

### Question

A 6-month old Labrador Retriever presents for failure to thrive and stranguria. Abdominal ultrasound shows a small liver and stones in the urinary bladder. Abdominal radiographs show no visible stones. How can this be explained?

- An artifact from the ultrasound was perceived as stones. There are really no stones in the bladder.
- The dog has struvite stones.
- The dog has urate stones in its bladder.
- The dog has calcium oxalate stones.

**Explanation** - The correct answer is the dog has **urate stones**. The dog is described as having a **portosystemic shunt** which is often accompanied by urate stones in the bladder. Urate stones (and cysteine stones) are radiolucent, so they can't be detected by radiography. Remember "I can't C U": ("C" is for cysteine, and "U" is for urate).

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### Question

Which of these is an important nutritional goal in the management of struvite urolithiasis?

- Maintaining urine specific gravity of  $<1.020$
- Increasing dietary protein
- Maintaining a urine pH of 8 to 8.5
- Increasing magnesium in the diet

**Explanation** - The correct answer is maintaining urine specific gravity  $<1.020$ . An important principle in management of any patient with urolithiasis is to maintain dilute urine so that solutes do not concentrate to the degree that they form precipitates that lead to stone formation. Struvite stones (magnesium ammonium phosphate) tend to form in alkaline urine so ideal urine pH for struvite stone formers is usually around 6.5. Other principles of management are to decrease urea in the urine, often done by moderate protein restriction and to decrease the minerals involved (magnesium and phosphate). Finally, a key element in struvite stone formation is the presence of a urinary tract infection, particularly with urease-producing microbes, most notably staphylococcus and protease. Monitoring, preventing, and treating UTIs is an important aspect of management of these patients.

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### Question

Which of the following is most suggestive of pyelonephritis?

- Pain on abdominal palpation
- Bacteria or white blood cells in the urine
- Small, irregular kidneys on ultrasound
- Bacterial or white blood cell casts in urine

**Explanation** - The correct answer is bacterial or white blood cell casts in urine. Bacterial or white blood cell casts are highly suggestive of a past or present bacterial infection in the kidneys. Bacteria or white blood cells in the urine may be due to cystitis. Small, irregular kidneys may be due to any chronic pathology in the kidneys. Pain on abdominal palpation can be caused by pain from any abdominal organ or structures adjacent to the abdomen. Other signs associated with pyelonephritis include fever, anorexia, depression, and vomiting. A nephroptelogram may show blunted, dilated calices and dilated, tortuous ureters. Renal biopsy and culture would give the definitive diagnosis of pyelonephritis.

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### Question

Which of the following reasons explains why Dalmatians are predisposed to urinary tract obstructions?

- Dalmatians are born with a congenital defect that predisposes them to urethral narrowing and the formation of urethral strictures.
- Dalmatians have a genetic defect in making allantoin from urates in their liver. The low solubility of urates predisposes the dogs to forming urate stones, which can cause urinary tract obstructions.
- Dalmatians have a genetic defect in the immune system of their lower urinary tract, predisposing them to bacterial cystitis and the formation of struvite stones, which can cause urinary tract obstructions.
- Dalmatians have a genetic defect in the renal tubular reabsorption of cysteine, predisposing them to a build-up of cysteine and the formation of cysteine stones, which can cause urinary tract obstructions.

**Explanation** - The correct answer is Dalmatians have a genetic defect in making allantoin from urates in their liver. The low solubility of urates predisposes the dogs to forming **urate stones** which can cause UT obstructions. Medical management involves feeding a low purine diet to neutralize or alkalinize the urine pH and administration of allopurinol, a xanthine oxidase inhibitor.

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### Question

Which of the following is not a component of nephrotic syndrome?

- Proteinuria
- Hypercoagulability
- Hypercholesterolemia
- Hypoproteinemia
- Edema or ascites

**Explanation** - The correct answer is hypercoagulability. The four components of nephrotic syndrome are proteinuria, hypoproteinemia, hypercholesterolemia, and ascites or edema. This syndrome occurs with protein-losing nephropathies such as glomerulonephritis or amyloidosis. Hypercoagulability is not a component of nephrotic syndrome, although it can occur with protein-losing nephropathies due to the loss of antithrombin III.

### Nephrotic Syndrome in Dogs

- The glomeruli function to filter waste from the blood. When filtration cells (**podocytes**) in the kidney's glomeruli become damaged due to either immune complexes in the blood (called **glomerulonephritis**), or due to dense deposits of amyloid protein abnormal accumulation of which is called **amyloidosis**, degeneration of the kidney's tubular system occurs. This is medically referred to as **nephrotic syndrome**. Patients with nephrotic syndrome lose too many necessary proteins into the urine (**proteinuria**). Two of these proteins are **albumin**, which helps to maintain **blood pressure** and keep blood in the vessels, and **antithrombin III**, which prevents blood clotting.
- When greater than 3.5g of proteins are lost each day, blood pressure falls, less blood stays in the blood vessels, and consequently, the kidneys act to conserve sodium in the body. This causes swelling of the limbs, **hypertension** and **Ascites**.
- To compensate protein loss, the liver increases its production of proteins and lipids, further raising the levels of cholesterol-rich lipids circulating in the blood. This can lead to **hypercholesterolemia** and **arteriosclerosis**.
- Progressive glomerular disease can lead to **BUN** and **creatinine** accumulation in the bloodstream, and eventually, long-term kidney failure. Glomerular disease is relatively common in dogs.

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### Question

A 7-year old male Shar-Pei presents to you with lethargy, polyuria and polydipsia, and decreased appetite. Bloodwork shows a hematocrit of 29%, white blood cell count of 4,800/uL, and 250,000 platelets/uL. The chemistry panel shows Ca=10.2 mg/dL, P=3.9 mg/dL, bilirubin=0.1 mg/dL, albumin=2.8 g/dL, globulin=2.6 g/dL, ALT=47 IU/L, glucose=94 mg/dL, BUN=174 mg/dL, Creatinine=7.2 mg/dL, and cholesterol=120 mg/dL. Urinalysis shows a specific gravity of 1.010 with no bilirubin, glucose, or ketones detected but 4+ protein.

The dog has only a minimal response to supportive care with IV fluids, gastric protectants, and pain medications. He is euthanized after 2 days of hospitalization. On postmortem exam, you find that his kidneys are grayish in color and enlarged. The cut surface is firm and waxy. What is your presumptive diagnosis?

- Amyloidosis
- Lyme disease
- Renal infarct
- Hydronephrosis
- Glomerulonephritis

**Explanation** - The marked proteinuria suggests glomerular disease. The necropsy finding of a waxy kidney is highly suggestive of amyloidosis. Shar-Pei dogs are predisposed to this condition.

In hydronephrosis, you would see extensive dilation of the renal pelvis and calyces at postmortem.

With renal infarcts, you see triangular or pyramidal shaped lesions.

Lyme disease can lead to glomerulonephritis where the surface of the kidney is covered by hemorrhagic spots.

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### Question

The pyramid-shaped lesion in the canine kidney depicted below is indicative of what pathologic process?



- Protein-losing nephropathy
- Pyelonephritis
- Thrombosis
- Glomerulonephritis
- Tubulointerstitial nephritis

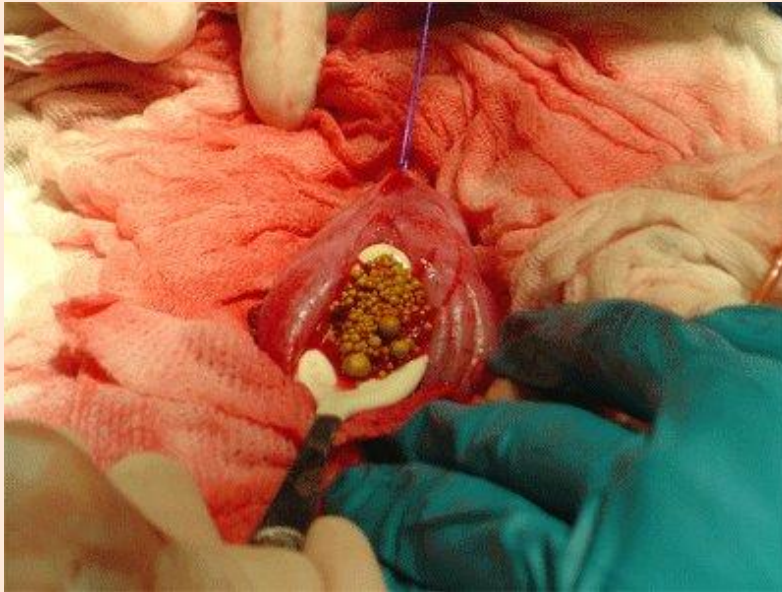
**Explanation** - Due to the organization of vasculature and circulation in the kidney, renal infarcts typically appear as triangular lesions, fanning out from the medulla to the cortex.

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### Question

A 5-year old male neutered Dalmatian presents for hematuria, pollakiuria, and stranguria. Abdominal radiographs were unremarkable and an abdominal ultrasound showed evidence of

urolithiasis. The patient was taken to surgery and the image depicts the surgical findings. What additional treatment options should be recommended to the owner?



- Soy-based and acidifying diet
- Alkalizing diet and allopurinol therapy
- Acidifying diet and 2-mercaptopyruvylglycine (2-MPG) therapy
- Acidifying and low-salt diet
- Alkalizing diet and d-penicillamine (Cuprimine) therapy

**Explanation** - The stones in the image are most consistent with the appearance of urate stones, but even without recognizing their appearance, you should be able to guess that the dog has urate stones based on the Dalmatian breed, as they are highly predisposed to forming urate stones, and the apparent radiolucency of the stones since they were not visible radiographically.

Urate stone formation is promoted by acidic urine and diets high in purines which are metabolized to uric acid. Generally a low-purine alkalizing diet is recommended. Allopurinol therapy may also be used to reduce uric acid production but it requires monitoring as it may predispose dogs to different types of stones (Xanthine).

Soy is high in purines and is not recommended for dogs prone to forming urate stones.

Cuprimine and 2-MPG are treatments used for cystine stones.

A low salt diet is sometimes used for dogs with calcium phosphate stones because high sodium intake increases urinary calcium.

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### Question

What type of urinary stone is likely to form in an animal being treated with too much allopurinol?

- Struvite
- Cysteine
- Urate
- Xanthine

**Explanation** - The correct answer is xanthine stones. Allopurinol is used in the treatment of urate stone forming Dalmatians. It acts by inhibiting the enzyme, xanthine oxidase, which metabolizes xanthine. The idea is that by stopping the purine metabolism pathway at this point, uric acid will not be formed in high quantities. However, if given at too high of a dose, xanthine will accumulate to levels where xanthine stones will form.

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### Question

Which of the following is not an indication for performing a urine culture?

- White blood cells seen on urinalysis sediment
- Bacteria already visible on urinalysis sediment
- Isosthenuria
- Bilirubinuria

**Explanation** - The correct answer is bilirubinuria. Bacteria seen on a UA should be cultured to determine the type of bacteria present and the type of antibiotics it is sensitive to. The presence of white blood cells in urine is indicative of a urinary tract infection, indicating that a culture should be performed. Isosthenuria or low urine specific gravity makes it difficult to identify bacteria in the sample since it is so dilute.

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### Question

A 4-year old female spayed mixed breed dog presents for dysuria. Urinalysis shows a pH of 9.0 and numerous cocci and crystals in the sediment. The dog is otherwise normal and healthy. Which crystal type is most likely present?

- Struvite
- Urate
- Cysteine
- Calcium oxalate

**Explanation** - The correct answer is struvite. Struvite or magnesium ammonium phosphate crystals form in alkaline urine, whereas most other crystal types form in acidic urine. The cocci present are urease positive bacteria that cleave urea to ammonia causing the urine pH to rise and

making the environment more favorable for struvite crystals to form. Cysteine crystals form as a result of a genetic defect of the renal tubules, and are almost exclusively seen only in males. Urate crystals only form in Dalmatians (due to a genetic defect in urate metabolism) and animals with portosystemic shunts or liver dysfunction. Urates are less likely in this patient, since it is not a Dalmatian and shows no signs of liver disease.

## Key Points

- **Most common type:** Dogs and cats - struvite and calcium oxalate
- Medical dissolution is possible for most stones except **calcium oxalate**
- Use an **alkalinizing diet** for treatment of **cystine and urate** stones. **Acidify** for **struvite**
- The radiolucent stones are **cystine and urate**, they may not be visible on a radiograph
- **Reduced protein diet** for management of **cystine, urate, canine struvite and to a lesser degree, calcium oxalate stones**

## General Management (For All Stone Types):

- Increase urine volume (to keep urine dilute) into which crystal forming substrates are dissolved. This is usually done with a **high moisture content food**
- Reduce the quantities of crystal forming substrates in the urine (specifics depend on stone type)
- Increase the urine solubility of crystal forming substrates (often by affecting pH)

## Struvite Stones (Magnesium Ammonium Phosphate)

### Dietary Management:

In dogs, struvite stones are usually induced by urinary tract infections (UTI) by urease positive microbes. The goal of treatment is to decrease the three components of the crystals:

- Magnesium - Low magnesium diet
- Ammonium - High quality, reduced protein diet to reduce urine urea concentration which will be converted to ammonia by microbial urease. This is not important in most cats which have sterile struvite stones.
- Phosphate - Low phosphorous diet



Additionally, because dog struvite stones are usually associated with infection, treat with appropriate antimicrobials based on culture and sensitivity, ideally ones that are excreted at high levels in the urine.

## Question

Which of the following choices is the best candidate for successful urohydropropulsion removal of a cystic calculus?

- A thin female dog
- A large male dog

- A thin male dog
- A large female dog

**Explanation** - The correct answer is a thin female dog.

Urohydropropulsion is the expulsion of cystic calculi after anesthetizing an animal by application of manual pressure to the urinary bladder to expel the stone through the urethra. Urohydropropulsion should not be attempted in male dogs because they have long, narrow urethras compared to females and an os penis which increases the likelihood of the calculi becoming lodged in the urethra. Obesity (and large size in general) makes it more difficult to manipulate the bladder effectively.

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### Question

You are presented with a 6-year old female spayed toy poodle mix who has a 4 day history of stranguria and pollakiuria. The owner says that this is the 3rd time she has had these signs in the last 4 months; each of the other times the signs resolved after a week of amoxicillin.

Physical exam is normal except for discomfort on bladder palpation.

CBC and chemistry panels are within normal limits. Urinalysis results are as follows:

USG = 1.030  
pH = 8.5  
Color = yellow  
Clarity = turbid  
Glucose = neg  
Ketones = neg  
Protein = 3+  
RBC = 50-100/hpf  
WBC = 20-30/hpf  
Bacteria = ++++ cocci  
Crystals = 4+ magnesium ammonium phosphate crystals

Abdominal radiographs show several large (>2 cm) rounded mineral opacities in the bladder.

What is the most likely diagnosis, and what are your treatment options?

- Cystine stones. Treat with culture-based antibiotics, surgical removal and decreased dietary calcium.
- Calcium oxalate stones. Treat with culture-based antibiotics, and either dietary dissolution or surgical removal of stones.
- Struvite urolithiasis. Treat with culture-based antibiotics, and either dietary dissolution or surgical removal of stones
- Ammonium urate stones. Treat with culture-based antibiotics, dietary dissolution, and management of underlying liver disease.



**Explanation** - Large bladder stones in the presence of UTI and alkaline urine are usually struvite, particularly when accompanied by struvite (magnesium ammonium phosphate) crystalluria. In dogs, struvite stones are almost invariably infection-associated. The infecting organisms are usually urease-producers (Staphylococcus, Proteus, Klebsiella, some E. coli) which alkalinize the urine and favor struvite formation. The single most important long-term management is prevention of infection.

Calcium oxalate stones are usually small (1 cm or less), are often present in the absence of UTI, and cannot be dissolved. Cystine stones occur most often in Newfoundland dogs, dachshunds, and bulldogs. They are radiolucent and occur due to metabolic defects. Urate stones are usually small and many. They are frequently radiolucent and can be related to underlying liver disease.

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### Question

What is the most appropriate medical treatment for transitional cell carcinoma at the trigone of the bladder, as depicted in the photo?



- Piroxicam and platinum chemotherapy
- Clavamox and furosemide
- Prednisone and combination chemotherapy with cyclophosphamide, vincristine, doxorubicin
- Carprofen and combination chemotherapy with cyclophosphamide, vincristine, doxorubicin
- Prednisone and vinblastine or lomustine chemotherapy

**Explanation** - Transitional cell carcinoma of the bladder in dogs can be palliatively managed with non-steroidal anti-inflammatory drugs such as piroxicam. Progression-free interval and survival can be extended with the addition of chemotherapy. The most commonly used agents are carboplatin, cisplatin, and mitoxantrone. Secondary infections can be treated with appropriate antibiotics.

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### Question

What breed of dog is predisposed to forming urate uroliths due to a metabolic defect?

- Dalmatians
- Yorkshire Terriers
- Doberman Pinschers
- Labrador Retrievers

**Explanation** - The correct answer is Dalmatians. Dalmatians have a metabolic defect where they are unable to convert uric acid to allantoin, a much more soluble compound. As a result, urate levels in the urine reach high levels and frequently form stones. Yorkshire Terriers, in a way, are predisposed to making urate stones, but not from a metabolic defect. Instead, Yorkies frequently have portosystemic shunts. This anatomic abnormality is a common reason that animals other than Dalmatians form urate stones.



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### Question

Having just repaired a femoral fracture on an 8 year old male Labrador with mild chronic renal insufficiency, your technician asks you for post-operative orders. Which of these drugs is contraindicated for analgesia in your patient?

- Dexmedetomidine
- Tramadol
- Gabapentin
- Butorphanol
- Carprofen
- Ketamine

**Explanation** - Carprofen is a non-steroidal anti-inflammatory and has analgesic properties but may exacerbate the chronic renal disease by causing decreased blood perfusion to the kidneys by vasoconstricting the afferent arteries by diminishing the effects of prostaglandins.

**Dexmedetomidine** and ketamine can each be used as a constant rate infusion to provide pain control. **Butorphanol** is an opioid that has partial agonist and antagonist effects on the mu and kappa receptors. **Tramadol** is a synthetic opioid. **Gabapentin** is an anticonvulsant that is often used for its analgesic effects, particularly against neuropathic pain.

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### Question

Dextrose, insulin, sodium bicarbonate and calcium gluconate are all drugs used to treat life-threatening hyperkalemia in emergencies such as urethral obstructions. All these drugs, except one, work to lower potassium via intracellular translocation. Which drug has a different mechanism of action in treating hyperkalemia?

- Sodium bicarbonate
- Calcium gluconate
- Insulin
- Dextrose

**Explanation** - Dextrose, insulin, and sodium bicarbonate infusions all drive potassium intracellularly. Calcium gluconate does nothing to lower the measurable serum potassium. Calcium gluconate is used to treat hyperkalemia by **antagonizing the effects of elevated serum potassium on the myocardium**. Its action is targeted at keeping the myocardial tissue normally excitable so the heart rhythm does not develop a life threatening bradycardia as seen with untreated hyperkalemia.

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