### Azotemia

<table>
<thead>
<tr>
<th>Condition</th>
<th>Facts/Cause</th>
<th>Presentation/CS</th>
<th>Diagnosis</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azotemia</td>
<td>† Blood Urea Nitrogen (BUN) &amp;/or creatinine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>† Types: prerenal, renal or postrenal azotemia</td>
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<tr>
<td></td>
<td>† Differentiating the type is important for accurate diagnosis, treatment &amp; prognosis</td>
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<tr>
<td></td>
<td>† Uremia: clinical syndrome resulting from the accumulation of metabolic waste products due to renal failure</td>
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</tr>
</tbody>
</table>

**Prerenal azotemia**

- ‡ Renal perfusion causing ‡ glomerular filtration of metabolites
  - Results in ‡ BUN &/or creatinine in bloodstream
  - Urine concentration ability remains normal (tubular function remains normal)
- If decreased perfusion corrected rapidly kidney will return to normal function
- If not corrected: renal ischemia & kidney destruction

**Postrenal azotemia**

- ‡ Blockage of urine outflow
- ‡ Oliguria or anuria
- ‡ Hyperkalemia

**DDx: Azotemia**

- ‡ BUN - normal creatinine - normal GFR
  - High protein diet
  - Excess protein catabolism
  - Intestinal bleeding
  - Fever
  - ‡ Fractional reabsorption of urea as with dehydration

### Causes - prerenal azotemia

- Dehydration
- Shock
- Hypoadrenocorticism
- Heart failure

### Prerenal azotemia

- Reduced renal perfusion
- ‡ BUN & creatinine
- ‡ Urine specific gravity > 1.030

### Renal Azotemia

- Loss of 75% of nephrons
- ‡ BUN & creatinine
- ‡ Urine specific gravity < 1.017

### Postrenal azotemia

- Blockage of urine outflow
- ‡ BUN & creatinine
  - Oliguria or anuria
  - Hyperkalemia

### Kidney normal

- Restore circulating fluid volume & renal perfusion
- Correct electrolyte abnormalities
- Treat cause:
  - Dehydration: fluids
  - Shock: fluids, steroids
  - Hypoadrenocorticism: fluids
  - Heart failure: ???

### Prognosis

- Usually resume normal function when re-perfusion reestablished if not prolonged ischemia

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### Renal Review - Azotemia, PU/PD, Urolithiasis, Incontinence, Glomerulonephropathy

#### Guide to Sm An Clinics, Pasquini, 3rd Edition

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<th>Facts/Cause</th>
<th>Presentation/CS</th>
<th>Diagnosis</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Renal azotemia</strong></td>
<td>✷️ GFR due loss of &gt; 75% of nephrons</td>
<td>• Acute</td>
<td>• ↑ BUN &amp; creatinine</td>
<td>• Acute: - Support until repair itself</td>
</tr>
<tr>
<td></td>
<td>• Renal diz resulting in azotemia = renal failure</td>
<td>- Anuric, oliguric, occasionally polyuric</td>
<td>• Acute &amp; chronic</td>
<td>• Fluids, Tx hyperkalemia &amp; acidosis</td>
</tr>
<tr>
<td></td>
<td>- Acute renal failure: reversible or irreversible</td>
<td>- Chronic</td>
<td>• Low SpG &lt; 1.017</td>
<td>• Initiate urine flow (Lasix, mannitol)</td>
</tr>
<tr>
<td></td>
<td>- Chronic renal failure: irreversible</td>
<td>- PU/PD</td>
<td></td>
<td>• Chronic: - NO cure, palliative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- GI (vomiting &amp; diarrhea)</td>
<td></td>
<td>- Fluids</td>
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<tr>
<td></td>
<td></td>
<td>- Oral ulcers</td>
<td></td>
<td>• <strong>Diet:</strong> restrict proteins &amp; phosphorus (Hill's k/d)</td>
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<td></td>
<td></td>
<td></td>
<td><strong>Cause renal azotemia</strong></td>
<td><strong>Prognosis:</strong></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Acute renal failure</td>
<td>• Acute: may be reversed</td>
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<td></td>
<td></td>
<td></td>
<td>- Ischemia (prerenal)</td>
<td>• Chronic: irreversible</td>
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<td></td>
<td></td>
<td></td>
<td>- Dehydration</td>
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<td></td>
<td>- Hypovolemia</td>
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<td></td>
<td>- Toxins</td>
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<td></td>
<td></td>
<td></td>
<td>- Ethylene glycol</td>
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<td>- Aminoglycosides</td>
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<td></td>
<td>- Heavy metals</td>
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<td></td>
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<td></td>
<td>- Hypercalcemia</td>
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<td>- Infections (e.g., pyelonephritis)</td>
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<td></td>
<td></td>
<td>- Others</td>
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<td></td>
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<td></td>
<td>• Chronic renal failure</td>
<td></td>
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<tr>
<td><strong>Postrenal azotemia</strong></td>
<td>• Blockage of urine outflow</td>
<td>• Oliguria</td>
<td>• ↑ BUN &amp; creatinine</td>
<td>• Hyperkalemia - priority</td>
</tr>
<tr>
<td></td>
<td>• Hyperkalemia develops (potassium can't be eliminated)</td>
<td>• Straining</td>
<td>• Oliguria or anuria</td>
<td>• Unblock animal</td>
</tr>
<tr>
<td></td>
<td>- Life-threatening: effects cardiac conduction, causing bradycardia &amp; death</td>
<td>• Abdominal discomfort</td>
<td>• CS: dysuria, discomfort</td>
<td>• Cystocentesis if can't immediately unblock</td>
</tr>
<tr>
<td></td>
<td>- Initially kidneys resume normal function if corrected. With time obstruction may result in renal lesion; e.g., hydronephrosis</td>
<td>• Sequelae:</td>
<td>• ECG (hyperkalemia)</td>
<td>• Fluid therapy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Heart failure: hyperkalemia</td>
<td>- Bradycardia</td>
<td>- Sodium bicarbonate: 0.5-1 mmol/kg by slow IV over 15 min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Hydronephrosis</td>
<td>- Spiked T-waves</td>
<td>- 20% dextrose: 0.5-1 g/kg IV w/ ≤1 U regular insulin per 3 g dextrose</td>
</tr>
<tr>
<td></td>
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<td>- Absence of P-waves</td>
<td>- 10% calcium gluconate: up to 0.5-1 g/kg IV. Rapid, but short-lived effect (minutes)</td>
</tr>
<tr>
<td><strong>Cause - postrenal azotemia</strong></td>
<td>• Urinary obstruction</td>
<td></td>
<td>• Check creatinine of abdominal fluid if rupture suspected</td>
<td><strong>Prognosis:</strong></td>
</tr>
<tr>
<td></td>
<td>- Calculi: renal pelvis, ureter or urethra</td>
<td></td>
<td></td>
<td>• Good if corrected</td>
</tr>
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<td></td>
<td>- Tumor block</td>
<td></td>
<td></td>
<td>• Guarded if renal lesions</td>
</tr>
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<td></td>
<td>- Entrapment of urinary tract (hernia)</td>
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<td>- Trauma, stricture</td>
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<td></td>
<td>- Iatrogenic: surgery or catheterization</td>
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<tr>
<td></td>
<td>- Ruptured urinary tract</td>
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</tbody>
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Renal Review-Azotemia, PU/PD, Urolithiasis, Incontinence, Glomerulonephropathy

Polyuria & Polydipsia

**Condition**
- Increased thirst & urine production
  - Urine production > 25 ml/lb/day (50 ml/kg/day)
  - Water consumption > 50 ml/lb/day (100 ml/kg/day)

**Facts/Causes**
- Manifestation of diz; not a diagnosis
- PU & PD usually exist concurrently
- Mechanism of polydipsia:
  - Low plasma osmolality stimulates chemoreceptors in thirst center (hypothalamic supraoptic nucleus)
  - Posterior pituitary gland releases ADH (antidiuretic hormone)
  - Renal response to ADH is to concentrate urine requiring 1/3rd functioning nephrons & a hypertonic renal medullary interstitium
  - 2/3rds nonfunctional nephrons for kidney not to concentrate urine (polyuria)

**Presentation**
- Polyuria
  - Nocturia
  - Inappropriate urination
  - Incontinence
  - Pollakiuria (frequent urination)

**Diagnosis**
- Polydipsia (excess drinking)

**DDx - Polyuria/Polydipsia**
- Dipsogenic diabetes insipidus (DDI)/Psychogenic polydipsia
- Pituitary diabetes insipidus
- 1° renal diz
  - Chronic primary renal failure
  - Hydronephrosis??
  - Renal amyloidosis
  - Chronic pyelonephritis
  - Familial renal diz
  - Primary renal glycosuria
  - Fanconi’s Syndrome
  - Acute renal failure

- Pyometra (uterine infection)
- Hyperadrenocorticism
- Liver diz
- Hypercalcemia
- Hyperparathyroidism
- Hypoparathyroidism
- Hyperthyroidism
- Hypoadrenocorticism
- Lymphosarcoma
- Pheochromocytoma
- Diabetes mellitus

**History** (empty water dish, constant drinking)
- Lymphadenopathy (lymphoma), cataracts (diabetes mellitus), symmetrical alopecia (hyperadrenocorticism), vaginal discharge (pyometra), small kidney (chronic FR)

**Metabolism cage:** Urine volume: 25-45 ml/kg/24 hrs

**Urinalysis:**
- USpG (urine specific gravity)
  - > 1.030 unlikely to be polyuria
  - < 1.007 (hyposthenuria) tentative Dx of CDI, NDI or PPD

**>1.025 + PU/PD suggests hyperadrenocorticism, diabetes mellitus or renal glycosuria**

**Blood values:**
- Azotemia (*+ BUN/creatinine*) indicates renal diz
- Liver enzymes
- CBC: infection (pyometra)
- Radiographs, ultrasound
- Other tests
  - Lymph node biopsy (lymphoma)
  - Low dose dexamethasone suppression test (hyperadrenocorticism)

**Provocative tests to differentiate normal psychogenic polydipsia, hyperadrenocorticism, pituitary DI, nephrogenic DI or medullary washout**
- **Water deprivation** if PU/PD & no signs or diz (kidney, liver, etc.)
  - USG > 1.025 - psychogenic polydipsia or Cushing’s diz
  - USG < 1.025 - then do ADH test

**ADH test**
- USG > 1.025 - pituitary diabetes insipidus (no ADH)
- USG < 1.025 - then do gradual H2O deprivation test

**Gradual H2O test** (to correct possible medullary washout)
- USG > 1.025 - psychogenic polydipsia or Cushing’s diz
- USG < 1.025 - then do ADH test

**ADH + gradual H2O deprivation tests**
- USG < 1.025 - kidney unresponsive to ADH
- USG > 1.025 - pituitary diabetes insipidus
Water deprivation test:
- Determines if:
  - 1. ADH released in response to subclinical dehydration
  - 2. If kidneys can respond to ADH & concentrate urine
- Contraindications (potentially dangerous - death):
  - Dehydration
  - Azotemia (BUN, creatinine)
  - Hypercalciemia
- Terminate test when:
  - Urine concentrated > 1.025
  - > 5% weight loss
  - Azotemia
  - Dehydration

Abrupt water deprivation test
- Normal animal concentrate USG to 1.075 - cats: 1.045 - dogs: > 1.285 considered adequate for test
- Negative result (failure to concentrate - USG < 1.025) w/ or other laboratory abnormalities indicates neurogenic or nephrogenic diabetes insipidus &/or medullary washout (DDI)

Gradual water deprivation test
- For psychogenic polydipsia w/ medullary washout (can’t concentrate on abrupt test), allows gradient to be reestablished
- Procedure: Reduce water intake by 5% daily
- Results: Negative result (failure to concentrate) w/ renal diz or laboratory abnormalities indicates neurogenic or nephrogenic diabetes insipidus not DDI

ADH response test (after abrupt of gradual H2O deprivation tests)
- If inadequate concentration after water deprivation test
- Tests renal tubular ability to concentrate urine
- Procedure:
  - Vasopressin (Pitressin®) IM
  - Measure USG at 30, 60, 90 & 120 min
- Interpretation:
  - Negative water deprivation + positive ADH concentration > 1.285 diagnostic of neurogenic DI
  - Both negative water deprivation & negative ADH tests indicates nephrogenic DI or DDI if after abrupt H2O deprivation

NO azotemia (normal BUN)

A abrupt H2O test
- USG < 1.025
  - ADH test
    - USG < 1.025
      - Gradual H2O test
        - USG < 1.025
          - ADH test
            - USG > 1.025
              - Evaluate for hyperadrenocorticism
                - Normal - Psychogenic polydipsia (medullary washout)
        - USG < 1.025
          - ADH test
            - USG > 1.025
              - Kidney DI (NDI)

Polyuria (USG < 1.025 & normal serum glucose)

Signs or kidney diz (low BUN)

Signs or liver diz

Liver diz

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### Renal Review - Azotemia, PU/PD, Urolithiasis, Incontinence, Glomerulonephropathy

**Diabetes insipidus**
- **M8k 412, 1734; H2B 502, E-hb 85, 549; Dx-L 39**
- **3 basic types - Also see Endo pg 670**
  1. Nephrogenic DI (NDI) partial or complete renal tubule insensitivity to ADH
  2. Central DI (CDI): partial or complete primary deficiency of ADH
  3. Dipsogenic DI or psychogenic polydipsia/polyuria: excessive water intake
- **Neg H2O & ADH test**
- **Neg. H2O, positive ADH**
- **Positive H2O (abrupt or gradual)**

**Nephrogenic diabetes insipidus, NDI**
- **M8k 412, 1734; E-hb 666, 85, H3B 514; H2B 502, 564; SAP 268, 812; IM-WW 338; IM 458, 528; IM-WW 338; SmH 514, 130, 1020; E 1804; Cat 1410; R&P 2; R&E-M 251; Lab-C 219; Psy-R 195; Ddx 68; Dx-L 39**
- **Renal tubules nonresponsive to ADH**
  - Distal tubules & collecting ducts
  - ADH levels normal to increased
  - Partial or complete unresponsiveness to ADH
- **Causes:** see rounded box
  - Congenital: rare
  - Acquired secondary NDI
  - Renal & metabolic disorders affecting renal tubules' ability to respond to ADH
- **Most acquired forms reversible following correction of cause**
  - Similar CS, Hx & physical to pituitary diabetes insipidus, except for trauma

**Unresponsive renal tubules**
- **CS: PU/PD**
- **Dx: No response to water or ADH tests**
- **Tx: Tx cause, Unlimited H2O**

---

### URINARY SYSTEM

#### NUPTERY SYSTEM

**Diabetes insipidus**
- **Neg H2O & ADH test**
- **Neg. H2O, positive ADH**
- **Positive H2O (abrupt or gradual)**

**Nephrogenic diabetes insipidus, NDI**
- **Neg H2O, positive ADH**
- **Positive H2O (abrupt or gradual)**

---

**Nephrogenic diabetes insipidus**
- **2nd nephrogenic DI**
  - Renal disorders
    - Acute renal failure
    - Chronic primary renal failure
    - Hydronephrosis
    - Renal amyloidosis
    - Chronic pyelonephritis
    - Familial renal dizz
    - Primary renal glycosuria
    - Fanconi's Syndrome
    - 2nd renal disorders
  - Pyometra (urinary infection)
  - Diabetes mellitus
  - Liver dizz
  - Lymphosarcoma
  - Pheochromocytoma
  - Endocrine
  - Hyperadrenocorticism
  - Hypoadrenocorticism
  - Hyperthyroidism
  - Hypoparathyroidism
  - Metabolic disorders
  - Hypercalcemia
  - Hypokalemia
  - Drugs
  - Corticosteroids
  - Anticonvulsants
  - Diuretic
  - Congenital 1st NDI (rare)

---

**Prognosis:**
- **2nd NDI:** depends on response of underlying cause
- **1st NDI (rare) guarded to poor**

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<tbody>
<tr>
<td>Pituitary diabetes insipidus, Central diabetes insipidus, CDI, Neurogenic diabetes insipidus, Neurohypophyseal diabetes insipidus</td>
<td>Lack of ADH (antidiuretic hormone); either formation &amp;/or release of endogenous ADH</td>
<td>PD/PU</td>
<td>CS: PU/PD: Hx PU/PD &gt; 100 m/l/kg/d normal 40–70</td>
<td>Not mandatory if unlimited water</td>
</tr>
<tr>
<td></td>
<td>Cause of CDI (central DI)</td>
<td>Nocturia</td>
<td>Urine specific gravity: Dog 1.000–1.007, Cat 1.006–1.012</td>
<td>Unlimited water paramount</td>
</tr>
<tr>
<td></td>
<td>- Idiopathic (most common)</td>
<td>± Weight loss (if preoccupied with drinking)</td>
<td>Partially concentrated</td>
<td>Desmopressin (DDAVP® - synthetic vasopressin analog) drops in conjunctival sac</td>
</tr>
<tr>
<td></td>
<td>- CNS trauma</td>
<td>± CNS signs (expanding tumor)</td>
<td>Physical exam: usually unremarkable, m/b thin (thirst overshadows hunger)</td>
<td>- Limit water for couple of hours after Tx to avoid over hydration</td>
</tr>
<tr>
<td></td>
<td>- CNS infection</td>
<td>Stupor, disorientation, circling, pacing, convulsions</td>
<td>Dehydration if water unavailable for 4-6 hours</td>
<td>- Repostol vasopressin (Pitressin®) IM</td>
</tr>
<tr>
<td></td>
<td>- Parasitic migration</td>
<td>Distended abdomen related to over distention of bladder with urine</td>
<td>Lab: persistent hypotension, CBC normal or consistent with dehydration</td>
<td>- Chlorpropamide (Diabinese®) sulfonamide agent for partial CDI; potentiates renal tubular effect of ADH. Ineffective in complete CDI &amp; NDI needs some ADH</td>
</tr>
<tr>
<td></td>
<td>- Neoplasia (cranioencephalonal metastatic tumors - mammary carcinoma, lymphoma, melanoma, pancreatic carcinoma) or diminished blood flow</td>
<td>- Congenital defects (rare)</td>
<td>Water deprivation + ADH tests</td>
<td>Chlorothiazide diuretics + oral salt restriction may reduce urine output by inhibiting sodium resorption; up to 60% reduction</td>
</tr>
<tr>
<td></td>
<td>- ADH acts on distal tubules &amp; collecting ducts † reabsorption of water</td>
<td>- ADH = water diuresis (polyuria)</td>
<td>- Water deprivation = SpG &lt; 1.025 = (CDI or nephrogenic)</td>
<td>Chlorothiazide (Diumil®), Hydrochlorothiazide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>** Psychogenic polydipsia, Primary polydipsia, Dipsogenic diabetes insipidus, Compulsive water drinking</td>
<td>- ADH = water diuresis (polyuria)</td>
<td>Pituitary or hypothalamic tumors</td>
</tr>
<tr>
<td></td>
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<td>M8k 412, 1734; E-hb 85; IM 459; H2B 502; Smin 514; Ddx 68; Dx-L 39</td>
<td></td>
<td>- Cobalt radiation</td>
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<tr>
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<td>Lack of ADH</td>
<td>Diuretic effects</td>
<td>- Caramustine (BCNU)</td>
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<td></td>
<td>CS: PU/PD, ± CNS</td>
<td>Psychogenic polydipsia</td>
<td>- Unpredictable; dramatic improvement in some</td>
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<td>Dx: + ADH tests</td>
<td>Other causes of PU/PD</td>
<td>Desmopressin</td>
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<td>Tx: Unlimited water, Drugs</td>
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<td>Progabide, Progabine</td>
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<td>Progabide, Progabine, Progabine, Progabine</td>
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<td>Progabide, Progabine, Progabine, Progabine</td>
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</tbody>
</table>

**Psychogenic polydipsia**
- Cause:
  - Disorder of thirst centers, resulting in 1° PD
  - Behavior problem
  - Pharmacologic agents: salt, diuretics, glucocorticoids, fluids, anticonvulsants
  - Polyuria to rid excessive H2O
  - Large breed dogs
  - Kidney is usually functional
  - Causes medullary washout

**PU/PD**
- Hx (large breeds), CS (PU/PD)
- Urinalysis: USG 1.001-1.003
- Water deprivation = concentrated urine
  - Abrupt water deprivation: diagnoses 2/3rds of cases
  - Gradual water deprivation in other third to eliminate medullary washout
  - Results in concentrated urine > 1030 dog, 1035 cat

**Valium**
- Not mandatory if unlimited water
- Unlimited water paramount
- Desmopressin (DDAVP® - synthetic vasopressin analog) drops in conjunctival sac
- Limit water for couple of hours after Tx to avoid over hydration
- Repostol vasopressin (Pitressin®) IM
- Chlorpropamide (Diabinese®) sulfonamide agent for partial CDI; potentiates renal tubular effect of ADH. Ineffective in complete CDI & NDI needs some ADH
- Chlorothiazide diuretics + oral salt restriction may reduce urine output by inhibiting sodium resorption; up to 60% reduction
- Chlorothiazide (Diumil®), Hydrochlorothiazide
- Pituitary or hypothalamic tumors
  - Cobalt radiation
  - Caramustine (BCNU)
  - Unpredictable; dramatic improvement in some

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**Urolithiasis**

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<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dog</strong></td>
<td>Uroliths: crystal of minerals in matrix material</td>
<td>Variable depending on size, # &amp; location of uroliths</td>
<td>Hx, CS</td>
<td>ABs for 2-3 wks for UTI &amp; struvite</td>
</tr>
<tr>
<td></td>
<td>95% organic or inorganic crystalloids, &lt; 5% organic matrix</td>
<td>Asymptomatic in some:</td>
<td>Palpation: bladder &amp; urethra</td>
<td>- Ampicillin if no culture or trimethoprim-sulfonamide</td>
</tr>
<tr>
<td></td>
<td><strong>Struvite #1 in dog &amp; cats</strong></td>
<td>- Lower UTI (cystitis/urethritis)</td>
<td>Blood values</td>
<td>- Give after urination &amp; discourage urination as long as possible to keep drug where needed</td>
</tr>
<tr>
<td></td>
<td>Dog: &lt; 3% prevalence, 3-7 yrs old</td>
<td>- Dysuria (painful)</td>
<td>- CBC usually normal leukocytosis, UTI</td>
<td>- Re-culture 5 days after stop ABs, if + reinstitute</td>
</tr>
<tr>
<td></td>
<td><strong>Location:</strong></td>
<td>Pollakiuria (frequent)</td>
<td>- Postrenal azotemia: in obstruction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Urinary bladder: bladder stones</td>
<td>Bloody (hematuria)</td>
<td>Urinalysis (UA): UTI</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Urethra: partial or complete obstruction</td>
<td>Strong ammonium odor</td>
<td>- Hematuria</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Ureter calculi (rare): hydronephrosis</td>
<td>Lumbar pain</td>
<td>- Pyuria/Bacteriuria</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Kidney (rare): pyelonephritis</td>
<td></td>
<td>- Urase producing - Staph. aureus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Usually originate in bladder, but may come from kidney or ureter into bladder</td>
<td></td>
<td>- struvite</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Cause in dogs:</strong></td>
<td></td>
<td>± Crystalluria - ID (usually same as uroliths, not always)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- UTI (urinary tract infec:) commonaly present in all, except oxalate uroliths</td>
<td></td>
<td>Urine culture &amp; sensitivity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(cat not due to UTI)</td>
<td></td>
<td>- Radiographic density (see chart)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Staphylococcus aureus or proteus spp (split uses to ammonium)</td>
<td>- Kidneys, ureters &amp; urethra for calcul 0 = not visible</td>
<td>- Ultrasound</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Alkaline urine precipitates</td>
<td>1+ = barely visible</td>
<td>- Uroliths analysis - quantitative (crystallographic)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Metabolic disorders:</strong></td>
<td>2-4+ = readily visible</td>
<td>- Commercial kits not recommended</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Urate:</td>
<td></td>
<td>Hepatic function tests if urate uroliths (except in Dalmatians)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Dalmatian: Inborn error in purine metabolism</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>- Portal vascular shunts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Cystinuria: cystine uroliths</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Calcium phosphate: hyperparathyroidism</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Dietary factors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- High magnesium alkalinizing - struvite</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>- Cm gluten or soybean hull diets - silica</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>- Hi Ca or P diets - calcium phosphate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Idiopathic conditions: Ca oxalate, sterile struvite, silica</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Breeds:**

- **Struvite:** Females > males: Miniature Schnauzer, also Welsh Corgis, Dachshunds, Poodles, Pugs, Pekingese, Beagles, Scottish terriers
- **Oxalate:** Males - Miniature Schnauzer, Miniature Poodles, Yorkshire terriers, Lhasa Apso, Shih Tzu & Dalmatians
- **Urate:** Dalmatian (60% of all urate uroliths) Portosystemic shunts (Miniature Schnauzers, Yorkshire terriers, Pekingese)
- **Silica:** German shepherd
- **Cystine:** Males: Dachshund, also Basenji hounds, English bulldogs, Yorkshire terriers, Irish terriers, Chihihauas

**DDx:**

- UTI
- Neoplasia of bladder
- FUS
- Coagulation disorders

**Prevention:**

- 5-50% recur
- Diet, urine pH modification & drugs (see chart below)

**Monitor monthly** for dissolution of uroliths: Complete urinalysis & radiographs; ABs - culture & sensitivity if UTI. If not dissolved after 2 mo, consider surgery

**Prognosis:** Guarded to good, depending on calculi & owner/dog dietary compliance

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<table>
<thead>
<tr>
<th>Types of stone</th>
<th>Facts/cause</th>
<th>Rads</th>
<th>Diagnosis</th>
<th>Treatment</th>
<th>Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Dogs &amp; Cats</td>
<td>90% Cats - 60% Dogs</td>
<td>2-4+</td>
<td>pH: alkaline</td>
<td>Med: ABs (UTI)</td>
<td>Control UTI</td>
</tr>
<tr>
<td>- Struvite (magnesium ammonium-phosphate)</td>
<td>Urease-producing bacteria</td>
<td>UTI - urease bacteria (UA)</td>
<td>s/d Hill’s diet (don’t add salt)</td>
<td>c/d Hill’s diet (low-protein, Ca, P)</td>
<td></td>
</tr>
<tr>
<td>- Staph. aureus - dog</td>
<td>Sterile in most cats</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Oxalate (Ca, Mg, &amp; ammonium)</td>
<td>20% - dog - Calciumuria (hyperparathyroidism, excessive Vit D intake, osteolytic neoplasia, hypercalcitonism &amp; prox. renal tubular damage)</td>
<td>4+</td>
<td>UTI</td>
<td>Hypercalcemia</td>
<td>Sx - removal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pH: variable</td>
<td></td>
<td>Rough, quartz-like</td>
<td></td>
</tr>
<tr>
<td>- Urate (ammonium)</td>
<td>Dalmatians &amp; others Hepatic dysfunction/shunts</td>
<td>0-2+</td>
<td>UTI</td>
<td>pH: neutral - acidic</td>
<td>Alkalinate urine (Bicarb)</td>
</tr>
<tr>
<td></td>
<td>5% dog, 4% cats</td>
<td>Smooth, round, oval</td>
<td>u/d diet</td>
<td>Allopurinol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2+ years old</td>
<td>- Jack-stone</td>
<td>± Correct hepatic diz + k/d</td>
<td>Allopurinol (Zyloprim®)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sx: those that don’t dissolve or obstruct</td>
<td></td>
<td>u/d diet (low purine)</td>
<td></td>
</tr>
<tr>
<td>- Ca-phosphate (apatite)</td>
<td>Metabolic disorders Excessive Ca &amp; P diet, renal tubular acidosis, Hyperparathyroidism</td>
<td>4+</td>
<td>Hypercalcemia</td>
<td>Sx - removal</td>
<td>Acidify urine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Smooth, round or faceted</td>
<td></td>
<td>s/d diet??</td>
<td>s/d</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Control hypercalcuria - diet?</td>
<td></td>
</tr>
<tr>
<td>• Dog Only</td>
<td>Genetic defect/metabolism</td>
<td>1-2+</td>
<td>pH: acidic Urinary cystine</td>
<td>Med:</td>
<td>u/d diet</td>
</tr>
<tr>
<td>- Cystine (amino acid cystine)</td>
<td>&lt; 2%, 1.5 - 4 years</td>
<td>Smooth, small round to oval</td>
<td>Potassium citrate (alkalinizes)</td>
<td></td>
<td>Potassium citrate (alkalinizes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>D-penicillamine or MPG</td>
<td>u/d diet</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sx: those that don’t dissolve or obstruct</td>
<td>Don’t breed males</td>
<td></td>
</tr>
<tr>
<td>- Silica calculi</td>
<td>Rare &lt; 2% - Many breeds (Germ. Shepherd) Diet: corn gluten, soybean hulls</td>
<td>2 - 4+</td>
<td>UTI</td>
<td>pH: neutral - acidic</td>
<td>Sx - removal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Jack stone</td>
<td>Meat-based diet, Salt (diuresis)</td>
</tr>
<tr>
<td>• Mixed</td>
<td>15%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
- Med: ABs (UTI)
- s/d: standard diet
- c/d: controlled diet
- u/d: urinary diet
- > pH: Urine pH should be greater than 7.5
- < pH: Urine pH should be less than 7.5
### Renal Review—Azotemia, PU/PD, Urolithiasis, Incontinence, Glomerulonephropathy

#### FUS

<table>
<thead>
<tr>
<th>Condition</th>
<th>Facts/Causes</th>
<th>Presentation</th>
<th>Diagnosis</th>
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<tbody>
<tr>
<td><strong>Feline urolithiasis</strong></td>
<td><strong>FUS</strong></td>
<td><strong>URINARY SYSTEM</strong></td>
<td><strong>Rationale</strong></td>
</tr>
<tr>
<td><strong>Feline urologic syndrome</strong></td>
<td><strong>Urethral plug, idiopathic lower urinary tract dz, ILUTD; FLUTD, Feline lower urinary tract dz</strong></td>
<td><strong>Calculi w/o obstruction (females &amp; males)</strong></td>
<td><strong>History</strong> (house cat, etc.)</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td><strong>Male &gt; female, house cats 2-6 years</strong></td>
<td><strong>Dribbling of urine</strong></td>
<td><strong>CS</strong> (straining to urinate)</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td><strong>4-10% of all cat hospital visits</strong></td>
<td><strong>Frequent urination</strong> (pollakiuria, owners think trying to defecate)</td>
<td><strong>Physical exam - palpation</strong></td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td><strong>Urethral obstruction in males</strong></td>
<td><strong>Strong ammonia-like odor</strong></td>
<td><strong>Obstructed cat</strong></td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td><strong>Cystitis &amp; urethritis in female</strong></td>
<td><strong>Obstruction males</strong></td>
<td><strong>Distended, turgid bladder, inability to express bladder</strong> (careful)</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td><strong>Struvite plugs/uroliths (see box)</strong></td>
<td><strong>Squat &amp; strain (stranguria)</strong></td>
<td><strong>Hard, inflamed, discolored penis</strong></td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td><strong>Cause: unknown</strong></td>
<td><strong>Hematuria, anuria</strong></td>
<td>± <strong>Protruding plug</strong></td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td><strong>Predisposing factors:</strong></td>
<td><strong>Lick penis (traumatize)</strong></td>
<td><strong>Thickened bladder wall w/ grafting</strong></td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>- Bacterial, viral infection</td>
<td><strong>Screaming</strong> (vocalization)</td>
<td><strong>Unobstructed cat</strong></td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>- Decreased activity (house cats, castration, weather, illness, obesity)</td>
<td><strong>Postrenal uremia, depending on duration:</strong></td>
<td><strong>Painful bladder &amp;/or caudal abdomen</strong></td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>- Dirty litter box</td>
<td>- Anorexia, lethargy, depression</td>
<td><strong>Bladder usually empty</strong></td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>- Alkaline urine</td>
<td>- ± Vomiting &amp; dehydration</td>
<td>- Lumbar pain</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>- High Mg/ammonium diets</td>
<td>- Bradycardia</td>
<td><strong>Blood values (obstructed)</strong></td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>- Castration</td>
<td>- Hypothermia, muscle weakness</td>
<td>- CBC no specific abnormalities, ± PCV/TP (dehydration), stress leukogram</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>- Urethritis/cystitis, urethral abnormalities</td>
<td>- Coma &amp; death in 3-5 days if complete obstruction</td>
<td><strong>Hyperkalemia</strong> (may be life threatening)</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>- Dry &gt;&gt; canned food</td>
<td><strong>Sequelae:</strong></td>
<td><strong>Acidosis</strong> (life-threatening)</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td><strong>High incidence of recurrence</strong>: 30-70%</td>
<td>- Chronic renal dz due to ascending pyelonephritis (especially if repeated catheterization)</td>
<td>± Blood pH &amp; HCO3-</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td><strong>Penile urethra #1 blockage site</strong></td>
<td>- Rupture bladder</td>
<td><strong>Postrenal azotemia</strong> (increased BUN, creatinine), hyperphosphatemia, hyperglycemia (stress)</td>
</tr>
</tbody>
</table>

**DDx:**
- Constipation (straining)

- **Urethral plugs:** sand in organic matrix, like toothpaste, poorly organized - protein matrix, struvite crystals (magnesium ammonium phosphate) & cellular debris, etiology unknown

- **Urolithiasis: Struvite:** magnesium-ammonium-phosphate 80% of uroliths, sterile 80%, sand-like, crystalluria (microscopic ppt) or urolithiasis: macroscopic aggregates

- **Ammonium urate uroliths:** uncommon; portal vascular anomalies

- **Calcium oxalate uroliths:** 1% of uroliths becoming more common as struvite is decreased due to diet dissolution

- **Calcium phosphate uroliths:** uncommon, hyperparathyroidism

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Renal Review - Azotemia, PU/PD, Urolithiasis, Incontinence, Glomerulonephropathy

Treatment:
- **Obstruction**
  - **Emergency:** life-threatening hyperkalemia, acidosis, postrenal azotemia or ruptured bladder
  - **IV catheter** (draw blood for electrolyte & acid-base)
  - ** Unblock cat** (see box) (before giving fluids), **sedate**
  - **Massage penis or catheterization**
  - **Cystocentesis** if can't immediately unblock
  - **Indwell catheter** 1-3 days to prevent re-blocking
  - Routine use not recommended, remove as soon as possible (12-36 hours)
  - **Fluids** to stabilize cat & for life-threatening hyperkalemia & acidosis
  - Saline + unblocking will quickly ↓ potassium
  - **Antibiotics** 7-10 days

- **Polyuric renal failure** often ensues following relief of obstruction:
  - Hyponatremia: Salt tablets: 1 gm tid initially PO, normal saline IV to correct
  - Hypokalemia: K+ elixir PO, K+ salts in parenteral fluids (< 20 mEq/hour)
  - Elizabethan collar if self-trauma
  - Monitor for re-blockage

- **Treatment of unobstructed/unplugged cat**
  - Hill’s Feline s/d diet - to dissolve struvite uroliths (acid, low Mg, hi salt)
  - Only long enough to dissolve crystals (30 d past radiographic evidence)
  - Dysuria/stranguria
  - Propantheline bromide (Pro-Banthine®), diazepam (Valium®)
  - Corticosteroids - controversial
  - ABs if infection

- **Surgery:**
  - **Penile urethrostomy** m/b considered w/ multiple recurrence (≥ 2x)
  - Altered cat m/b more prone to cystitis

Unblock cat (before giving fluids)
- **Sedate, don’t stress - fatal arrhythmias w/ catecholamine & hyperkalemia** (not required in moribund cat, but most others, PAINFUL, carefully)
  - Gas anesthesis: mask down - isoflurane & O2
  - Acepromazine: reduce dose < 0.1 mg total IV
  - Ketamine (reduced dose because removed by kidney) < 5 mg/kg IV

- **Massage distal end of penis** to try to dislodge distal plug
  - Protrude penis & massage
  - Keep gentle pressure on urinary bladder (if dislodges, urine will flow, yeah!)
  - Manually empty bladder
  - If this doesn’t work:
  - **Catheterize** (lubricated Tom cat catheter)
    - Extrude penis (pull caudally on prepuce to line the penis up parallel w/ the spine to straighten its normal curve)
    - Advance catheter (gently, if obstruction)
    - Gently flush cath to bladder (occlude penis around catheter)
    - Collect urine for urinalysis & culture
    - Lavage bladder w/ sterile saline to remove all crystalluria (100-200 ml)

Fluids for life-threatening hyperkalemia & acidosis
- **ECG rhythm strip to evaluate**
  - 0.9% saline + unblocking will quickly ↓ potassium
  - If doesn’t: glucose & insulin therapy IV (IU Regular insulin w/1-3g glucose)
  - Bicarbonate if acidic (pH < 7.2) 1-2 mEq/kg IV slowly
  - Calcium gluconate if life-threatening arrhythmias (0.5-1 ml/kg of 10% solution) slowly IV
  - Fluid therapy for dehydration & maintenance, postobstructive diuresis, phenomena in unblocked cats
  - Monitor & replace fluids and electrolytes (K+)

Prevention:
- Tends to recur in 70% of cats
- **Low Mg diet** (Hill’s c/d diet or homemade) < 2.0 mg of magnesium/100 kcal
- Canned food over dry, Mix water w/ food
- Salt food lightly (not if S/D diet)
- Encourage exercise, free choice water
- Urinary acidifiers: methionine, ammonium chloride added to diet if not on c/d or s/d
- Prednisolone considered for persistent hematuria & urethritis
- Clean litter box often

Male, neutered, obese house cat on dry food
CS: Straining, Uremia
Dx: Hx, PE, UA
Tx: Unblock, Fluids, ABs, S/D diet, Sx

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Urinary Incontinence

- Inappropriate passage of urine
- Needs to be differentiated from abnormal elimination behavior & inadequate house training
- Middle aged & geriatric dogs > 5 yrs-old
- Definitions:
  - Micturition: voiding of urine
    - 2 stage process: passive storage & active voiding
  - Incontinent: loss of voluntary control of micturition
  - Enuresis: urinary incontinence while animal is asleep
  - Nocturia: urge or need to urinate at night

Causes: Incontinence

- Nonneurogenic
  - Hormone-responsive incontinence
  - Stress incontinence, urethral incompetence
  - Pelvic bladder
  - Urachal remnant
  - Idiopathic urinary incontinence
  - Ectopic ureters
- Neurogenic
  - Lower motor neuron, atonic bladder
  - Upper motor neuron, automatic bladder
  - Detrusor-urethral disorders
  - Urge incontinence, detrusor hyperreflexia
- Others
  - Senility
  - Decreased bladder capacity

Clinical signs

- Urinary incontinence
  - Dribbling of urine
  - Loss of voluntary control
  - Urine-scalding dermatitis
- Abnormal micturition
  - Inability to urinate
  - Disruption of urine stream (dysuric sensation)
  - Stranguria/Dysuria
  - Abdominal pain/discomfort

Normal micturition

- Storage (filling) phase
  - Sympathetic (ANS): relaxes bladder detrusor muscle & increases internal urethral sphincter tone
- Somatic: external urethral sphincter (urethralis muscle)
- Stretch of bladder wall: sensory fibers to reflex & brain
- Voiding (emptying) phase
  - Parasympathetic (ANS): contraction of detrusor muscle
  - Inhibition of sympathetic & somatic urethral sphincters

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Diagnosis urinary incontinence:
• History: very important - Questions to ask:
  - Chronology of progression?
  - Ability to voluntarily initiate & maintain urination?
  - Reproductive status (neutered or not)?
  - Trauma?
  - Age of onset?
  - Previous problems (especially urinary)?
  - Description of abnormality - night? dribbling? etc.
    - Continuous or intermittent? Amount passed?
  - Frequency of urination?
  - Current medication?
  - Dysuria, nocturia, hematuria?

• Physical exam:
  - Examine perineum for urine scalding
  - Palpation of urinary bladder before & after urination
    - Small bladder: bladder hypercontractility or ↓ urethral resistance
    - Distended bladder: ↑ urethral resistance or ↓ bladder contractility
      - Evaluate distention, tone, ease of expression
        - UMN - difficult
        - LMN - easy
  - Neurogenic exam: check integrity of sacral reflex arc ( pudendal nerve [sensory & motor] & sacral cord segment)
    - Perineal reflex: pinch perineum = contraction of anal sphincter & ventroflexion of tail
    - Bulbospongiosus reflex: squeeze distal penis or vulva = constriction of anus
    - Rectal exam: prostate gland, anal tone, pelvic diaphragm, pelvic urethra, trigone of bladder
  - Observe urination: Measure residual volume after urination (catheterization) normal < 0.4 ml/kg

DDx:
• Causes of polyuria
• Causes of pollakiuria
• Causes of stranguria
• Causes of nocturia

• Blood values
  - ↑ BUN & creatinine - renal function
• Urinalysis in all incontinent animals
  - Urine culture (cystocentesis)
• R/O Polyuria/polydipsias which can result in urge incontinence
  - Diabetes mellitus, pyometra, hyperadrenocorticism & hypercalcemia

• Radiography:
  - Survey: for obvious abnormalities of bladder, urethra, pelvis or spine
  - Contrast radiographs
  - Excretory urogram
  - Positive contrast vaginogram
  - Vaginourethrography or retrograde urethrogram

• Vaginoscopy w/ or w/o new methylene blue dye (dogs); visualization of contrast for ectopic ureter
  - Check for: urachal diverticulum, bladder wall thickening, calculi, prostatic enlargement, urethral strictures, pelvis bone abnormalities

• Urodynamic studies for micturition disorders
  - Cystometrogram: bladder tone & volume, detrusor reflex
  - Urethral pressure profile: intra-urethral resistances

• Electromyography (EMG): coordination of detrusor & urethral sphincter by checking anal sphincter
<table>
<thead>
<tr>
<th>Condition</th>
<th>Cause</th>
<th>Clinical signs</th>
<th>Diagnosis</th>
<th>Treatment</th>
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<td>Neurogenic</td>
<td></td>
<td></td>
<td>No perineal reflex</td>
<td>No effective Tx</td>
</tr>
<tr>
<td>LMN - atonic bladder</td>
<td>Trauma - LMN</td>
<td>Continuous dribbling</td>
<td>Large, expressible bladder</td>
<td>Manually express tid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>involuntary</td>
<td></td>
<td>± Bethanecho (Urecholine®), ABs</td>
</tr>
<tr>
<td></td>
<td>Trauma - UMN</td>
<td>Intermittent incontinence</td>
<td>+ Perineal reflex (hyperactive)</td>
<td>Intermittent catheterization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>involuntary</td>
<td>Large turgid, nonexpressible bladder</td>
<td>ABs - frustrating</td>
</tr>
<tr>
<td></td>
<td>Trauma - ANS</td>
<td>Start &amp; abrupt stop</td>
<td>CS, + Perineal reflex</td>
<td>♦ Alpha sympathetic tone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>urination w/ stranguria</td>
<td>Large, nonexpressible bladder</td>
<td>- Phenoxybenzamine (Dibenzyline®)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Voluntary</td>
<td>Easily catheterized</td>
<td>- ± Bethanecho (Urecholine®)</td>
</tr>
<tr>
<td>Nonneurogenic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hormone-responsive</td>
<td>Older, spayed female</td>
<td>Voluntary control</td>
<td>Hx, Tx response</td>
<td>Diethylstilbestrol</td>
</tr>
<tr>
<td>incontinence</td>
<td></td>
<td>intermittent dribbling</td>
<td>Normal reflexes &amp; bladder</td>
<td>± Phenylpropanolamine (Triaminio®)</td>
</tr>
<tr>
<td>Urethral incompentence</td>
<td>Stress</td>
<td>Voluntary control</td>
<td>Hx, Tx response</td>
<td>♦ Alpha sympathetic urethral tone</td>
</tr>
<tr>
<td></td>
<td></td>
<td>intermittent incontinence</td>
<td>Normal reflexes &amp; bladder</td>
<td>- Phenylpropanolamine (Triaminio®)</td>
</tr>
<tr>
<td>Urge incontinence</td>
<td>UTI, FUS, etc.</td>
<td>Frequent small urinations</td>
<td>Hx, CS (UTI, FUS) - Tx response</td>
<td>Treat cystitis/FUS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Urine spraying, Stranguria</td>
<td>Hyperreflexive detrusor, normal bladder</td>
<td>Inhibit detrusor - Propantheline (Pro-Banthine®)</td>
</tr>
<tr>
<td>Atony over distention</td>
<td>Obstruction</td>
<td>Continuous dribbling - long</td>
<td>Large, flaccid bladder</td>
<td>Remove obstruction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>involuntary</td>
<td>- large residual urine volume</td>
<td>Indwelling catheter - Bethanecho (Urecholine®)</td>
</tr>
<tr>
<td>Paradoxical incontinence</td>
<td>Partial obstruction</td>
<td>Continuous dribbling - short</td>
<td>Large, turgid bladder (nonexpressible)</td>
<td>Remove obstruction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>involuntary</td>
<td>Normal reflexes</td>
<td>Indwelling catheter</td>
</tr>
<tr>
<td>Ectopic ureters</td>
<td>Young</td>
<td>Continuous dribbling</td>
<td>Hx (young), CS</td>
<td>Ureteral transposition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Voluntary urination</td>
<td>Bladder, reflexes normal</td>
<td>± Phenylpropanolamine (Triaminio®)</td>
</tr>
</tbody>
</table>

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Renal Review - Azotemia, PU/PD, Urolithiasis, Incontinence, Glomerulonephropathy

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**Renal Review - Azotemia, PU/PD, Urolithiasis, Incontinence, Glomerulonephropathy**

**Glomerulonephritis, GN, Immune complex glomerulonephritis**
- Causes: unknown in most cases
  - 2° to inflammation/infectious dizes, neoplasia or other causes
- Pathophysiology:
  - Deposition of antigen-antibody complexes in glomeruli
  - Immune complexes changes permeability of glomerulus
- **Proteinuria & hypoproteinemia**
- Dogs over 5 years old, cats
- Familial - Dobermans?
- Reversible or irreversible

**Prognosis: guarded**

**Amyloidosis**
- Disposition of fibrillar glycoprotein in organs
  - Results in organ dysfunction
  - Dogs: disposition primarily in glomeruli
  - Results in protein losing glomerulonephropathy
  - Cats: disposition 1° in renal medullary interstitium
  - Results in chronic renal failure
- Causes:
  - Idiopathic
  - 2° to inflammatory of neoplastic process
  - Tissue injury stimulates liver amyloid precursor
  - Liver, spleen, & kidney primarily affected
  - Progressive kidney dysfunction
  - Familial form in Shar Pei, Abyssinian & possibly Beagles

**Prognosis: poor**

**Nephrotic syndrome; NS**
- Descriptive term, not a diagnosis - edema, ascites
- **Proteinuria, hypoalbuminemia, hypercholesterolemia & edema**
  - Proteinuria of sufficient magnitude to cause hypoalbuminemia
    - Onocytic pressure - edema
  - Hypercoagulopathy - loss of antithrombin III protein
    - Thromboembolism
  - Compromised immunological system
- Dogs & cats
- Cause:
  - Glomerulonephritis
  - Amyloidosis
- Most patients w/ glomerular diz don't develop nephrotic syndrome

**Prognosis:**
- Glomerulonephritis: Guarded
- Amyloidosis: Poor, diz relentlessly progressive to CRF & uremia
- Nephrotic syndrome: Guarded

**Treatment:**
- Difficult & often unrewarding
- Treat underlying cause if found
- Corticosteroids controversial, not recommended unless specific underlying diz indicates (SLE)
- **Diet**
  - Sodium restricted diets
  - Protein restricted diet (Hill’s k/d)
  - If proteinuria remains great consider protein supplementation (boiled egg)
- Enalapril (Enacard®) vasodilator, sodium retention in some, proteinuria hypertension in some
- Diuretics as needed w/ caution
- Anticoagulants TX if antithrombin III < 70% of normal & fibrinogen > 300 mg/dl
  - Aspirin, Coumadin®, heparin
- Vitamin B & C, Free choice water

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