1. Micturition refers to the process of storing and periodically voiding urine.
   a. Disorders of urine storage usually lead to urinary incontinence, whereas disruption of urine voiding leads to incomplete emptying, dysuria, or urine retention
   b. Micturition is a complex integration of central, sympathetic, parasympathetic, and somatic nervous systems, with resultant muscular activity
   c. The two functional units of the lower urinary tract include the reservoir/pump (urinary bladder) and the continence/conduit (urethra).

2. Muscle components
   a. Muscular components blend together and include the detrusor smooth muscle (bladder), proximal urethral smooth muscle (internal urethral sphincter), and urethral striated muscle (external urethral sphincter)
   b. Detrusor muscle
      i. Smooth muscle
      ii. Organized as random interlacing meshwork of smooth muscle bundles
      iii. Body (fundus) muscles arranged in circular pattern
         1. Very distensible (collagen, elastin)
      iv. Neck (base) muscles arranged in longitudinal pattern
         1. May be organized into a sling
         2. Less distensible
         3. Transformed into “funnel” during micturition
      v. Detrusor muscle, smooth muscle of apex, and body of urinary bladder act to expel urine when contracted by parasympathetic innervation via pelvic nerves
   c. Urethral smooth muscle
      i. Internal urethral sphincter mechanism (lissosphincter)
         1. Extension of longitudinal smooth muscle of bladder trigone/neck
         2. Involuntary resistance when contracted by sympathetic innervation via hypogastric nerves (which also inhibits detrusor activity)
         3. Supported by surrounding collagen and pelvic floor muscles
         4. Intrinsic urethral resistance also provided by mucosal folding, submucosal vasculature
   d. Urethral striated muscle
      i. Extrinsic urethral sphincter (rhabdosphincter)
         1. Innervated by somatic pudendal nerves opposes sudden increases in bladder pressure and voluntary continence
         2. Male dog – prostatic, postprostatic urethra
         3. Female dog – mid-urethra
         4. Male and female cats – distal urethra
         5. Outside but intimately associated by urethral smooth muscle
            a. Thick ventrally
            b. Thicker in males
         6. Probably mixed slow-twitch and fast-twitch fibers with mixed innervation
3. Neuroanatomy
   a. Higher control center
      i. Pontine micturition center
         1. Primary higher control center
         2. Modulates storage and voiding cycles
         3. Facilitates coordination of urinary bladder and urethral sphincter responses during voiding
      ii. Cortical and thalamic input is important
          1. Voluntary control of micturition
          2. Inhibitory input
          3. Mediated in part by mu, delta opiates
   b. Spinal cord input
      i. Lumbar cord
         1. SYMPATHETIC nuclei project to HYPOGASTRIC NERVE
            a. Projects to caudal mesenteric ganglia
            b. Postganglionic branches to adrenergic receptors in urinary bladder and urethra
               i. BETA-ADRENERGIC receptors in urinary bladder
                  1. Relaxation
               ii. ALPHA-ADRENERGIC receptors in bladder neck and urethra
                  1. Contraction
               iii. Some afferent information (pain-high threshold) from bladder and urethra and external urethral sphincter mechanoreceptors
         2. Segments
            a. L2-5 in cat
            b. L1-4 in dog
      ii. Sacral segments
         1. PARASYMPATHETIC nuclei project to PELVIC NERVE
            a. Detrusor muscle
            b. Afferents from tension and nociceptors in bladder wall (low threshold)
               i. Low threshold A-delta small myelinated fibers (normal)
               ii. High threshold unmyelinated C fibers (chemicals, cold, heat)
               iii. Neurotransmitters – eg CGRP, VIP, Substance P, Enkephalins, CCK
         2. S1-3
      iii. Somatic
         1. Project from sacral cord (S1) to PUDENDAL NERVE
            a. Efferent impulses to external urethral sphincter, genitalia, pelvic floor muscles
            b. Reflexively activated by increased intra-abdominal pressure
            c. Afferent information from urethra (temperature, pain, urine flow)
iv. **Interneurons**

1. Local "cross talk" occurs at postganglionic nerve terminals between sympathetic and parasympathetic nerves
   a. Predominantly in detrusor muscle and pelvic plexus via mural ganglia
2. Spinal interneurons also play role in coordination of lower urinary tract function (sacral parasympathetic nuclei)

4. **Bladder compliance, filling, and continence**
   a. **Bladder compliance and wall tension**
      i. Bladder has compliance – able to undergo large volume increases with only minor elevation in intravesical pressure over a wide range of filling
         1. Consequence of wall tension interacting with viscoelastic properties of wall
         2. Tension initially taken up by elastic elements is transferred to viscous elements that elongate and moderate wall tension
         3. Wall is reshaped as tension stretches lumen epithelium and wall connective tissue; latter rearrange muscle fascicles and elongates individual myocytes
         4. At some point viscoelastic accommodation and bladder compliance approach limit
         5. Therefore, wall tension and intravesical pressure rapidly rise with additional filling
      ii. **During voiding detrusor generates sufficient lumen pressure to overcome sphincter resistance**
         1. When bladder contains a large volume, it will require a higher wall tension to generate the necessary intravesical pressure
         2. As bladder enlarges, detrusor fascicles shift from an encircling orientation to a tangential one
         3. Urine flow improves as distended detrusor recovers mechanical advantage
         4. Decreased urine flow that persists is a sign of excess urethral resistance
         5. Detrusor responds to elevated urethral resistance by contracting more slowly
   b. **Bladder filling**
      i. Urine moves into bladder periodically due to ureteral peristalsis
      ii. Increased intracellular calcium spreads among smooth muscle cells of renal pelvis and urine via gap junctions leading to peristaltic wave of smooth muscle contraction forcing a bolus of urine
      iii. **Bladder filling requires sufficient peristaltic force to open the terminal intramural ureter, normally held closed by intravesical pressure and wall tension**
   c. **Urinary continence**
      i. Ability to store urine without leakage requires outlet resistance to exceed intravesical pressure
      ii. When bladder volume and pressure are low, passive viscoelastic resistance by urethral wall provides adequate resistance
      iii. In quadrupeds passive resistance is augmented when urine weight pulls bladder cranially into abdomen away from urethra, which simultaneously elongates (squatting to urinate shifts urine weight caudally against urethral opening)
      iv. As bladder volume approaches half-full, continued continence requires spinal sympathetic reflexes that contract smooth muscle sphincter and inhibits spontaneous detrusor contractions. Reflexes involve bladder afferent axons that run through pelvic nerve to sacral spinal segments and efferent axons that come from lumbar spinal segments and travel through hypogastric nerves to bladder and urethra
      v. To prevent urine leakage when tonic smooth muscle sphincter is breached during abrupt increase in intravesical pressure, striated urethral sphincter contracts in a spinal reflex triggered by urine flow into the urethra
      vi. Afferent axons run through pudendal nerve to enter sacral spinal cord; efferent axons run down pudendal nerve. Striated urethralis muscle is also used for voluntary continence including retrograde closure during abrupt cessation of urine flow
vii. Continence also facilitated by striated muscles comprising pelvic diaphragm. Levator ani muscle reflexly contracts to support pelvic viscera when muscles of abdominal wall contract and increases intra-abdominal pressure. Innervated by axons from sacral part of lumbosacral plexus.

d. Urine storage - summary
   i. Sympathetic system dominates
   ii. Slow filling of urinary bladder (beta receptors)
   iii. Outlet resistance
      1. Urethral wall tension
      2. Alpha adrenergic receptor activity
      3. Basal tonic striated muscle activity
   iv. Reflexive or voluntary contraction of striated muscle if needed (cough, laugh, etc)
   v. Alpha adrenergic mediated inhibition of parasympathetic system
   vi. Afferent impulses increase as stretch receptors are activated (parasympathetic)
   vii. Central modulation mediated by enkephalins, GABA, serotonin

5. Micturition
   a. As volume expands there is increase in afferent nerve activity generated by tonic mechanoreceptors sensitive to wall tension
   b. Afferent activity increases with spontaneous detrusor contractions
   c. Afferent axons travel through pelvic plexus and pelvic nerve to enter sacral spinal cord where they synapse on interneurons and on projection neurons. Interneurons generate continence-related spinal reflexes and produce feeble contractions of detrusor. Projection neurons relay wall tension status to brain
   d. In forebrain a sense of bladder awareness/fullness/urgency is detected along with cognitive interpretation of surroundings and consideration of emotional status as it relates to urination resulting in decision to inhibit or initiate micturition
   e. Pons switches from continence to micturition by deactivating a pontine continence center and activating a pontine micturition center
   f. Descending tracts from pontine micturition center inhibit neurons to smooth and striated sphincters and excite parasympathetic preganglionic neurons to the detrusor
   g. Following voluntary relaxation of striated sphincter, detrusor contraction boosts wall tension and intravesical pressure within the bladder
   h. Detrusor pulls open the bladder neck and intravesical pressure forces urine into the relaxed bladder neck and urethra
   i. Eventually wall tension and mechanoreceptor activity decline along with bladder volume, but brain facilitation sustains detrusor contraction until the bladder is empty (unless urination is used to mark territory)
   j. Spinal lesions that damage descending tracts from the opns impair normal micturition by diminishing sustained detrusor contraction and by producing detrusor-sphincter dyssynergy (failure to inhibit sphincter spinal reflexes during detrusor contraction). Dyssynergy impedes attempts to manually empty the bladder in paraplegic patients and chronically results in detrusor hypertrophy and predisposition to cystitis
   k. Urine voiding - summary
      i. Normal micturition is a voluntary act entailing coordinated actions of detrusor and sphincter musculature to produce virtually complete emptying of the urinary bladder at appropriate times
      ii. Voluntary release of inhibition, pelvic floor relaxation
      iii. Parasympathetic motor impulses via reticulospinal pathways, pelvic nerve
      iv. Bladder contraction facilitated by discharges of “pacing” muscle fibers, spread through bladder via interstitium, tight cellular junctions
      v. Contraction of bladder mechanically opens the bladder neck
      vi. Sympathetic and somatic input to outlet musculature is inhibited at local, spinal, and brainstem levels
vii. Circular muscle of urethra relaxes (mediated by nitric oxide) whereas longitudinal muscle may contract, shortening and opening the urethra

viii. In dogs and cats, some striated urethral muscle activity is observed during voiding; this period is silent in human beings

ix. Afferent information regarding contraction (pelvic ganglia) and urine flow (sacral spinal cord) through the urethra triggers facilitatory secondary reflexes; also facilitates inhibition of external urethral sphincter

x. Central input facilitates complete voiding

**BOTTOM LINE:**

PARASYMPATHETIC PROMOTES PEEING  
SYMPATHETIC STIMULATES STORAGE

**HOST DEFENSES AGAINST INFECTIOUS AGENT INVASION**

- Urinary tract is in contact with external environment and bacteria normally reside in distal urogenital tract
- Urinary tract has many defense mechanisms to prevent bacterial urinary tract infection
  - Anatomically
    - Length of urethra
    - Presence of high pressure zones in urethra
    - Urethral and ureteral peristalsis
    - Vesicoureteral flaps
    - Extensive renal blood supply and flow
  - Mucosal defense barriers
    - Glycosaminoglycan layer
    - Antibody production
    - Intrinsic mucosal antimicrobial properties
    - Exfoliation of cells
    - Commensal non-pathogenic microbes in distal urogenital tract
  - Composition of urine
    - Concentration/osmolality
    - High urea nitrogen concentration
    - Organic salts
    - Low molecular weight carbohydrates
    - Tamm-Horsfall mucoprotein
  - Cell-mediated and humoral-mediated immunity
  - Frequent and complete voiding
Neuroanatomy of lower urinary tract
Diagnostic Techniques for Urinary Tract Disease:

• **Historical examination**
  - Upper urinary tract disease
    - May be asymptomatic
    - More likely to be associated with polysystemic clinical signs than diseases of the lower urinary tract
      - Acute upper tract disease more likely to be sick
      - Chronic upper tract disease are less likely to be sick
  - Lower urinary tract disease
    - May be asymptomatic
    - More likely to be associated with change in urination habits
      - **Pollakiuria** – small volume of urine
      - **Stranguria** – straining to urinate
      - **Dysuria** – difficulty urinating
      - **Periuria** - inappropriate urination
      - **Nocturia** – urination at night
      - **Incontinence** – unconscious urination
  - **Hematuria** does not localize the disease process to a specific part of the urinary tract; however, when associated with lower urinary tract signs, it is often due to a lower urinary tract disease
  - **Azotemia** = increased concentrations of nitrogenous products in the blood – remember pre-renal, renal, and/or post-renal

Lateral abdominal radiograph demonstrating the position of the kidneys (right = RK, left = LK) and urinary bladder (UB). B. Schematic of performing a rectal palpation for examination of the prostate gland in dogs.

- Radiography may include survey (or non-contrast) or contrast radiography. Ultrasonography, computerized tomography, and magnetic resonance imaging is also done; however, we will focus only on radiographic procedures. NOTE: I do NOT expect you to know HOW to perform these procedures or to know some of the subtle changes – you will get that in the radiology course! I DO expect you to understand the utility of radiography and to be able to identify normal vs. major abnormal findings.

• **Kidneys**
  - The kidneys and ureters are commonly referred to as the “upper urinary tract.”
  - **Survey radiographs**
    - Survey right lateral and VD radiographs of the abdomen from the level of the diaphragm to at least the level of the hip joints are routinely obtained for evaluation of the kidneys. Survey radiographs are the best and quickest way to assess renal size and shape. The kidneys lie within the “retroperitoneal” space and are normally surrounded by fat that allows them to be observed. Proper preparation of the abdomen is essential for diagnostic evaluation of the kidneys.
    - Basic radiographic interpretation of each organ or structure should include evaluation for the following:
      - Number: 2
      - Size
• The size of the kidneys is measured on the ventrodorsal (VD) radiograph only. Unequal magnification and distortion of the kidneys on lateral views do not allow uniform measurements of size.
• The normal dog kidney ranges from 2.5 to 3.5 times the length of the L2 vertebral body.
• The normal kidney in INTACT cats ranges from 2.4 to 3.0 times the length of the L2 vertebral body. NEUTERED (especially older) cats have smaller kidneys, ranging from 1.9 to 2.5 times the length of the L2 vertebral body.
• The kidneys should be the same size although a slight difference may be due to poor positioning and not disease.

Renal length is compared to the length of the second lumbar vertebra (L2)

• Urinary bladder
  • The urinary bladder and the urethra are commonly referred to as the “lower urinary tract.”
  • Survey radiographs
    • Normal survey right lateral and VD radiographs of the abdomen extending from the diaphragm to the hip joints may be used to evaluate for urinary bladder abnormality.
    • The urinary bladder functions as a storage reservoir for urine produced by the kidney, and as an excretory organ for expulsion of urine through the urethra.
    • The urinary bladder is divided into three parts. From cranial to caudal these are:
      ▪ The vertex, making up the blunt cranial aspect
      ▪ The body, in the middle
      ▪ The neck (trigone), at the caudal aspect.

Normal urinary bladder in a dog.
Three parts of the urinary bladder are vertex (V), body (B) and neck (N).
The normal urinary bladder varies greatly in size on survey radiographs from non-visible when empty, to extremely large with displacement of adjacent viscera in some dogs that have not had an opportunity to void while confined prior to radiography. The urinary bladder is one of the three most distendable (normal) organs in the abdomen. The other two organs are the stomach and uterus.

**Shape**
- The shape of the bladder depends on the degree of distention at the time of radiography. When non-distended, the bladder can appear as a flattened linear structure in the caudoventral abdomen. With further distention, the bladder becomes oval shaped with a tapered neck region caudally. When fully distended, the bladder appears more ellipsoid with caudal tapering in the neck region. Distortion of the shape of the bladder may be caused by the colon or small bowel in the normal dog and cat.

**Margination: smooth**

**Position**
- The bladder is positioned immediately cranial to the pubis. Occasionally, a portion of the bladder can be within the pelvic canal. The bladder is bounded dorsally by the colon in the male and the uterus in the female. The feline bladder extends farther into the abdomen and has a longer neck region than the dog.

**Opacity**
- The normal bladder is a fluid/soft-tissue opacity that may appear less opaque toward the periphery as it is a spherical structure that is thicker in the center.

- **Contrast cystography:** Positive, negative, and double contrast
  - There are three basic procedures for evaluating urinary bladder anatomy: retrograde positive-contrast cystography, retrograde negative-contrast cystography (pneumocystogram), and retrograde double-contrast cystography. All these procedures entail instillation into the bladder of an iodinated positive-contrast medium, a negative-contrast medium (carbon dioxide, nitrous oxide), or a combination of the two. Room air can be used as the negative-contrast medium, although its use is not advised because its low solubility in blood may predispose to the formation of air emboli should air gain access to the circulation.

Positive-contrast cystography is the method of choice to evaluate urinary bladder position and wall integrity.

Negative-contrast cystography, in combination with excretory urography, is the best procedure for evaluation of ectopic ureters. It can also be used to localize a bladder not visible on survey radiographs and to demonstrate non-opaque bladder calculi.

Double-contrast cystography is superior for demonstrating mural disease and intraluminal filling defects.
• Urethra
  o Survey right lateral and VD radiographs are made for evaluation of the urethra. However, if the urethra is of interest, the radiographs should include the perineal area as well. This often requires lateral and VD radiographs centered more caudal in addition to the standard abdominal views.
  o Number: 1
  o Size: depends on size of patient
  o Shape: The normal male dog urethra is a long tubular structure extending from the tip of the penis to the neck of the bladder. The colliculus seminalis in male animals can show as smoothly margined indentation of the dorsal prostatic urethral lumen and should not be mistaken for abnormal stricture. In cats, the crista urethralis is occasionally visible as linear filling defect associated with the dorsal wall of the urethra.
  o Margination: smooth
  o Position: The urethra should extend from the neck of the bladder through the pelvic canal to the tip of the penis or, in the female, empties into the vaginal vestibule.
  o Opacity: The normal urethra is of soft tissue opacity and cannot be distinguished from the surrounding soft tissues. Contrast media must be infused to observe the normal urethra.

Normal double contrast cystogram in a dog. Note gas dilation of the bladder and pooling of positive contrast material in the dependent portion. The bladder wall is thin and smooth, and there is no evidence of filling defects in the contrast pool.

Normal urethrogram in a large male dog. The catheter tip is located at the level of the os penis. Impression of narrowing of the pelvic urethra (prostatic and membranous part) is artifactual and related to incomplete distension of the urethra during
• **Prostate**
  - Survey right lateral and VD radiographs that include the pelvic canal are necessary to evaluate the prostate gland in the dog. On the lateral projection there may be a triangular fat pad between the ventral-caudal aspect of the urinary bladder, the cranial-ventral portion of the prostate gland, and the caudal-ventral abdominal wall. This triangular fat area can be helpful in identifying the prostate gland. The cat does not have a radiographically observable prostate gland.
  - **Number:** 1
  - **Size**
    - The size of the normal prostate varies tremendously with age, body size, reproductive status, and breed.
    - The intact male canine prostate generally should not occupy an area greater than 70% of the distance between the sacral promontory and the pubis on a lateral view and 50% of the pelvic canal on a VD view.
    - Scottish terriers are reported to have normally larger prostate glands.

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**Urethrogram in a male cat.** Note indistinct filling defects representing colliculus seminalis (*) and crista urethralis (arrowheads).

**Vaginourethrogram in a female dog.** Note concurrent contrast filling of vaginal vault, vestibule and urethra.
• Shape: ovoid and bilobed and bilaterally symmetrical.
• Margination: smooth
• Position: immediately caudal to the neck of the urinary bladder, and ventral to the rectum. The gland may be completely within the pelvic canal, partially within the pelvic canal or cranial to the pubis.
• Opacity: soft tissue

• **Urine Collection**
  • Cystocentesis is best method for sample collection for culture as urine is normally sterile in the bladder
  • Mid-stream void, table top, or catheterization may be adequate depending on what you are interested in – e.g. glucosuria, hematuria, etc
  • **Voided: mid-stream or table top**
    • Catch urine in cup
    • Aspirate urine that has been voided in cage or table top
  • **Expression**
    • Can stimulate micturition by compressing the urinary bladder. Difficult to do in a non-relaxed patient and may induce hematuria if excessive pressure is used.
  • **Cystocentesis**
    • Use a 22G, 1 ½ inch needle and 6 ml syringe
    • 5 ml for urinalysis and 1 ml for culture
    • Stabilize syringe with thumb and index fingers. Aspirate by pulling back on plunger using middle and ring fingers
  • **Procedure**
    • Cats – dorsal or lateral recumbency
    • Dogs – dorsal or lateral recumbency (females), dorsal or lateral recumbency or standing (males)
      • Females: insert needle where alcohol puddles or draw an “X” between the last 2 pairs of nipples and insert at the intersection
    • Direct needle towards trigone to minimize potential for urine leakage
    • Can also use ultrasound to perform cystocentesis

• **Catheterization**
  • Urinary catheterization may be used to collect a urine sample, relieve a urinary obstruction, monitor urine output, to perform radiographic procedures, and to post-operatively monitor a patient
  • Urinary catheters may be composed of soft material (e.g. red rubber) or stiff material (e.g. polypropylene). Foley catheters are soft and have a balloon at end to facilitate retention within the urinary tract. Male cat catheters may be composed of red rubber, polypropylene, silicone, or polytetrafluoroethylene.
  • Catheters are sized in French
    • **The size in French divided by 3 is the external diameter in millimeters.**
      • For example, a 3.5Fr catheter is approximately 1.2 mm in diameter
    • **Stylets** such as wire or a smaller but stiff catheter may be used to facilitate passage of a soft catheter (e.g. red rubber)
    • **Foley catheters** are designed to be indwelling
      • The end is “flared” so a catheter-tipped syringe or connection tubing may be used
      • A second lumen runs within the wall of the catheter and is used to inflate a balloon at the tip
        • The volume of the balloon is marked in cc (ml)
        • There is a valve to prevent leakage
        • Can fill balloon with air or fluid
  • **Feline urinary catheters**
    • Small diameter for use in male cats (@ 3.5Fr = 1 mm diameter)
    • Composed of polypropylene, silicone, polytetrafluoroethylene, or polypropylene
Some come with a plastic butterfly or flared end for suturing to prepuce

• Urinary catheters may be placed in awake dogs, but cats usually require sedation.
  • If severely ill, catheters may be placed without sedation
  • There are many sedative protocols including gas anesthesia and injectable drugs

• **Male dogs**
  • Small dogs: 3.5 to 5 Fr
  • Medium to large dogs: 5 to 8 and possibly 10 Fr
  • Procedure
    o Extrude penis
    o Clean tip of penis with soapy water
    o Cut end of tip of catheter package (without cutting catheter) and remove end and make a cut across package an inch or 2 from the first cut. This section of package is used to pass the catheter and maintain sterility
      ▪ Alternatively, wear sterile gloves to handle catheter
    o Lubricate end of catheter with sterile lubricant
    o Insert into penile urethra and slowly insert
    o There will be some drag at base of os penis
    o Some resistance will be felt at prostatic urethra
    o Insert slowly – when catheter enters bladder urine will flow from catheter end
    o The catheter may also be inserted using sterile gloves

• **Female dogs**
  • Most dogs except for small dogs can take an 8 Fr catheter; small dogs can take a 5 Fr
  • The urethra enters the vagina at the ischial arch along the ventral floor of the vestibule
    o Can insert catheter in lateral or sternal recumbency
  • Procedures
    o **Blind catheterization**
      ▪ Lubricate the catheter and insert through vulva
      ▪ Keep catheter tip along ventral floor on midline and insert until it passes into the urethral orifice
    o **Digital catheterization**
      ▪ Wear sterile gloves and insert a finger through vulva into the vestibule.
      ▪ Palpate the urethral papilla
      ▪ Pass the catheter on the underside of the finger and direct it into the urethral orifice
      ▪ This is difficult to do and often the vestibule is atrophied with OHE and there is a narrowing at the level of the urethral orifice
      ▪ A stylet may be used to stiffen the catheter
    o **Vaginoscopic catheterization**
      ▪ Can use a vaginascope or otoscope
      ▪ Clean vulva and peri-vulvar area
      ▪ Can use stylet in catheter
      ▪ Visualize the urethral orifice and insert catheter

• **Male cats**
  • Urethra has a curve to S-shape beyond ischial arch
  • There are many catheters for male cats including metallic Olive-tipped catheters, polypropylene (stiff but easy to place, may induce reaction over time), polyvinyl (flexible, less reactive, and typically longer), silicone, and polytetrafluoroethylene (easy to place, “slippery sam”)
  • Can use a stylet to stiffen a soft catheter (e.g. red rubber catheter)
  • Lubricate the entire catheter, lubricate stylet if used, can use xylocaine gel as a portion of lubricant as a topical anesthetic
  • Procedure
    o Sedate or anesthetize cat
- Place in lateral or dorsal recumbency – dorsal is better
- Extrude penis and pull caudally and push towards spine in order to straighten the urethra
- Clean end of penis with soapy water
- Lubricate entire catheter and insert into tip of penis
- Slowly and gently insert catheter – maintain urethra in a straight “extended” position

**Female cats:**
- Actually very easy to catheterize
- Urethral orifice is usually approximately 1 cm along the ventral floor
- Most female cats can take a 5Fr catheter; 8Fr used if bigger
- Procedure
  - Anesthetize and place in lateral or ventral recumbency
  - Catheter placement similar to female dogs – blindly or using a scope

**Pyelocentesis:** It is possible to obtain urine from the renal pelvis by inserting the needle through the renal parenchyma into the pelvis using ultrasound guidance.

**Cystostomy catheters** may be inserted and used long term
- These may be mushroom-tipped catheters or low-profile catheters
- Allows for long term, indefinite use

**Sample handling**
- If collected urine is not analyzed immediately, it should be refrigerated to slow degeneration of cells and inhibit bacterial growth.
- The amount of time between collection and analysis, as well as refrigerating urine, increases likelihood of crystal formation; therefore the clinician should take into account these factors when interpreting a urinalysis.
- If urine is obtained via cystocentesis, the needle must be changed before transferring the sample into a sterile submission vial or container.
  - Failure to replace the used-contaminated needle with one that is new and clean can affect analysis results.
- If urine is collected for analysis only, a small amount should always be saved in a sterile container and refrigerated, in case the submitted sample demonstrates signs of active inflammation.
- If inflammatory cells are identified, the stored sample can be submitted for culture and sensitivity testing to rule in or out bacterial infection.
- Red blood cells may be observed on urinalysis with cystocentesis collection, but this blood is usually inconsequential and in quite small amounts.
- This blood is often caused by the needle puncturing the bladder and/or skin during collection. Resulting hematuria is usually microscopic and short-lived.

**Management of an indwelling urethral catheter**
- An indwelling urethral catheter should be considered on an individual case basis
  - Severely ill patients
  - If difficult to catheterize
  - Poor urine stream post obstruction
  - Detrusor atony (atonic bladder)
- A urethral catheter should be connected to a closed collection system
  - Required materials are catheters, adapters, sterile tubing, and a collection bag.
  - Once the catheter is placed, an adapter should be tightly connected to collection tubing.
    - A tight connection helps avoid leakage from the collection set and decreases likelihood of inadvertent detachment.
  - Once all tubing is connected, a reservoir bag can be secured to the distal end of the system to hold urine until emptied.
  - Sterile pre-packed single-use collection bags with one way valves to prevent urine from refluxing back into the line are available.
    - These bags often contain a drain at the distal end with easy open/close valves.
  - Alternatively, empty IV fluid bags can be used.
Used IV bags, however, do not provide the safeguards of purpose-made bags nor should they be considered sterile, if not re-sterilized after use.

- If traditional IV fluid lines are used for collection tubing, their clamps should either be disabled or removed to avoid unintentional clamping of the line that will obstruct urine outflow.

### Securing the system
- Securing the catheter at multiple points is recommended through a combination of catheter balloon inflation, suturing, and stress loops on legs or tail to avoid inadvertent removal.
- The steps taken to secure a catheter in place and to keep the patient from self-removal cannot be overemphasized, as catheter removal often leads to a second round of sedation, additional time, need for a new catheter, unnecessary patient stress, and owner expense.

### Management
- Always wash hands and don disposable gloves before handling urinary catheters and lines to protect patients and personnel from contamination during examination.
  - Gloves should be changed if they become soiled.
  - New gloves should be used with each patient.
- The collection bag and tubing should be placed at a level lower than the patient to encourage urine drainage, to decrease the likelihood of backflow or stagnant urine within lines.
  - Urine pooling in collection lines can lead to sediment build up and occlusion.
  - Avoid placing the collection bag and/or tubing on floors.
- All connections should be checked and secured frequently.
  - When urethral diameter is larger than catheter diameter, leakage will be noted at the catheter insertion site. In this case, the catheter should replaced with a larger size.
  - If leakage is noted at a connection site, those sites should be cleaned and tightened.
- Catheter and collection system cleanliness must be maintained by periodically wiping down the lines with antiseptic solution.
  - Skin around the catheter should be gently cleaned and monitored for signs of infection.
- Urine volumes should not be measured using marks on a reservoir, as this is unreliable.
  - Instead, pour the urine into a measuring beaker for an accurate volume reading.
  - Tracking volume of urine produced is imperative.
  - Urine should be assessed for appearance every 2 to 4 hours after being emptied, the volume measured and recorded.
  - Normal urine output is about 1-2 mL/kg/h or more depending on fluid rates and the cause for illness.
- Urine output volume should never be zero.
  - If no urine is noted the collection system and the bladder size should immediately be assessed.
  - Possible issues leading to an empty urine collection bag include occlusion within the system, a leak between connections in the system, or a displaced catheter.
  - If the urine output is in fact zero then oligoanuria may be occurring and should be addressed immediately.

- **Systemic antibiotics** should not be administered unless given for some other reason
  - The risk of bacterial urinary tract infection decreases with antibiotic administration
  - However, when an infection occurs, the organism has a high degree of resistance
  - Furthermore, the bacterial organism may invade the upper urinary tract resulting in chronic pyelonephritis

- **Anti-inflammatory agents** – such as an NSAID – may be beneficial as long as renal function is good
  - With an indwelling catheter, a **urethral relaxing agent** (alpha blocker) is administered to minimize catheter-induced urethral trauma and irritation
  - With bladder atony, a drug to stimulate bladder contraction, parasympathomimetic, is administered

### Catheter-associated UTI
- Occurs in 50-80% of catheterized patients
Prophylactic antibiotics decrease incidence, but increase likelihood of resistance or of an unusual organism

Prevention:
- Use as clean to aseptic technique as possible
- Physically separate patients with indwelling catheters from others
- Wear gloves and wash hands between patients
- Replace catheters when damaged or dirty

• Typically, an indwelling urinary catheter is maintained for 2 to 3 days
  - This is not a hard and fast rule, however
  - Decision to remove the catheter should be based on the progress of the patient, appearance of the urine, and likelihood that the tight junctions of the detrusor muscle have re-established
  - Remove if catheter is non-patent, damaged, or contaminated

• Post-obstructive diuresis must be addressed
  - Due to back pressure from the obstructive uropathy being transmitted to the upper urinary tract, a heavy diuresis may develop when the obstruction is relieved
  - This may be as much 2.4 L per day (most cats urinate 30-40 ml per day)
  - It is important to adjust fluid intake to match urine output so that dehydration does not occur

• Intravesicular instillation of agents to minimize UTI
  - Infections may be minimized by instilling 1:100 diluted chlorhexidine solution (2% solution) into the urinary bladder
    - Empty the urinary bladder via the indwelling catheter
    - Instill 30 ml of 1:100 diluted 2% chlorhexidine solution (resultant solution is a 0.02% solution)
    - Leave indwelling for 5 to 10 minutes and have patient move around or position the patient in various positions
    - Remove 20 ml from the bladder via the urinary catheter leaving 10 ml behind
  - Other solutions that can be instilled into the urinary bladder include Tris-EDTA, antimicrobial agents (such as aminoglycosides), glycosaminoglycans

Summary including KEY “TAKE HOME” POINTS
1. Collection of urine for urinalysis is an important part of a minimum database
2. Urine may be collected by voiding, cystocentesis, or passing a urinary catheter
3. Appropriate technique is important in order to minimize trauma to the patient and to collect a urine sample that is useable
4. Indwelling urinary catheter management is important to minimize trauma and to prevent complications associated with an indwelling urinary catheter

Summary
Collection of urine and placement of urinary catheters is an important part of veterinary practice. Proper technique decreases trauma and other complications. Management of indwelling urinary catheters involves good hygiene and intravesicular instillation of antiseptic agents to minimize catheter-associated UTI.

References/Suggested Reading