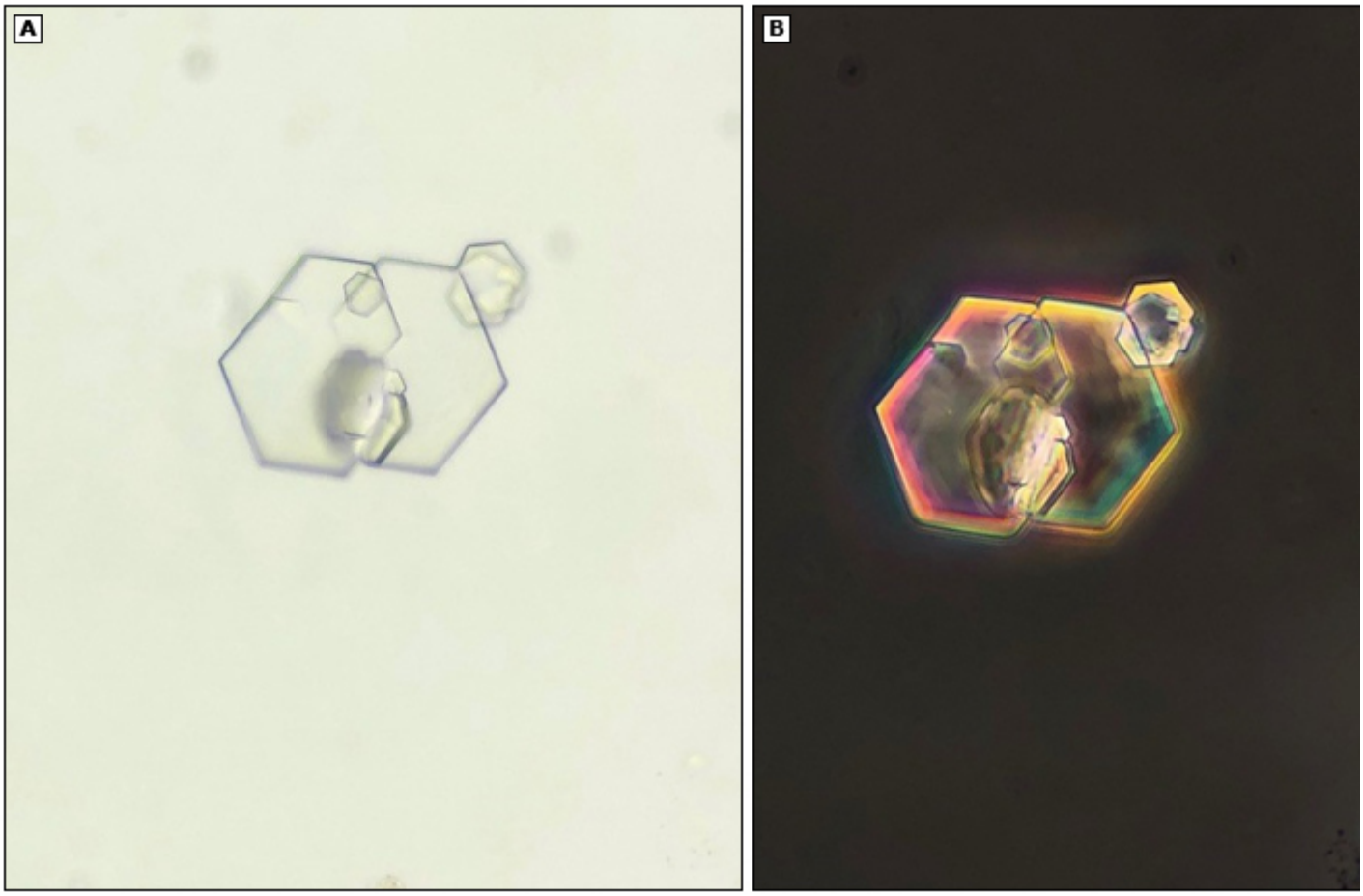


Urine sediment showing uric acid crystals viewed under polarized light.

Reproduced with permission from Jay Seltzer, MD (@jrseltzer).

Graphic 73642 Version 3.0

Urine sediment showing cystine crystals



Brightfield (A) and polarized light (B) microscopic images of a urine sediment showing 2 overlapping hexagonal cystine crystals that are pathognomonic of cystinuria.

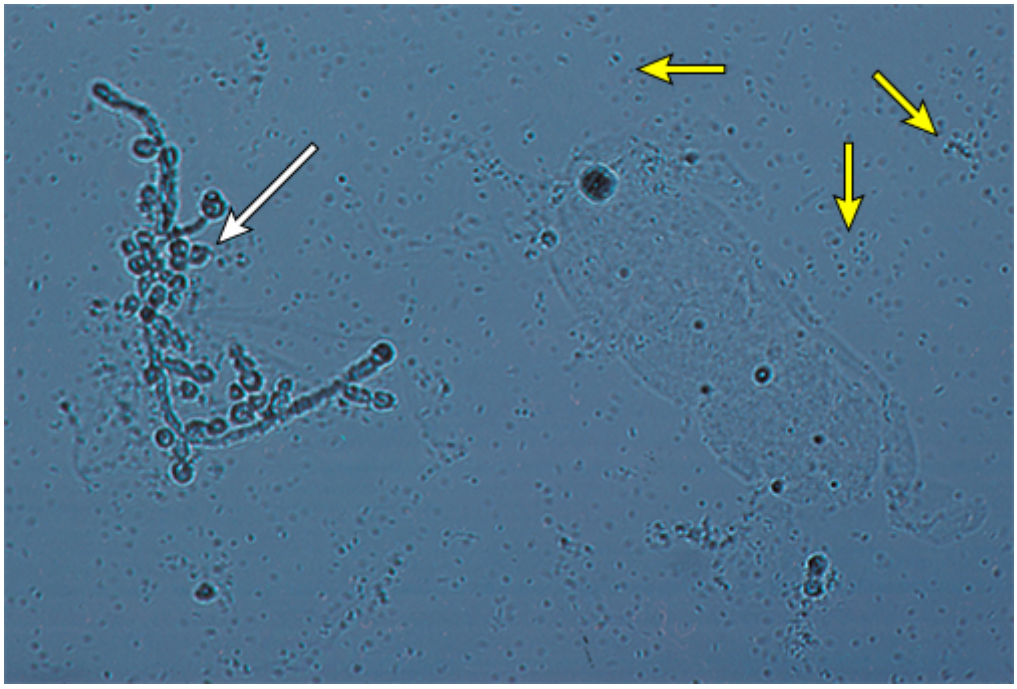
Graphic 56834 Version 3.0

Light microscopic image of urinary methotrexate crystals

From: Garneau AP, Riopel J, Isenring P. Acute methotrexate-induced crystal nephropathy. N Engl J Med 2015; 373:2691. Copyright © 2015 Massachusetts Medical Society. Reprinted with permission from Massachusetts Medical Society.

Graphic 132241 Version 1.0

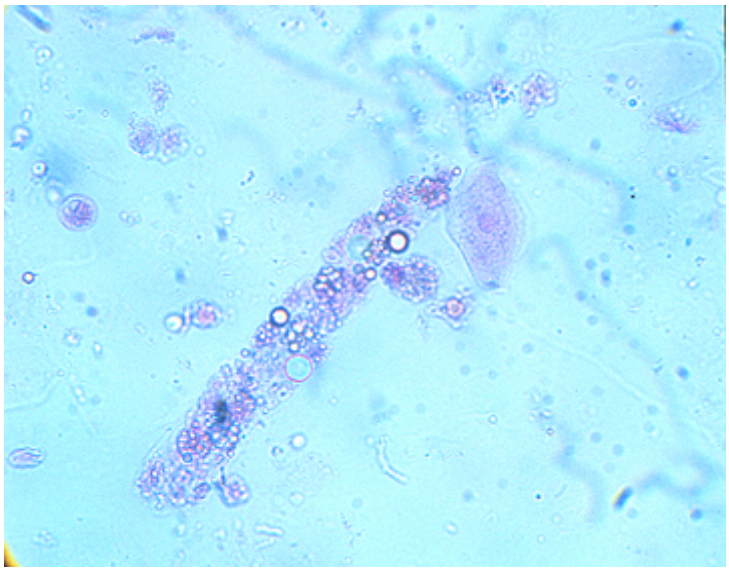
Urine sediment showing bacteria, budding yeast, and hyphae



The background contains budding yeast and hyphae (white arrow), as well as a bacteria (yellow arrows). There is also a broad hyaline cast. (Bright-field microscopy, 3100.)

Graphic 83631 Version 1.0

Fatty cast

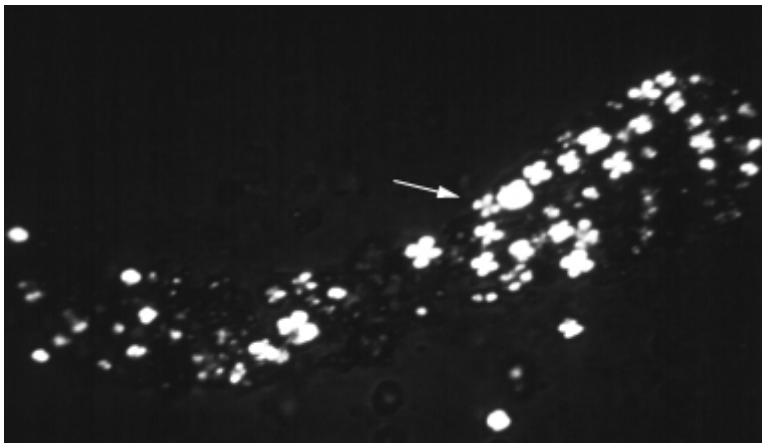


Urine sediment showing a fatty cast. The fat droplets (or globules) can be distinguished from red cells (which also have a round appearance) by their variable size (from much smaller to much larger than a red cell), dark outline, and "Maltese cross" appearance under polzarized light.

Courtesy of Frances Andrus, BA, Victoria Hospital, London, Ontario.

Graphic 69603 Version 1.0

Fatty cast



Urine sediment showing fatty cast under polarized light. The fat droplets have a characteristic "Maltese cross" appearance (arrow).

Courtesy of Harvard Medical School.

Graphic 79604 Version 1.0

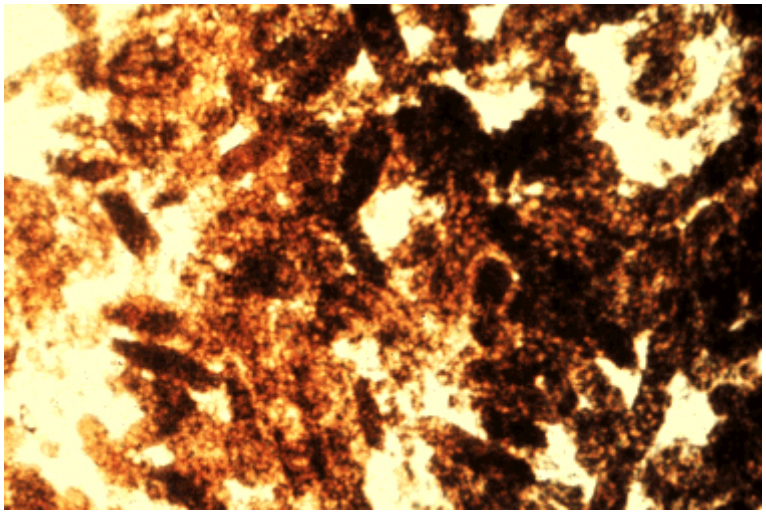
Urinary patterns associated with different kidney diseases

Urinary pattern	Kidney disease suggested by pattern
Hematuria with dysmorphic red blood cells, red blood cell casts, varying degrees of albuminuria	Proliferative glomerulonephritis (eg, IgA nephropathy, ANCA-associated vasculitis, lupus nephritis)
Heavy albuminuria with minimal or absent hematuria	Nonproliferative glomerulopathy (eg, diabetes, amyloidosis, membranous nephropathy, focal segmental glomerulosclerosis, minimal change)
Multiple granular and epithelial cell casts with free epithelial cells	Acute tubular necrosis in a patient with underlying acute kidney injury
Isolated pyuria	Infection (bacterial, mycobacterial) or tubulointerstitial disease
Abnormal kidney function with normal dipstick and sediment containing few cells, no casts, and no or minimal proteinuria	▪ Prerenal acute kidney injury due to either volume contraction or an effective decrease in circulating volume (eg, heart failure, liver disease) ▪ Hypercalcemia ▪ Light chain cast nephropathy in multiple myeloma ▪ Tumor lysis syndrome ▪ Vascular disease that produces glomerular ischemia but not infarction (eg, hypertensive emergency, scleroderma, thrombotic microangiopathies) or that affects extraglomerular vessels (eg, cholesterol atheroemboli, polyarteritis nodosa) ▪ Urinary tract obstruction

IgA: immunoglobulin A; ANCA: antineutrophil cytoplasmic antibody.

Graphic 56160 Version 11.0

Photomicrograph showing urine sediment with muddy brown granular casts

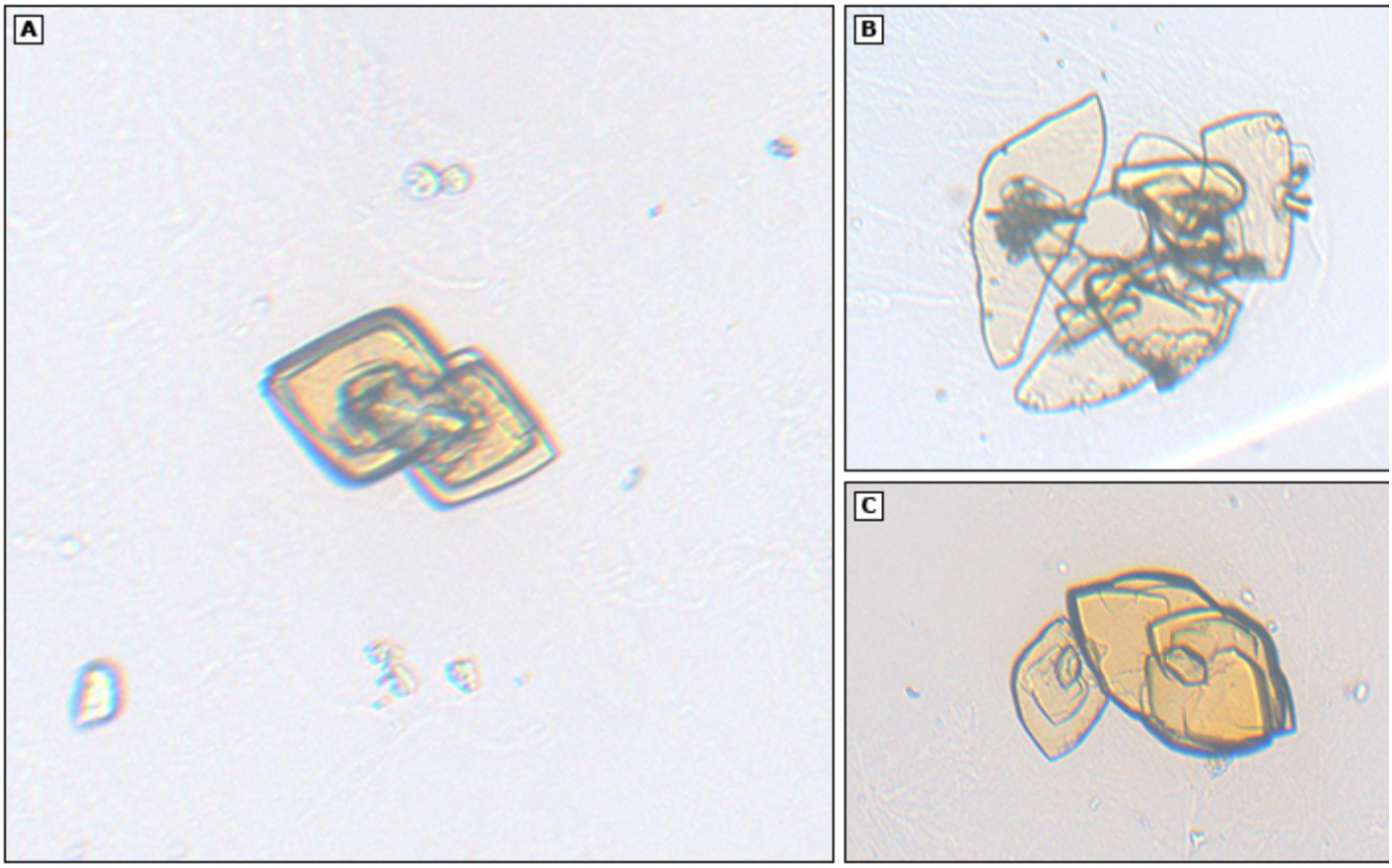


Urine sediment showing multiple muddy brown granular casts. These findings are highly suggestive of acute tubular necrosis in a patient with acute kidney injury.

Courtesy of Harvard Medical School.

Graphic 56438 Version 6.0

Uric acid crystals in the urine



These crystals are pleomorphic, most often appearing as rhombic plates or rosettes. They are yellow or reddish-brown and form only in an acid urine (pH 5.5 or less).

Courtesy Gary C Curhan, MD, ScD.

Graphic 61827 Version 5.0

Contributor Disclosures

Ron Wald, MDCM, MPH, FRCPC No relevant financial relationship(s) with ineligible companies to disclose. **Gary C Curhan, MD, ScD** Equity Ownership/Stock Options: Allena Pharmaceuticals [Oxalate]. Grant/Research/Clinical Trial Support: Decibel Therapeutics [Hearing loss, tinnitus];GlaxoSmithKline [Shingles]. All of the relevant financial relationships listed have been mitigated. **Albert Q Lam, MD** No relevant financial relationship(s) with ineligible companies to disclose.

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