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Interpretation of Canine and Feline Urinalysis

Dennis J. Chew, DVM
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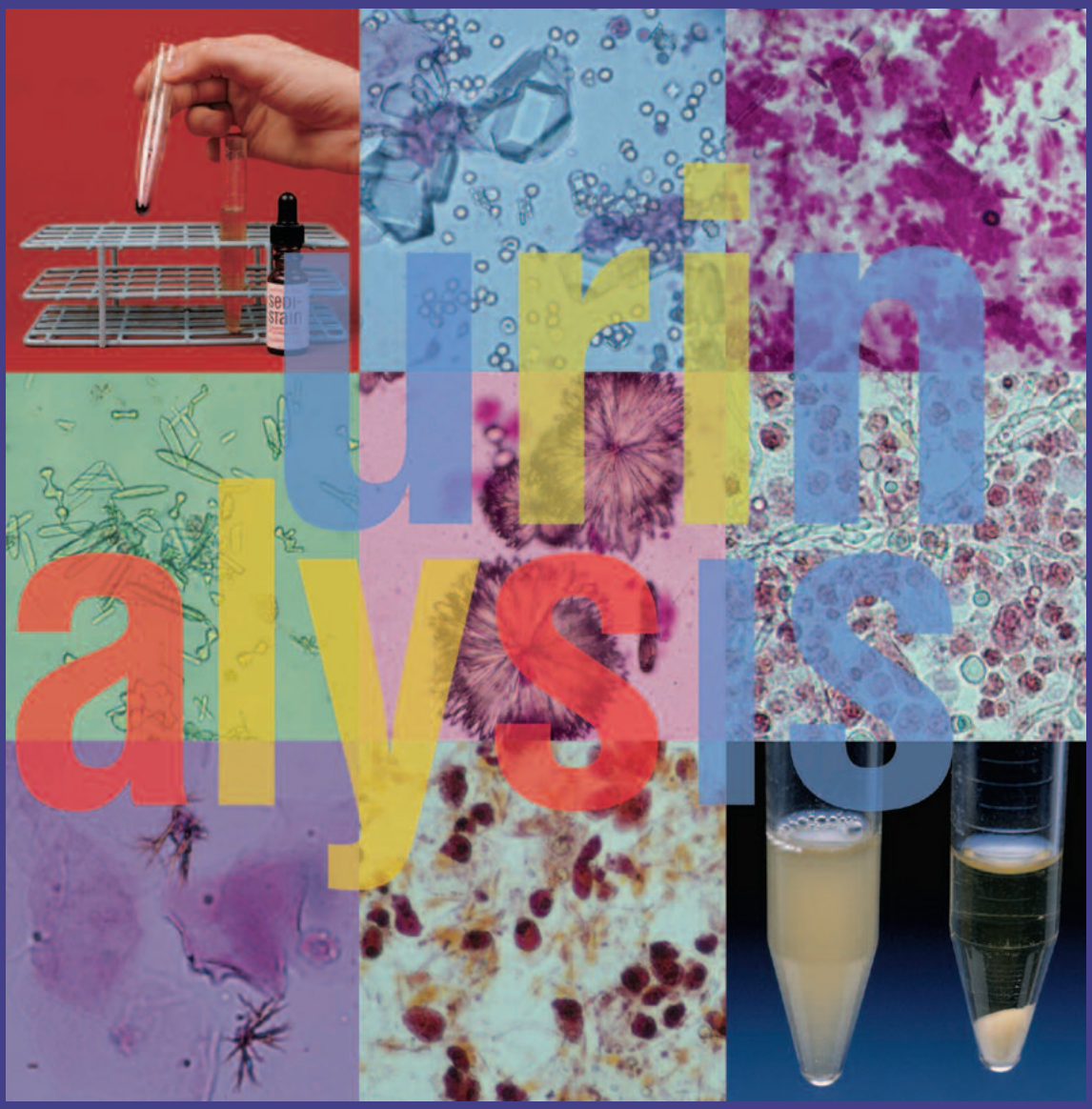

Nestlé PURINA Clinical Handbook Series

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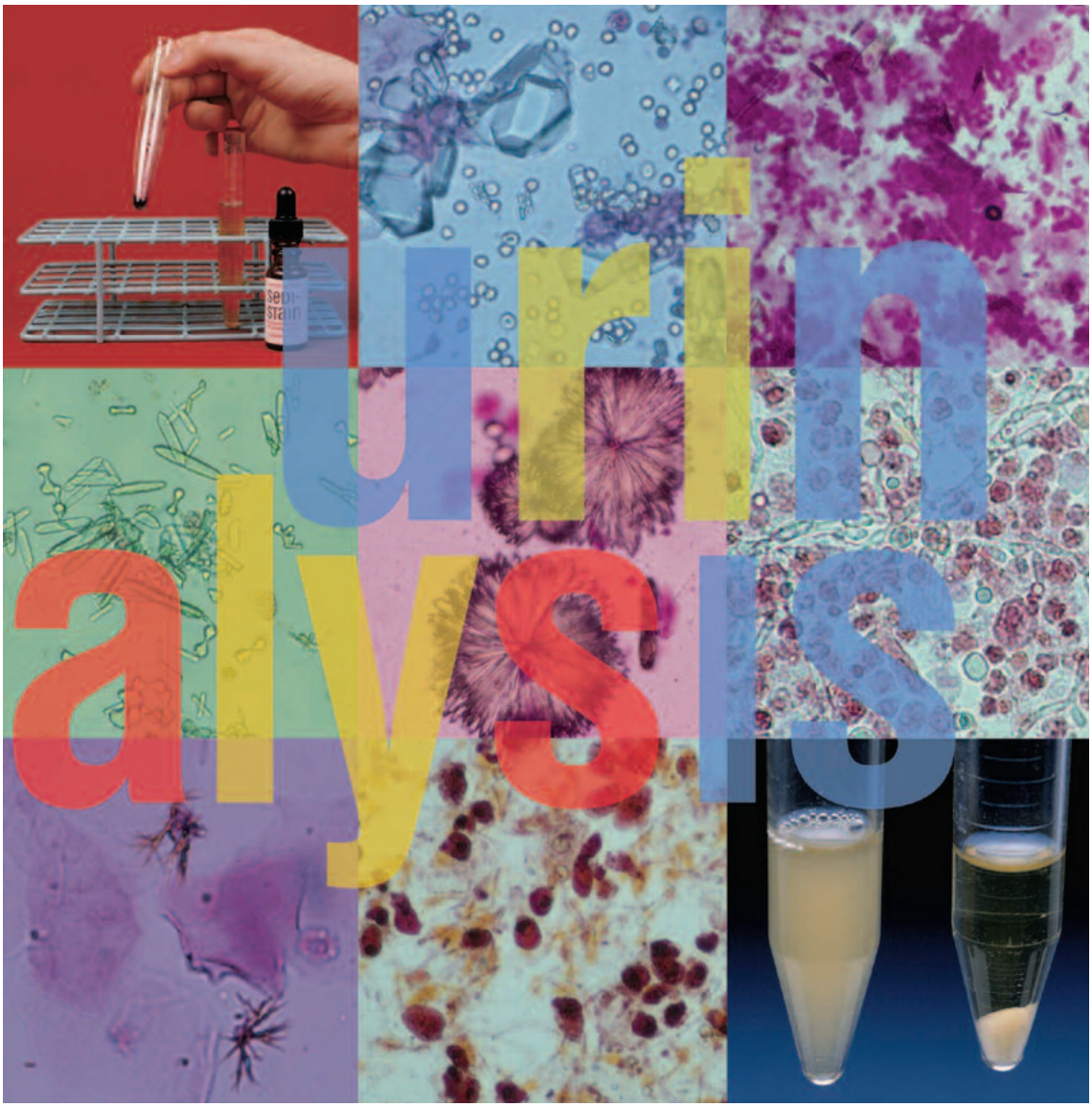

Nestlé PURINA Clinical Handbook Series

Preface

Urine is that golden body fluid that has the potential to reveal the answers to many of the body's mysteries. As Thomas McCrae (1870-1935) said, "More is missed by not looking than not knowing." And so, the authors would like to dedicate this handbook to three pioneers of veterinary nephrology and urology who emphasized the importance of "looking," that is, the importance of conducting routine urinalysis in the diagnosis and treatment of diseases of dogs and cats.

To Dr. Carl A. Osborne, for his tireless campaign to convince veterinarians of the importance of routine urinalysis;
to Dr. Richard C. Scott, for his emphasis on evaluation of fresh urine sediments; and
to Dr. Gerald V. Ling for his advancement of the technique of cystocentesis.

Published by The Gloyd Group, Inc.
Wilmington, Delaware

Printed in the United States of America.
Nestlé Purina PetCare Company: Checkerboard Square, Saint Louis, Missouri, 63188
First printing, 1998.

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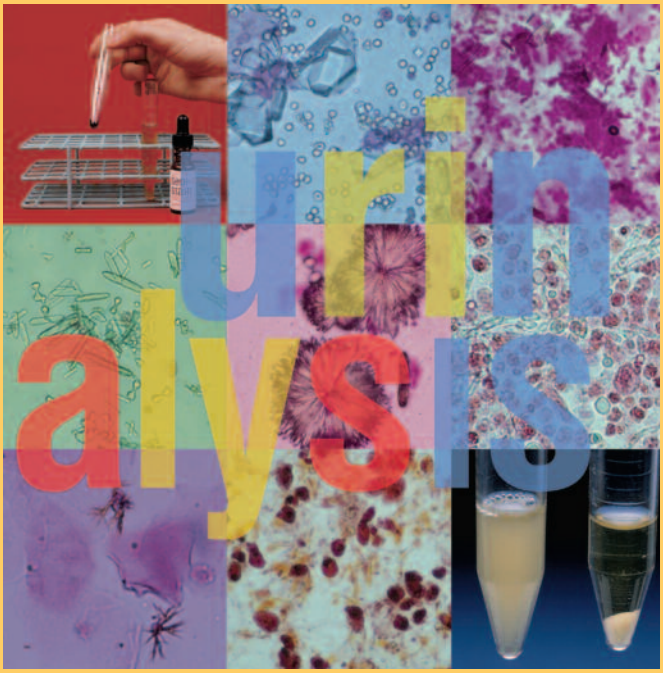
ISBN 0-9678005-2-8

Table of Contents

Introduction



Routine urinalysis is an extremely valuable yet inexpensive diagnostic tool that sometimes is overlooked in veterinary practice. The complete urinalysis includes both macroscopic and microscopic evaluation. Physical and chemical properties are examined and measured, and the urinary sediment is studied. The following lists common indications for performing urinalysis:

- Clinical signs of lower urinary tract disease (eg, pollakiuria, stranguria, dysuria, hematuria, inappropriate urinations) or polyuria and polydipsia.
- Change in character of urine (eg, darker, paler, bloody, sticky), either observed or reported by pet owner.
- Known or suspected renal disease or urolithiasis.
- Previous history of urinary tract infection.

Urinalysis may also provide additional diagnostic and prognostic information in a number of other clinical situations, as follows:

- In the evaluation of animals with non-renal systemic diseases (eg, animals with hepatic disease or portosystemic shunts may have bilirubinuria or ammonium biurate crystals).
- In animals with suspected infectious diseases (eg, proteinuria due to glomerular disease may complicate several chronic infectious diseases).
- In febrile animals (a urinary tract infection can elicit a fever due to sepsis).
- In preliminary evaluation of renal function in dehydrated animals. Note: Urinalysis should always be completed before initiating fluid therapy (eg, a high urine specific gravity in a dehydrated animal may be reassuring with respect to renal function, whereas a low urine specific gravity in a dehydrated animal is cause for concern).
- As a starting point for the evaluation of any animal with non-specific signs of illness (eg, anorexia, lethargy, weight loss) in conjunction with hemogram data and a serum biochemical profile.
- As a baseline reference point for future evaluation in normal healthy animals.
- As a screening tool for geriatric animals and animals that must undergo general anesthesia.

Because test results can be affected by the method of urine collection as well as by sample handling, certain steps must be followed to assure accurate and reliable information. The following chapters discuss these important aspects of urinalysis.

Part I

Chapter 1: **Sample Collection**

The method by which urine is collected affects test results and influences urinalysis interpretation. The appropriate method of urine collection is chosen after several considerations are made, such as:

- The likelihood of obtaining an adequate (ie, diagnostic) urine sample using a particular method.
- The risk of traumatizing the urinary tract.
- The expense of collection equipment.
- The degree and type of animal restraint necessary.
- The level of technical expertise required to collect the urine sample.

Urine samples collected at random times of the day usually are sufficient for routine diagnostic evaluation. However, samples collected in the morning, before the animal has consumed food or water, are most likely to have the highest urine specific gravity and, therefore, are most useful in the evaluation of urine concentrating ability. In a recent study, osmolality of morning urine samples in dogs was significantly higher than in evening samples, but the range of values was very wide in both instances. Also, a first-morning sample may offer the ability to measure increased numbers of cellular elements and bacteria. Of course, this advantage must be balanced against the possibility of more fragile elements (eg, casts) degenerating overnight in the bladder. If possible, it is best to collect urine before drugs have been administered. Some drugs (eg, glucocorticoids, diuretics) interfere with concentrating ability (ie, specific gravity) and may lead to erroneous conclusions about renal function. Antimicrobial drugs may affect the numbers of leukocytes and bacteria observed in the urine sediment. Some antimicrobials may precipitate in the urine, which can lead to the development of unfamiliar crystals in the urine sediment. Sequentially collected urine samples may be of special value in an animal whose condition is changing over time.

Voided samples

Voided urine specimens are acceptable for initial routine evaluation of suspected urinary disorders and for medical screening purposes. Because voided urine traverses several anatomical areas (ie, the urethra, vagina or prepuce, and perineal or preputial hair), cells, chemical substances, bacteria, and debris from these areas are more likely to be present in the voided sample. This usually is not the case with other techniques of urine collection.

The distal urethra, prepuce, and vagina normally harbor bacteria that may contaminate urine samples. In normal male dogs, contamination of voided urine samples (with cells, protein, and bacteria) commonly occurs as urine passes through preputial exudate. The extent of contamination from the vagina and vulva in normal female dogs is much less, but can become clinically important during estrus. Minimal contamination of voided urine specimens occurs in cats of either sex.

Midstream voided urine samples are preferable to initial stream specimens because they more accurately assess processes occurring in the bladder, ureters, or kidneys. The initial stream mechanically flushes out cells and debris from the urethra, vagina, prepuce, or perineum, which in turn can contaminate the sample. However, samples of the initial urine stream may be of benefit when evaluating disease

processes that occur distal to the bladder (eg, urethra, vagina). Comparison of initially-voided and midstream urine samples may be helpful in selected cases.

Voided urine samples collected from the cage floor, litter pans, and examination tables are less desirable due to environmental contamination. Analysis of these voided samples still may be useful if such contamination is taken into consideration when interpreting results. Also, this may be the only option for obtaining a sample, as some animals with pollakiuria may not accumulate sufficient urine in their bladders to allow collection by other means.

Successful collection of voided samples from dogs sometimes requires ingenuity and quickness of hand. The low squatting posture of female dogs during voiding makes it difficult to collect a voided specimen. Some female dogs are startled by the abrupt placement of a collection container and stop urinating. A clean pie pan or other similar device is helpful in these cases, and can also be used for collection by pet owners. Intermittent territorial marking causes many male dogs to void small volumes of urine in many places. This behavior can frustrate those who are attempting to collect an adequate sample of voided urine.

Collection of voided urine samples from cats can be quite challenging. One technique that may work with house cats that are accustomed to using a litter pan is to allow the cat to void in the pan when the litter has been removed. Placing plastic cellophane wrap loosely over the litter is another technique that is particularly well suited to declawed cats. The use of a non-absorbable cat litter (NOSORB®—CATCO, Ohio) is perhaps the most convenient method, allowing the pet owner or veterinarian to easily obtain voided urine specimens from cats. Other non-absorbable materials such as aquarium gravel or plastic packing materials also may be used. After washing, litter pans should be thoroughly rinsed so that there is no residue of cleaning agents (eg, soap, bleach); many cleansers can cause artifacts in the chemical analysis of urine, especially when using dip strip reagent tests.

The advantages of collecting a voided urine sample include no need for special equipment or physical restraint, and no risk of injury to the animal's urinary tract. Other subsequent methods of collection may be necessary to further evaluate abnormalities that are detected in the initial voided urine specimens. Nothing is gained by the collection of urine via another (ie, more invasive) method if the results of urinalysis on a voided specimen are normal. Comparison of abnormal results from a voided urine specimen to those results obtained on urine collected by catheterization or cystocentesis may be helpful in anatomical localization of a disease process. Voided urine samples should be used in the initial evaluation of hematuria as other methods of collection (eg, catheterization, cystocentesis) often cause contamination (ie, red cells) due to iatrogenic trauma. This recommendation is especially important in cats with lower urinary tract disease.

Manually-expressed samples

Collection of urine by manual expression of the bladder is no longer a recommended method. It inflicts trauma to the bladder and introduces red cells and protein into the sample. Gentle palpation of the urinary bladder with gradual increments of pressure may stimulate reflex voiding or may cause the animal to expel urine directly as intravesical pressure exceeds urethral resistance. However, in animals with bacterial cystitis, increased hydrostatic pressure in the bladder may propel infected urine back up into the ureters and kidneys. Rupture of the normal urinary bladder can occur if excessive pressure is applied; rupture of the diseased bladder may occur more readily. Like normally voided urine samples, specimens collected by manual expression are subject to contamination as urine passes through the distal urogenital tract. Finally, it is more difficult to express urine from male dogs and cats than from females due to greater urethral resistance. Thus, this method of urine collection should be used only when urine cannot be obtained by any of the other techniques.

Catheterized samples

Urine specimens collected by careful catheterization of the urinary bladder avoid much of the contamination from the distal urogenital tract, but urethral contamination still may occur. Also, catheterization does carry some degree of risk of physical injury, although usually infrequent and minor in nature.

In female dogs and cats, aseptic technique is facilitated by direct visualization of the external urethral orifice using a sterile speculum with a self-contained directed light source. The lubricated speculum is gently inserted into the vagina at a 45° angle. (The authors prefer an anoscope designed for use in human patients.) The obturator of the anoscope facilitates vaginal entry and prevents contamination of the lumen of the anoscope. After removal of the obturator, the urinary catheter is inserted into the urethral

orifice by direct visualization. Although not recommended, digital palpation of the external urethral orifice in female dogs by vaginal palpation with a sterile glove (blind technique) may be used to guide the urinary catheter into the urethra. However, this method is less satisfactory due to the inherent contamination from perivulvar hair, vulva, and the vagina.

A small sterile otoscopic speculum works well for direct visualization of the external urethral orifice in female cats. In general, female cats will not tolerate this procedure without some form of chemical restraint. A blind technique similar to that described above for the female dog also can be used after inserting the otoscope speculum. In some cats, the blind technique is facilitated when performed with the animal in dorsal recumbency.

Collection of catheterized urine samples from male dogs is accomplished after extrusion of the penis from the prepuce and thorough cleansing with sterile 0.9% NaCl or a benzalkonium chloride solution (ZEPHIRAN®—Sanofi-Winthrop Pharmaceuticals, New York). Lubrication with a sterile lubricant jelly will facilitate passage of the catheter and minimize trauma to the urethra, especially where the urethra curves in the region of the ischial arch.

Collection of catheterized urine samples from male cats is difficult without chemical restraint and generally is avoided. Catheters placed during initial management of cats with idiopathic urethritis and urethral obstruction can be used for urine collection at the time of the procedure.

Complications related to catheterization include trauma to the urinary tract and infection. Perforation of a diseased urethra or bladder may occur if excessive force is used during catheterization. Traumatic urethritis or cystitis and hemorrhage also may result from the catheterization. Urinary tract infection may occur due to poor technique. Even when proper aseptic technique has been followed, bacteria from the distal urogenital tract may be introduced into the bladder during catheterization. The risk of iatrogenic urinary tract infection after a single episode of catheterization is low in normal male dogs, but may be as high as 20% in normal female dogs. The risk of iatrogenic urinary tract infection also is relatively high after repeated catheterization in normal male dogs when clean, non-sterile technique is used. Immunosuppressed animals and those with abnormal urinary tract anatomy or function may be at greater risk for infection.

The procedure of catheterization may introduce red cells, protein, and epithelial cells to the collected urine sample as a result of trauma. The extent of difficulty encountered during catheterization should be considered when evaluating the proteinuria and the presence of cellular elements in the urine sediment. Inadvertent aspiration of bladder epithelium by suction on the catheter may dislodge clumps of transitional epithelial cells. Catheter-induced elements are more likely when urine samples are obtained from patients with indwelling urinary catheters. When collecting a catheterized urine sample, it is advisable to discard the first few milliliters (ml) of urine obtained because this portion is most likely to be contaminated. Ideally, a bacterial culture of a urine sample collected by cystocentesis should be obtained 7 to 14 days after urinary bladder catheterization to exclude the possibility of iatrogenic infection.

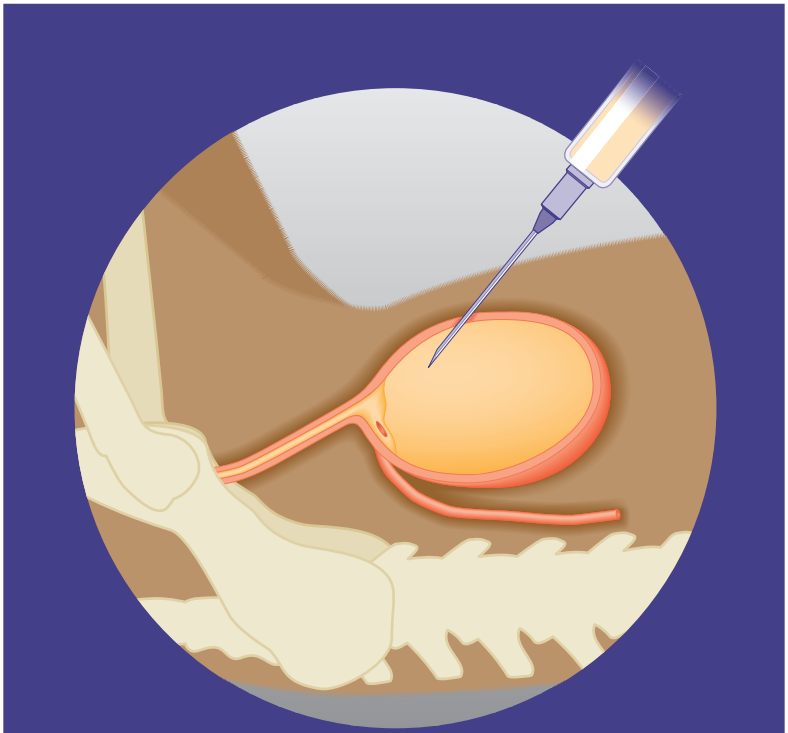
Samples collected by cystocentesis

Urine samples collected by cystocentesis are not subject to contamination from the distal urogenital tract, skin, or hair. Elements arising from the proximal urethra and prostate gland still may be found in specimens collected by cystocentesis due to retrograde movement of these elements into the urine. In general, collection of urine from normal animals by cystocentesis results in the lowest numbers of cellular elements (red blood cells (RBCs), white blood cells (WBCs)) in the sediment. However, up to 50 RBCs per high-power field (hpf) occasionally may be found as a result of trauma from the needle puncture of cystocentesis. Cystocentesis is particularly useful when urine samples for bacterial cultures are necessary.

Cystocentesis is easier to perform and trauma is less likely if the urinary bladder is readily palpable. The region of the bladder entered by the needle is not critical and both ventral and lateral aspects of the bladder are used. It is not necessary to clip the hair or disinfect the skin overlying the area to be punctured. Topical disinfectant is not applied because even a small amount of disinfectant can contaminate the urine specimen and reduce the extent of bacterial growth in samples submitted for bacterial culture.

The body position chosen for cystocentesis depends on the size and demeanor of the animal. As stated earlier, the bladder should be easily palpable. Large dogs may be sampled while standing whereas smaller dogs may be sampled in lateral or dorsal recumbency. Cats may be sampled either in dorsal or lateral recumbency. Usually, a 1-inch, 22-gauge needle attached to a 6-ml or 12-ml syringe is used for cystocentesis. Ideally, the needle should be introduced

through the skin, abdominal musculature, bladder wall, and into the bladder lumen at an oblique angle to reduce the possibility of urine leakage after the needle is withdrawn. Regardless of the angle of penetration, urine leakage after cystocentesis has not been identified as a clinical problem. In very large or obese dogs, cystocentesis may be performed more easily using a 1-1/2-inch or 2-inch, 22-gauge needle. If the expected alteration in urine specific gravity is taken into consideration, 2 milligrams per killigrams (mg/kg) of furosemide can be administered subcutaneously and cystocentesis attempted approximately 20 to 30 minutes later when the bladder has partially filled with urine. Bladder palpation should be avoided for several hours after cystocentesis to prevent leakage of urine into the peritoneal space.



Cystocentesis is performed by inserting a 22-gauge needle into the bladder at an oblique angle, toward the pelvic inlet. The bladder may be entered from the ventral surface as shown, or from either the left or right side during lateral recumbency. (*Illustration by Mark Driscoll*)

Cystocentesis is well tolerated by most dogs with minimal restraint. No local anesthetic agent is required prior for the procedure. Cats tolerate this procedure much better than they tolerate catheterization. A rare complication of cystocentesis is penetration of other viscera, but this usually is of no clinical consequence to the patient. Inadvertent penetration of the small intestine or colon may confuse interpretation of urinalysis and bacterial culture results because enteric bacteria often contaminate the sample.

Cystocentesis should not be attempted for routine sample collection in animals with severe bladder distension due to outflow obstruction or bladder atony. If there is high intravesicular pressure, the bladder may continue to leak urine after puncture or it may rupture. Despite this concern, cystocentesis can be safely used to decompress the bladder in animals with urethral obstruction. In this clinical setting, puncture of the cranial pole of the bladder should be avoided because the bladder will be drawn away from the needle as urine is removed. Cystocentesis should not be performed if the bladder is known to be severely devitalized, if the bladder has sustained recent major trauma, or if a cystotomy has been performed recently.

Inability to obtain a urine sample by cystocentesis may be due to inadequate bladder distension, improper bladder immobilization, or inability to identify the bladder by palpation. If the bladder cannot be palpated in a large or obese dog, cystocentesis may be performed blindly with the dog in dorsal recumbency and the needle entering at the midline between the last two pairs of teats. Alternatively, the cranial aspect of the pubis may be identified by palpation and puncture performed approximately 3 centimeters (cm) cranial to this landmark. Rarely, it may be necessary to perform cystocentesis by ultrasound guidance in animals with small, non-palpable bladders.

Cystocentesis has been used safely in veterinary medicine for approximately 25 years with rare complications. The procedure is relatively simple to perform, does not require specialized equipment, provides samples of superior diagnostic value due to less contamination, minimizes the risk of iatrogenic urinary tract infection, and is well-tolerated by dogs and cats with minimal restraint. In some cases, iatrogenic introduction of RBCs may occur from needle tip laceration or excessive suction on the syringe, especially if the bladder is minimally distended at the time of cystocentesis.

Chapter 2: **Sample Handling, Preparation, and Analysis**

Urinalysis results can be affected by sample handling, including transportation and preparation of the specimen.

The vessel used to transport the urine sample must be clean and free of detergents and other cleaning agents. If even a small amount of residue (from the cleaning agent) remains in the sample container, it could lead to spurious results. Disinfectants should be avoided during sample collection as some agents may interfere with dip strip chemistry determinations. Also, an airtight container is recommended to avoid pH changes in the sample.

The urinalysis should be performed within 30 minutes of sample collection. A delay in examination may result in growth of contaminating bacteria, a change in pH, disruption and dissolution of fragile casts, and loss of cellular detail due to cell degeneration (especially white cells and epithelial cells). Cooling of the urine sample may lead to precipitation of chemical substances that may then be observed microscopically and misinterpreted as crystals. This effect is magnified by prolonged storage of the urine at room temperature or refrigeration.

If the examination is delayed, the urine sample should be refrigerated. Preservatives (eg, formalin, thymol, toluene, boric acid, chloroform) may be added to the urine to prevent bacterial growth or to preserve specific elements in the urine specimen. However, it should be noted that some preservatives affect the results of certain chemical reactions. Urine may be frozen for later chemistry determinations although freezing will destroy cellular elements. Many of the chemical determinations are temperature dependent and so refrigerated or frozen specimens should be slowly warmed to room temperature before examination. A suggested method for performing a complete urinalysis when time is limited is to measure the urine specific gravity and dipstrip chemical reactions on fresh urine, and then refrigerate the sample for later sediment evaluation.

The urine sample should always be mixed well before being transferred from the collection vessel to the centrifugation tube. As urine sits after collection, heavier elements gravitate to the bottom of the sample container. If these elements are not resuspended by gentle mixing, they may be lost or underrepresented in the urinary sediment. Centrifugation concentrates cells and other elements into a pellet at the bottom of a centrifugation tube. (Use of a conical tube with a tapered end facilitates decanting of the supernatant after centrifugation.) This concentrating step increases the ability to identify abnormal elements in the urine sediment. Small numbers of abnormal elements might otherwise go undetected when examining uncentrifuged urine.

Possible Undesirable Outcomes Due to Delayed Analysis

- ❑ Bacterial contamination
- ❑ Altered pH
- ❑ Disrupted and/or dissolved casts
- ❑ Cellular detail loss (especially WBCs and epithelial cells)
- ❑ Chemical precipitation (may be confused with crystals)

The volume of urine centrifuged is not critical (however, 10 to 15 ml of urine often is recommended). In some cases, as little as 1 to 2 ml of urine may be an adequate sample for evaluation. The volume of urine centrifuged should be standardized by each laboratory and recorded on the urinalysis result form. Semi-quantitative comparison of several sediments from the same patient (or among groups of patients) is facilitated if urine volume and centrifugation technique are consistent. The test tube should be centrifuged at 1000 to 1500 revolutions per minute (rpm) for 3 to 5 minutes. The g force rather than the rpm may be a more reliable factor in centrifuging urine specimens. Very high rpm or prolonged centrifugation time will promote compression artifact of cellular elements, cellular rupture, and fracture of casts.

After the appropriate time, the centrifuge should be brought to a slow, gradual stop. An abrupt stop (using the braking mechanism) may resuspend the sediment and

cause inaccurate results (ie, underestimation of the numbers of elements present in the urine sediment).

After centrifugation, the supernatant should be poured off by inverting the tube, leaving a small pellet of sediment in the bottom tip of the tube. Alternatively, the supernatant may be decanted until only 0.5 ml remains. (A pellet of material may not be visible to the naked eye.) As the tube is turned upright and agitated, fluid lining the inside of the tube will settle to the bottom and resuspend the sediment. When performed correctly, only a small amount of fluid (ie, approximately 0.5 ml) should remain in the bottom of the tube.

Both unstained and stained sediment should be examined. Remove a sample of unstained material before adding stain. For a stained sediment sample, 1 to 2 drops of stain (or an amount equal to the volume remaining in the tube) should be added (*Fig. 2.1*). After adding the stain, the tube should be gently agitated to insure complete resuspension and adequate mixing of the sediment. This is accomplished one of two ways: by flicking the tube with the index finger or by aspiration using a pipette. After mixing is complete, the sediment should be aspirated by pipette and a drop transferred to a clean glass microscope slide. The volume of sediment transferred to the microscope slide for examination should be standardized by each laboratory. (Although microscope slides with standardized volume wells are commercially available they are not routinely used in veterinary medicine.) A coverslip should be applied carefully to avoid trapping air bubbles in the preparation. Also, an excessive volume of fluid under the coverslip may cause motion artifacts that result in confusion during examination. If this occurs, allow the sample to sit a few minutes. Eventually, the motion will cease and most of the sediment will settle into the same plane of focus. Now, the slide is ready for microscopic examination.

Supravital staining of urine sediment with new methylene blue or Sternheimer-Malbin (SEDI-STAIN®—Becton-Dickinson, Maryland) stain improves nuclear detail and facilitates differentiation of cells and other elements. The authors routinely use Sternheimer-Malbin stain to increase accuracy of identification of cellular elements (by both experienced and inexperienced observers), although others prefer to examine unstained specimens. Bright field microscopic examination of the urine sediment is enhanced by reduced illumination, which is best accomplished by reducing the aperture of the diaphragm or lowering the condenser. Some elements in the urine sediment have a refractive index similar to that of the urine itself and consequently will be difficult to detect if the illumination is not reduced. Special microscopic techniques such as phase contrast and interference microscopy have been advocated to increase the accuracy of evaluation of urinary sediment. Fluorescence microscopy also has been used to enhance accurate sediment evaluation. These techniques are rarely used clinically.

Figure 2.1 **After centrifugation, the supernatant is decanted by inverting the tube. Approximately 0.5 ml of liquid is left in the tube. An equal volume of stain (0.5 ml) is added to the remaining sediment and gently mixed.**

Bright field microscopy begins with general scanning of the preparation under low power (100 X) magnification to determine if abnormalities are present and where they are located on the slide. Casts tend to be distributed near the margins of the cover glass. High, dry power magnification (400 X) is then used to further characterize those abnormalities identified at low power magnification. High power also allows the identification of elements such

as bacteria (which can not be seen under low power magnification). Numbers of bacteria are estimated as none, few, moderate or many and an attempt should be made to differentiate rods from cocci. Extra care should be taken at this point in the analysis as particulate debris and stained mucus sometimes are misinterpreted as bacteria. Casts usually are reported as the number observed per low power field (lpf). RBCs, WBCs, and epithelial cells are reported as the number observed per high power field (hpf) after averaging the numbers seen in at least 10 microscopic fields. Crystal types and numbers are noted as none, few, moderate or many and aggregates of crystals should be noted as such.

Permanent mounts of urine sediment may be made if a portion of sediment is mixed with gelatin, glycerin, and phenol or with formaldehyde and gelatin. The coverslip then is sealed with vaseline, balsam, or methacrylate polymer (SHANDON-MOUNT®— Shandon, Pennsylvania). Excellent cellular detail and integrity of casts may be maintained for 6 months, and these techniques allow evaluation of changes in a patient's urine sediment over time or comparison of sediment abnormalities among groups of patients. Although some cells and casts may be lost during processing, examination of a dry mount sediment sample can provide greater cellular detail and confirmation of bacteria.

The chemical reagent dip strip analysis should be performed on a sample of well-mixed urine at room temperature before centrifugation (*Fig. 2.2*). However, if the urine specimen is visibly bloody or turbid, the dip strip analysis is better performed on the supernatant after centrifugation of the urine. Comparison of color reactions with standards provided by the manufacturer should be done in good lighting. Some results are time-sensitive; these particular color reactions should be read at the specified time interval recommended by the manufacturer (*Fig. 2.3*). Despite these precautions, color perception can be quite subjective and there may be considerable variation in interpretation of color reactions among different individuals. The expiration date of the reagent strips should be noted and outdated strips should not be used. The chemical reaction pads on the reagent strip should not be touched. To keep the strips dry and uncontaminated, the container lid should be promptly and tightly replaced after removal of each dipstrip.

Figure 2.2 **The chemical reagent dip strip is quickly immersed into a well-mixed sample of urine or into urine supernatant after centrifugation.**

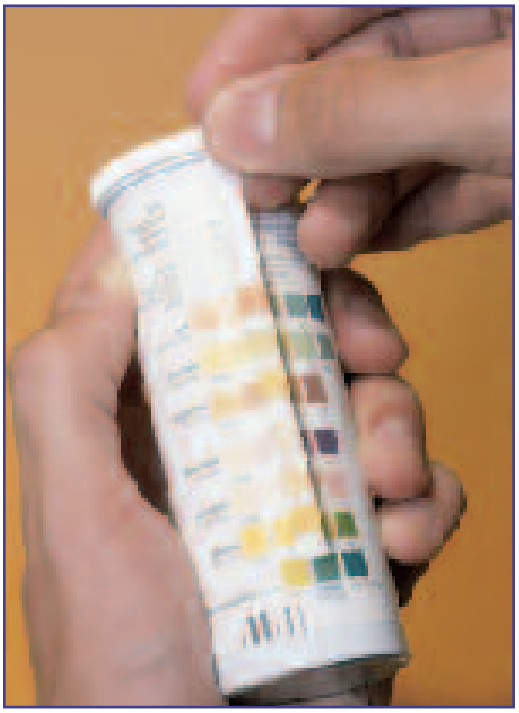


Figure 2.3 **The development of color on the reagent pads is matched with test standards provided by the dip strip manufacturer. The results are recorded semi-quantitatively.**

Part II

Chapter 3: **Urinalysis Interpretation**

A complete urinalysis combines evaluation of physical and chemical properties with microscopic examination of the urinary sediment. Chemical reagent dip strip evaluation provides useful information, but chemical analysis alone is insufficient. Unfortunately, chemical analysis has been the only portion of the urinalysis consistently performed on dogs and cats in some veterinary practices.

Microscopic examination should be performed to rule out false-negative results that may be detected on macroscopic evaluation alone and to further characterize abnormalities found on macroscopic evaluation. Macroscopic examination will not specifically identify casts, white blood cells, bacteria, fungi, epithelial cells, crystals, sperm, or parasites.

Relative concentrations of chemical substances or excreted elements may change as urine volume and concentration change despite the fact that total daily excretion of these substances may remain unchanged. Routine urinalysis allows semi-quantitative chemical determinations recorded as 0, trace, 1+, 2+, 3+, or 4+. The numbers of abnormal elements seen microscopically also are reported in relative terms as number observed per low or high power microscopic field.

Physical Properties

The physical properties of urine other than specific gravity are assessed subjectively. These include color, transparency, and odor.

Color

Normal urine is light yellow, yellow, or amber in color due to the presence of the pigment urochrome (which results after oxidation of urochromagen). Urochrome excretion is relatively constant over a 24-hour period, however, it may be increased during fever and starvation as a result of increased catabolism. Urine color may indicate the degree of urine concentration, but this should be verified by measuring specific gravity or osmolality. The fact that urine is normal in color does not insure that the urine is normal. Color is a nonspecific property, and urine must be evaluated further by chemical analysis and sediment examination.

Colorless or pale yellow urine often is dilute, while darker amber-colored urine may be concentrated or may contain increased amounts of specific pigments (eg, urochrome, bilirubin, urobilin). The most common abnormal urine color (ie, pigmenturia) is red or reddish brown. This usually is due to the presence of intact red blood cells (hematuria) (*Fig. 3.1*). Hemoglobinuria arising from intravascular hemolysis or lysis of previously intact red cells in the urine specimen also may produce a reddish color (*Fig. 3.2*). Uncommonly, myoglobinuria is the cause of reddish brown urine. Very dark brown or black urine most often results from the conversion of hemoglobin to methemoglobin in acidic urine.

Transparency

Freshly collected urine from normal dogs and cats usually is clear when evaluated in a clean test tube with good lighting. Cloudy urine may be normal in the absence of other macroscopic or microscopic abnormalities and is often a result of crystalluria, especially in refrigerated samples (ie, cooling induces crystal precipitation). Excessive numbers of red cells, white cells, or epithelial cells also can

Causes of Abnormal Colored Urine

Red or reddish brown	Hematuria Hemoglobinuria Myoglobinuria
Dark brown or black	Methemoglobinuria
Yellow-brown to green-brown	Concentrated sample Bilirubin *Pseudomonas* infection
Green or greenish blue	Methylene blue Dithiazinine iodide
Orange	Bilirubin AZO-GANTRISIN® (Roche Laboratories—New Jersey)

cause cloudiness (*Fig. 3.3*). Additional causes of cloudiness include bacteria, fungi, spermatozoa, prostatic fluid, mucous threads, lipid droplets, and contaminants. Flocculent material often settles out on standing, and usually consists of aggregates of white cells or occasionally clumps of epithelial cells. Small calculi (ie, "sand" or "gravel") also may be observed.

Odor

Normal urine typically has a slight odor, which arises from volatile fatty acids. Odor may vary in intensity among animals and between gender (eg, the urine of mature intact male cats has a strong characteristic odor). The most common abnormal odor of urine is an ammonia-like odor. A urinary tract infection by urease-producing bacteria will result in hydrolysis of urea and the release of ammonia.

Specific gravity

Urine specific gravity:

- is the ratio of the weight of urine compared to the weight of an equal volume of pure water at the same temperature;
- is the only actual test of renal function in routine urinalysis; and
- indirectly indicates urine volume.

There is a relationship between specific gravity and total solute concentration in urine, but specific gravity is dependent on molecular size and weight, as well as on the total number of solute molecules. Total urine solute concentration is an important tool for clinical evaluation of renal function and is most accurately determined by osmometry (though infrequently used in routine urinalysis).

Urine specific gravity, as determined by refractometry, is the recommended procedure for estimating total solute concentration in clinical patients. Refractometry provides an approximation of total urine solute concentration that is inexpensive and simple to perform and consequently remains widely used by clinicians (*Fig. 3.4*).

Animals that produce a large volume of urine are expected to have low urine specific gravity whereas animals that produce a very small volume of urine are expected to have high specific gravity. An important exception to this general rule is the animal with oliguric acute intrarenal failure that has a low urine volume and low urine specific gravity.

Urine specific gravity, or osmolality, is a function of fluid and solute intake, glomerular filtration, renal tubular function, release and action of vasopressin, and extent of extrarenal fluid losses. Fluid therapy and administration of diuretics and glucocorticoids affect urine specific gravity, and, therefore, specific gravity measurements should be determined before treatment is initiated.

The average specific gravity of urine produced throughout the day by both dogs and cats usually is moderately high. Urine specific gravity values of 1.001 to 1.070 for dogs and 1.001 to 1.080 for cats can be considered normal depending upon the individual circumstances and must be interpreted in light of each clinical situation. For example, a urine specific gravity of 1.010 may be normal in a dog that recently drank a bowl of water but the same value in a dehydrated dog that has been anorexic would be cause for concern about renal function.

Repeatedly low urine specific gravity values from successive samples in an individual dog or cat should prompt concern about an underlying renal or non-renal disorder. If urine specific gravity exceeds

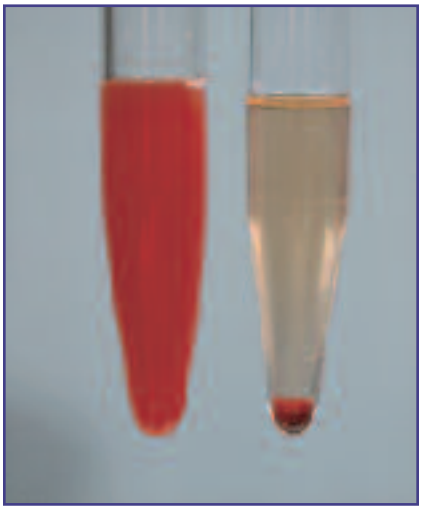


Figure 3.1 **Red colored urine that clears completely after centrifugation is due to the presence of RBCs.**

Figure 3.2 **Red to amber colored urine that is transparent, and that does not clear after centrifugation, may be due to the presence of dissolved pigments, such as hemoglobin or myoglobin. Examination of the patient's serum will show a pink color if hemoglobin is present but no abnormal color if myoglobin is present.**

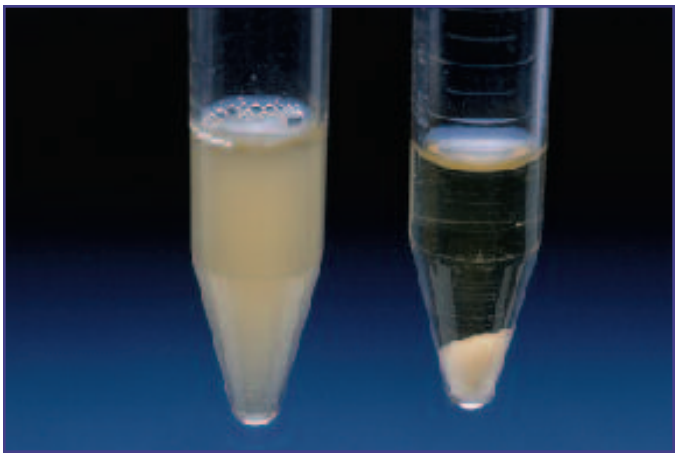


Figure 3.3 Turbid urine that clears upon centrifugation is due to abnormal elements (eg, white blood cells, crystals, mucus) in the urine sediment.

the upper limit of the scale (usually 1.035), the reading is repeated using a small sample of urine diluted with an equal amount of distilled water. The last two digits of the new result are then multiplied by two to obtain the adjusted final value.

The urine specific gravity of healthy dogs varies widely. Often, normal dogs have urine specific gravity values ranging from 1.018 to 1.025, and values have been noted as high as 1.023 to 1.064 in laboratory dogs. In a recent study of healthy pet dogs, urine specific gravity values ranged from 1.006 to greater than 1.050. Values tended to be higher in morning samples and were observed to decrease as the age of the animal increased.

The effect of diet on specific gravity may be more pronounced in cats than in dogs. Cats fed primarily dry food usually have urine specific gravity values greater than 1.030 whereas cats fed only canned food may have urine specific gravity values as low as 1.025.

Urine with specific gravity values of 1.001 to 1.007 coupled with osmolality measurements of less than that of plasma (300 mOsm/kg) is referred to as *hyposthenuric*. The presence of hyposthenuria implies a relative water diuresis. In a case of overhydration, this would be considered acceptable. Pathologic hyposthenuria occurs in animals with diabetes insipidus, hyperadrenocorticism, pyometra, hypercalcemia, hypokalemia, liver disease and psychogenic polydipsia. Occasionally, dogs with primary intrinsic renal failure will have hyposthenuric urine.

Urine with specific gravity values of 1.007 to 1.017 and osmolality the same as that of plasma is referred to as *isosthenuric*. Traditionally, if the urine specific gravity never

Figure 3.4 A drop of the patient's urine is placed on the refractometer to measure specific gravity.

exceeds 1.017 or falls below 1.008 it is said to be "fixed." This often occurs in animals with advanced primary intrinsic renal disease.

In animals with urine specific gravity values higher than that of plasma (so-called *hypersthenuria* or *baruria*), the extent of patient dehydration must be considered in an attempt to determine if the urine specific gravity is physiologically appropriate. Dehydrated animals should produce urine that is maximally concentrated if their hypothalamic-pituitary-renal axis is normal. Urine specific gravity values for dehydrated animals are expected to be greater than 1.040; values of 1.030 to 1.040 are considered questionable in dehydrated animals; values less than 1.030 are considered abnormal in dehydrated animals. Water deprivation studies of normal animals have shown concentrated urine specific gravity values of 1.050 to 1.076 for dogs and 1.047 to 1.087 for cats.

Chemical Properties

A number of chemical properties are assessed in routine urinalysis and include pH, protein, occult blood, glucose,

bilirubin, leukocyte esterase, and nitrites. These parameters are strong indicators for physiological abnormalities (eg, metabolic and respiratory acidosis) and disease (eg, urinary tract infection).

The use of commercially available chemical reagent dip strips for routine urinalysis is subject to many potential errors, as listed below. The magnitude of the color reaction always should be interpreted in light of the urine specific gravity; some chemical reactions may be negative or reduced in intensity when very dilute urine samples are tested. Abnormal dip strip results (eg, proteinuria) may justify further analysis by a more sensitive, quantitative method.

Chemical Properties Assessed in Routine Urinalysis

- ❑ pH
- ❑ Protein
- ❑ Occult blood
- ❑ Glucose
- ❑ Bilirubin
- ❑ Ketones

pH

An approximation of urine pH by dip strip is adequate for routine urinalysis. (However, when necessary, a more precise pH measurement can be achieved with a pH meter.) Dip strip reagent pads containing methyl red, bromothymol blue, and phenolphathalein can detect pH in the range of 5 to 9. The color reaction occurs quite rapidly and should be read immediately after applying urine to the reagent pad. Results should be estimated to the nearest 0.5 pH unit.

Urine pH varies with diet and acid base balance. The urine pH of dogs and cats on meat-based, high protein diets usually is in the acidic range (due to the excretion of acid end products following protein metabolism) but may vary in normal dogs and cats from 5.5 to 7.5. Animals on cereal or vegetable-based diets normally may have alkaline urine (due to excretion of alkaline end products following metabolism.) Postprandial urine is usually alkaline. This is due to the "alkaline tide" that occurs while acid is being secreted into gastric juice.

Animals with urinary tract infections may have alkaline urine when urease-producing bacteria are present. *Proteus* spp and *Staphylococcus aureus* are the most common isolates associated with alkaline urine. Many bacterial urinary tract infections, however, do not result in alkaline urine.

Other causes of alkaline and acidic urine are listed here.

Potential Sources of Error when Using Urine Dip Strip Test Methods

- ❑ Refrigerated urine sample not returned to room temperature before testing
- ❑ Contamination of urine sample with disinfectant
- ❑ Outdated reagent strips
- ❑ Improper storage of reagent strips (eg, exposure to air)
- ❑ Loss of chemicals from reagent pads after prolonged immersion in urine
- ❑ Leakage of reagent chemicals from adjacent reagent pads if dip strips are held vertically (strips should be read horizontally)
- ❑ Reagent pads contaminated by materials from the technicians' fingers
- ❑ Reading colorimetric reactions at incorrect times
- ❑ Poor ambient lighting
- ❑ Poor visual acuity of laboratory technician in determining color reactions
- ❑ Difficulty reading reagent pad reaction due to highly pigmented urine (eg, severe hematuria, severe bilirubinuria, nitrofurantoin or other drugs, large amounts of B vitamins)
- ❑ Failure to use positive and negative control strips to verify accuracy of new containers of dip strips

Causes of *Acidic* Urine

- ❑ Meat-based diet
- ❑ Administration of acidifying agents (eg, d,l-methionine, NH_4Cl)
- ❑ Metabolic acidosis
- ❑ Respiratory acidosis
- ❑ Paradoxical aciduria in metabolic alkalosis with hypokalemia
- ❑ Chloride depletion
- ❑ Protein catabolic states

Causes of *Alkaline* Urine

- ❑ Vegetable-based diet
- ❑ Administration of alkalinizing agents (eg, $NaHCO_3$, citrate)
- ❑ Metabolic alkalosis
- ❑ Respiratory alkalosis (including stress-induced)
- ❑ Urinary tract infection by urease-positive organism
- ❑ Postprandial alkaline tide
- ❑ Distal renal tubular acidosis
- ❑ Urine allowed to stand open to air at room temperature

Protein

Urine protein can be qualitatively and semi-quantitatively assessed by reagent dip strip pads. The color indicator (tetrabromophenol blue) is much more sensitive to albumin than to globulins and must be read at the proper time interval. The lower limit of sensitivity for detection of proteinuria is approximately 10 mg/dl to 20 mg/dl; the upper limit (ie, maximal color intensity) is 1 g/dl.

The term proteinuria includes both albumin and globulins. Because normal dogs (and cats) excrete small amounts of protein, randomly collected, voided urine samples from normal dogs may contain up to 50 mg/dl of protein. Clinically relevant proteinuria may go unappreciated in very dilute urine samples due to the lower limit of sensitivity of the dip strip.

Causes of Pathologic Renal Proteinuria

- Increased glomerular filtration of protein
- Failure of tubular reabsorption of protein
- Tubular secretion of protein
- Protein leakage from damaged tubular cells
- Renal parenchymal inflammation
- A combination of the above

On routine urinalysis, the protein concentration of urine is reported qualitatively as trace (10 mg/dl), 1+ (30 mg/dl), 2+ (100 mg/dl), 3+ (300 mg/dl), or 4+ (1000 mg/dl). False-positive results occur in very alkaline urine and in urine contaminated with quaternary ammonium compounds (eg, benzalkonium chloride) commonly used as disinfectants. False-negative results may occur in urine that is acidic or very dilute. Quantitative methods for protein determination are recommended to confirm proteinuria detected by dip strip methods and when globulins are suspected in the urine (eg, multiple myeloma) or when the urine sample is highly alkaline.

Proper interpretation of proteinuria cannot be made by a dip strip alone; it includes the animal's history, physical findings, method of urine collection, and urine sediment examination. Proteinuria with hematuria or pyuria cannot be readily localized; hemorrhage or inflammation can occur at any point along the urinary tract, which allows entry of plasma proteins into the urine. Marked hematuria often is associated with moderate to severe proteinuria whereas pyuria often is associated with mild to moderate proteinuria.

The urine specific gravity results also must be taken into consideration when evaluating proteinuria. For example, 1+ proteinuria (30 mg/dl) in a urine sample with a specific gravity of 1.007 may be clinically relevant. The same magnitude of proteinuria in a urine sample with a specific gravity of 1.065 is unlikely to be clinically relevant. Proteinuria associated with an inactive urine sediment or sediment with large numbers of casts usually is of renal origin. Persistent moderate to severe proteinuria in the absence of abnormal urine sediment findings is the hallmark of glomerular disease (eg, glomerulonephritis, glomerular amyloidosis).

Occult blood

Dip strip reagent pads can detect the presence of intact erythrocytes, free hemoglobin, and free myoglobin in urine when read at the recommended time interval. The colorimetric test (containing organic peroxide) reacts with heme pigments and is slightly less sensitive to intact erythrocytes than to either hemoglobin or myoglobin. False-positive results may occur in urine contaminated with bleach (sodium hypochlorite) or if the urine contains large amounts of iodide or bromide. False-negative results may occur if the urine sample is not well mixed before testing (red blood cells settle out rapidly).

Urine from normal dogs and cats should be negative for occult blood. A positive reaction indicates the presence of intact erythrocytes, hemoglobin, or myoglobin in the urine and must be interpreted in conjunction with the urinary sediment findings. Hematuria is the most common cause of a positive occult blood result; free hemoglobin is an uncommon cause and myoglobin is rare.

Hematuria can occur from any lesion along the genitourinary tract that allows entry of red cells into urine (eg, trauma, inflammation, infection, infarction, neoplasia, calculi, coagulopathy). Hematuria becomes macroscopically apparent when more than 0.5 ml of blood mixes with 1.0 liter of urine. Dip strip reagent pad methods allow detection of hematuria before it becomes visible macroscopically.

Glucose

Dip strip reagent pads measure glucose by means of a specific and sequential method involving glucose oxidase, peroxidase, and chromagen (glucose oxidase will not react with other substances). The color reaction corresponds to the quantity of glucose present in the urine sample when read at the appropriate time interval. False-positive reactions may occur if the color indicators are directly activated (eg, when the urine sample is contaminated with hydrogen peroxide, chlorine, or hypochlorite). Large amounts of

ascorbic acid (vitamin C) in the urine may lead to false-negative reactions. The presence of formaldehyde or fluoride in urine samples may result in inactivation of glucose oxidase (formaldehyde is a metabolite of the urinary antiseptic, methenamine).

Glucose is not present in detectable amounts in the urine of normal dogs and cats. Filtered glucose is almost entirely reabsorbed by the proximal tubular cells, and only a very small amount is excreted in urine.

Hyperglycemia leads to glucosuria when the capacity of the proximal tubular cells to reabsorb the filtered load of glucose has been exceeded. (The renal threshold for glucose is approximately 180 mg/dl in dogs and 300 mg/dl in cats.) Glucosuria without hyperglycemia may occur in some cats with chronic disease, possibly due to altered proximal renal tubular function.

Ketones

Beta-hydroxybutyrate, acetoacetate, and acetone are ketones, the products of exaggerated and incomplete oxidation of fatty acids. They are not present in the urine of normal dogs and cats. Ketones (in plasma) are filtered by the glomeruli and incompletely reabsorbed by the renal tubular cells due to a saturated tubular transport process. For this reason, ketonuria often precedes detectable ketonemia. Ketonuria occurs more readily in young animals and diabetic ketoacidosis is the most important cause in adult dogs and cats.

Dip stick reagent pads (containing nitroprusside) react with acetone and acetoacetate (and are much more reactive with the latter); they do not react with beta-hydroxybutyrate. False-positive color reactions reportedly are rare, although highly pigmented urine may occasionally result in a false-positive reaction. False-negative reactions also are uncommon.

Bilirubin

Bilirubin is derived from the breakdown of heme by the reticuloendothelial system. Conjugated or direct-reacting bilirubin is water-soluble and normally is present in the glomerular filtrate. Unconjugated bilirubin does not pass through the glomerular capillaries due to its protein binding. Only conjugated bilirubin appears in the urine.

The canine kidney can degrade hemoglobin to bilirubin. The renal threshold for bilirubin is low in dogs, and bilirubin may be detected in the urine before it appears increased in serum in dogs with liver disease. It is not unusual to find small amounts of bilirubin in concentrated urine samples from normal dogs, especially males. Bilirubin is absent from normal feline urine.

Dip stick reagent pads (containing a diazonium salt) are much more sensitive for conjugated bilirubin than unconjugated bilirubin. False-negative results or artifactually low readings may occur in urine samples that contain large amounts of ascorbic acid or nitrites (sometimes present with bacterial urinary tract infection). False-positive results may occur if large doses of chloropromazine have been administered. A dip strip reaction of 2+ or 3+ for bilirubin is considered abnormal in dogs with moderately concentrated urine (1.020 to 1.035).

Bilirubinuria occurs as a consequence of primary intrahepatic diseases, but the bilirubinuria associated with extrahepatic biliary obstruction typically is more severe.

Leukocyte esterase reaction

Indoxyl released by esterases from intact or lysed leuko-

Causes of Glucosuria

- ❑ Diabetes mellitus
- ❑ Stress or excitement in cats (associated with hyperglycemia)
- ❑ Chronic disease unrelated to the kidneys in some cats (associated with normoglycemia)
- ❑ Administration of glucose-containing fluids
- ❑ Renal tubular disorders

Causes of Ketonuria

- ❑ Diabetic ketoacidosis
- ❑ Prolonged fasting or starvation
- ❑ Glycogen storage disease
- ❑ Low carbohydrate diet
- ❑ Persistent fever
- ❑ Persistent hypoglycemia

Causes of Bilirubinuria

- ❑ Hemolysis (eg, autoimmune hemolytic anemia)
- ❑ Liver disease
- ❑ Extrahepatic biliary obstruction
- ❑ Fever
- ❑ Prolonged fasting or starvation

Causes of Hematuria

- **Cystitis/Urethritis**
  - Urinary tract infection
  - Idiopathic cystitis (usually cats)
  - Mechanical—urolithiasis
  - Chemical—cyclophosphamide
  - Parasites (eg, *Capillaria plica*)
- **Urinary tract neoplasia**
- **Genital tract contamination**
  - Estrus (voided sample)
  - Prostatic disease
  - Uterine disease
  - Vaginal disease
  - Preputial disease
- **Renal problems**
  - Nephritis
  - Nephrosis
  - Renal infarct
  - Renal pelvic hematoma
  - Benign renal hematuria
  - Renal parasites (eg, *Dioctophyma renale*)
- **Systemic coagulopathy**
- **Strenuous exercise**
- **Trauma**

cytes can be measured with dip stick reagents pads (which contain a diazonium salt). This test is specific for pyuria in canine urine samples but has low sensitivity (ie, many false-negative results). Therefore, a positive leukocyte esterase reaction indicates pyuria, but a negative result is not reliable. The leukocyte esterase reaction often leads to false-positive results in cats.

Nitrites

Testing for the presence of nitrites in urine is of limited value in veterinary medicine because false-negative results are common in both dogs and cats. Nitrites arise from bacterial conversion of nitrates in the urine in the presence of urinary tract infection. However, not all bacteria are able to convert nitrate to nitrite. Furthermore, urine must remain in the bladder for at least 4 hours to allow sufficient time for bacterial conversion to occur.

Sediment Examination

Microscopic examination of the urine sediment is a clinically important component of the routine urinalysis. Abnormal physical and chemical findings mandate careful evaluation of the urine sediment. There are no dip strip methods for sediment examination.

Proper evaluation of the urine sediment includes identification of cells (eg, red cells, white cells, epithelial cells), casts, organisms, and crystals. To avoid some elements (eg, casts, white cells, red cells) from settling to the bottom of the collection container (and being missed on evaluation), all urine samples should be mixed well before centrifugation.

The urine sediment of normal dogs and cats contains very few cells, casts, bacteria, or crystals. A few more red and white cells are expected and considered normal in a voided sample. Also, the urine sediment content is affected by specific gravity. For example, 10 red cells/hpf in a urine sample with a specific gravity of 1.014 might be comparable to 20 to 30 red cells/hpf in a urine sample with a specific gravity of 1.050. Each laboratory must define its own normal values for sediment elements.

A number of chemical and physical factors can affect the morphology of the sediment elements. For example, concentrated urine often yields crenated cells; dilute urine often causes lysis of cells; in highly alkaline urine, red and white cells and casts may be lysed; and bacterial toxins also affect some sediment elements.

Technical variables play a part in accurate sediment evaluation, such as the volume of urine centrifuged, the speed and duration of centrifugation, and how soon after collection the sample is examined (ie, the longer the urine sits, the greater potential for morphologic changes in the sediment).

Red Cells

Small numbers of red cells may be found in the urine of healthy dogs and cats. The source of these red cells and their point of entry into the urinary tract usually are not known but may include the kidney, ureter, bladder, urethra, and genital tract.

Although normal values will vary between laboratories, the following guidelines are recommended:

- Voided samples: 0/hpf to 8/hpf
- Catheterized samples: 0/hpf to 5/hpf
- Cystocentesis: 0/hpf to 3/hpf

Excessive numbers of red cells in urine is called hema-

turia and may be microscopic or macroscopic. The possibility and extent of trauma during sample collection must always be considered when evaluating hematuria. This is especially true for samples collected by cystocentesis; even more so when repeated attempts are made (up to 50 red cells/hpf may occur). There are many potential causes of hematuria in dogs and cats as listed here.

Unstained red cells appear as pale yellow discs without nuclei. Red cells may appear colorless when longstanding hematuria is present (hemoglobin leaches from the cells over time). Red cells are variably stained by Sedi-Stain and may range from light pink to dark red. Feline red cells often stain more deeply than do canine red cells. Red blood cells in highly concentrated urine will be smaller than normal and may appear crenated. Very dilute urine will cause red cells to swell and some may rupture leaving "ghost" membranes behind. Ghost cells are not readily detected by routine light microscopy but often can be observed using phase microscopy if the cell membranes have not completely disintegrated. Alkaline urine also contributes to lysis of red blood cells.

Hemoglobinuria due to intravascular hemolysis may result in the presence of precipitated hemoglobin and appear as orange globules that may be confused with red cells. Careful observation shows the wide variation in particle size of hemoglobin precipitates as opposed to the more uniform size of red cells.

Lipid droplets occasionally are confused with red blood cells although lipid droplets are of varying sizes, highly refractile, and are in a plane of focus just below the coverslip.

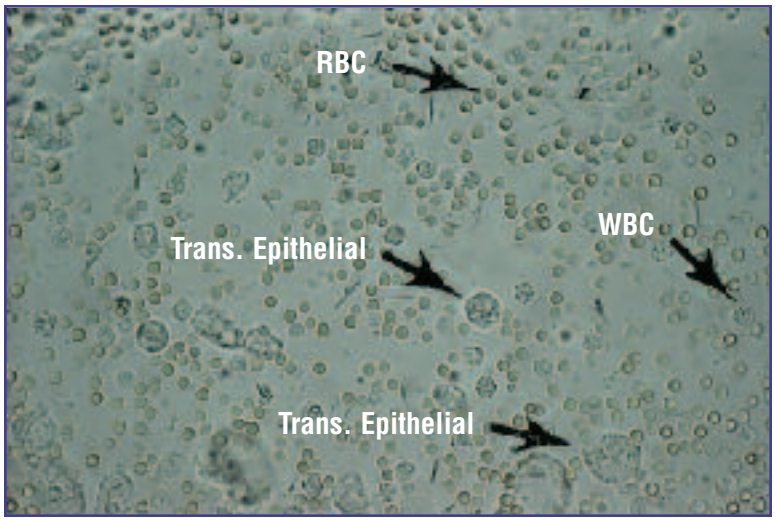


Figure 3.5 **Too numerous to count RBCs, many WBCs, and a few transitional epithelial cells in the urine sediment. The different sizes of cells are clearly represented; RBCs are the smallest, WBCs are larger than RBCs, and transitional epithelial cells are the largest. (Unstained; 100 X)**

White Cells

Small numbers of white cells may be found in urine from healthy dogs and cats; their origin often is not known. Neutrophils are the predominant type of white cell reported on urine sediment examination (lymphocytes and monocytes are not easily differentiated from small epithelial cells).

The normal ratio of white cells to red cells in the urine is approximately 1.0. Normal values for white cells in the urine sediment of dogs and cats are:

- Voided samples: 0/hpf to 8/hpf
- Catheterized samples: 0/hpf to 5/hpf
- Cystocentesis: 0/hpf to 3/hpf

Neutrophils in urine usually are one and a half to two times the size of red cells. Neutrophils with distinct nuclei are easily identified, but cellular degeneration with loss of nuclear detail frequently occurs making it difficult to distinguish neutrophils, lymphocytes, tubular epithelial cells, or transitional epithelial cells. Fusion of the segmented nucleus of the neutrophil occurs initially and is followed by nuclear fragmentation that contributes to the overall granular appearance of these cells (*Fig. 3.5*). Nuclear staining of neutrophils (using Sedi-Stain) ranges from pink to blue or dark purple. In dilute urine, neutrophils may swell, stain poorly, and demonstrate Brownian movement of their cytoplasmic granules.

An increased number of white cells in the urine sediment is called pyuria and usually indicates urinary tract inflammation or contamination from the genital tract. Urine samples with the most severe pyuria usually are obtained from animals with bacterial urinary tract infection, but sterile pyuria may accompany some urinary tract disorders including urolithiasis and neoplasia. Clumps of white cells often occur with bacterial urinary tract infection even when bacteria are not visible. Careful examination of the spaces between clumped neutrophils often discloses bacterial organisms.

Epithelial Cells

Urine from normal dogs and cats contains few epithelial cells. Only an occasional small epithelial cell or transitional

cell (per high power field) should be observed.

Epithelial cells that arise from the urinary and genital tracts vary greatly in size. Generally the smallest epithelial cells arise from the kidney, however, other small cells and larger cells also originate from the ureter, bladder, and proximal urethra. The largest non-neoplastic cells are from the distal urethra, vagina, and prepuce.

Small numbers of squamous cells are most commonly seen in catheterized and voided specimens due to vaginal or urethral contamination (*Fig. 3.6*). These cells are very large, thin polygonal epithelial cells that tend to fold on themselves and may appear singularly or in sheets. Squamous epithelial cells that roll up into cylindrical form can be confused with casts although these cells are much larger than casts. When present, the nucleus is relatively small and round. A large increase in the numbers of squamous epithelial cells may occur in female dogs during estrus. Squamous cells are usually of little diagnostic consequence.

Transitional epithelial cells line the urinary tract from the renal pelvis to the urethra. The size and shape (eg, round, oval, linear) of transitional epithelial cells varies greatly (though they are smaller than squamous epithelial cells). Small epithelial cells are slightly larger than white cells and may arise from the renal tubules or from more distal sites. The nuclei of transitional epithelial cells are round, centrally located, and occasionally binucleated. Caudate cells are small transitional epithelial cells that arise from the renal pelvis and have tapered or tail-like shapes (*Fig.3.7*).

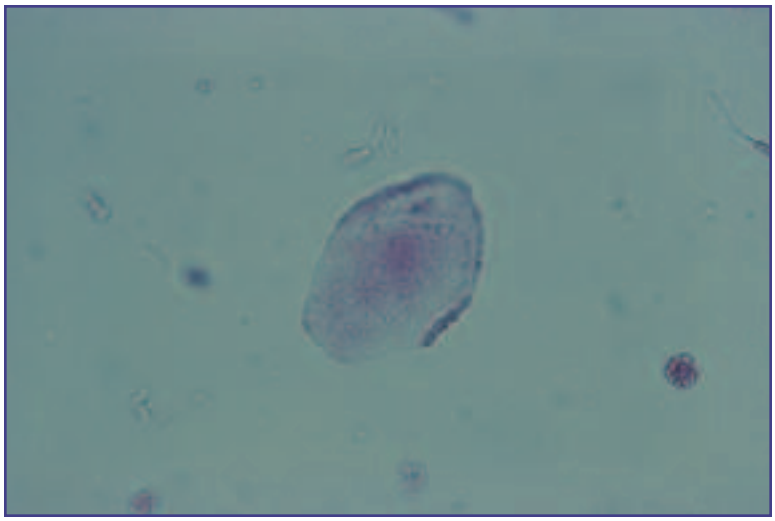


Figure 3.6 **Solitary, large squamous epithelial cell in the urine sediment. (Sedi-Stain; 400 X)**

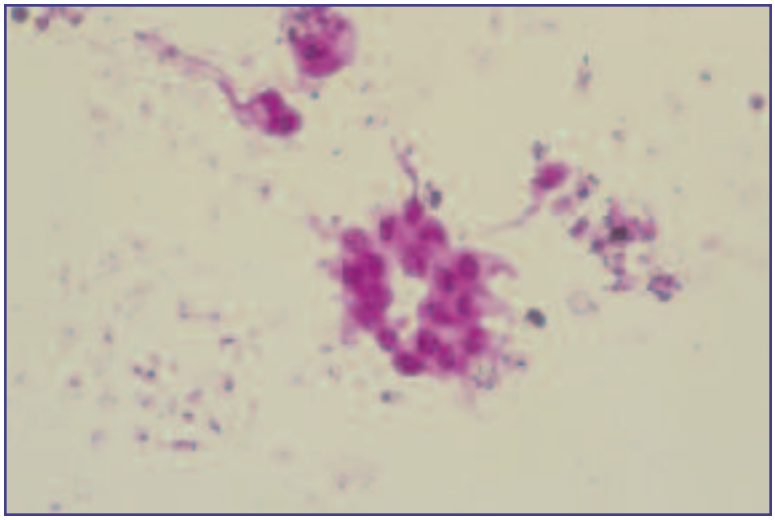


Figure 3.7 **Group of small epithelial cells, many of which have tails. This feature is useful in presumptive identification of renal pelvic epithelial cells but occasionally may be observed in transitional epithelial cells originating from the trigone area of the bladder. (Sedi-Stain; 100 X)**

Cellular Atypia Suggestive for Neoplasia

- Increased cell size
- Increased nuclear to cytoplasmic ratio
- Multiple nuclei
- Increased nucleoli
- Increased staining of nucleus
- Change in chromatin pattern in nucleus
- Mitotic figures

Renal tubular epithelial cells are cuboidal while in the kidney but assume a round shape once released from the tubular basement membrane. These cells tend to have relatively large eccentric nuclei. In general, there is no reliable way to differentiate small epithelial cells of renal tubular origin from those of transitional epithelial origin unless the cells are identified within casts, thus confirming their renal epithelial origin.

Large numbers of transitional epithelial cells may enter the urine as a consequence of infection, inflammation, mechanical abrasion (eg, catheterization, urolithiasis), neoplasia, or chemical irritation (eg, cyclophosphamide). Transitional epithelial cells may exfoliate into urine either singularly or in clumps (*Fig. 3.8*). It can be very difficult to differentiate neoplastic transitional cells from those that are reactive due to inflammatory processes. Transitional cell carcinomas of the lower urinary tract are most likely to

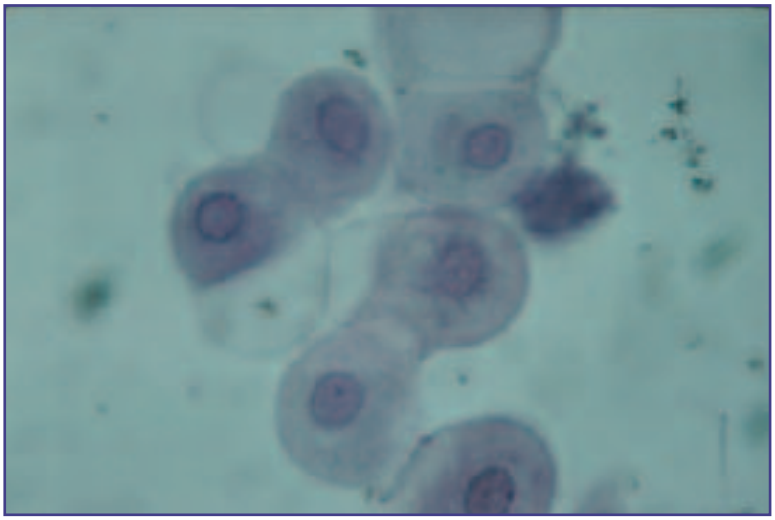


Figure 3.8 **Clump of normal-appearing transitional epithelial cells in urine sediment. The presence of large numbers and/or clumps of transitional epithelial cells may be an artifact found in urine samples collected by catheterization. (Sedi-Stain; 400 X)**

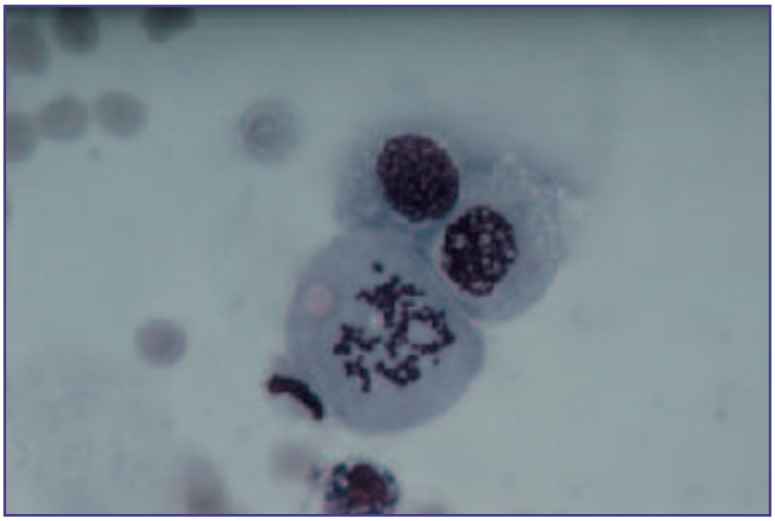


Figure 3.9 **Small clump of transitional epithelial cells in urine sediment. The presence of a mitotic figure should raise suspicion of neoplasia. The final diagnosis in this case (a dog) was transitional cell carcinoma. (Sedi-Stain; 400 X) (*Courtesy Dr. Richard Scott*)**

exfoliate (*Fig. 3.9*). Preparation of dry mount smears using Wright-Giemsa stain can be helpful for cytological evaluation. Ultimately, biopsy of affected tissue is necessary to confirm or exclude a diagnosis of urinary tract neoplasia.

Casts

Casts are cylindrical molds formed within renal tubular lumina and are comprised of varying combinations of cells and matrix mucoprotein (*Fig. 3.10*). A spectrum of cast forms ranging from those that are nearly all matrix to those that are nearly all cells or granules may be observed depending on the animal's disease state. Tamm-Horsfall mucoprotein (THM) serves as the matrix for most casts in human urine and presumably this also is true for the casts observed in the urine of animals. Serum proteins do not serve as matrix material for casts, but the presence of serum proteins in tubular fluid can promote cast formation. Tamm-Horsfall mucoprotein is secreted in small quantities by normal tubular epithelial cells in the loop of Henle, distal tubule, and collecting tubule, and it is in these locations that most casts form. Precipitation of THM is the initial event in the formation of any cast. Other materials (eg, cellular debris, brush border, intracellular organelles, serum proteins) present within the tubular lumen at the time of matrix precipitation will be trapped by THM. However, renal tubular fragments have a different origin; intact portions of renal tubules may slough into urine and do not require matrix protein precipitation. The presence of renal tubular fragments indicates severe disruption of tubular basement membranes and more severe renal injury than is implied by the presence of eptihelial cell casts.

Anything that favors secretion or precipitation of THM will promote cast formation. Tamm-Horsfall mucoprotein precipitates more readily in urine that is acidic and highly concentrated, and during times of low tubular flow rate. Conversely, urine that is highly alkaline and very dilute does not favor the formation of casts and promotes cast dissolution. The presence of normal serum proteins, hemoglobin, or myoglobin in tubular fluid favors precipitation of THM.

Casts have parallel sides with a definite outline and usually are the same diameter throughout the length. Casts typically are several times as long as wide. The ends of casts often are rounded, but sometimes slight tapering occurs (see cylindroids). The width or diameter of casts varies according to the segment of the nephron in which they were formed. Very large casts form either in the collecting tubule or a pathologically dilated portion of the distal tubule. Very thin casts may have formed in the loop of Henle or in segments of the nephron that have been compressed by edema or interstitial infiltrate.

Although very few normal cats and dogs have any casts

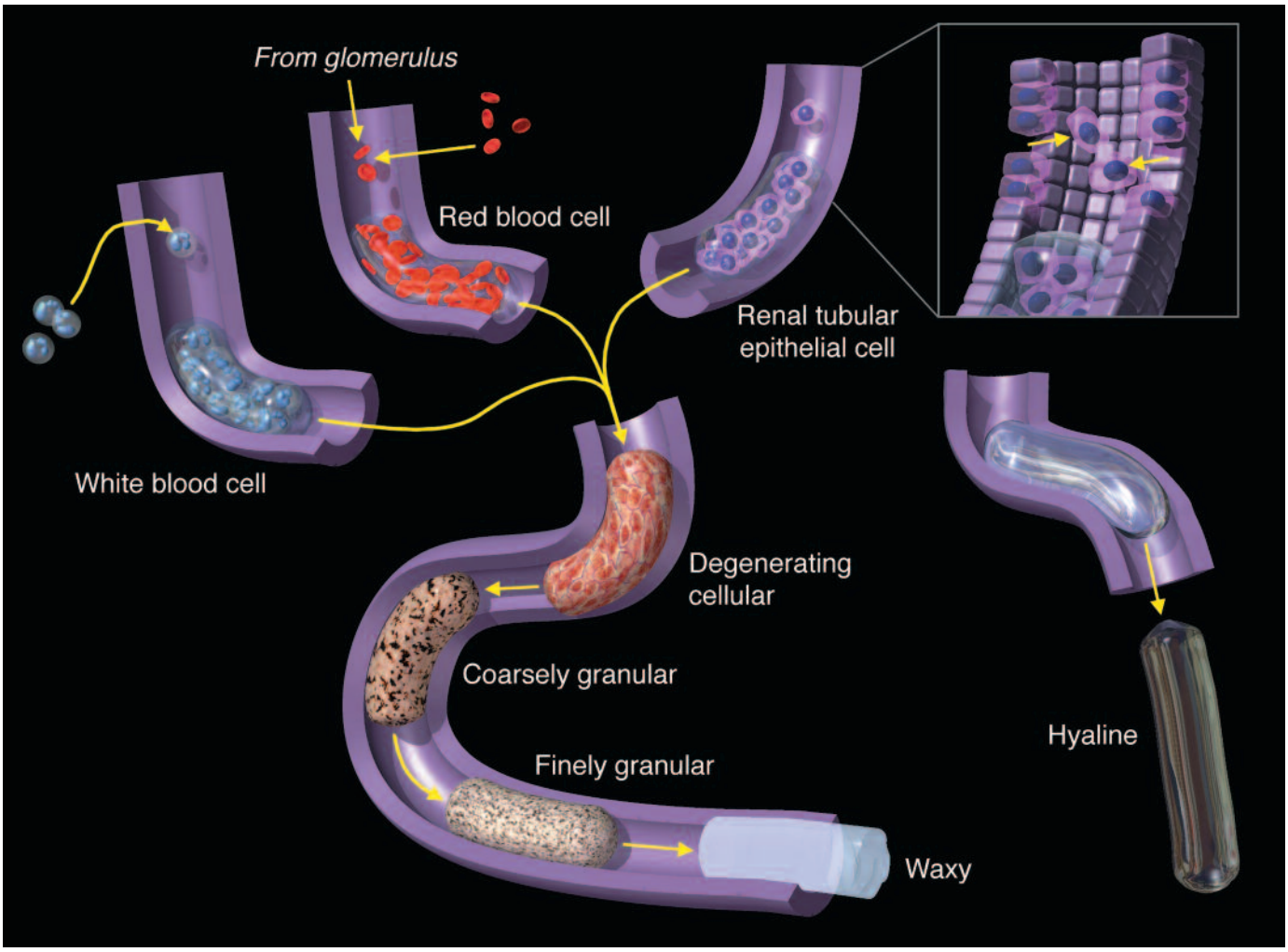


Figure 3.10 **ADDIS THEORY OF CAST FORMATION.* Casts are cylindrical molds of varying combinations of cells and matrix mucoprotein formed within renal tubules. According to the theory of Addis, cellular casts undergo progressive degeneration to granular (from coarse to fine) then to waxy casts. The hyaline cast shown is a pure precipitate of matrix protein (Tamm-Horsfall mucoprotein). (*Illustration by Tim Vojt*)**

in their urine, up to two hyaline casts per low power field and one granular cast per low power field are considered normal in urine that is moderately concentrated. No cellular casts should be observed in the sediment of normal urine. An excessive number of casts is referred to as cylindruria and implies that some type of disease process is occurring in the kidney. The presence of excessive numbers of casts in the urinary sediment indicates activity in the kidney itself. Glomerular, tubular, and interstitial disease processes can result in cylindruria (although the presence of casts alone does not allow discrimination among these types of diseases).

*Thomas Addis, born 1881, was an early pioneer of nephrology.

Hyaline Casts

Hyaline casts are pure protein precipitates of THM and small amounts of albumin. The refractive index of hyaline casts is very similar to that of urine making them nearly transparent. Consequently, they can be easily missed, especially if the microscope lighting has not been appropriately adjusted. Occasionally, refractile droplets may be included in hyaline casts but the largest portion of the cast typically is clear and non-refractive (*Figs. 3.11, 3.12*). Hyaline casts sometimes stain light pink or purple with Sedi-Stain making them easier to visualize. Animals with proteinuria of renal origin (eg, glomerulonephritis, glomerular amyloidosis) frequently form hyaline casts. Hyaline casts also form during processes that change glomerular hemodynamics

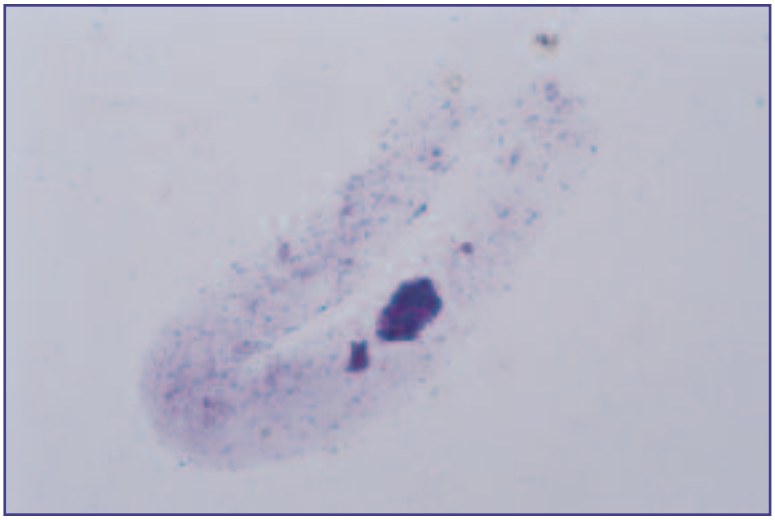


Figure 3.11 Hyaline cast in urine sediment. A small number of granules are present in this cast. Casts are named for their principal component. (Sedi-Stain; 400 X)

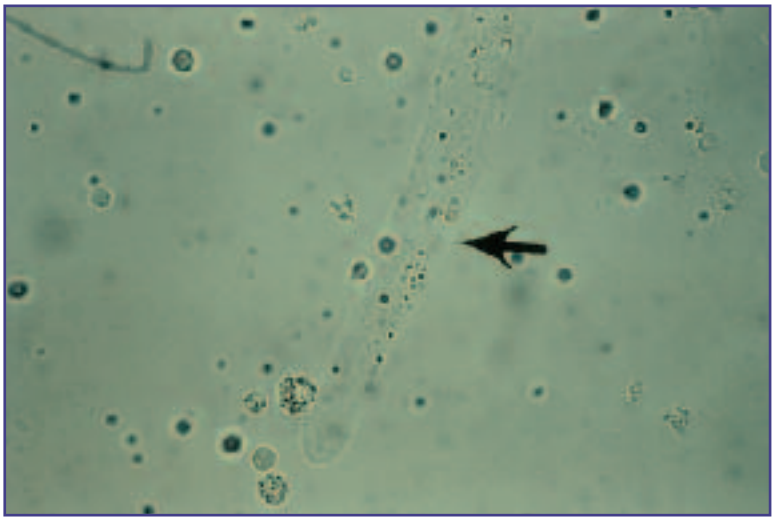


Figure 3.12 Unstained hyaline cast in urine sediment. Occasional WBCs and epithelial cells also are present. (Unstained; 400 X)

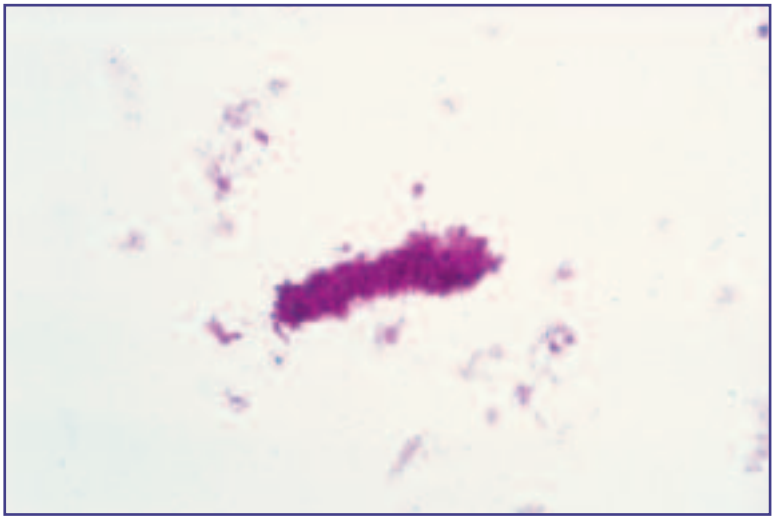


Figure 3.13 Epithelial cell cast in urine sediment. Occasional RBCs and free small epithelial cells also are present. (Sedi-Stain; 100 X)

and favor proteinuria, such as fever or passive congestion of the kidneys.

Cellular Casts

Cellular casts are never observed in the urine of normal dogs or cats. It is not always possible to distinguish the origin of the cells in cellular casts when substantial cellular degeneration has occurred. The amount of cellular degeneration within casts is a function of how long the cast remained within the kidney before release into the urine sample. Cellular detail also is more likely to be preserved if the urine sediment is examined immediately after collection and preparation (ie, within 15 minutes). Of the cellular casts, renal tubular epithelial casts are most likely to be observed. White cell casts occasionally are observed, but red cell casts are rarely observed in dogs and cats.

Epithelial Cell Casts

Renal epithelial cells are larger than white cells and contain a large round central nucleus. They are easy to identify when cellular detail is good but sometimes cannot be differentiated from white cells when the renal epithelial cells have undergone degeneration. In these instances, the cast simply is reported as a cellular cast.

Epithelial cell casts are formed when renal tubular epithelium sloughs (*Figs. 3.13, 3.14, 3.15*). The presence of epithelial cell casts in the urine sediment indicates active renal tubular cell necrosis or damage that results in the detachment of the tubular cell from its basement membrane and attachments to other tubular cells. In some instances, epithelial cell casts contain intact sheets of epithelial cells representing a segment of the nephron that has desquamated (ie, so-called renal fragments). The finding of epithelial cell casts in the urine sediment usually suggests the presence of severe intrarenal disease and associated acute tubular cell injury, often associated with nephrotoxicity or ischemia. Epithelial cell casts also may be observed during episodes of renal infarction, acute nephritis (eg, leptospirosis), and pyelonephritis.

White Cell Casts

White blood cell casts ("pus" casts) consist predominantly of neutrophils and are readily identified when cellular detail has been preserved. They can be impossible to differentiate from renal tubular epithelial cell casts when substantial white cell degeneration has occurred. White cell casts degenerate readily and therefore fresh urine sediment should be examined in order to document their presence (*Fig. 3.16*). White cell casts must be differentiated from white cells that have fortuitously clumped in a linear fashion ("pseudocast" formation). Mucus or fibrin strands can facilitate such white cell aggregation. In dogs and cats, white cell casts are most commonly associated with acute bacterial pyelonephritis. Other forms of interstitial nephritis (eg, leptospirosis, allergic interstitial nephritis) occasionally result in excretion of white cell casts. Casts containing white cells and epithelial cells may be seen in patients with acute tubular necrosis.

Red Cell Casts

Red cell casts rarely are observed in urine from dogs and cats. These casts form when red cells aggregate within the tubular lumen and their presence indicates intrarenal bleeding (*Fig. 3.17*). Red cell casts are very fragile and subject to rapid dissolution, consequently fresh urine sediment must be examined to identify them. Dogs and cats with glomerulonephritis may excrete red cell casts on occasion. Renal trauma (eg, vehicular accident after renal biopsy) may cause bleeding and rarely result in the transient excretion of red cell casts.

Old red cell casts may contain red cells that have lost their hemoglobin and consequently do not stain or appear pale. The term "blood cast" is used to describe an older red cell cast in which the red cell membranes have become indistinct but the hemoglobin color still is present (*Fig. 3.18*). Blood casts are best detected in unstained urine sediment and their presence has the same clinical significance as does the presence of intact red cell casts. Red cells also may be found in casts containing renal tubular epithelial cells and white cells (referred to as "mixed" casts).

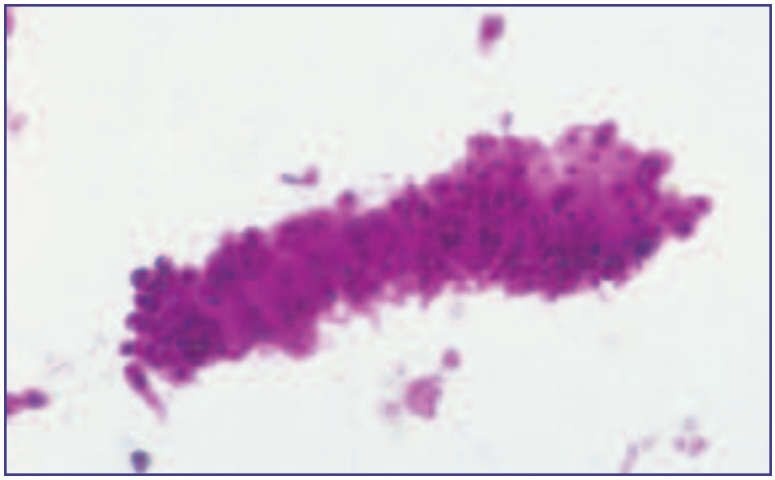


Figure 3.14 Higher magnification of epithelial cell cast depicted in Fig. 3.13. (Sedi-Stain; 400 X)

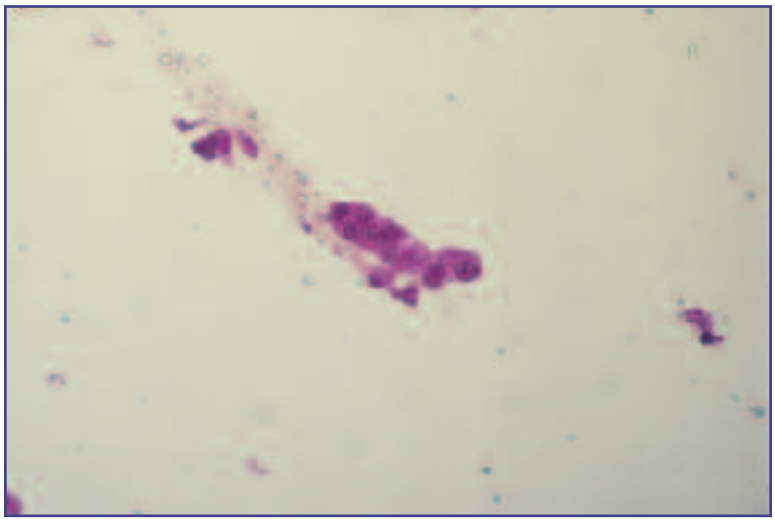


Figure 3.15 Hyaline cast with small numbers of refractile droplets and short epithelial cell cast with well-preserved cellular detail. (Sedi-Stain; 400 X)

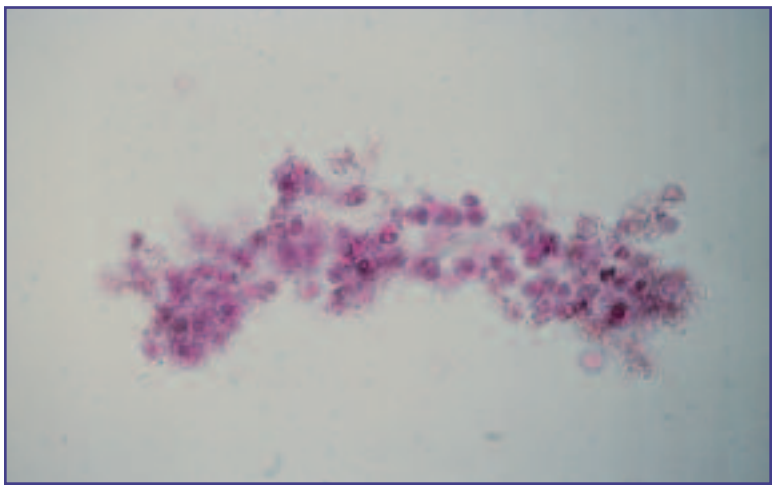


Figure 3.16 WBC cast in urine sediment that is beginning to undergo fragmentation. Neutrophils and mononuclear cells are present in the cast and moderate numbers of bacteria also may be seen. Caution should be taken to avoid confusing clumps of WBCs with WBC casts (Sedi-Stain; 400 X)

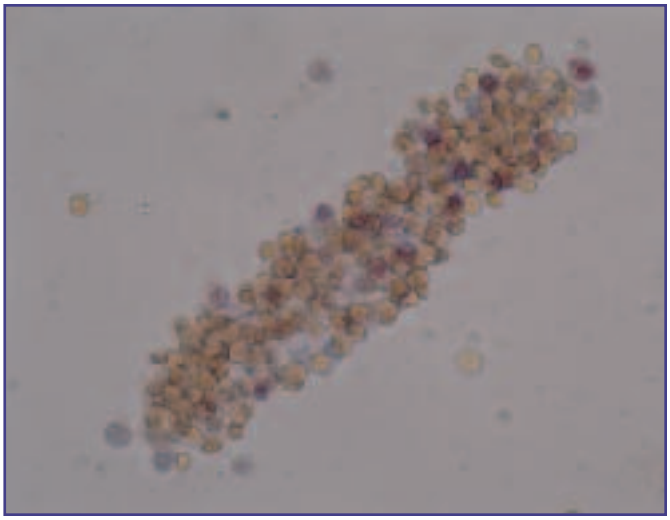


Figure 3.17 RBC cast in urine sediment. These casts are very fragile and rarely are observed in the urine of dogs and cats. (Sedi-Stain; 400 X)

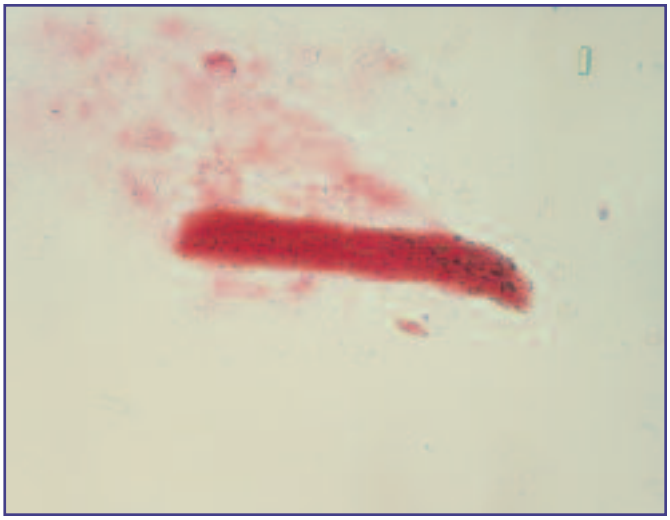


Figure 3.18 Blood cast in urine sediment. Blood casts represent the degeneration of red cell casts and are characterized by the presence of hemoglobin and faint red cell membrane outlines. (Sedi-Stain; 400 X)

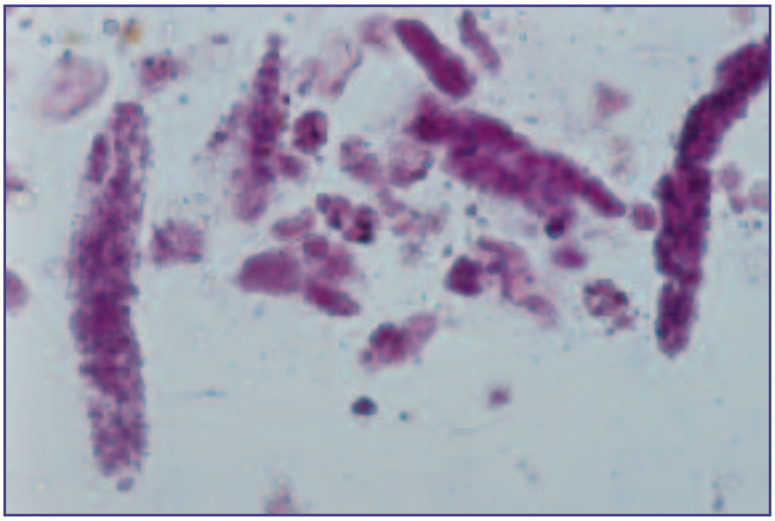


Figure 3.19 Three coarsely granular casts in various stages of degeneration. Free epithelial cells also are present. (Sedi-Stain; 400 X)

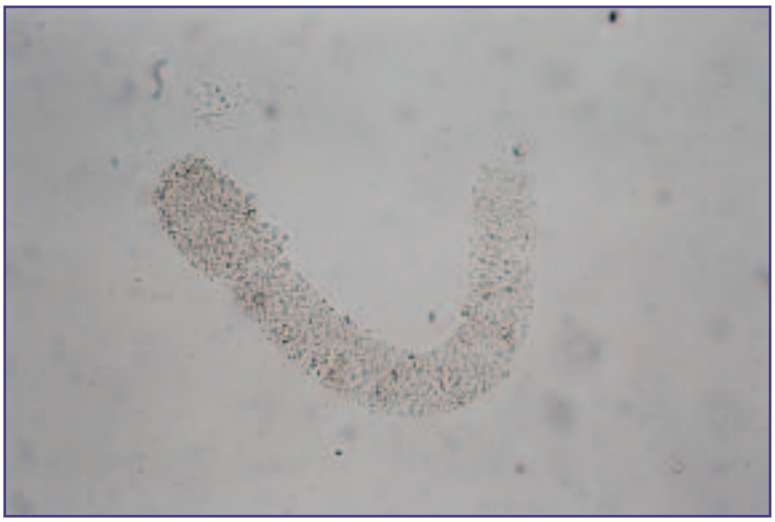


Figure 3.20 Finely granular cast in urine sediment. (Unstained; 400 X)

Granular Casts

Granules in casts are thought to represent particulate matter arising from renal tubular cell necrosis and degeneration (*Fig. 3.19*). Cellular degeneration can occur within the renal tubule resulting initially in coarse granules and later in fine granules (*Fig. 3.20*). Differentiation between coarsely and finely granular casts is of little clinical significance. The presence of granular casts in the urine sediment usually indicates some underlying tubulointerstitial disorder or occasionally proteinuria of glomerular origin. Lipid casts are a type of coarsely granular cast containing lipid droplets that may be seen in patients with nephrotic syndrome or diabetes mellitus. Lipid droplets accumulate in casts as a result of lipid degeneration of cells (*Fig. 3.21*).

Waxy Casts

Waxy casts are thought to represent the final stage of granular cast degeneration (*Fig. 3.22*). They are easy to see because of their high refractive index and homogeneous, translucent appearance. Waxy casts are the most stable of the casts. They are stable in dilute or alkaline urine, but their brittleness often results in blunt ends and cracks. Casts that are highly convoluted are likely to be waxy casts. Waxy casts stain variably with Sedi-Stain and may appear very dark purple. Sufficient degeneration to produce a waxy cast

requires considerable time, and substantial intrarenal stasis (eg, local nephron obstruction or oliguira) is implied by the presence of waxy casts. Waxy casts usually are associated with chronic renal disease. Their presence is ominous and they have been called "renal failure casts."

Broad Casts

Unusually wide casts of any type are called broad casts and are formed in the collecting ducts or in pathologically dilated segments of the distal nephron. Tubular flow rate in the large collecting tubules normally is rapid, and a severe reduction in flow rate must occur to allow casts to form in this segment of the nephron. Broad casts often are waxy in nature due to associated intrarenal stasis, but any kind of cast can be classified as a broad cast. The presence of large numbers of broad casts suggests severe renal disease but may also indicate recovery as oliguria is converted to diuresis in patients with acute renal failure. Broad casts have been referred to as "renal failure casts" due to the severity of disease process thought to be associated with their formation.

Organisms

Normal bladder urine is sterile. The distal urethra and genital tract harbor bacteria and voided or catheterized urine samples may be contaminated with bacteria from the distal urethra, genital tract,

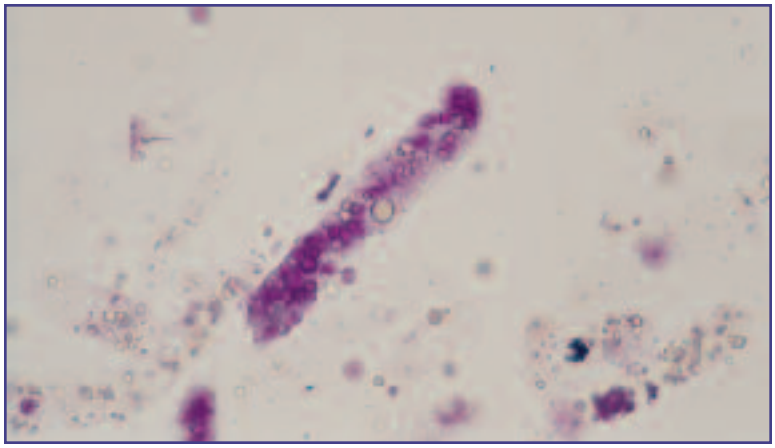


Figure 3.21 Several hyaline casts and one mixed cast comprised of hyaline, refractile droplet, and cellular components. (Sedi-Stain; 400 X)

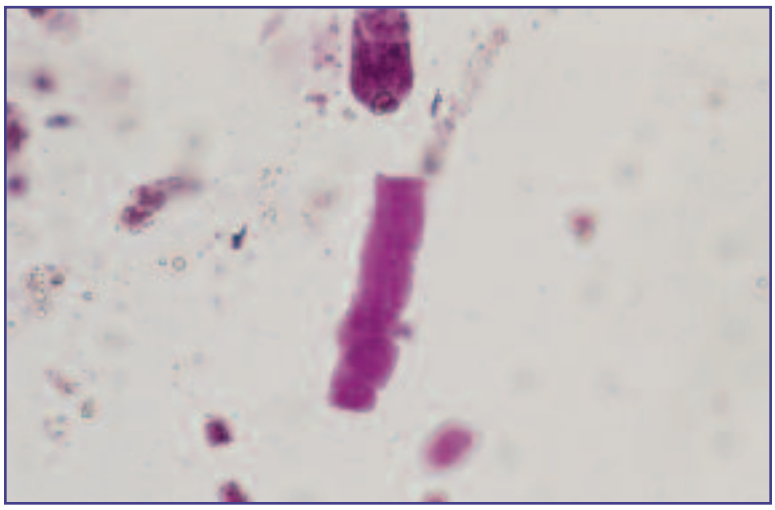


Figure 3.22 Waxy and granular casts in urine sediment. Note the translucent nature of the waxy cast. This feature sometimes leads to confusion with hyaline casts, which are transparent. (Sedi-Stain; 400 X)

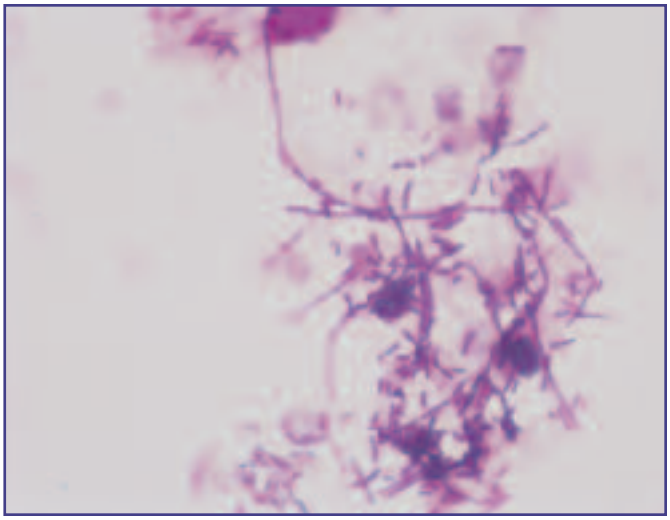


Figure 3.23 Many filamentous rod-shaped organisms in the urine sediment. Bacterial urine culture yielded large numbers of *Escherichia coli*. Enteric organisms may assume a filamentous conformation when growing in urine. (Sedi-Stain; 400 X)

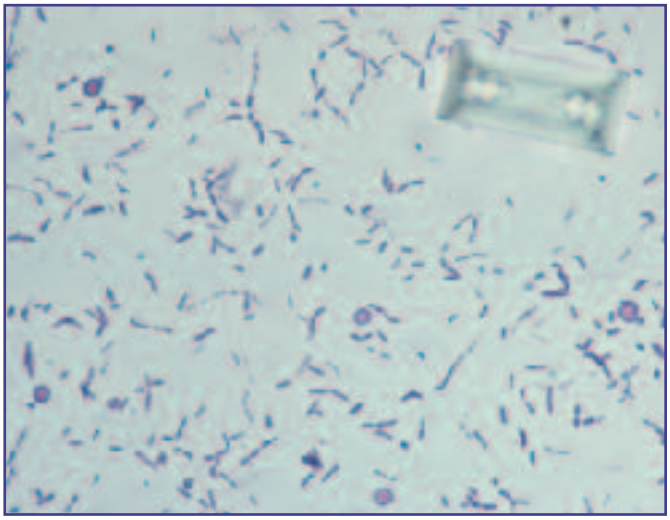


Figure 3.24 Many rod-shaped bacteria and a few RBCs in the urine sediment. Note the presence of one large struvite crystal. The occurrence of many bacteria in the absence of WBCs (pyuria) should raise suspicion of bacterial contamination of the urine sample. (Sedi-Stain; 100 X)

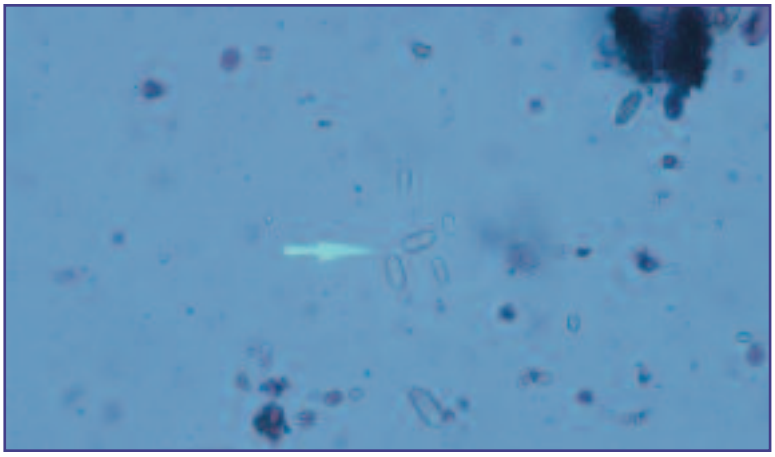


Figure 3.25 Oval yeast organisms in the urine sediment. Yeast organisms in urine sediments usually are contaminants present in the stain or acquired during voiding. (Sedi-Stain; 400 X) (*Courtesy Dr. Michael Horton*)

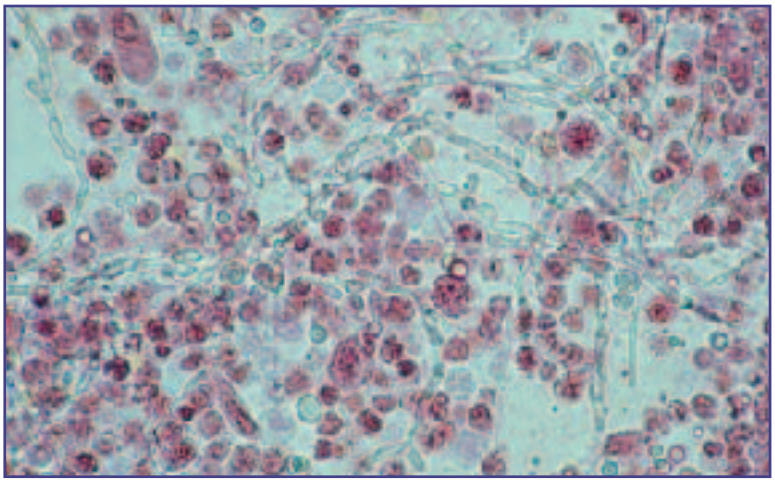


Figure 3.26 Numerous WBCs in varying stages of degeneration and a few transitional epithelial cells. Many non-staining septate hyphae are present in the background. Usually fungal elements observed in the urine sediment are artifacts, but this sample was obtained from a dog with fungal urinary tract infection. (Sedi-Stain; 160 X)

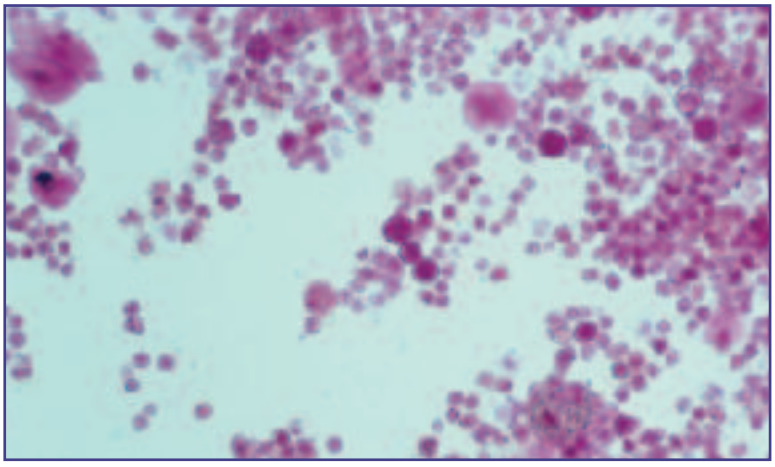


Figure 3.27 Many WBCs in varying stages of degeneration and a few epithelial cells (squamous and transitional). A budding *Blastomyces* organism is present at the center of the field. This urine sediment was obtained from a dog with systemic blastomycosis and urogenital involvement. (Sedi-Stain; 100 X) (*Courtesy Dr. James Brace*)

or skin. Contamination from the urethra in voided or catheterized specimens usually does not result in large enough numbers of bacteria to be visualized microscopically in the urine sediment. If allowed to incubate at room temperature, however, these contaminants may proliferate. It is easier to confirm the presence of rod-shaped bacteria than cocci. Enteric bacteria sometimes assume a filamentous form while growing in urine (*Fig. 3.23*). It is important not to confuse these bacteria with fungal hyphae.

Particulate debris in the sediment (eg, cellular debris, small lipid droplets, small crystals) may be confused with bacteria and cause false-positive results. Dry mount cytology or Gram staining can be used to confirm the presence of bacteria. Also, the bottle of stain may be contaminated with bacteria. Contaminated stain as the source of the organisms can be eliminated by microscopic examination of a drop of stain alone.

The presence of large numbers of bacteria in urine collected by catheterization or cystocentesis suggests the presence of urinary tract infection. Usually, there is accompanying pyuria. The finding of substantial numbers of bacteria in urinary sediment without an associated cellular response suggests contamination of the urine sample or prolonged delay from the time of sample collection until analysis without preservatives or refrigeration (*Fig. 3.24*).

Yeast and fungal hyphae in the sediment usually are contaminants (*Fig. 3.25*). Fungal urinary tract infection occurs rarely in dogs and cats, and usually is seen in urinary tract obstruction or with prolonged use of antimicrobial agents or immunosuppressive therapy (*Fig. 3.26*). Systemic mycoses (eg, blastomycosis) may be identified by examination of the urine sediment if the urinary or genital tract has been colonized by the organism (*Fig. 3.27*).

Crystals

The observation of crystals in urine sediment depends on a number of factors: the extent of urinary saturation with crystal precursors, urine pH, total urine solute concentration (ie, urine specific gravity), presence of crystal promoters and inhibitors in the urine, time between collection

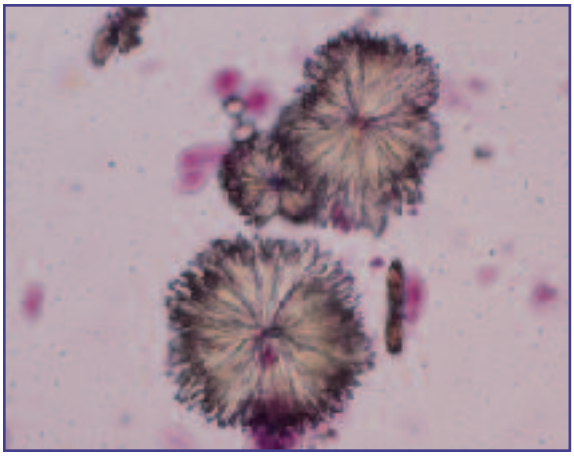


Figure 3.28 Sulfonamide crystal in urine sediment of a dog treated with trimethoprim-sulfadiazine. (Sedi-Stain; 400 X)

and analysis, and refrigeration before analysis. Crystalluria often is present in urine that has been refrigerated, but may not be observed in the same urine sample if analyzed soon after collection. Cyrstalluria in urine that has been refrigerated is of little clinical significance..

Struvite, amorphous phosphates, and oxalates are examples of crystals that may be found in normal urine samples. Uric acid, calcium oxalate, and cystine typically are found in acidic urine whereas struvite ($MgNH_4PO_4 \bullet 6H_2O$ or "triple phosphate"), calcium phosphate, calcium carbonate, amorphous phosphate, and ammonium biurate typically are found in alkaline urine. Characteristic crystals also may be found in the urine sediment of animals receiving specific drugs, especially sulfonamides (*Fig. 3.28*). Bilirubin crystals may be found in concentrated samples of normal dog urine. Urates are commonly observed in the urine of Dalmatian dogs and may be seen in the urine of animals with liver disease or portosystemic shunts. Struvite crystals may be observed in the urine of cats with idiopathic or interstitial cystitis without pathophysiologic significance, in dogs and cats with struvite urolithiasis, or in the urine of normal animals. In the presence of oliguric acute renal failure, the presence of calcium oxalate crystals is highly suggestive of ethylene glycol intoxication (*Fig. 3.29*). Calcium oxalate crystals also may be observed in the urine of animals with calcium oxlalate urolithiasis. The presence of cystine crystals in urine of dogs and cats is abnormal and suggestive of cystinuria.

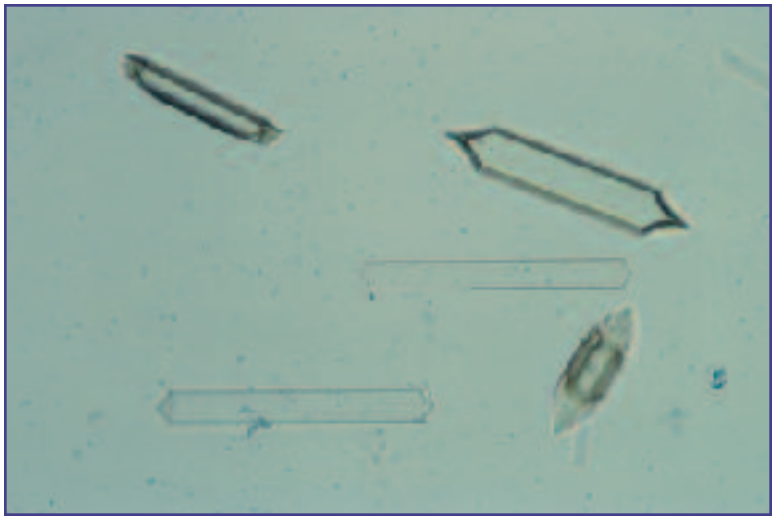


Figure 3.29 Calcium oxalate crystals (monohydrate form). These oxalate crystals have the classic "picket fence" form. Also present is an oxalate crystal with the "hemp seed" appearance with a budding daughter crystal. (Unstained; 400 X)

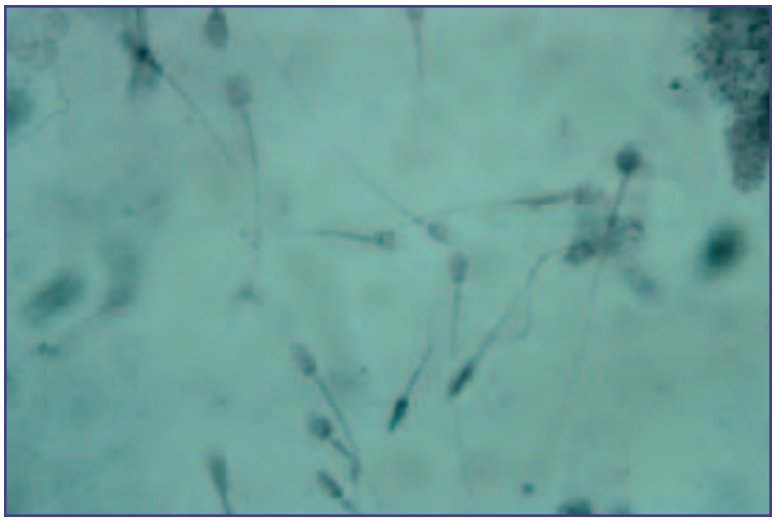


Figure 3.30 Spermatozoa in urine sediment. Spermatozoa may be observed in the urine of male dogs. (Unstained; 400 X)

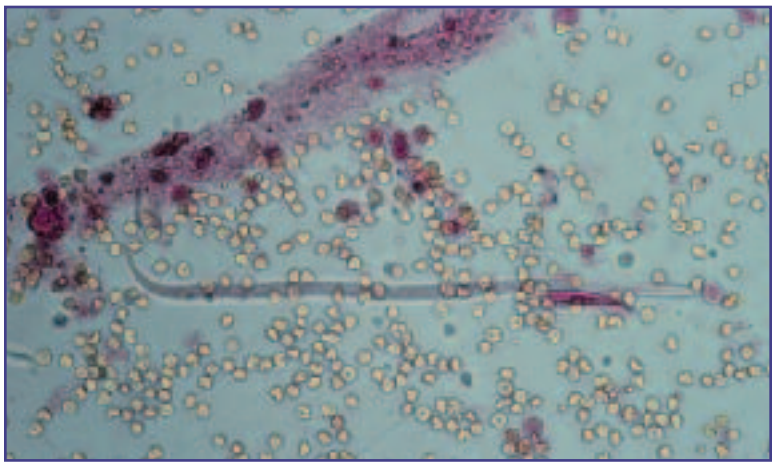


Figure 3.31 Microfilaria of *Dirofilaria immitis* in the urine sediment. Many RBCs also are present. Microfilaria observed in the urine sediment are an artifact of the presence of blood in urine. (Sedi-Stain; 400 X)

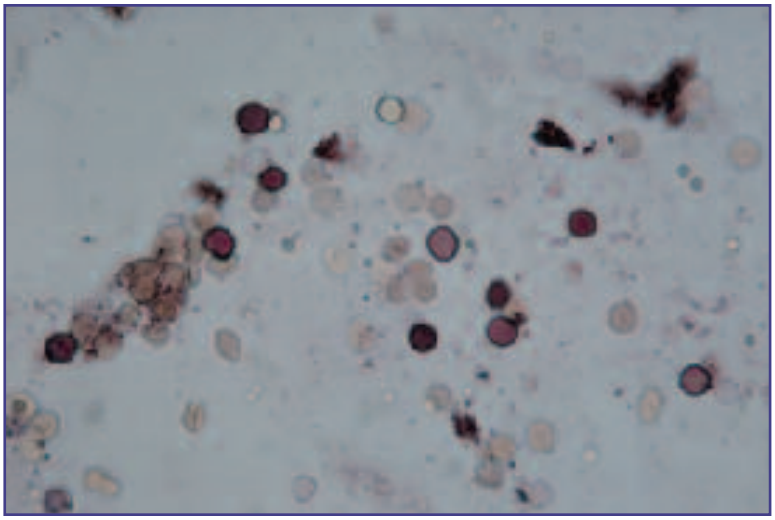


Figure 3.32 Refractile lipid droplets and RBCs in urine sediment. Refractile lipid droplets may be confused with RBCs. Lipid droplets are a normal finding in urine from cats. (Sedi-Stain; 400 X)

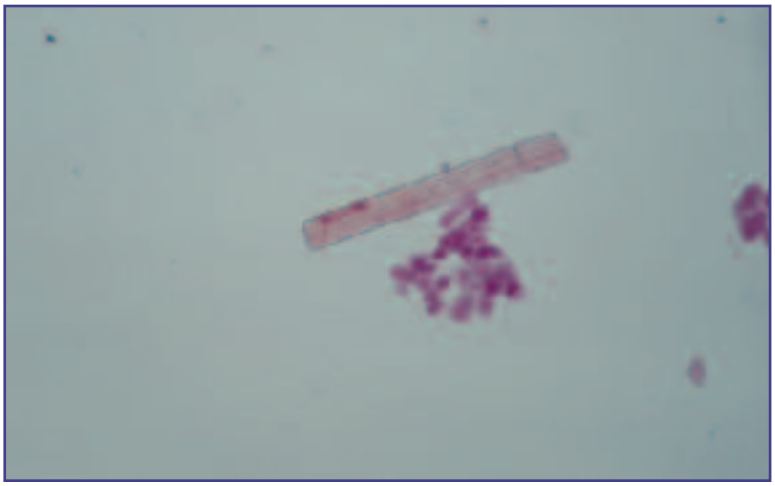


Figure 3.33 Fiber artifact in urine sediment that may be confused with a cast. Note that the sides of the fiber are perfectly parallel and that there are parallel internal lines. Neither of these features would be found in a cast. (Sedi-Stain; 100 X)

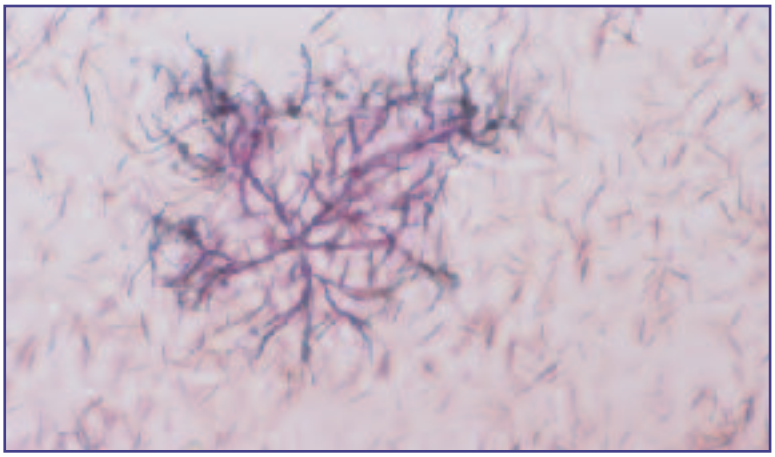


Figure 3.34 Precipitated stain in urine sediment may be confused with crystals, fungi, or bacteria. These precipitated stain crystals often are found at the edge of the coverslip. (Sedi-Stain; 400 X)

Other Elements

Sperm may be found in urine samples taken by cystocentesis from intact male cats and dogs (*Fig. 3.30*). Some regurgitation of sperm into bladder urine is considered normal. Amorphous debris may be a normal finding in some urine samples. Mucus threads may occur in urine from normal animals and may be present in increased numbers in animals with inflammatory conditions of the urogenital tract.

Rarely, ova of *Dioctophyma renale* or *Capillaria plica* or microfilaria of *Dirofilaria immitis* (*Fig. 3.31*) may be found in the urine sediment. Care must be taken to be certain that fecal contamination of urine has not occurred when evaluating ova in urine. Refractile lipid droplets may occur in diabetes mellitus or nephrotic syndrome. They also may be observed in cats due to degeneration of lipid-laden tubular cells (*Fig. 3.32*).

Many artifacts can be present in the urine sediment which may confuse interpretation. Foreign material often enters the urine during collection of a voided or catheterized sample. Plant matter, spores, fibers (*Fig. 3.33*), straw, hair, surgery glove powder, and fecal contamination also may be seen. Lubricants used to facilitate catheterization may contribute refractile droplets to the urine sediment. Stain precipitates may be confused with bacteria. Old, unfiltered stain may result in unusual crystals in the urine sediment, particularly near the coverglass edge (*Fig. 3.34*). Squamous

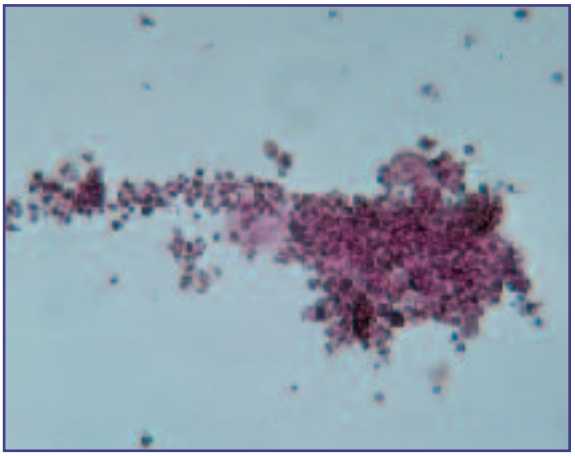


Figure 3.35 So-called pseudocast created by the accumulation of WBCs along a mucus thread. (Sedi-Stain; 100 X) (***Courtesy Dr. Richard Scott***)

epithelial cells may roll on themselves and create elements that resemble casts ("pseudocasts"). Mucus strands may cause cells in the sediment to appear in a linear array resembling a cellular cast (*Fig. 3.35*). Close inspection will reveal the irregularity of these clumps, and often these clumps are recognized to be too large and non-linear to be casts.

CASE 1

SIGNALMENT: 6-year-old neutered male Poodle

HISTORY: Owner reports blood in the dog's urine (intermittently for almost one year before this visit); owner has not observed any increased frequency or straining to urinate; no history of trauma; dog shows no discomfort; normal appetite and attitude.

P.E.: The dog was bright and alert and in good body condition. There were a few small cutaneous masses suspected to be sebaceous adenomas and a few small subcutaneous masses thought to be lipomas. There was moderate dental tartar and lenticular sclerosis in both eyes. A II/VI left apical systolic murmur was auscultated. Abdominal palpation was normal and no prostate gland could be felt on rectal examination.

URINALYSIS:

Specimen: Cystocentesis Refrigerated: No
Color: Brown Appearance: Opaque

Sp. gr.	1.039	**Casts**	
pH	7.0	Granular	rare/lpf
Protein	100 mg/dl	**WBC**	5-7/hpf
Occ. blood	4+	Clumped	No
Glucose	Negative	**RBC**	Too numerous to count/hpf
Ketones	Negative		
Bilirubin	Negative	**Epithelial**	7-10/hpf
		Squamous/Medium	
		Clumped	No
		Crystals	None
		Bacteria	None

Initial Assessment

This dog demonstrated painless hematuria, which should lead to the suspicion of upper urinary tract disease. Differential diagnosis would include renal neoplasia, nephrolithiasis, renal pelvic blood clot from trauma, and benign essential renal hematuria. The proteinuria and slightly increased number of leukocytes in the dog's urine could reflect hemorrhage into the urinary tract but bacterial infection should be ruled out by culture.

Presumptive Diagnosis

Hematuria of renal origin.

Diagnostic Plan

A urine sample collected by cystocentesis was submitted for bacterial culture and results were negative. A hemogram was performed and was normal except for moderately severe microcytic hypochromic anemia (PCV 23%, MCV 50 fl, MCHC 28 g/dl) compatible with chronic blood loss. A biochemical profile was performed to evaluate for systemic disease and it was within normal limits. Plain radiographs and abdominal ultrasonography were performed to evaluate the kidneys for structural disease and both studies were normal. Excretory urography was performed and also was normal. A clotting profile and buccal mucosal bleeding time were performed to rule out systemic coagulopathy and both were within normal limits.

Outcome

An exploratory laparotomy was performed. The urine in the bladder was hemorrhagic but no mucosal lesions of the bladder were detected. A catheter was passed into the left ureter and normal-appearing urine was observed to come from the catheter. Another catheter was passed into the right ureter and turbid red urine was observed. A right nephrectomy was performed. The dog recovered uneventfully and hematuria resolved within one week of surgery. The animal was released from the hospital on iron supplementation. At re-evaluation 6 months later, the anemia had resolved. The final diagnosis was benign renal hematuria.

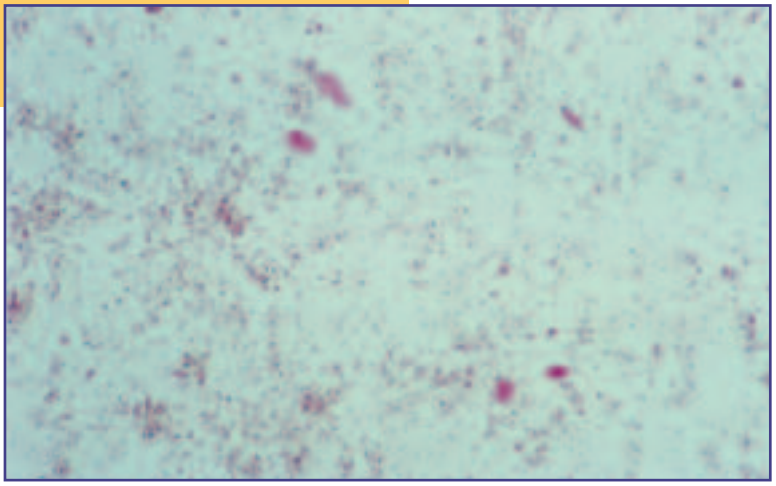


Figure 4.1 Low power view of urine sediment showing too numerous to count RBCs, several WBCs, and a few squamous epithelial cells. (100X)

CASE 2

SIGNALMENT: 3-year-old spayed female Domestic Shorthair cat

HISTORY: Owner reports cat is urinating outside the litterpan in several locations for the past year; cat has demonstrated pollakiuria, stranguria, and occasionally hematuria over the past 4 days; no medications in the past 3 months; owner reports cat is otherwise healthy; cat eats a commercial diet formulated to acidify the urine.

P.E.: Normal except for resistance to palpation of the urinary bladder. The bladder contains a small amount of urine and the bladder wall feels normal. Nothing is palpable in the bladder lumen.

URINALYSIS:

Specimen: Cystocentesis Refrigerated: No
Color: Dark amber Appearance: Cloudy

Sp. gr.	1.039	**Casts**	None
pH	6.5	**WBC**	1-3/hpf
Protein	100 mg/dl	Clumped	No
Occ. blood	2+	**RBC**	15-20/hpf
Glucose	Negative	**Epithelial**	1-3/hpf
Ketones	Negative	Transitional/Medium	
Bilirubin	Negative	Clumped	No
		Crystals	Struvite/Few
		Bacteria	Cocci/Moderate

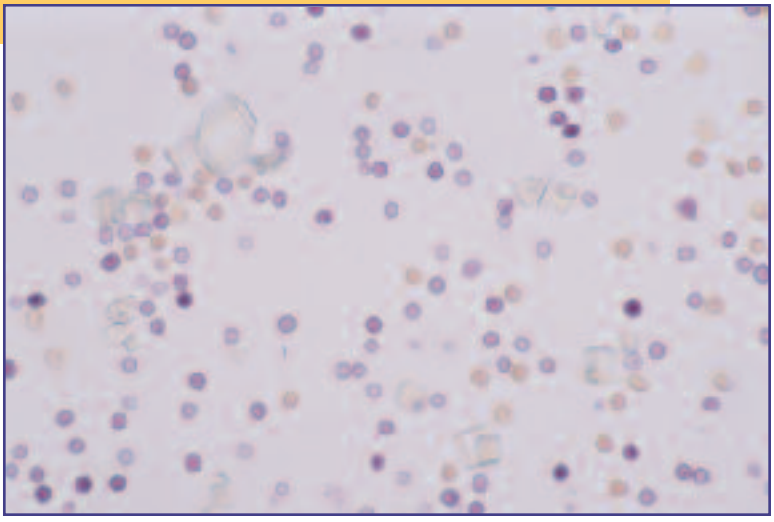


Figure 4.2 **Red blood cells in urine. Several struvite crystals also are present. Note variable intensity of staining of RBCs. (Sedi-Stain; 100 X)**

Initial Assessment

Total urine solute concentration (ie, specific gravity) lies in the range typically seen in cats that eat dry food; the urine is moderately acidic. Proteinuria and occult blood are detected on the dip stick and microscopic hematuria is verified in the urinary sediment.

The excess number of red blood cells on sediment examination could be from lower urinary tract disease or from trauma during the collection of urine by cystocentesis. However, collection of the urine was uneventful and trauma during collection was considered unlikely. An occasional small epithelial cell and a few white blood cells were observed in the sediment. Moderate numbers of cocci were reported. Caution must be used in the interpretation of reported bacteria because many artifacts in urine can be misinterpreted as bacteria, especially in cats. Brownian motion of small particles in urine sometimes leads to misinterpretation of these particles as bacteria. Small crystals, lipid droplets, cellular debris, mucus threads, and precipitated stain can all resemble bacteria. Bacterial urinary tract infections are rare in cats less than 10 years of age, especially in cats with highly concentrated urine that have not been catheterized or have not undergone urinary tract surgery (eg, perineal urethrostomy). It also would be unusual for this cat to have bacterial urinary infection in the absence of pyuria. Idiopathic cystitis occurs in over 60% of cats presenting with signs of irritative voiding associated with lower urinary tract disease.

Presumptive Diagnosis

Idiopathic cystitis or urolithiasis. (Bacterial urinary tract infection is considered very unlikely.)

Diagnostic Plan

Plain abdominal radiographs should be taken to rule out the presence of struvite or calcium oxalate uroliths not detected during abdominal palpation. Gram stain and urine culture can be performed to rule out bacterial urinary tract infection because "cocci" were described in the urinary sediment.

Outcome

Abdominal radiographs were normal (ie, no radiopaque uroliths were observed). Gram stain did not confirm the presence of bacterial organisms and urine culture returned with no growth of bacteria. The cocci described in the urinary sediment apparently were artifacts. Reports of bacteria on urine sediment examination that are not substantiated by bacterial culture of urine are common. This cat was diagnosed as having idiopathic cystitis rather than bacterial urinary tract infection. Crystalluria need not be present to diagnose idiopathic cystitis and most cats with this disorder have few or no crystals in their urine sediment, especially when consuming diets designed to promote urinary acidification.

CASE 3

SIGNALMENT: 9-year-old spayed female German Shepherd

HISTORY: Owner reports increased frequency and straining to urinate over the past 3 days, some blood in the dog's urine, and an unusually strong odor; owner reports no change in water consumption or daily urine volume output; normal appetite and attitude; urine sample collected by owner.

P.E: Temperature, pulse, and respiration were within normal limits. The dog is bright, alert, and hydration seems normal based on skin turgor. Mild mucopurulent vaginal discharge is noted. The bladder seems small and possibly thickened on abdominal palpation, and the dog is very uncomfortable during palpation of the bladder.

URINALYSIS:

Specimen: Voided, floor/table/cage Refrigerated: Yes
Color: Brown Appearance: Cloudy

Sp. gr.	1.024	**Casts**	None
pH	8.0	**WBC**	20-30/hpf
Protein	100 mg/dl	Clumped	Yes
Occ. blood	3+	**RBC**	20-30/hpf
Glucose	Negative	**Epithelial**	4-6/hpf
Ketones	Negative	Transitional and squamous/Large and medium	
Bilirubin	Negative	Clumped	No
		Crystals	None
		Bacteria	Cocci/Few

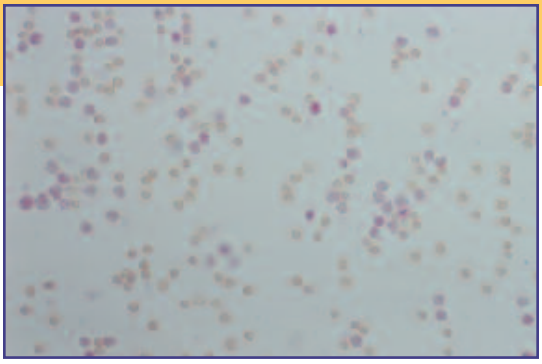


Figure 4.3 Many RBCs and several WBCs in urine sediment stained with Sedi-Stain. (400 X)

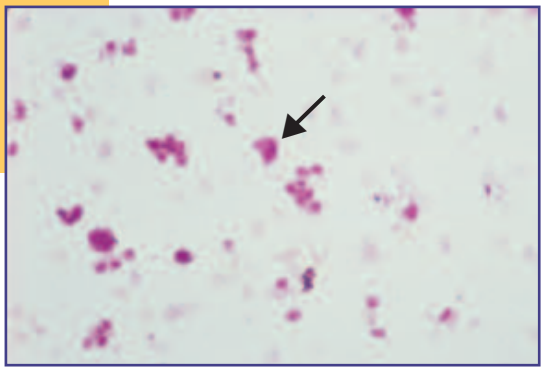


Figure 4.4 WBCs, a few epithelial cells, and many pale-staining RBCs in the urine sediment. Note the single squamous epithelial cell in the center of the field (arrow). The presence of multilobulated nuclei in the WBCs allows their identification as neutrophils. (Sedi-Stain; 100 X)

Initial Assessment

The pyuria observed in the urine sediment along with the clinical signs are compatible with a bacterial urinary tract infection. The bacteria observed in the urine sediment also are supportive, but the clinician should remember that particulate matter in the urine sediment (eg, stain particles) can be misinterpreted as bacteria. (Skepticism is warranted when "bacteria" are reported in the urine sediment in the absence of pyuria.) Clumping of leukocytes in the urine often supports an underlying bacterial etiology. Contamination from the genital tract also must be considered because the sample was voided and the dog had a mucopurulent vaginal discharge. The high urine pH (8.0) is compatible with infection by a urease-producing organism (eg, *Staphylococcus aureus*, *Proteus* spp). In this setting, urea is hydrolyzed to ammonium and carbonate ions. The carbonate ions bind hydrogen ions and remove them from solution resulting in more alkaline urine. Infection by cocci is suspected based on the appearance of the bacterial organisms in the urine sediment.

Presumptive Diagnosis

Bacterial urinary tract infection, suspect *Staphyloccus aureus*.

Diagnostic Plan

Urinalysis on another urine sample collected by another method would be helpful. In instances of suspected bacterial urinary tract infection, samples collected by cystocentesis are preferable to avoid confusion about contamination from the lower urogenital tract. A portion of the urine sample collected by cystocentesis should be submitted for bacterial culture and sensitivity testing. A Gram stain could be performed on urine sediment to identify Gram-positive or Gram-negative organisms while awaiting culture results. Given the age of the dog, if response to treatment is poor, the clinician should consider additional diagnostic testing (eg, radiography, ultrasonography, urine cytology) to rule out urolithiasis or urinary tract neoplasia.

Outcome

The dog was released on a course of amoxicillin while awaiting urine culture results. Three days later, the quantitative urine culture returned with a count of greater than 30,000 colony-forming units per ml of urine (cfu/ml) of *Staphylococcus aureus*. Greater than 1,000 cfu/ml in a properly collected and handled urine sample (collected by cystocentesis) supports a diagnosis of bacterial urinary tract infection. The dog's clinical signs resolved after a two-week course of amoxicillin.

CASE 4

SIGNALMENT: 3-year-old intact male Great Dane
HISTORY: Vomiting and anorexia of 1 week duration; owner reports dark urine over past few days; no history of trauma; no exposure to rodenticides.
P.E.: The dog was painful on abdominal palpation and the spleen was markedly enlarged. The mucous membranes were slightly pale.

URINALYSIS:

Specimen: Catheterized Refrigerated: No
Color: Dark brown Appearance: Turbid

Sp. gr.	1.025	**Casts**	
pH	6.5	Granular	3-4/lpf
Occ. blood	3+	**WBC**	3-6/hpf
Protein	100 mg/dl	Clumped	No
Glucose	Negative	**RBC**	10-20/hpf
Ketones	Negative	**Epithelial**	3-6/hpf
Bilirubin	Negative	Transitional/Medium	
		Clumped	No
		Crystals	None
		Bacteria	None

Miscellaneous: Precipitated hemoglobin

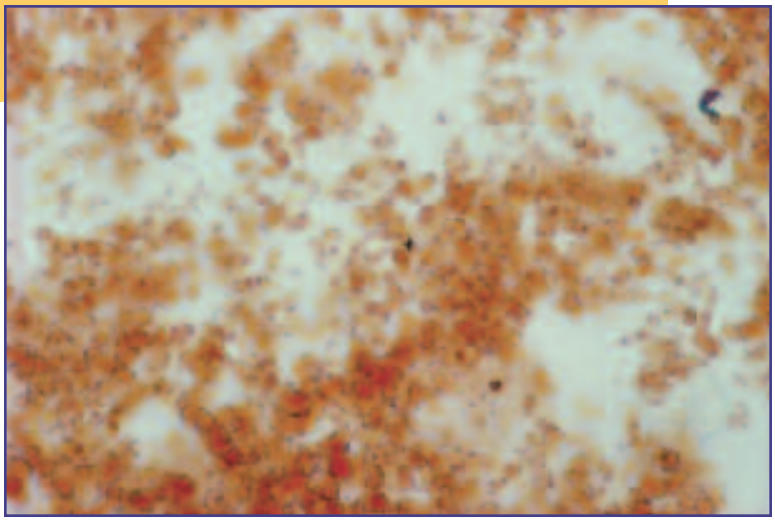


Figure 4.5 **Precipitated hemoglobin in urine sediment. Care should be taken not to confuse precipitated hemoglobin in the urine sediment with RBCs. Note extreme variable in particle size and characteristic orange color. (Sedi-Stain; 100 X)**

Initial Assessment

The urine is moderately concentrated. The strong occult blood reaction is due to the presence of hemoglobin and red cells in the urine sediment. Precipitated hemoglobin in the urine sediment can sometimes be confused with red blood cells, therefore, the sediment should be reviewed to confirm that the reported red blood cells do not represent precipitated hemoglobin. Hemoglobinuria can be associated with several conditions in dogs including transfusion reaction, disseminated intravascular coagulation, postcaval dirofilariasis syndrome, heat stroke, zinc toxicity, severe hypophosphatemia, red cell enzyme deficiencies, and autoimmune hemolytic anemia. The young age of the dog and the presence of splenomegaly on physical examination led to suspicion of splenic torsion. The presence of granular casts in the urine sediment led to concern about hemoglobinuric nephrosis.

Presumptive Diagnosis

Splenic torsion with hemoglobinuria and possible hemoglobinuric nephrosis.

Diagnostic Plan

Blood was submitted for a hemogram and biochemical profile. Abdominal radiographs and ultrasonography were scheduled for evaluation of the suspected splenomegaly. A heartworm test, direct Coombs' test, and test for fibrin degradation products were submitted.

Outcome

The hemogram disclosed moderate anemia (PCV 27%) with target cells, polychromasia, and red cell fragmentation. The platelet count was 78,000/µl and fibrin degradation products were detected in serum. A biochemical profile was normal except for a mild increase in alkaline phosphatase (178 IU/l). The heartworm and Coombs' tests were negative. The radiographs disclosed marked splenomegaly and ultrasonography showed diffuse enlargement of the spleen with uniform echogenicity. Exploratory laparotomy revealed splenic torsion and splenectomy was performed. Renal damage as indicated by the presence of granular casts was subclinical and azotemia did not develop in this dog. The mechanism of hemolysis and hemoglobinuria in splenic torsion is unknown but may be due to microangiopathy and damage to red cells by intraluminal fibrin strands. This is supported by the presence of red cell fragments on the hemogram. The presence of thrombocytopenia and fibrin degradation products support a diagnosis of concurrent disseminated intravascular coagulation.

CASE 5

SIGNALMENT: 7-year-old spayed female Domestic Shorthair cat

HISTORY: Owner reports that the cat has stopped eating during the past week and is less active; owner unsure of water consumption and urine output (but had not noted any increased amounts of wet litter in the box); mild weight loss over the past several months.

P.E.: The cat was slightly thin and had reduced skin turgor. The kidneys were slightly small and irregular and the cat resisted palpation. A small thyroid nodule on the left side was suspected on palpation of the neck. The bladder was moderately full. The cat had a grade II/VI right sternal border systolic murmur.

URINALYSIS:

Specimen: Cystocentesis Refrigerated: No
Color: Straw Appearance: Slightly cloudy

Sp. gr.	1.019	**Casts**	None
pH	6.5	**WBC**	30-40/hpf
Protein	100 mg/dl	Clumped	Yes
Occ. blood	1+	**RBC**	10-15/hpf
Glucose	Negative	**Epithelial**	5-7/hpf
Ketones	Negative	Transitional/Medium	
Bilirubin	Negative	Clumped	No
		Crystals	None
		Bacteria	Rods/Few

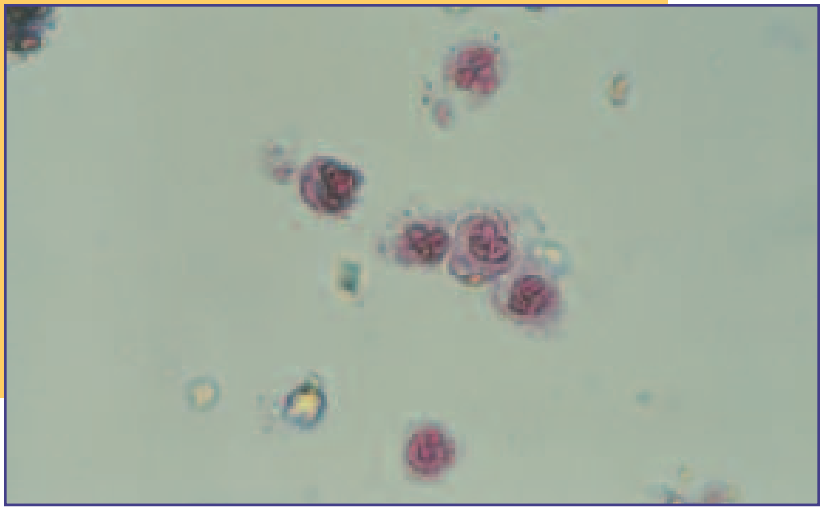


Figure 4.6 **Clump of neutrophils. The finding of clumps of WBCs should prompt a search for bacterial urinary tract infection as the underlying cause of clumping. (Sedi-Stain; 100 X)**

Initial Assessment

The presence of relatively dilute urine in a cat with historical and physical findings suggestive of dehydration is of concern. The presence of pyuria and bacteriuria in a urine sample collected by cystocentesis suggests bacterial urinary tract infection, and in the presence of small irregular kidneys that are painful on palpation, the clinician should be concerned about the possibility of acute pyelonephritis superimposed on chronic interstitial renal disease. The positive occult blood reaction and mild hematuria could be a consequence of cystocentesis or could be related to the underlying urinary tract disease. The proteinuria is relatively mild and compatible with inflammatory disease of the urinary tract.

Presumptive Diagnosis

Renal failure due to acute pyelonephritis superimposed on chronic renal disease; probable hyperthyroidism with non-thyroidal illness.

Diagnostic Plan

Blood was submitted for a hemogram, biochemical profile, and serum thyroxine concentration. Urine collected by cystocentesis was submitted for bacterial culture and abdominal ultrasonography was performed. The hemogram disclosed leukocytosis (41,000/µl) due to neutrophilia (37,000/µl) and a left shift (2,000 bands/µl). The PCV (28%) and plasma proteins (7.6 g/dl) were normal. The biochemical profile disclosed azotemia (BUN 68 mg/dl, creatinine 4.1 mg/dl), mild hyperphosphatemia (8.5 mg/dl), decreased serum bicarbonate (10 mEq/l), and mild hypokalemia (3.2 mEq/l). Abdominal ultrasonography showed that the kidneys were slightly smaller than normal and had increased medullary echogenicity. Mild renal pelvic dilatation also was noted. Serum thyroxine concentration was 2.1 µg/dl. Bacterial culture of the urine grew more than 30,000 cfu/ml of *E coli*.

Outcome

The cat was treated with intravenous lactated Ringer's solution supplemented with 30 mEq/l of KCl, famotidine, and intravenous sodium cephalothin. There was improvement in the cat's attitude and appetite over the next 4 days. The cat was released to the owner with instructions to return for re-evaluation in 10 to 14 days. At re-evaluation, the cat was doing well and had a good appetite. A hemogram showed resolution of the leukocytosis but the PCV was now mildly decreased (21%). The biochemical profile showed

Continued

improvement in azotemia (BUN 43 mg/dl, creatinine 2.6 mg/dl) and resolution of hypokalemia, metabolic acidosis, and hyperphosphatemia. Urinalysis on a urine sample collected by cystocentesis showed resolution of pyuria and no bacteria were observed. Urine specific gravity was 1.017. These findings are compatible with successful treatment of acute pyelonephritis superimposed on underlying chronic interstitial renal disease, possibly chronic pyelonephritis. It is likely that the cat is hyperthyroid but that the serum thyroxine concentration is within the normal range due to nonthyroidal illness. The cat's thyroid condition should be monitored at the present time but not treated. If the renal function remains stable, the clinician could consider a trial of methimazole at a low dosage (2.5 mg q24h or q12h) while carefully monitoring renal function. In many cats with stable chronic renal failure, treatment of hyperthyroidism exacerbates renal failure.

CASE 6

SIGNALMENT: 3-year-old intact male German Shepherd

HISTORY: Presented to emergency service for acute onset of vomiting and severe lethargy; owner reports rapid breathing and possible exposure to antifreeze.

P.E.: Temperature 100.1° F. The dog was lethargic and estimated to be 7% dehydrated based on skin turgor and dryness of mucous membranes.

URINALYSIS:

Specimen: Voided, floor/table/cage Refrigerated: No
Color: Light yellow Appearance: Cloudy

Sp. gr.	1.010	**Casts**	
pH	6.5	Cellular	3-5/lpf
Protein	30 mg/dl	**WBC**	0-1/hpf
Occ. Blood	Trace	Clumped	No
Glucose	Negative	**RBC**	3-5/hpf
Ketones	Negative	**Epithelial**	5-10/hpf
Bilirubin	Negative	Transitional/Small	
		Clumped	No
		Crystals	None
		Bacteria	None

Miscellaneous: Many sperm

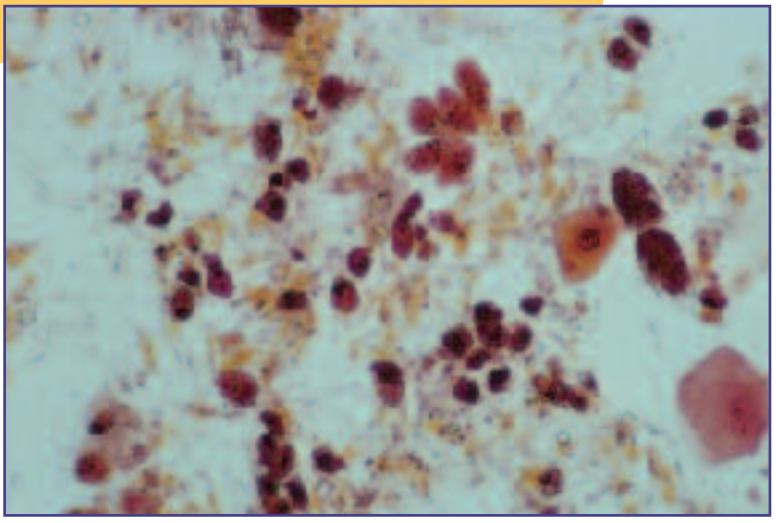


Figure 4.7 **Large number of small epithelial cells and a few large squamous epithelial cells in urine sediment. Some of the small epithelial cells are oval and others are cuboidal. The small size of the cells and the presence of eccentric nuclei suggest possible renal origin. Cells with similar appearance were also observed in cellular casts in this animal, supporting renal origin of the epithelial cells. The final diagnosis was ischemic acute tubular necrosis. Many sperm are noted in the background. (Sedi-Stain; 100 X)**

Initial Assessment

The low urine specific gravity in association with dehydration indicates a renal concentrating defect that could be caused by a number of different disorders including ethylene glycol intoxication. A thorough search of the urine sediment did not disclose any calcium oxalate dihydrate or monohydrate crystals. However, absence of oxalate crystalluria does not exclude a diagnosis of ethylene glycol intoxication. (Some animals with ethylene glycol intoxication have oxalate crystalluria within 6 hours of toxin ingestion.) The presence of a large number of free small epithelial cells and epithelial cell casts indicates that the kidneys are being actively damaged by some disease process (eg, nephrotoxins, ischemia, nephritis).

Presumptive Diagnosis

Ischemic or nephrotoxic renal damage, possibly associated with renal failure; pre-renal azotemia may also be a contributing factor.

Diagnostic Plan

Dehydration was rapidly corrected and the extracellular fluid volume expanded by intravenous administration of lactated Ringer's solution to improve renal perfusion. Serum biochemistry profile, hemogram, and abdominal imaging by radiographs and ultrasound were recommended. Serology for leptospirosis could be considered if routine testing is non-diagnostic.

Outcome

The dog became progressively weaker and collapsed. The heart sounds were muffled and thoracic radiographs disclosed an enlarged cardiac silhouette. Gas-filled bowel loops were observed in the pericardial sac resulting in a diagnosis of pericardiodiaphragmatic hernia. Serum creatinine concentration was 3.7 mg/dl and BUN was 120 mg/dl. The hematocrit was 54% and total protein concentration was 8.1 g/dl. Surgery was performed to decompress the hernia. The BUN and serum creatinine concentrations returned to normal within 72 hours after surgery and the hematocrit and total protein concentrations also returned to normal 24 hours after beginning fluid therapy. The initial azotemia was considered prerenal because it resolved with fluid therapy. The presence of free renal tubular epithlial cells and epithelial cell casts in the urine sediment suggest that renal ischemia was contributing to renal injury in this dog.

CASE 7

SIGNALMENT: 10-year-old spayed female mixed-breed dog

HISTORY: Owner reports that over the past several months the dog takes a longer time to urinate; in the past few weeks, owner observed straining to urinate and a small amount of blood in the urine, and licking at vulvar area (which had not been observed previously); appetite and attitude are normal.

P.E.: The dog was bright and alert and in good body condition. There was moderately severe dental tartar and lenticular sclerosis in both eyes. No abnormalities were detected on abdominal palpation and thoracic auscultation. A rectal examination was performed and a firm irregular focal thickening of the urethra (approximately 1.5 cm diameter) was palpated in the urethra on the pelvic floor.

URINALYSIS:

Specimen: Voided, midstream Refrigerated: No
Color: Amber Appearance: Cloudy

Sp. gr.	1.031	**Casts**	None
pH	7.5	Clumped	No
Protein	100 mg/dl	**WBC**	15-20/hpf
Occ. blood	2+	**RBC**	20-30/hpf
Glucose	Negative	**Epithelial**	15-20/hpf
Ketones	Negative	Transitional and squamous/	
Bilirubin	Negative	Large and medium	
		Clumped	Yes
		Crystals	None
		Bacteria	None

Initial Assessment

The history and physical examination findings in this dog were suggestive of a urethral neoplasm. The urinalysis results on a voided urine sample indicated presence of inflammation and hemorrhage. The pyuria could also be the result of a complicating bacterial urinary tract infection. There were increased numbers of clumped transitional epithelial cells but no comment was made about their morphology.

Presumptive Diagnosis

Urethral tumor, probable transitional cell carcinoma.

Diagnostic Plan

Voided urine was submitted for cytology. Vaginoscopy was performed and a catheter was passed with minimal difficulty although resistance was encountered approximately 3 to 4 cm into the urethra. A sample of catheterized urine was submitted for bacterial culture and sensitivity and returned with 10,000 cfu/ml *E coli*. A hemogram and biochemical profile were within normal limits. Results of urine cytology showed presence of anaplastic transitional cells some of which were binucleate. Biopsy was recommended.

Outcome

A urethral biopsy was obtained by urethrocystoscopy. The urethral mucosa was roughened, irregular and pale in one focal area, presumed to be the region of the previously palpated mass. The proximal urethra, bladder neck, and bladder appeared normal except for focal hemorrhages. Histopathology of the urethral lesion returned a transitional cell carcinoma. The dog was treated with amoxicillin for the bacterial urinary tract infection and with piroxicam for its palliative effects in dogs with transitional cell carcinoma. The dog improved considerably within the first month after beginning treatment but still had some difficulty urinating. The dog did reasonably well for approximately 9 months after which time it began to lose weight, had a reduced appetite, and increased difficulty urinating. At that time, the owner elected euthanasia.

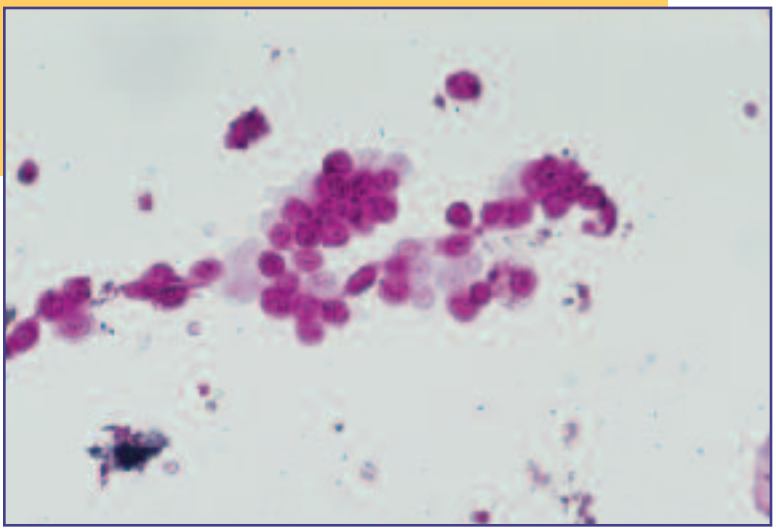


Figure 4.8 **Large clump of transitional epithelial cells in urine sediment. Clumping of cells, increased nuclear-to-cytoplasmic ratio, presence of nucleoli, and clumping of chromatin should arouse suspicion of neoplasia. The final diagnosis in this case was transitional cell carcinoma. (Sedi-Stain; 100 X)**

CASE 8

SIGNALMENT: 8-year-old spayed female Scottish Terrier

HISTORY: Owner reports recent observation of blood in the dog's urine (the urine is initially yellow and blood is observed toward the end of urination); owner reports increased frequency in urination; normal appetite and attitude.

P.E.: The dog was alert and in good body condition. There was moderately severe dental tartar. The bladder seemed thickened on abdominal palpation.

URINALYSIS:

Specimen: Voided, midstream Refrigerated: No
Color: Amber Appearance: Cloudy

Sp. gr.	1.033	**Casts**	None
pH	8.0	**WBC**	10-15/hpf
Protein	100 mg/dl	Clumped	No
Occ. blood	2+	**RBC**	15-20/hpf
Glucose	Negative	**Epithelial**	10-15/hpf
Ketones	Negative	Transitional and squamous/ Large and medium	
Bilirubin	Negative	Clumped	No
		Crystals	None
		Bacteria	Cocci/Few

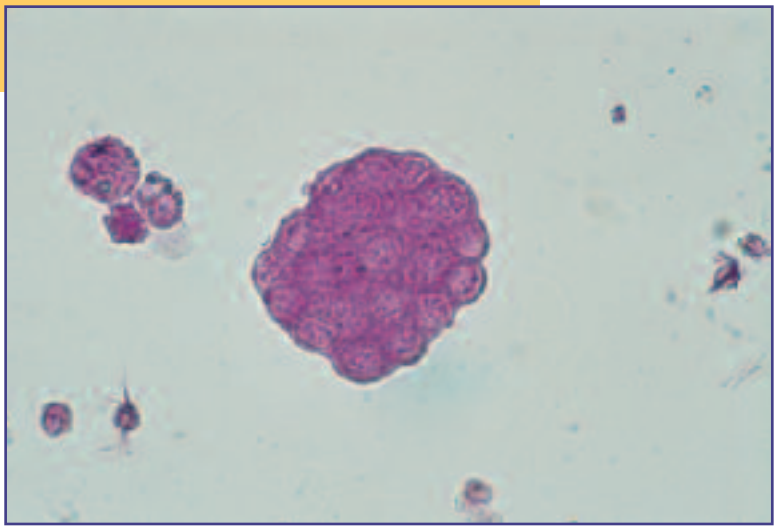


Figure 4.9 **Large clump or raft of transitional epithelial cells in urine sediment suggestive of neoplasia. Cellular detail is difficult to ascertain. The final diagnosis in this case was transitional cell carcinoma. (Sedi-Stain; 400 X)**

Initial Assessment

The history and physical examination findings in this dog could be compatible with a bladder tumor, cystic calculi, or a bacterial urinary tract infection. The urinalysis results on a voided urine sample indicated presence of inflammation and hemorrhage. The pyuria could be the result of a bacterial urinary tract infection.

Presumptive Diagnosis

Bladder neoplasia, cystic calculi or bacterial cystitis cannot be differentiated by the urinalysis findings.

Diagnostic Plan

Voided urine was submitted for cytology. A sample of catheterized urine was submitted for bacterial culture and sensitivity and returned with more than 30,000 cfu/ml *Staphylococcus aureus*. A hemogram and biochemical profile were within normal limits. Results of urine cytology showed presence of transitional cells with some atypical cytological features. Some of these cells were binucleate. Biopsy was recommended.

Outcome

A cystourethrogram was performed and disclosed a mass involving the cranioventral aspect of the bladder and protruding into the lumen of the bladder. The mass was also visualized by ultrasonography. The dog was treated with cefadroxil for the bacterial urinary tract infection. At exploratory surgery, a 3 cm mass was removed from the bladder and partial cystectomy performed. The mass was a transitional cell carcinoma on histopathology. The dog also was treated with piroxicam for its palliative effects in dogs with transitional cell carcinoma. The dog improved considerably after surgery and did well for approximately 21 months. At that time, there was a recurrence of clinical signs and imaging studies disclosed multiple masses within the bladder. The owner elected euthanasia.

CASE 9

SIGNALMENT: 6-year-old spayed female mixed-breed dog

HISTORY: Owner reports decreased appetite, weight loss, and bloated appearance of the abdomen over the past month.

P.E.: The dog is thin and has a dry haircoat. The abdomen is distended and a fluid wave can be ballotted.

URINALYSIS:

Specimen: Cystocentesis Refrigerated: No
Color: Straw Appearance: Clear

Sp. gr.	1.019	**Casts**	
pH	6.5	Hyaline	1-3/lpf
Protein	1000 mg/dl	**WBC**	0-3/hpf
Occ. blood	Negative	Clumped	No
Glucose	Negative	**RBC**	3-6/hpf
Ketones	Negative	**Epithelial**	Occasional/hpf
Bilirubin	Negative	Transitional/Medium	
		Clumped	No
		Crystals	None
		Bacteria	None

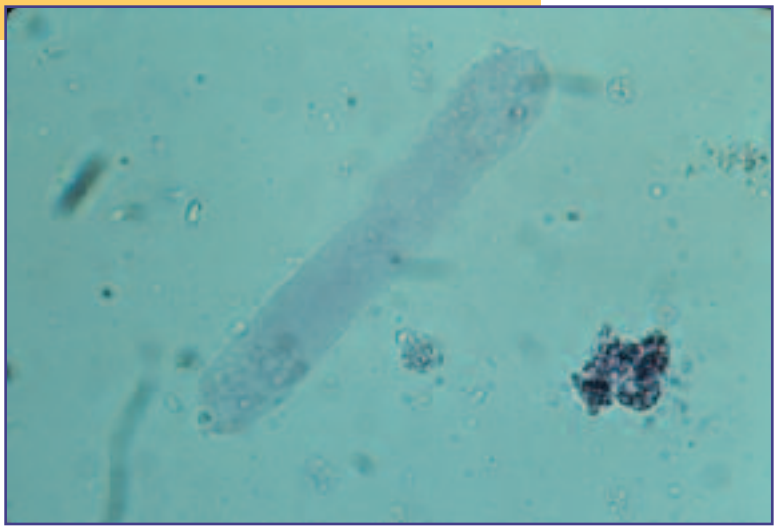


Figure 4.10 **Hyaline cast in urine sediment. Note transparent appearance and lack of inclusions. (Sedi-Stain; 400 X) (*Courtesy Dr. Glade Weiser*)**

Initial Assessment

The presence of marked proteinuria, relatively low urine specific gravity, and hyaline casts observed in the urine sediment are compatible with proteinuria of glomerular origin.

Presumptive Diagnosis

Glomerular disease (glomerulonephritis or amyloidosis).

Diagnostic Plan

A urine sample should be obtained for determination of a urine protein-to-creatinine ratio.

Outcome

The urine protein-to-creatinine ratio was 17.0. This value is compatible with primary glomerular disease. Dogs with glomerular amyloidosis often have values above 10.0 but dogs with glomerulonephritis may have values that range from normal to 40.0. Therefore, a renal biopsy is necessary to distinguish these two diseases. A hemogram was normal except for low plasma proteins (5.0 g/dl; normal = 6.0 to 8.0 g/dl). On serum biochemistry, the dog was non-azotemic but had hypercholesterolemia (435 mg/dl), hypoalbuminemia (1.2 g/dl), and low serum proteins (4.5 g/dl). A sample of fluid obtained by abdominocentesis was interpreted as a pure transudate. This dog underwent ultrasound-guided renal biopsy after assessment of buccal mucosal bleeding time (1 minute; normal = < 2 minutes) and systolic blood pressure by Doppler technique (110 mm Hg; normal = 100 to 140 mm Hg). Results of routine histopathology and immunofluorescence microscopy resulted in a final diagnosis of membranous glomerulonephritis. The dog was treated with a sodium-restricted diet and furosemide. Re-evaluation at 4 weeks showed stable laboratory results with continued proteinuria. Re-evaluation at 6 months showed resolution of ascites, normal serum cholesterol concentration, and improvement in serum albumin concentration.

CASE 10

SIGNALMENT: 8-month-old spayed female Yorkshire Terrier

HISTORY: The puppy was bumping into walls and experienced an acute onset of generalized seizures. Lead poisoning was diagnosed by the local veterinarian based on a blood lead concentration of >150 µg/dl (normal, < 20 µg/dl) and treated with calcium ethylene diamine tetraacetate (EDTA), intravenous fluids, and anticonvulsants as needed. The dog initially responded well to therapy.

P.E.: The dog was very quiet on physical examination but no specific abnormalities were detected.

URINALYSIS:

Specimen: Voided, floor/table/cage Refrigerated: No
Color: Light yellow Appearance: Cloudy

Sp. gr.	1.010 (on fluids)	**Casts**	
pH	6.5	Cellular	5-10/lpf
Protein	30 mg/dl	**WBC**	0-1/hpf
Occ. blood	Trace	Clumped	No
Glucose	Negative	**RBC**	3-5/hpf
Ketone	Negative	**Epithelial**	10-15/hpf
Bilirubin	Negative	Transitional/Small	
		Clumped	No
		Crystals	None
		Bacteria	None

Miscellaneous: Tubular fragments; free epithelial cells same size as those in casts

Initial Assessment

The low urine specific gravity (1.010) could have been the result of intravenous fluid therapy or due to renal tubular damage. Unfortunately, there were no urinalysis results obtained before fluid therapy was initiated. (Showers of casts are not commonly observed, even in patients with renal disease.) The free epithelial cells were of similar size and shape as those observed in the accompanying casts, suggesting common origin in the kidney (ie, renal tubular epithelium). Some of these casts would be better considered tubular fragments because entire tubular segments have sloughed into the urine. (Cellular casts are not found in normal urine.) The finding of excessive numbers of renal tubular epithelial cells and epithelial cell casts and tubular fragments indicates marked damage to the renal tubular epithelium.

Presumptive Diagnosis

Acute renal damage due to nephrotoxic agents (lead and calcium EDTA).

Diagnostic Plan

Serial urinalyses with evaluation of fresh urine sediments were planned. Renal function was evaluated by measuring BUN, serum creatinine, and serum phosphorus concentrations on a serial basis.

Outcome

The dog's BUN, serum creatinine, and serum phosphorus concentrations were normal and remained so throughout treatment.

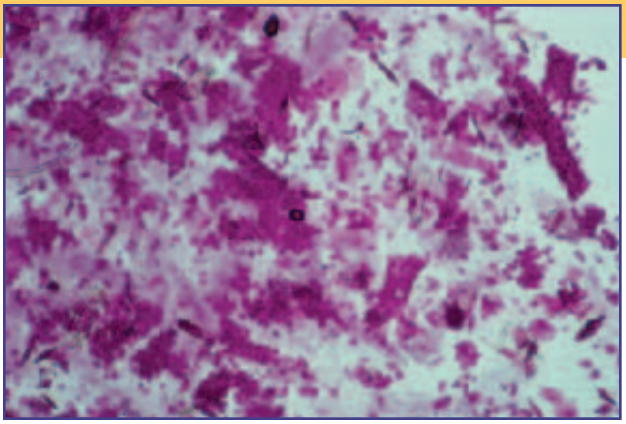


Figure 4.11 Shower of epithelial cell casts and large numbers of free small epithelial cells in urine sediment of a dog with lead poisoning and calcium EDTA toxicity. (Sedi-Stain; 100 X)

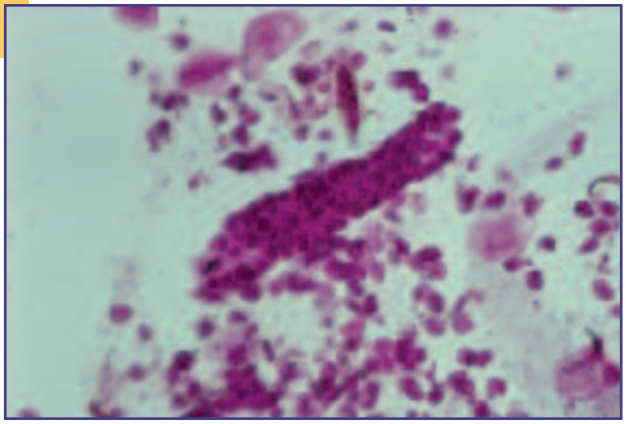


Figure 4.12 Higher magnification view of epithelial cell cast depicted in Fig. 4.11 and many free small epithelial cells. When epithelial cells are very tightly packed together with minimal matrix, such structures may be better termed tubular fragments. (Sedi-Stain; 400 X)

CASE 11

SIGNALMENT: 6-year-old spayed female Doberman Pinscher
HISTORY: Severe polyuria and polydipsia for 1 week.
P.E.: No abnormalities detected.

URINALYSIS:

Specimen: Cystocentesis Refrigerated: No
Color: Pale yellow Appearance: Clear

Sp. gr.	1.014	**Casts**	
pH	6.5	Granular	0-1/lpf
Protein	Trace	Cellular	0-1/lpf
Occ. blood	Trace	**WBC**	0-2/hpf
Glucose	Negative	Clumped	No
Ketone	Negative	**RBC**	1-3/hpf
Bilirubin	Negative	**Epithelial**	0/hpf
		Crystals	None
		Bacteria	None

Initial Assessment

The historical complaint of polyuia and polydipsia is supported by the finding of dilute urine. The observation of cellular casts in urine is always abnormal and indicates some active process in the kidneys. White blood cell casts are associated with renal inflammation and most commonly caused by bacterial infection (ie, pyelonephritis). An occasional granular cast can be normal, but in the presence of cellular casts indicates renal tubular injury. There are few free white blood cells and no bacteria observed in the urine sediment. Pyuria and bacteriuria can be intermittent and are not always observed in animals with upper urinary tract infection.

Presumptive Diagnosis

Bacterial pyelonephritis.

Diagnostic Plan

Bacterial urine culture, serum biochemistry profile and hemogram were performed to evaluate renal function and potential systemic response to suspected renal infection.

Outcome

Bacterial urine culture returned with no growth of bacteria. Serum biochemistry profile and hemogram were normal. (Renal function often is normal in acute pyelonephritis in animals that are well hydrated. Neutrophilia and left shift can be observed in dogs with acute pyelonephritis, but often it is an early and transient finding.) The dog was treated with a cephalosporin antibiotic for 4 weeks on the suspicion of upper urinary tract infection despite the negative culture. Polyuria and polydispsia resolved within 4 days and the dog appeared to be normal 2 years later. Urine specific gravity values greater than 1.025 were observed on subsequent urinalyses.

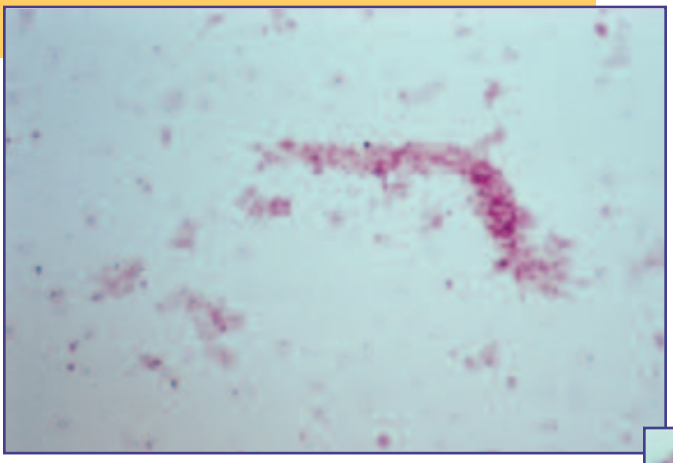


Figure 4.13 WBC cast in urine sediment. At this magnification individual cells can be identified but it is not possible to conclusively identify this cast as a white cell cast. White cell casts may be observed in the urine of animals with acute pyelonephritis. (Sedi-Stain; 100 X)

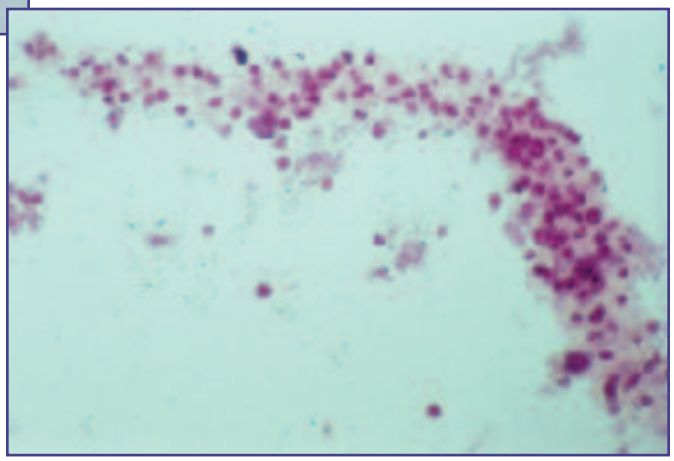


Figure 4.14 Higher magnification of the WBC cast in Fig. 4.13. Note presence of neutrophils and small mononuclear cells in the cast. (Sedi-Stain; 400 X)

CASE 12

SIGNALMENT: 5-year-old neutered male Border Collie

HISTORY: Owner reports that the dog has urinated in the house and was observed to be lethargic while being watched by a friend when the owner was out of town; owner believes the dog may have been polyuric and polydipsic for the past 7 to 10 days.

P.E.: Normal temperature, pulse, and respiration. The dog was alert but very quiet during physical examination. No abnormalities were detected.

URINALYSIS:

Specimen: Catheterized Refrigerated: No
Color: Pale yellow Appearance: Hazy

Sp. gr.	1.008	**Casts**	
pH	5.5	Granular	3-5/lpf
Protein	100 mg/dl	**WBC**	5-10/hpf
Occ. blood	1+	Clumped	No
Glucose	Negative	**RBC**	3-5/hpf
Ketones	Negative	**Epithelial**	0/hpf
Bilirubin	Negative	**Crystals**	None
		Bacteria	None

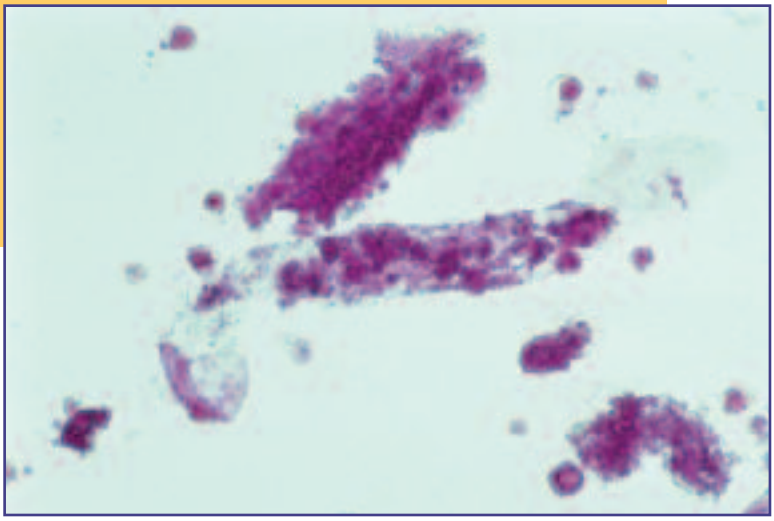


Figure 4.15 Three casts in various stages of degeneration from cellular to coarsely granular. Occasional WBCs also are present. (Sedi-Stain; 400 X)

Initial Assessment

The presence of low urine specific gravity in this dog supports the owner's suspicion of polyuria and polydipsia. The proteinuria and mild pyuria could be the result of a bacterial urinary tract infection or non-bacterial inflammation. The proteinuria with dilute urine specific gravity and minimal sediment abnormalities warrants follow up. The positive occult blood reaction and detection of hemoglobin by the dip strip reagent pad may reflect lysis of erythrocytes despite limited numbers of erythrocytes in the sediment.

Presumptive Diagnosis

Renal disease or failure of uncertain cause.

Diagnostic Plan

A bacterial urine culture and urine protein-to-creatinine ratio were performed and blood was submitted for hemogram and biochemical profile. Ultrasonography was performed to evaluate renal size and architecture.

Outcome

The urine culture yielded no growth and the urine protein-to-creatinine ratio was 4.0. The hemogram disclosed mild thrombocytopenia (72,000/µl) and hyperproteinemia (8.1 g/dl) with a normal leukogram. The biochemical profile disclosed azotemia (BUN 70 mg/dl, creatinine 7.1 mg/dl), hyperphosphatemia (8.4 mg/dl), hyponatremia (134 mEq/l), hypochloremia (106 mEq/l), and hypokalemia (3.0 mEq/l). A clotting profile was within normal limits except for mild thrombocytopenia. Radiographs and abdominal ultrasonography revealed enlarged kidneys (9 to 9.5 cm long) with poor corticomedullary distinction on ultrasonography. The dog's azotemia and hyperphosphatemia became progressively worse over the next few days (serum creatinine 9.3 mg, BUN 101 mg/dl, serum phosphorus 9.5 mg/dl). Furthermore, the dog became oliguric. An exploratory laparotomy was performed to place a peritoneal dialysis catheter and a renal biopsy was taken. The surgeon remarked that the kidneys were very swollen and that renal parenchyma bulged from the incision that was made in the renal capsule. Histopathology disclosed acute interstitial nephritis characterized by infiltration of neutrophils and severe edema. The dog was treated with ampicillin and aluminium hydroxide and underwent peritoneal dialysis for approximately 2 weeks. Serology for leptospirosis was performed twice over a 10-day interval. A 4-fold increase in titer was found for serovars *pomona* and *bratislava* and a 2-fold increase for *grippotyphosa*. At the time of release from the hospital, the dog's serum creatinine concentration was 2.4 mg/dl and BUN was 40 mg/dl. The dog eventually made a full recovery. The final diagnosis was acute renal failure due to leptospirosis.

CASE 13

SIGNALMENT: 4-year-old neutered male Domestic Longhair cat

HISTORY: The cat had experienced 4 episodes of urethral obstruction over the past 6 months. During each episode, the cat was treated by use of an indwelling urinary catheter for at least 24 hours, antibiotics, and glucocorticoids. The cat has had signs of lower urinary tract irritation between episodes of urethral obstruction (eg, stranguria, pollakiuria). Perineal urethrostomy was performed to prevent future episodes of obstruction and the surgical procedure went well. A region of urethral stricture was observed and corrected during surgery. The cat did not do well postoperatively and had a low-grade fever (102.5° to 103.0° F) and a poor appetite. Urine flow through the urethrostomy site was excellent.

P.E.: The cat was lethargic and mildly febrile (103.0° F). The bladder was small and non-painful on abdominal palpation. The kidneys were normal to mildly enlarged but non-painful.

URINALYSIS: ***2 days post-operative; on IV fluids and antibiotics***

Specimen: Voided, floor/table/cage Refrigerated: No
Color: Light pink Appearance: Cloudy

Sp. gr.	1.008	**Casts**	
pH	6.5	Hyaline	0-2/lpf
Protein	100 mg/dl	Granular	2-4/lpf
Occ. blood	2+	Waxy	1-2/lpf
Glucose	Negative	**WBC**	1-3/hpf
Ketones	Negative	Clumped	No
Bilirubin	Negative	**RBC**	10-12/hpf
		Epithelial	0-1/hpf
		Transitional/Small	
		Clumped	No
		Crystals	None
		Bacteria	Cocci/Few

Miscellaneous: Occasional broad cast

Initial Assessment

The urine is dilute (1.008) but this may be a result of treatment with intravenous fluids. Alternatively, and considering the presence of cylindruria, renal disease could be present. The presence of broad and waxy casts is of concern and implies substantial intrarenal stasis. The presence of waxy casts suggest that some chronicity also is possible (waxy casts take the longest time to be formed in the kidney). Pyuria is not present, but the cat is being treated with antibiotics and this could reduce pyuria even in the presence of infection. Also, one to three WBCs/hpf in dilute urine may be more clinically relevant than a similar number in concentrated urine. Lastly, treatment with glucocorticoids may have suppressed WBC diapedesis into urine. The few cocci-like bacteria are difficult to interpret because the sample was collected from a cleaned litter pan.

Presumptive Diagnosis

Chronic pyelonephritis.

Diagnostic Plan

The plan was to evaluate a hemogram and serum biochemistry profile. Urine culture should be considered, but the cat is being treated with antibiotics making quantitative bacterial growth less likely (even if organisms are present in a properly collected sample). Renal imaging (eg, ultrasonography, excretory urography) to examine the collecting system for renal pelvic dilatation, dilatation of renal diverticuli, or proximal urethral dilatation was recommended. These findings would support a diagnosis of pyelonephritis. Of the two procedures, ultrasonography is preferable to excretory urography in this case because con-

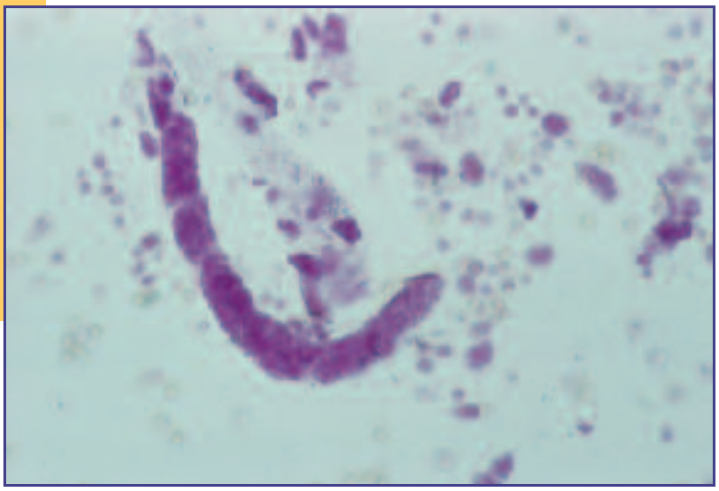


Figure 4.16 Cellular cast in early stage of degeneration to coarsely granular cast and broad cast with inclusion of few cells and refractile droplets. Numerous RBCs and epithelial cells are present in the background. (Sedi-Stain; 400 X)

trast agents have nephrotoxic potential. The antibiotics were changed to a bactericidal class of drugs that are relatively safe for the kidneys and still have a wide bacterial spectrum (eg, cephalosporins).

Outcome

Mild leukocytosis with a left shift was observed on the hemogram; it was not present 2 days before surgery. Renal function as evaluated by BUN and serum creatinine concentrations was normal. Ultrasound examination showed bilateral dilatation of the renal pelvis. Bacterial culture of a midstream voided sample of urine returned with no bacterial growth at a time when the cat was being treated with antibiotics. Several days after changing antibiotics, the cat's fever remitted and he began to eat. He was treated with antibiotics for 6 weeks. Serial urinalyses showed resolution of the cylindruria, but the urine remained dilute (1.020 to 1.025). He has had no further episodes of urethral obstruction or signs of lower urinary tract inflammation during the past year.

CASE 14

SIGNALMENT: 8-year-old intact male Bassett Hound
HISTORY: Owner reports poor appetite for the past few weeks and has observed vomiting several times a day for the past week; owner reports no prior health problems.
P.E.: The dog had a dry haircoat and was slightly thin. A few small subcutaneous masses thought to be lipomas were detected on the trunk and the dog's skin turgor was decreased suggesting moderate dehydration. The prostate was moderately enlarged but non-painful. Fundic examination revealed partial retinal detachment in the left eye and several retinal hemorrhages in the right eye.

URINALYSIS:

Specimen: Cystocentesis Refrigerated: No
Color: Straw Appearance: Clear

Sp. gr.	1.016	**Casts**	
pH	6.0	Hyaline	Occasional/lpf
Protein	500 mg/dl	Waxy	0-2/lpf
Occ. blood	Negative	**WBC**	5-7/hpf
Glucose	Negative	Clumped	No
Ketones	Negative	**Erythrocytes**	0-3/hpf
Bilirubin	Negative	**Epithelial**	5-7/hpf
		Transitional/Medium	
		Clumped	No
		Crystals	None
		Bacteria	None

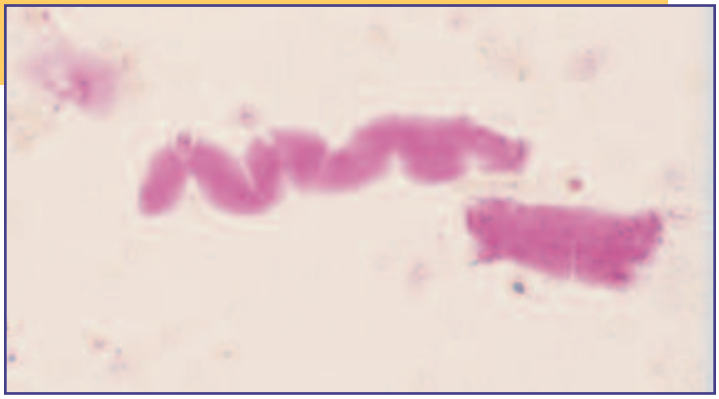


Figure 4.17 **Two waxy casts in urine sediment. The highly convoluted shape of one of these casts reflects the structure of the distal convoluted tubule. The other shorter cast may be described as a broad cast. Note the blunt ends and crack in the broad cast. (Sedi-Stain; 400 X) (*Courtesy Dr. Glade Weiser*).**

Initial Assessment

Relatively dilute urine in a dog with historical and physical findings suggestive of dehydration is reason for concern about renal function. The dog had not received any drugs (eg, corticosteroids, furosemide) that may have interfered with concentrating ability. The presence of moderately severe proteinuria with low urine specific gravity is suggestive of underlying glomerular disease (glomerulonephritis or glomerular amyloidosis). The mild increase in leukocytes in the urine sediment may reflect underlying prostatic disease, a bacterial urinary tract infection, or may be clinically insignificant.

Presumptive Diagnosis

Renal failure due to glomerular disease (glomerulonephritis or amyloidosis).

Diagnostic Plan

The presence of retinal detachment and retinal hemorrhages prompted evaluation of the dog's systemic blood pressure by Doppler technique; it was 190 mm Hg (normal = 110 to 140 mm Hg). Blood was submitted for hemogram and biochemical profile and results showed azotemia (BUN 145 mg/dl, creatinine 8.4 mg/dl), hyperphosphatemia (9.2 mg/dl), decreased serum bicarbonate (11 mEq/l), hypercholesterolemia (402 mg/dl), hypoalbuminemia (1.8 g/dl), hypoproteinemia (5.3 g/dl), increased creatinine kinase (875 IU/l), nonregenerative anemia (PCV 34%), and lymphopenia (500/µl). A urine culture was submitted to evaluate the mild pyuria and was negative for bacterial growth. Abdominal radiographs were performed to evaluate renal size and showed the kidneys to be at the upper limit of normal in size. Mild splenomegaly was also noted.

Outcome

The dog was treated with intravenous lactated Ringer's solution, famotidine, aluminium hydroxide, and amlodipine. After 2 days of fluid therapy, azotemia was improved but not resolved (BUN 85 mg/dl, creatinine 6.1 mg/dl). Serum phosphorus and bicarbonate concentrations had returned to normal. The nonregenerative anemia was more severe (PCV 30%). These changes were attributed to rehydration and resolution of pre-renal azotemia. Blood pressure remained high (170 mm Hg). A buccal mucosal bleeding time was 1 minute (normal = < 2 minutes). The owner elected to have ultrasound-guided renal biopsy performed despite a guarded prognosis. On light microscopy, glomeruli were hypocellular with presence of amorphous pink material on H&E stained sections. This material demonstrated green birefringence when stained with Congo red and examined by polarization microscopy. Moderately severe interstitial fibrosis and infiltration of lymphocytes and plasma cells also were observed. Tubular atrophy and focal tubular dilatation were noted. The final diagnosis was glomerular amyloidosis and secondary chronic tubulointerstitial nephritis.

CASE 15

SIGNALMENT: 3-year-old spayed female Miniature Schnauzer

HISTORY: Presented for evaluation of vague signs of intermittent lethargy and anorexia, and occasional vomiting; owner reports a few episodes of urinating in the house overnight; owner states that the dog was always a relatively big water drinker and suspected that it might also produce a large volume of urine each day; owner did not observe any dysuria or hematuria.

P.E.: The dog was small for its age and weighed 16 pounds. It was quiet on physical examination. Although it was well hydrated, it had a dry haircoat, mild scaling, and several comedones along the dorsum. No other abnormalities were noted.

URINALYSIS:

Specimen: Cystocentesis Refrigerated: No
Color: Yellow Appearance: Clear

Sp. gr.	1.017	**Casts**	None
pH	7.5	**WBC**	0-3/hpf
Protein	30 mg/dl	Clumped	No
Occ. blood	Negative	**RBC**	3-6/hpf
Glucose	Negative	**Epithelial**	Rare/hpf
Ketones	Negative	Transitional/Medium	
Bilirubin	Negative	Clumped	No
		Crystals	Ammonium biurate, struvite/Few
		Bacteria	None

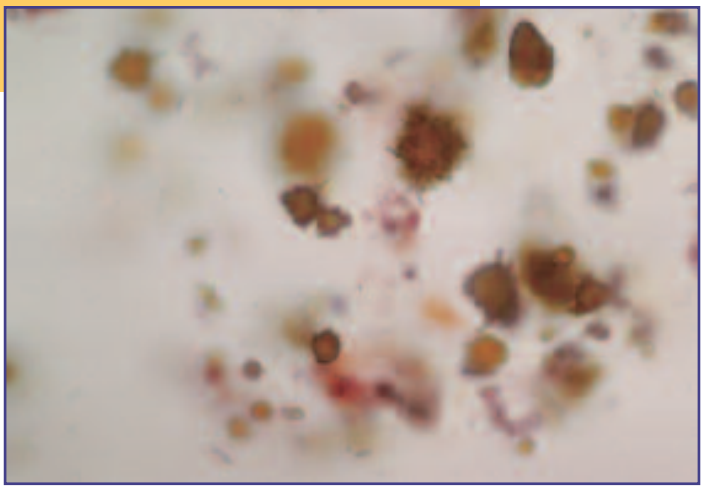


Figure 4.18 **Ammonium biurate crystals in urine sediment. These crystals are commonly observed in normal Dalmatian dogs, dogs with urate urolithiasis, and in dogs with liver disease or portosystemic shunts. (Sedi-Stain; 400 X)**

Initial Assessment

This dog's history is nonspecific, but the signalment and physical findings considered along with the history make consideration of a portosystemic shunt reasonable. Urinalysis showed low specific gravity and ammonium biurate crystals. These findings are compatible with portosystemic shunt or liver disease. The dog should be screened with routine biochemical tests.

Presumptive Diagnosis

Portosystemic shunt.

Diagnostic Plan

Blood was submitted for hemogram and biochemical profile and urine was collected by cystocentesis for routine urinalysis. The hemogram disclosed low plasma proteins (5.0 g/dl) and mild microcytosis (MCV 57 fl). Serum biochemistry disclosed low serum proteins (4.8 g/dl), low BUN (5 mg/dl), and mild hypoalbuminemia (2.0 g/dl). Liver enzyme concentrations were normal. The urinalysis findings did not lead to suspicion of urinary tract infection and the slightly increased numbers of erythrocytes could have been due to trauma of cystocentesis or underlying disease of the urinary tract. Abdominal radiography was planned to evaluate liver size and screen for radiopaque urinary calculi. Serum bile acids were planned.

Outcome

Plain abdominal radiographs showed presence of a few mildly radiopaque cystic calculi. The liver was small based on the angle of the gastric gas shadow. Resting serum bile acids were 85 µmol/l and the post prandial serum bile acids were 325 µmol/l. These results were compatible with a portosystemic shunt, which was confirmed by rectal scintigraphy. A mesenteric venous angiogram identified a single extrahepatic shunt that was partially ligated at surgery. Also at surgery, a cystotomy was performed and several small, smooth, tetrahedral, brownish-green cystic calculi were removed and submitted for quantitative analysis. The results of analysis indicated that the core of the calculi consisted of 100% ammonium acid urate whereas the outer covering of the calculi was 90% struvite (magnesium ammonium phosphate) and 10% hydroxyapatite (calcium phosphate). The dog recovered well from surgery and was treated with a low protein diet.

CASE 16

SIGNALMENT: 2-year-old neutered male Burmese cat
HISTORY: The cat had one episode of urethral obstruction. A urethral plug was retrieved at that time and it was observed to contain struvite. The owner was instructed to feed the cat a canned food diet with moderate acidifying potential. A bacterial urine culture 1 month after the episode of urethral obstruction showed no bacterial growth. Three months after the initial episode of urethral obstruction, the cat was doing well with no clinical signs referable to the urinary tract.
P.E.: Normal.

URINALYSIS:

Specimen: Cystocentesis Refrigerated: Yes (*15 hours*)
Color: Yellow Appearance: Clear

Sp. gr.	1.025	**Casts**	None
pH	6.5	**WBC**	0/hpf
Protein	Negative	**RBC**	1-3/hpf
Occ. Blood	Negative	**Epithelial**	0/hpf
Glucose	Negative	**Crystals**	Struvite/
Ketones	Negative		Many
Bilirubin	Negative	**Bacteria**	None

Initial Assessment

The urine specific gravity is in the range expected for cats eating canned food. None of the dip strip chemical test results or urine sediment findings suggest any active inflammation at the present time. The finding of marked struvite crystalluria prompts concern about the potential of recurrence of struvite plugs and urethral obstruction should another episode of cystitis or urethritis develop. Struvite crystalluria in the presence of hematuria and proteinuria, however, would be more cause for concern. The urine is moderately acidic and only moderately concentrated. These findings suggest that few struvite crystals should form. The fact that the urine sample was collected during the evening and was refrigerated for 15 hours before analysis also must be considered. Refrigeration of the sample may have resulted in the artifactual precipitation of struvite crystals.

Presumptive Diagnosis

Normal urinalysis. Crystalluria likely is a result of prolonged refrigeration of the sample.

Diagnostic Plan

Repeat the urinalysis using a fresh, unrefrigerated sample.

Outcome

No crystals were observed on examination of a fresh urine sample. The crystals likely were an artifact of prolonged refrigeration of the urine before analysis. Struvite crystalluria by itself is not a disease and should not be overinterpreted, especially in samples that have been refrigerated.

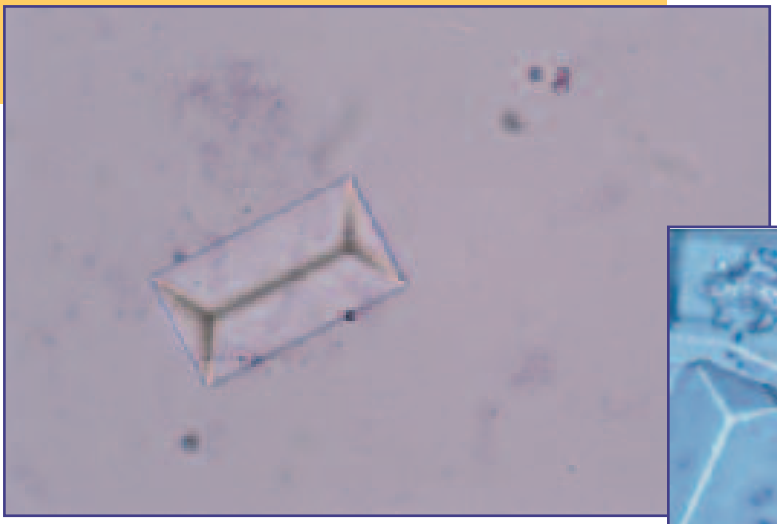


Figure 4.19 Struvite crystal in urine sediment. Note the classic "coffin lid" appearance. (Sedi-Stain; 400 X)

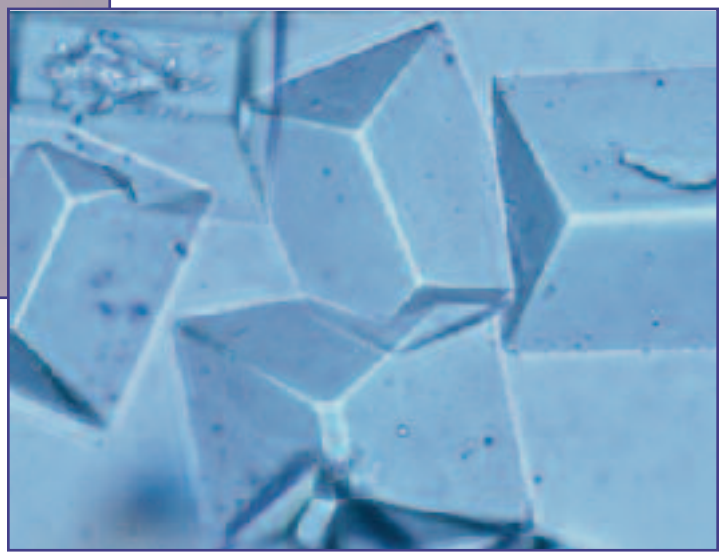


Figure 4.20 Several very large struvite crystals with classic "coffin lid" appearance. (Sedi-Stain; 400 X) (*Courtesy Dr. Michael Horton*)

CASE 17

SIGNALMENT: 5-year-old spayed female Bichon Frise

HISTORY: Presented for dysuria and hematuria; was treated with antimicrobials in the past 3 weeks. The dog had a long history of recurrent urinary tract infection and had been treated with several antimicrobials (eg, amoxicillin, cefadroxil, trimethoprim-sulfadiazine). The dog would respond to antimicrobial therapy and clinical signs (eg, dysuria, hematuria, and increased frequency) disappeared several days after beginning antibiotic therapy. Clinical signs returned several weeks after discontinuing antibiotics. No additional studies had been performed.

P.E.: The dog was alert and friendly. It had normal temperature, pulse, and respiration and was normally hydrated on physical examination. Crepitation was sensed during palpation of the caudal abdomen.

URINALYSIS:

Specimen: Cystocentesis Refrigerated: No
Color: Yellow Appearance: Cloudy

Sp. gr.	1.030	**Casts**	None
pH	7.0	**WBC**	10-15/hpf
Protein	100 mg/dl	Clumped	No
Occ. blood	2+	**RBC**	15-20/hpf
Glucose	Negative	**Epithelial**	5-7/hpf
Ketones	Negative	Transitional and Medium	Squamous/
Bilirubin	Negative	Clumped	No
		Crystals	Struvite and calcium oxalate/Few
		Bacteria	None

Initial Assessment

This dog has a history of recurrent urinary tract infections. The hematuria and pyuria could indicate another infection but also could be due to trauma from the presence of urolithiasis. Urolithiasis is relatively common in this breed and the recurrent urinary tract infections could be the cause or consequence of urolithiasis. A follow up bacterial culture and sensitivity of urine is warranted to determine the presence or absence of urinary tract infection. The presence of both struvite and calcium oxalate crystals in the urine is difficult to assess. (Both of these crystals may be observed in the urine of normal dogs. On the other hand, bacterial urinary tract infection is known to predispose dogs to struvite urolithiasis, and bacterial urinary tract infection can occur secondarily in dogs with other types of primary metabolic urolithiasis including calcium oxalate urolithiasis.) The Bichon Frise breed has a higher relative risk for urolithiasis than many other breeds. An imaging study such as plain abdominal radiographs or ultrasonography is warranted to evaluate for the presence of urolithiasis. Ultrasonography is not as sensitive as radiography in detecting small calculi. Thus, negative ultrasonography and plain radiography would warrant performance of a contrast cystogram.

Presumptive Diagnosis

Bacterial urinary tract infection, possible urolithiasis (struvite or oxalate).

Diagnostic Plan

Bacterial culture and sensitivity were performed on a sample of urine collected by cystocentesis and disclosed

Continued

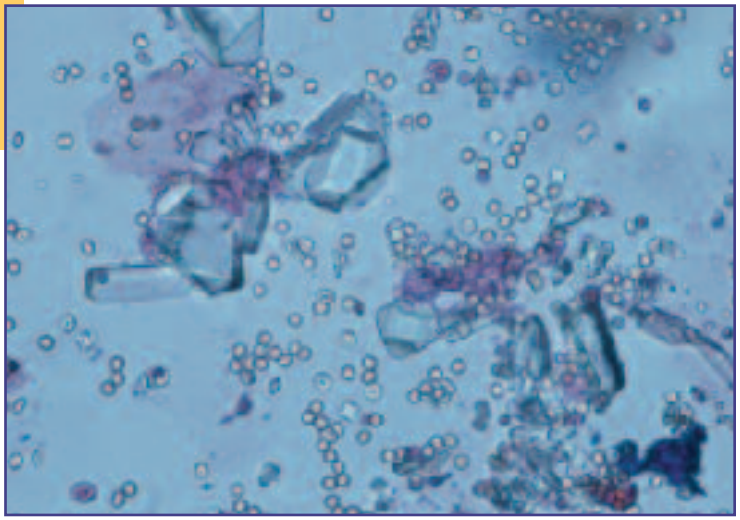


Figure 4.21. Struvite crystals, many RBCs, several transitional epithelial cells, and one very large squamous epithelial cell in urine sediment. (Sedi-Stain; 400 X) (*Courtesy Dr. Michael Horton*)

presence of greater than 30,000 cfu/ml of enterococci, which was sensitive only to tetracycline, chloramphenicol, amoxicillin-clavulanic acid, and enrofloxacin. Plain abdominal radiographs and ultrasonography disclosed presence of many small (< 5 mm) radiopaque cystic calculi. The dog was anesthetized, the bladder infused with saline, and voiding hydropulsion performed. Approximately 50 to 60 small, smooth, tetrahedral, greenish-gray calculi were retrieved. A follow up plain abdominal radiograph was negative for the presence of additional calculi. The calculi were sent out for quantitative analysis; results were 90% struvite (magnesium ammonium phosphate) and 10% hydroxyapatite (calcium phosphate).

Outcome

The dog was released from the hospital on a course of enrofloxacin for 3 weeks with instructions to return for a bacterial culture of a urine sample obtained by cystocentesis while the dog was on antimicrobial therapy. If this culture was negative, the dog was to be returned for a follow up culture, 3 to 5 days after finishing antibiotics. If urine culture was negative at that time, the dog was to have routine follow up urinalyses performed every 3 to 4 months to monitor for infection. The owner was advised to feed the dog a diet based primarily on animal protein rather than vegetable protein to foster acidic urine pH. The dog did well for 6 months, at which time routine urinalysis disclosed pyuria. The dog was asymptomatic at this time but bacterial culture of a urine sample collected by cystocentesis grew 3,000 cfu/ml of *E coli* and the dog was treated with a 3-week course of an antimicrobial based on results of sensitivity testing. The urine was negative for bacterial growth 5 days after completion of this course of antimicrobial therapy.

CASE 18

SIGNALMENT: 6-year-old neutered male Domestic Shorthair cat

HISTORY: Owner reports that the cat had been missing for 3 days; it returned very lethargic and wouldn't eat; owner also reports that on the morning of its return, the cat vomited four times; the cat was taken to the local veterinarian.

P.E.: The cat is very lethargic, has a body temperature of 98.5° F, and is estimated to be 8% dehydrated based on skin turgor. The bladder is intact but small on palpation and the kidneys feel slightly enlarged. No other abnormalities are found on palpation of the abdomen. The heart rate is 160 beats per minute and no murmurs are auscultated. The femoral pulses are weak. The lungs are normal on auscultation. There are no external signs of trauma.

URINALYSIS:

Specimen: Cystocentesis Refrigerated: No
Color: Light yellow Appearance: Clear

Sp. gr.	1.020	**Casts**	None
pH	6.0	**WBC**	3-5/hpf
Protein	100 mg/dl	**RBC**	10-15/hpf
Occ. Blood	1+	Clumped	No
Glucose	Trace	**Epithelial**	0/hpf
Ketones	Negative	**Crystals**	Calcium oxalate mono & dihydrate/ Moderate
Bilirubin	Negative		
		Bacteria	None

Miscellaneous: Crystals vary greatly in shape and size

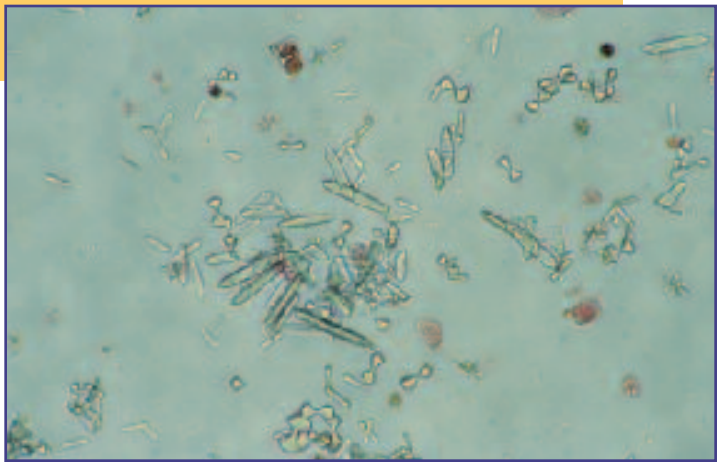


Figure 4.22 Calcium oxalate crystals (monohydrate form). This figure depicts the "picket fence" and "dumbbell" forms of this crystal. Also present are small numbers of epithelial cells and WBCs. (Sedi-Stain; 400 X)

Initial Assessment

The urine is inadequately concentrated (1.020) for a dehydrated cat. A urine specific gravity greater than 1.045 is expected in a dehydrated cat with normal renal function. Mild proteinuria, hematuria, and pyuria also are observed. The presence of "hippurate-like" crystals in the urine sediment in a cat with this history is supportive of a diagnosis of ethylene glycol intoxication. What have previously been called "hippurate-like" crystals have more recently been recognized to be calcium oxalate monohydrate (whewellite) crystals. These crystals can be quite small and easily missed without careful examination of the urine sediment. Calcium oxalate monohydrate crystals occur more commonly with ethylene glycol intoxication than do calcium oxalate dihydrate crystals (ie, the familiar so-called Maltese cross crystals or weddelite). The absence of cylindruria does not rule out acute renal failure because any casts that may have formed may still be trapped within the renal tubules if the cat is oliguric.

Presumptive Diagnosis

Ethylene glycol intoxication and nephrotoxicity.

Diagnostic Plan

The clinician should evaluate a serum biochemistry profile, with special attention to the BUN, creatinine, phosphorus, and calcium. Intravenous fluids should be provided for rehydration and extracellular fluid volume expansion. Urine production should be evaluated in response to fluid infusion. Measurement of serum osmolality and calculation of osmolal gap may provide supportive data for a diagnosis of ethylene glycol intoxication, depending upon when ingestion occurred (ie, the osmolal gap may be increased if ingestion occurred with the past 24 hours). Marked renal hyperechogenicity on ultrasound examination would also support a diagnosis of ethylene glycol intoxication.

Outcome

Serum creatinine concentration was 6.7 mg/dl, BUN 219 mg/dl, phosphorus 12.0 mg/dl, total CO_2 10.1 mEq/l, and calcium 5.8 mg/dl. The low total CO_2 suggests the presence of metabolic acidosis and the low calcium concentration could reflect chelation of calcium by metabolites of ethylene glycol. The cat deteriorated over the next 3 days and died despite aggressive fluid therapy. No urine production was observed. BUN, creatinine, and phosphorus concentrations increased progressively and hyperkalemia (7.2 mEq/l) was observed. The cat was over-hydrated at necropsy and other findings were typical of ethylene glycol-associated nephrotoxicity (eg, intratubular calcium oxalate crystal deposition, acute tubular necrosis).

CASE 19

SIGNALMENT: 8-year-old male Domestic Shorthair cat

HISTORY: Owner reports increased frequency in urination in the litter pan and occasional urination outside the litter pan; owner observed blood in urine (when cat urinated once on kitchen floor); the cat eats a dry, high-protein, acidifying, magnesium-restricted diet (fed this for the past 4 years); owner reports that the cat is otherwise healthy.

P.E.: The cat was bright, alert, and had good body condition. No abnormalities were detected except for a small firm bladder and the cat resisted palpation of the caudal abdomen.

URINALYSIS:

Specimen: Cystocentesis Refrigerated: No
Color: Red Appearance: Cloudy

Sp. gr.	1.058	**Casts**	None
pH	5.5	**WBC**	7-10/hpf
Protein	100 mg/dl	Clumped	No
Occ. blood	3+	**RBC**	60-80/hpf
Glucose	Negative	**Epithelial**	5-7/hpf
Ketones	Negative	Transitional/Small	
Bilirubin	Negative	Clumped	No
		Crystals	Calcium oxalate/Few
		Bacteria	None

Miscellaneous: Occasional sperm

Initial Assessment

The presence of hematuria, along with the historical and physical findings in this cat, is compatible with idiopathic cystitis or urolithiasis. Neoplasia of the urinary tract would be possible in an older cat but is rare in younger cats. The increased number of leukocytes in the urine could signify bacterial urinary tract infection or trauma and inflammation of non-bacterial origin. The presence of calcium oxalate crystals in the urine is of limited diagnostic value as these crystals may be present in normal cats and dogs and may be absent in animals with calcium oxalate urolithiasis.

Presumptive Diagnosis

Urolithiasis.

Diagnostic Plan

A urine sample collected by cystocentesis was submitted for bacterial culture and sensitivity; culture results were negative. Plain abdominal radiographs were taken and disclosed the presence of a single radiopaque cystic calculus compatible with struvite or calcium oxalate. It was recommended that the cat's diet be changed to a canned food that was non-acidifying and somewhat lower in protein. The litter pan was to be changed frequently and the cat was to have access to fresh water at all times. The hematuria gradually resolved in the first week after surgery and follow up urinalysis one month later was normal.

Outcome

A cystotomy was performed and a single roughened pale yellow calculus was removed from the bladder and submitted for quantitative analysis. Analysis of the calculus showed that it was composed of 100% calcium oxlate dihydrate.

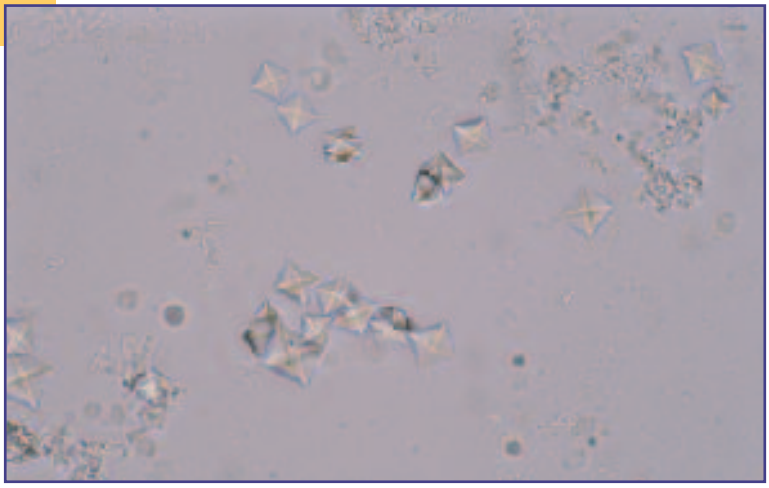


Figure 4.23 **Calcium oxalate crystals (dihydrate form). These oxalate crystals have the classic "Maltese cross" or "square envelope" form. Several small epithelial cells also are present. Note marked variation in size of oxalate crystals. Occasional sperm are noted in the background. (Unstained; 400 X).**

CASE 20

SIGNALMENT: 3-year-old neutered male Newfoundland dog

HISTORY: Owner reports that, until recently, the dog has been normal since puppyhood; owner observed straining to urinate, increased grooming of the penis and sheath, frequent attempts to urinate but only dribbled urine during these attempts; appetite remained normal.

P.E.: The dog was bright and alert. It was well-hydrated based on skin turgor, but the bladder was large on palpation. Resistance was met on passage of a 9 French urinary catheter. A 3.5 French catheter could be passed and urine was collected for urinalysis.

URINALYSIS:

Specimen: Catheterized Refrigerated: No
Color: Amber Appearance: Cloudy

Sp. gr.	1.029	**Casts**	None
pH	5.5	**WBC**	10-15/hpf
Protein	100 mg/dl	Clumped	No
Occ.blood	2+	**RBC**	20-25/hpf
Glucose	Negative	**Epithelial**	5-10/hpf
Ketones	Negative	Transitional and squamous/ Large and medium	
Bilirubin	Negative	Clumped	No
		Crystals	Cystine/ Moderate
		Bacteria	None

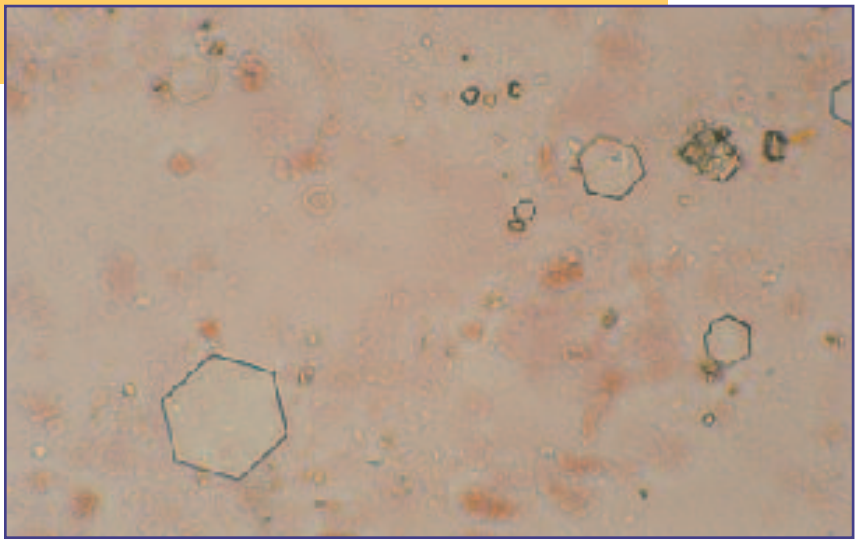


Figure 4.24 **Cystine crystals in urine sediment. Note the classic flat hexagonal appearance. Cystine crystals are always abnormal and should lead to suspicion of cystinuria or cystine urolithiasis. (Sedi-Stain; 400 X)**

Initial Assessment

The increased numbers of erythrocytes and leukocytes in the urine sediment are compatible with either bacterial urinary tract infection or trauma from urolithiasis. The history and difficulty passing a urinary catheter are compatible with the presence of urethral calculi. The presence of cystine crystals in the urine and the breed raises the suspicion for cystinuria and cystine urolithiasis. Cystine is one type of crystal that is not found in normal dog urine.

Presumptive Diagnosis

Urethral obstruction due to urethral calculi, presumptive cystinuria and cystine urolithiasis

Diagnostic Plan

A urine sample was submitted for bacterial culture and sensitivity to identify bacterial urinary tract infection that may be present. Plain abdominal radiographs and a contrast cystogram and urethrogram were performed to identify any urethral or cystic calculi. Cystine calculi may be radiolucent on plain radiographs and require a contrast study for identification. If uroliths are present, surgical removal should be followed by quantitative analysis to identify the crystal type. Urohydropulsion can be attempted to dislodge small urethral calculi back into the bladder and relieve obstruction. Small calculi for analysis also may be obtained by passage of a urinary catheter and manual agitation of the bladder with the dog under sedation or anesthesia.

Outcome

The urethral calculi were flushed back into the bladder using urohydropulsion, and several very small calculi were obtained by manual agitation of the bladder with a large gauge (9 French) polyvinyl catheter placed in the bladder after relief of urethral obstruction. Several small calculi were submitted for quantitative analysis and returned as 100% cystine. Many additional small calculi were observed in the urinary bladder by contrast cystography and urethrography. Bacterial culture of the urine yielded no growth. The dog was treated by alkalinization of the urine using sodium bicarbonate and with 2-mercaptoproprionyl glycine in an attempt to increase the solubility of cystine and increase the urine concentration of mixed disulfide at the expense of cystine. The dog

Continued

was also placed on a low-sodium, low-protein diet in an attempt to reduce the urinary excretion of cystine. The dog did well for 9 months after which time dysuria and hematuria returned and additional urethral calculi were identified. At that time, a scrotal urethrostomy was performed to facilitate passage of small cystine calculi.

CASE 21

SIGNALMENT: 6-year-old spayed female mixed-breed dog

HISTORY: previous fever, anorexia, lethargy, and vomiting 48 to 72 hours after eating raw bacon; serum lipase concentration was increased and a tentative diagnosis of acute pancreatitis was made. The dog was treated with intravenous lactated Ringer's solution and antibiotics. Jaundice was first observed 4 to 5 days after the onset of acute pancreatitis.

P.E.: The dog was approximately 7% dehydrated, lethargic and had icteric mucous membranes. It was uncomfortable and resisted attempts at abdominal palpation.

URINALYSIS:

Specimen: Cystocentesis Refrigerated: No
Color: Orange Appearance: Clear

Sp. gr.	1.032	**Casts**	
pH	6.0	Granular	Occasional/lpf
Protein	30 mg/dl	**WBC**	2-4/hpf
Occ. blood	Negative	Clumped	No
Glucose	Negative	**RBC**	1-3/hpf
Ketones	Negative	**Epithelial**	Occasional/hpf
Bilirubin	3+	Transitional/Medium	
		Clumped	Yes
		Crystals	Bilirubin/Few
		Bacteria	None

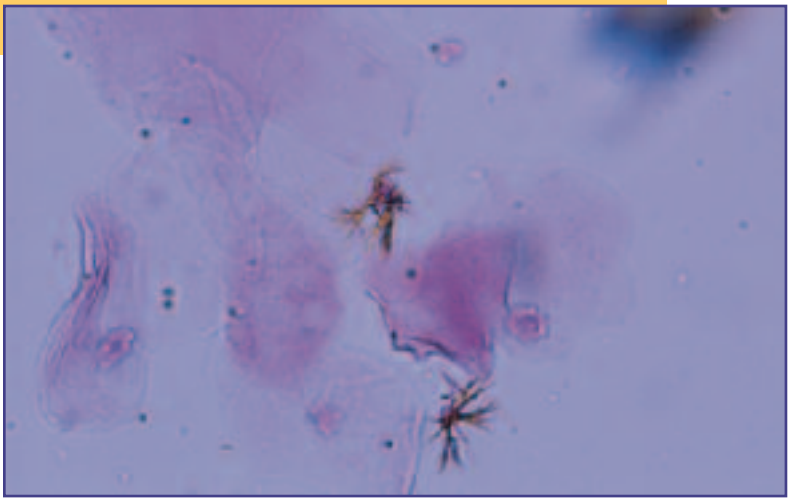


Figure 4.25 **Bilirubin crystals and large squamous epithelial cells in urine sediment. (Sedi-Stain; 400 X)**

Initial Assessment

The urine is moderately concentrated and contains a small amount of protein. There is marked bilirubinuria and occasional bilirubin crystals observed in the urine sediment. The urine sediment does not contain many cellular elements but occasional granular casts are observed.

Presumptive Diagnosis

Extrahepatic biliary obstruction secondary to pancreatitis

Diagnostic Plan

Blood was submitted for hemogram, serum biochemical profile, and serum amylase and lipase. Abdominal ultrasonography was performed to evaluate the liver and pancreas.

Outcome

The hemogram showed a leukocytosis (41,600/µl) due to neutrophilia (37,900/µl) and a left shift (2,500/µl) compatible with a severe inflammatory process. Serum direct bilirubin was 6.9 mg/dl and alkaline phosphatase was 2,690 IU/l. Alanine amino transferase was 250 IU/l, amylase was 876 IU/l, and lipase 754 IU/l. Abdominal ultrasound disclosed dilatation of the extra- and intra-hepatic biliary system and the pancreas was diffusely enlarged and hyperechoic. The gall bladder also was enlarged and there was a small amount of peritoneal effusion present. The bilirubinuria and bilirubin crystals are compatible with the extrahepatic biliary obstruction and increased excretion of direct-reacting bilirubin in the urine. The few granular casts could indicate underlying renal damage and may have appeared in the urine secondary to fluid therapy and diuresis. The dog was non-azotemic. The dog was treated medically for pancreatitis by intravenous fluid therapy, parenteral nutrition, and antibiotics. It responded poorly and exploratory laparotomy was performed. The pancreas was severely enlarged and inflamed. The pancreas also contained a moderately large organizing abscess. The owner elected euthanasia at the time of surgery.

CASE 22

SIGNALMENT: 3-year-old neutered male Domestic Shorthair cat

HISTORY: During past week, owner observed straining to urinate and drops of blood in the litterpan; owner reports that the cat makes more frequent trips to the litterpan and stays in the pan for much longer than usual; appetite was normal until yesterday; appetite is now poor. The cat was otherwise healthy and had not been to a veterinarian since receiving its vaccinations as a kitten.

P.E.: The cat was obviously uncomfortable. Abdominal palpation revealed an enlarged, turgid bladder that was very painful. The tip of the penis was reddened and some white mucoid material was observed at the external urethral meatus. The cat was slightly dehydrated based on skin turgor. Gentle massage of the distal penis dislodged some of the white, mucoid material and was followed by passage of a good stream of urine.

URINALYSIS:

Specimen: Voided, midstream Refrigerated: No
Color: Red Appearance: Cloudy

Sp. gr.	1.050	**Casts**	None
pH	7.0	**WBC**	3-5/hpf
Protein	300 mg/dl	Clumped	No
Occ. blood	4+	**RBC**	50-60/hpf
Glucose	Negative	**Epithelial**	1-3/hpf
Ketones	Negative	Transitional/Medium	
Bilirubin	Negative	Clumped	No
		Crystals	Struvite/Few
		Bacteria	None

Miscellaneous: *Capillaria* eggs—occasional

Initial Assessment

The urine sediment demonstrates evidence of hemorrhage and inflammation. There are many red blood cells but few white blood cells. The finding of *Capillaria* eggs was entirely unexpected. The adult *Capillaria* parasite can be an incidental finding or can cause hematuria due to associated cystitis. The small number of struvite crystals was considered incidental, and presumably a consequence of urine stasis and the urine pH of 7.0. Struvite becomes increasingly insoluble above urine pH 6.8. Urine pH often is neutral during episodes of urethral obstruction and anorexia in cats. Exudate of serum into the urine as a result of the inflammation may also have contributed to the urine pH of 7.0 in this cat. The proteinuria is attributed to the associated hemorrhage. The mild increase in transitional epithelial cells is compatible with increased desquamation secondary to inflammation.

Presumptive Diagnosis

Urethral obstruction secondary to sterile cystitis, possibly as a consequence of *Capillaria* infestation of the bladder.

Diagnostic Plan

Urine culture was submitted and the urinary plug material was further analyzed.

Outcome

The urethra remained patent and the cat was discharged on fenbendazole. The cat's dehydration was corrected by administration of subcutaneous fluids. No crystalline material was detected on further analysis of the mucoid plug material. On histopathology, the plug contained numerous ova and adult parasites of *Capillaria*. In this cat, the presence of *Capillaria* was pathologic.

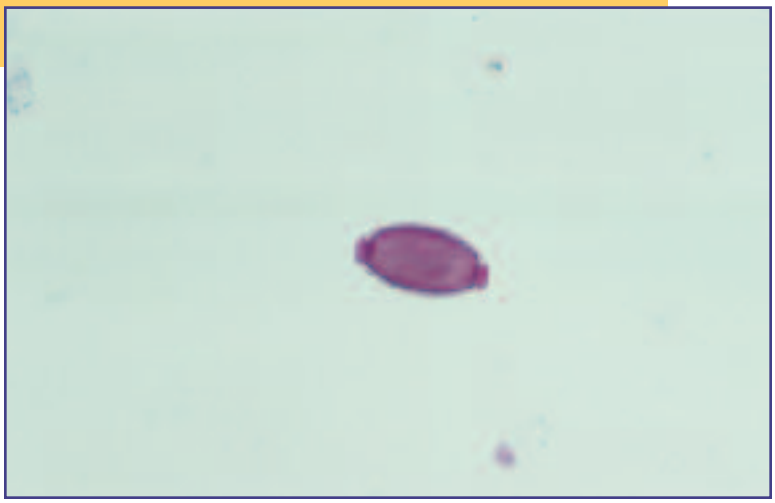


Figure 4.26 Ovum of the urinary tract parasite *Capillaria* spp in the urine sediment. Note the bioperculate structure. Care must be taken to avoid contamination of the urine with feces and confusion with *Trichuris* spp in dogs. (Sedi-Stain; 100 X)

CASE 23

SIGNALMENT: 9-year-old intact male German Shepherd dog

HISTORY: Lethargy and anorexia of 5 days' duration prior to hospitalization; weight loss and increased water consumption over past few weeks; urination not observed.

P.E.: The dog was thin and lethargic with increased inspiratory bronchovesicular sounds on thoracic auscultation and an abdominal component to respiration was noted.

URINALYSIS:

Specimen: Catheterized Refrigerated: No
Color: Yellow Appearance: Slightly turbid

Sp. gr.	1.023	**Casts**	None
pH	6.0	**WBC**	10-15/hpf
Protein	100 mg/dl	Clumped	No
Occ. blood	Negative	**RBC**	7-10/hpf
Glucose	4+	**Epithelial**	5-7/hpf
Ketones	2+	Transitional/Medium	
Bilirubin	1+	Clumped	No
		Crystals	None
		Bacteria	None

Initial Assessment

The urine is only mildly concentrated but contains a large amount of glucose, moderate amounts of ketones, and small amounts of bilirubin. The presence of proteinuria, mild pyuria, and mild hematuria could signify the presence of a urinary tract infection. Alternatively, the hematuria could be a consequence of catheterization.

Presumptive Diagnosis

Diabetic ketoacidosis

Diagnostic Plan

Blood was submitted for hemogram, biochemical profile, amylase and lipase. Blood gas analysis was performed.

Outcome

The blood glucose was 855 mg/dl, serum total CO_2 was 8 mEq/L indicating severe metabolic acidosis, and mild azotemia was present (serum creatinine concentration 3.2 mg/dl, BUN 54 mg/dl) despite only mildly concentrated urine. The urine specific gravity of 1.023 was lower than expected in a dehydrated dog. This is partially a result of solute diuresis due to glucosuria and ketonuria, but underlying renal disease (as evidenced by mild azotemia) also may have contributed to the low urine specific gravity. Blood pH was 7.017 indicating severe acidosis. The dog initially was treated with lactated Ringer's solution with KCl over the first 24 hours. The dog also was given 20 mEq $NaHCO_3$ intravenously after the blood gas results returned from the laboratory. Six units of regular insulin were administered intramuscularly every hour until blood glucose concentration reached approximately 250 mg/dl. After that, the dog received 7 units of regular insulin intramuscularly every 8 hours. After fluid therapy, the dog's serum creatinine concentration decreased to 2.3 mg/dl and the BUN to 41 mg/dl.

Part III

Normal Urinalysis Reference Ranges
of the Dog and Cat

	Dog	Cat
Color	Yellow to amber	Yellow to amber
Appearance	Clear	Clear
Specific Gravity	*Range:* 1.001 - 1.070 *Usual:* 1.020 - 1.050	*Range:* 1.001 - 1.080 *Usual:* 1.025 - 1.060
pH	5.5 - 7.5	5.5 - 7.5
Protein (mg/dl)	0 - 30	0 - 30
Occult blood	Negative	Negative
Glucose	Negative	Negative
Ketones	Negative	Negative
Bilirubin	0 - 1+	Negative
Casts (#/lpf)		
Hyaline	0 - 2	0 - 2
Granular	0 - 1	0 - 1
Cellular	0	0
Waxy	0	0
Leukocytes (#/hpf)		
Voided sample	<10	<10
Catheterized Sample	<5	<5
Cystocentesis Sample	<3	<3
Erythrocytes (#/hpf)		
Voided	<10	<10
Catheterized	<5	<5
Cystocentesis*	<3	<3
Epithelial Cells		
Type	Transitional squamous	Transitional squamous
Clumped	No	No
Size	Variable	Variable
Crystals		
Type†	Variable	Variable
Numbers (none, few, moderate, many)	Variable	Variable
Bacteria		
Type‡ (cocci, rods)	None	None
Numbers (none, few, moderate, many)	None	None

* Up to 50 erythrocytes may be present in samples collected by cystosentesis due to trauma from needle puncture.
† Struvite and calcium oxalate crystals may be found in the urine of normal dogs and cats. Urates may be found in normal Dalmatian dogs. Cystine crystals are always abnormal.
‡ Bacteria are not normally present in the urine of dogs and cats, however small numbers may contaminate samples collected by voiding or catheterization. These may proliferate if the sample stands at room temperature.

Index of Figures

All slides courtesy of Dennis J. Chew, DVM, and Stephen P. DiBartola, DVM.

Chapter 2: Sample Handling, Preparation, and Analysis

Chapter 3: Urinalysis Interpretation

All slides courtesy of Dennis J. Chew, DVM, and Stephen P. DiBartola, DVM.

Fig. 3.15.....Hyaline cast with small numbers of refractile droplets and short epithelial cell cast with well-preserved cellular detail. (Sedi-Stain; 400 X)

Fig. 3.16.....WBC cast in urine sediment that is beginning to undergo fragmentation. Neutrophils and mononuclear cells are present in the cast and moderate numbers of bacteria also may be seen. Caution should be taken to avoid confusing clumps of WBCs with WBC casts. (Sedi-Stain; 400 X)

Fig. 3.17.....RBC cast in urine sediment. These casts are very fragile and rarely are observed in the urine of dogs and cats. (Sedi-Stain; 400 X)

Fig. 3.18.....Blood cast in urine sediment. Blood casts represent the degeneration of red cell casts and are characterized by the presence of hemoglobin and faint red cell membrane outlines. (Sedi-Stain; 400 X)

Fig. 3.19.....Three coarsely granular casts in various stages of degeneration. Free epithelial cells also are present. (Sedi-Stain; 400 X)

Fig. 3.20.....Finely granular cast in urine sediment. (Unstained; 400 X)

Fig. 3.21.....Several hyaline casts and one mixed cast comprised of hyaline, refractile droplet, and cellular components. (Sedi-Stain; 400 X)

Fig. 3.22.....Waxy and granular casts in urine sediment. Note the translucent nature of the waxy cast. This feature sometimes leads to confusion with hyaline casts, which are transparent. (Sedi-Stain; 400 X)

Fig. 3.23.....Many filamentous rod-shaped organisms in the urine sediment. Bacterial urine culture yielded large numbers of *Escherichia coli*. Enteric organisms may assume a filamentous conformation when growing in urine. (Sedi-Stain; 400 X)

Fig. 3.24.....Many rod-shaped bacteria and a few RBCs in the urine sediment. Note the presence of one large struvite crystal. The occurrence of many bacteria in the absence of WBCs (pyuria) should raise suspicion of bacterial contamination of the urine sample. (Sedi-Stain; 100 X)

Fig. 3.25.....Oval yeast organisms in the urine sediment. Yeast organisms in urine sediments usually are contaminants present in the stain or acquired during voiding. (Sedi-Stain; 400 X)

Fig. 3.26.....Numerous WBCs in varying stages of degeneration and a few transitional epithelial cells. Many non-staining septate hyphae are present in the background. Usually fungal elements observed in the urine sediment are artifacts, but this sample was obtained from a dog with fungal urinary tract infection. (Sedi-Stain; 160 X)

Fig. 3.27.....Many WBCs in varying stages of degeneration and a few epithelial cells (squamous and transitional). A budding *Blastomyces* organism is present at the center of the field. This urine sediment was obtained from a dog with systemic blastomycosis and urogenital involvement. (Sedi-Stain; 100 X) (*Courtesy Dr. James Brace*)

Fig. 3.28.....Sulfonamide crystal in urine sediment of a dog treated with trimethoprim-sulfadiazine. (Sedi-Stain; 400 X)

Fig. 3.29.....Calcium oxalate crystals (monohydrate form). These oxalate crystals have the classic "picket fence" form. Also present is an oxalate crystal with the "hemp seed" appearance with a budding daughter crystal. (Unstained; 400 X)

Fig. 3.30.....Spermatozoa in urine sediment. Spermatozoa may be observed in the urine of male dogs. (Unstained; 400 X)

Fig. 3.31.....Microfilaria of *Dirofilaria immitis* in the urine sediment. Many RBCs also are present. Microfilaria observed in the urine sediment are an artifact of the presence of blood in urine. (Sedi-Stain; 400 X)

Fig. 3.32.....Refractile lipid droplets and RBCs in the urine sediment. Refractile lipid droplets may be confused with RBCs. Lipid droplets are a normal finding in urine from cats. (Sedi-Stain; 400 X)

Fig. 3.33.....Fiber artifact in urine sediment that may be confused with a cast. Note that the sides of the fiber are perfectly parallel and that there

are parallel internal lines. Neither of these features would be found in a cast. (Sedi-Stain; 100 X)

Fig. 3.34.....Precipitated stain in urine sediment may be confused with crystals, fungi, or bacteria. These precipitated stain crystals often are found at the edge of the coverslip. (Sedi-Stain; 400 X)

Fig. 3.35.....So-called pseudocast created by the accumulation of WBCs along a mucus thread. (Sedi-Stain; 100 X) (*Courtesy Dr. Richard Scott*)

Chapter 4: Case Studies

Fig. 4.1.....Case # 1. Low power view of urine sediment showing too numerous to count RBCs, several WBCs, and a few squamous epithelial cells. (100X)

Fig. 4.2.....Case # 2. Red blood cells in urine. Several struvite crystals also are present. Note variable intensity of staining of RBCs. (Sedi-Stain; 100 X)

Fig. 4.3.....Case # 3. Many RBCs and several WBCs in urine sediment stained with Sedi-Stain. (400 X)

Fig. 4.4.....Case # 3. WBCs, a few epithelial cells, and many pale-staining RBCs in the urine sediment. Note the single squamous epithelial cell in the center of the field (arrow). The presence of multilobulated nuclei in the WBCs allows their identification as neutrophils. (Sedi-Stain; 100 X)

Fig. 4.5.....Case # 4. Precipitated hemoglobin in urine sediment. Care should be taken not to confuse precipitated hemoglobin in the urine sediment with RBCs. Note extreme variable in particle size and characteristic orange color. (Sedi-Stain; 100 X)

Fig. 4.6.....Case # 5. Clump of neutrophils. The finding of clumps of WBCs should prompt a search for bacterial urinary tract infection as the underlying cause of clumping. (Sedi-Stain; 100 X)

Fig. 4.7.....Case # 6. Large number of small epithelial cells and a few large squamous epithelial cells in urine sediment. Some of the small epithelial cells are oval and others are cuboidal. The small size of the cells and the presence of eccentric nuclei suggest possible renal origin. Cells with similar appearance were also observed in cellular casts in this animal, supporting renal origin of the epithelial cells. The final diagnosis was ischemic acute tubular necrosis. Many sperm are noted in the background. (Sedi-Stain; 100 X)

Fig. 4.8.....Case # 7. Large clump of transitional epithelial cells in urine sediment. Clumping of cells, increased nuclear-to-cytoplasmic ratio, presence of nucleoli, and clumping of chromatin should arouse suspicion of neoplasia. The final diagnosis in this case was transitional cell carcinoma. (Sedi-Stain; 100 X)

Fig. 4.9.....Case # 8. Large clump or raft of transitional epithelial cells in urine sediment suggestive of neoplasia. Cellular detail is difficult to ascertain. The final diagnosis in this case was transitional cell carcinoma. (Sedi-Stain; 400 X)

Fig. 4.10.....Case # 9. Hyaline cast in urine sediment. Note transparent appearance and lack of inclusions. (Sedi-Stain; 400 X) (*Courtesy Dr. Glade Weiser*)

Fig. 4.11.....Case # 10. Shower of epithelial cell casts and large numbers of free small epithelial cells in urine sediment of a dog with lead poisoning and calcium EDTA toxicity. (Sedi-Stain; 100 X)

Fig. 4.12.....Case # 10. Higher magnification view of epithelial cell cast depicted in Fig. 4.11 and many free small epithelial cells. When epithelial cells are very tightly packed together with minimal matrix, such structures may be better termed tubular fragments. (Sedi-Stain; 400 X)

Fig. 4.13.....Case # 11. WBC cast in urine sediment. At this magnification individual cells can be identified but it is not possible to conclusively identify this cast as a white cell cast. White cell casts may be observed in the urine

All slides courtesy of Dennis J. Chew, DVM, and Stephen P. DiBartola, DVM.

of animals with acute pyelonephritis. (Sedi-Stain; 100 X)

Fig. 4.14.....Case # 11. Higher magnification of the WBC cast in Fig. 4.13. Note presence of neutrophils and small mononuclear cells in the cast. (Sedi-Stain; 400 X)

Fig. 4.15.....Case # 12. Three casts in various stages of degeneration from cellular to coarsely granular. Occasional WBCs also are present. (Sedi-Stain; 400 X)

Fig. 4.16.....Case # 13. Cellular cast in early stage of degeneration to coarsely granular cast and broad cast with inclusion of few cells and refractile droplets. Numerous RBCs and epithelial cells are present in the background. (Sedi-Stain; 400 X)

Fig. 4.17.....Case # 14. Two waxy casts in urine sediment. The highly convoluted shape of one of these casts reflect the structure of the distal convoluted tubule. The other shorter cast may be described as a broad cast. Note the blunt ends and crack in the broad cast. (Sedi-Stain; 400 X) (*Courtesy Dr. Glade Weiser*)

Fig. 4.18.....Case # 15. Ammonium biurate crystals in urine sediment. These crystals are commonly observed in normal Dalmatian dogs, dogs with urate urolithiasis, and in dogs with liver disease or portosystemic shunts. (Sedi-Stain; 400 X)

Fig. 4.19.....Case # 16. Struvite crystal in urine sediment. Note the classic "coffin lid" appearance. (Sedi-Stain; 400 X)

Fig. 4.20.....Case # 16. Several very large struvite crystals with classic "coffin lid" appearance. (Sedi-Stain; 400 X) (*Courtesy Dr. Michael Horton*)

Fig. 4.21.....Case # 17. Struvite crystals, many RBCs, several transitional epithelial cells, and one very large squamous epithelial cell in urine sediment. (Sedi-Stain; 400 X) (*Courtesy Dr. Michael Horton*)

Fig. 4.22.....Case # 18. Calcium oxalate crystals (monohydrate form). This figure depicts the "picket fence" and "dumbbell" forms of this crystal. Also present are small numbers of epithelial cells and WBCs. (Sedi-Stain; 400 X)

Fig. 4.23.....Cases # 19. Calcium oxalate crystals (dihydrate form). These oxalate crystals have the classic "Maltese cross" or "square envelope" form. Several small epithelial cells also are present. Note marked variation in size of oxalate crystals. Occasional sperm are noted in the background. (Unstained; 400 X)

Fig. 4.24.....Case # 20. Cystine crystals in urine sediment. Note the classic flat hexagonal appearance. Cystine crystals are always abnormal and should lead to suspicion of cystinuria or cystine urolithiasis. (Sedi-Stain; 400 X)

Fig. 4.25.....Case # 21. Bilirubin crystals and large squamous epithelial cells in urine sediment. (Sedi-Stain; 400 X)

Fig. 4.26.....Case # 22. Ovum of the urinary tract parasite *Capillaria* spp in the urine sediment. Note the bioperculate structure. Care must be taken to avoid contamination of the urine with feces and confusion with *Trichuris* spp in dogs. (Sedi-Stain; 100 X)

Glossary of Terms

-A-

acetonuria: presence of acetone in the urine.

albuminuria: presence of excessive amounts of plasma albumin in the urine.

anuria: total cessation of urine production and excretion.

azotemia: an increase in nitrogenous solutes in the blood, classically urea or creatinine.

-B-

bacteriuria: presence of bacteria in the urine.

baruria: excretion of urine of high specific gravity (>1.035 in the dog and cat).

Bence-Jones proteinuria: presence of immunoglobulin light chains in the urine in patients with multiple myeloma; these proteins are heat-sensitive, coagulating at 45° to 55° C.

bilirubinuria: presence of bilirubin in the urine; the form of bilirubin appearing in the urine is the conjugated or direct-reacting form.

-C-

calculus: general term referring to a solid concretion (stone) occurring in a hollow organ or duct.

***Capillaria plica*:** parasitic worm that can inhabit the bladder; can be incidental finding or at times associated with pathology.

cast: a cylindric mass of material formed in the distal portion of the nephron and passed in the urine; casts may be cellular, granular (coarse and fine), waxy, or hyaline.

cylindruria: presence of casts in the urine.

cystitis: inflammation of the urinary bladder.

cystocentesis: collection of urine by percutaneous needle puncture of the bladder.

-D-

diuresis: urine excretion in excess of the usual volume produced.

dysuria: difficulty or pain upon urination.

-F-

functional proteinuria: transient and mild proteinuria consisting mainly of albumin which occurs in certain situations associated with sympathetic nervous system discharge.

-G-

glitter cells: polymorphonuclear leukocytes in urine with granules in their cytoplasm that exhibit Brownian motion; suggestive of pyelonephritis if present in urine with specific gravity >1.015.

glomerular proteinuria: proteinuria of glomerular origin due to increased filtration of plasma proteins usually through an abnormally permeable glomerular filter; albumin predominates in glomerular proteinuria.

glomerulonephritis: a variety of nephritis characterized primarily by an inflammatory process in the glomeruli; most cases of glomerulonephritis involve immune-mediated injury.

glomerulonephropathy (glomerulopathy): any disease of the renal glomeruli.

glucosuria: presence of glucose in the urine.

glycosuria: presence of an abnormal amount of glucose in the urine. Often used interchangeably with the term glucosuria.

-H-

hematuria: presence of erythrocytes in the urine; may be gross (visible) or microscopic (occult).

hemoglobinuria: presence of free hemoglobin in the urine.

hyposthenuria: excretion of dilute urine with a specific gravity less than that of glomerular filtrate (1.001 to 1.007).

hypotonic: a solution which when bathing body cells causes a net movement of water across the semipermeable cell membranes *into* cells; denotes a *lower* osmotic activity than the solution being used for comparison.

hypertonic: a solution which when bathing body cells causes a net movement of water across the semipermeable cell membranes *out* of cells; denotes a *higher* osmotic activity than the solution being used for comparison.

-I-

idiopathic cystitis: no known cause for cystitis can be found. Diagnosis is made by exclusion, common in cats, rare in dogs.

incontinence: loss of voluntary control of urination.

interstitial nephritis: nephritis due to inflammation of the interstitial tissues of the kidney; chronic interstitial nephritis refers to interstitial fibrosis and mononuclear inflammatory cell infiltrate; etiology is not specified.

isosthenuria: excretion of urine with a specific gravity in the range of the glomerular filtrate (1.008 to 1.012); often used to describe the urine elaborated by diseased kidneys which have lost their ability to concentrate or dilute the urine.

isotonic: a solution in which body cells can be bathed without a net flow of water across the semipermeable cell membranes; denotes solutions which are of equal osmotic activity.

-K-

ketonuria: presence of ketone bodies in the urine.

-L-

LUTD: lower urinary tract disease(s); term was coined as an alternative to feline urologic syndrome (FUS) to try to shift focus away from FUS as a disease.

-M-

micturition: the act of urination; the passage of urine.

midstream catch: collection of a urine sample by allowing the animal to void spontaneously and collecting a sample after the initial stream of urine has been avoided to reduce the chance of urethral, genital, perineal, or preputial contamination.

myoglobinuria: the presence of the muscle pigment myoglobin in the urine.

-N-

nephritis: inflammation of the kidney, does not specify which area of the kidney is mainly involved (ie, tubules, glomeruli, vessels, interstitium).

nephron: the functional anatomic unit of the kidney consisting of the renal corpuscle (Bowman's capsule), proximal convoluted tubule, loop of Henle, distal convoluted tubule and collecting tubule.

nephropathy: any disease of the kidney.

nocturia: passage of urine at night.

-O-

occult blood: blood present in the urine in such small quantities that it can be detected only by chemical tests; these tests do not differentiate hemoglobinuria, myoglobinuria, and hematuria.

oliguria: excretion of a reduced amount of urine in relation to normal (<12 to 24 ml/lb/day).

osmolality: the concentration of osmotically active solutes per kilogram of solvent.

osmolarity: the concentration of osmotically active solutes per liter of solution.

-P-

pollakiuria: unduly frequent passage of urine that implies lower urinary tract distress.

polydipsia: frequent drinking due to excessive thirst; daily water intake in excess of normal (>40 ml/lb/day).

polyuria: passage of a large volume of urine in a given period; passage of urine in amounts in excess of normal (>12 to 24 ml/lb/day).

proteinuria: the presence of an abnormal amount of plasma protein in the urine.

pyelonephritis: inflammation of the renal pelvis and kidney proper beginning in the interstitium and extending to the tubules, glomeruli, and blood vessels; usually bacterial in nature.

pyuria: the presence of excessive numbers of white blood cells in the urine (the presence of "pus" in the urine).

-S-

Sedi-Stain®: brand name of supravital stain developed for use in urine sediment manufactured by Becton-Dickinson, Maryland.

specific gravity: the weight of a substance (in this context urine) divided by the weight of an equal volume of water as a standard.

stranguria (strangury): passage of urine with pain and straining.

-T-

Tamm-Horsfall mucoprotein (THM, uromucoid): an alpha-globulin derived from the ascending loop of Henle, distal tubule, and collecting ducts; normally present in canine and feline urine at very low concentrations (0.5 to 1.0 mg/dl).

tubular proteinuria: proteinuria associated with tubular dysfunction (reduced reabsorption of protein, secretion of protein or tubular necrosis); in tubular proteinuria, globulins predominate.

-U-

uremia: the constellation of clinical and biochemical abnormalities associated with a loss of a critical mass of functioning nephrons; includes the extra-renal manifestations of renal failure and is due to a critical loss of the conservation, excretory, and endocrine functions of the kidneys.

urethritis: inflammation of the urethra.

urinalysis: the systematic examination of a urine specimen which includes physical, chemical, and sediment findings.

urolith: a polycrystalline concretion which forms in the urinary tract; also known as calculus.

urolithiasis: the disease condition associated with the formation of calculi in the urinary tract.

uropathy: any disease of the urinary tract.

UTI: urinary tract infection.

-V-

void: to urinate; to micturate; to cast out as waste matter.

-W-

water deprivation test: a test used to assess kidney function; it is conducted by withholding water from a patient, then observing and measuring urine output to determine the release of vasopressin and response of the kidneys (elaboration of concentrated urine).

Suggested Reading

1. Barlough JE, Osborne CA, Stevens JB. Canine and feline urinalysis: Value of macroscopic and microscopic examinations. *Journal of the American Veterinary Medical Association.* 1981;178:61-63.
2. Chew DJ. Urinalysis. In: Bovee KC, ed. *Canine Nephrology*. Media: Harwal Publishing Co.; 1984:235-274.
3. DiBartola SP. Clinical approach and laboratory evaluation of renal disease. In: Ettinger SJ, Feldman EC, eds. *Textbook of Veterinary Internal Medicine*. Philadelphia: W.B. Saunders Co.; 1995:1706-1719.
4. Comer KM, Ling GV. Results of urinalysis and bacterial culture of canine urine obtained by antepubic cystocentesis, catheterization, and midstream voided methods. *Journal of the American Veterinary Medical Association*. 1981;179:891-895.
5. Fettman MJ. Comparison of urinary protein concentration and protein/creatinine ratio vs routine microscopy in urinalysis of dogs: 500 cases (1987-1988). *Journal of the American Veterinary Medical Association*. 1989;195:972-976.
6. Fettman MJ. Evaluation of the usefulness of routine microscopy in canine urinalysis. *Journal of the American Veterinary Medical Association*. 1987;190:892-896.
7. Hardy RM, Osborne CA. Water deprivation test in the dog: Maximal normal values. *Journal of the American Veterinary Medical Association*. 1979;174:479-483.
8. Henry JB, Lauzon RB, Schumann GB. Basic examination of urine. In: Henry JB, ed. *Clinical Diagnosis and Management by Laboratory Methods*. 19th ed. Philadelphia: W.B. Saunders Co.; 1996:411-456.
9. Lees GE, Hardy RM, Stevens JB, Osborne CA. Clinical implications of feline bilirubinuria. *Journal of the American Animal Hospital Association*. 1984;20:765-771.
10. Ling GV. Techniques of urine collection and handling. In: Ling GV, ed. *Lower Urinary Tract Diseases of Dogs and Cats*. St. Louis: Mosby; 1995:23-28.
11. MacDougall DF, Curd GJ. Urine collection and complete analysis. In: Bainbridge J, Elliott J, eds. *Manual of Canine and Feline Nephrology and Urology*. Ames: Iowa State University Press; 1996:86-106.
12. Osborne CA, Stevens JB. Handbook of Canine and Feline Urinalysis. St. Louis: Ralston Purina Company; 1981:155.
13. Osborne CA. Techniques of urine collection and preservation. In: Osborne CA, Finco DR, eds. *Canine and Feline Nephrology and Urology*. Baltimore: Williams & Wilkins; 1995:100-121.
14. Osborne CA, Stevens JB, Lulich JP, et al. A clinician's analysis of urinalysis. In: Osborne CA, Finco DR, eds. *Canine and Feline Nephrology and Urology*. Baltimore: Williams & Wilkins; 1995:136-205.
15. Ross LA, Finco DR. Relationship of selected clinical renal function tests to glomerular filtration rate and renal blood flow in cats. *American Journal of Veterinary Research*. 1981;42:1704-1710.
16. van Vonderen IK, Kooistra HS, Rijnberk A. Intra- and interindividual variation in urine osmolality and urine specific gravity in healthy pet dogs of various ages. *Journal of Veterinary Internal Medicine*. 1997;11:30-35.
17. Ringsrud KM, Linne JJ. Urinalysis and Body Fluids: A Color Text and Atlas. St. Louis: Mosby; 1995:249.
18. Zinkl JG. Urine sediment examination. In: Ling GV, ed. *Lower Urinary Tract Diseases of Dogs and Cats*. St. Louis: Mosby; 1995:29-36.

Subject Index

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