Objectives:

1. Describe the innervation of the detrusor smooth muscle, the bladder neck smooth muscle and the voluntary (striated) urethral sphincter. Describe the effects of anticholinergic, ?-adrenergic agonist and ??adrenergic antagonist medications on voiding function.
2. Describe the typical voiding problems of a patient with a sacral spinal cord injury.
3. Describe the typical voiding problems of a patient with a supra-sacral spinal cord injury.
4. Describe the typical voiding problems of patients with Parkinson's disease, stroke and brain tumour.
5. State four broad categories of urinary incontinence. State at least one example in each category.

Control of Micturition:

Normal Filling:

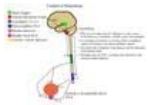
1. the normal viscous and elastic properties of the bladder allow it to stretch with a very small increase in pressure (e.g. bladder has high compliance)
2. as the bladder fills, spinal sympathetic reflexes are evoked which cause:
a. stimulation of a adrenergic receptors in the bladder outlet smooth muscle causing increased resistance
b. sympathetic activation of ß3 receptors in the detrusor muscle inhibiting contraction
c. direct inhibition of detrusor motor neurons in the sacral spinal cord during bladder filling
3. there is a gradual increase in urethral pressure as the bladder fills due to pudendal nerve activation of the striated sphincter (EUS) – guarding reflex
4. a urethral mucosal seal forms – secondary to the submucosal portion of the urethra (this can be affected after scarring, menopause etc. leading to a poor seal)

Normal Emptying:

1. when the bladder is full, coordination of detrusor and sphincter activity take place in the pontine micturition center resulting in:

a. firing in the sacral PNS pathways – contraction of the detrusor and relaxation of urethral smooth muscle
b. inhibition of sympathetic pathways – facilitating PNS mediated detrusor contraction and ceasing the sympathetic mediated constriction of the bladder neck
c. somatic pathways – inhibition of pudendal firing leading to relaxation of the EUS

i. the expulsion of urine consists of initial relaxation of the EUS followed in a few seconds by relaxation of the IUS and contraction of the detrusor muscle



2. the PMC or Barrington's nucleus has a crucial role in regulating micturition

a. it receives afferent input about the lower urinary tract
b. it receives input from the forebrain, cerebellum, hypothalamus and other brain stem areas

i. the cortical inputs to PMC are generally inhibitory, therefore damage to important cortical areas facilitates micturition via the removal of inhibitory signals
ii. the cerebellum is involved in the coordination of the detrusor contraction and the relaxation of the bladder neck, urethra and sphincter

c. PMC is important in turning off guarding reflexes to allow efficient bladder emptying

i. spinal cord injury leads to detrusor-sphincter dyssynergia

- the spinal cord emptying reflexes are efficient at causing detrusor contraction when the threshold is reached but very poor at controlling outlet relaxation so the patients get detrusor contraction against a closed bladder neck and the resulting poor emptying

Injuries and Diseases Affecting Micturition:

Injuries or diseases of the nervous system in adults can disrupt the voluntary control of micturition, causing the re-emergence of reflex micturition, resulting in bladder instability and incontinence. Because of the complexity of the central nervous control of the lower urinary tract, incontinence can occur as a result of a variety of neurologic disorders:

1. cerebral damage (e.g. stroke, tumor, brain injury):

a. generally causes a loss of voluntary control of micturition
b. hyperreflexia and urge incontinence are common
c. acutely, these injuries are often associated with urinary retention

2. basal ganglia damage (e.g. Parkinson's disease):

a. commonly results in detrusor hyperreflexia but onset of micturition is delayed, contractions are short and relaxation of the EUS is slowed ? patients generally have urgency, urge incontinence, hesitancy and slow urinary stream (similar to BPH)

3. suprasacral spinal cord damage (e.g. spinal cord injury or tumor at T5 level):

a. damage above the sacral spinal cord but below the PMC leads to reflex micturition with detrusor-sphincter dyssynergia

4. sacral spinal cord damage (e.g. cauda equina syndrome, pelvis fracture damage to S2-4):

a. leads to a completely acontractile bladder so the patient must strain (e.g. Valsalva maneuver) to urinate, partial lesion may leave weak reflexive contraction
b. patient may not be able to sense the need to urinate

5. atonic bladder: occurs during the phase of spinal shock following injury and can last for weeks

a. the bladder wall is relaxed and the IUS is contracted (due to loss of inhibition from higher levels) and the EUS is relaxed
b. the bladder becomes distended and eventually overflows

Anatomy:

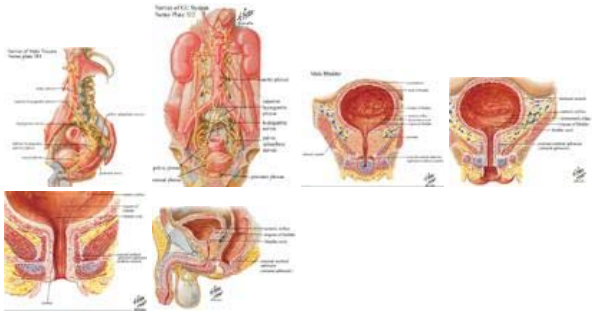
The lower urinary tract consists of the urinary bladder and the urethra along with their respective vascular and nervous supplies.

1. average capacity is approximately 400-600 ml but the urge to urinate begins when the volume is approximately 200 ml
2. muscular anatomy:

    a. the wall is composed chiefly of the detrusor muscle, made of bundles of smooth muscle organized in random directions
    b. towards the bladder neck the muscle fibers form the involuntary internal urethral sphincter (IUS) - functionally much more prominent in males
    c. in males the muscle fibers of the IUS are continuous with the fibromuscular tissue of the prostate, whereas in females it is continuous with smooth muscle surrounding the urethra
    d. the bladder neck in women is not as robust and has less a adrenergic innervation than in males ? in 50% of continent women urine enters the proximal urethra during a cough

3. Neuroanatomy:

    a. parasympathetic signals (from S2,3,4 via the pelvic splanchnic nerves to the pelvic and vesical plexi) utilize ACh to cause the detrusor muscle to contract (M3 muscarinic receptors)
    b. sympathetic signals (from T11-L2 via the aortic and superior hypogastric plexi to the hypogastric nerves to the pelvic plexus and vesical plexus) utilized NE to cause detrusor muscle relaxation (ß3 adrenergic receptors) and bladder outlet contraction (a1 adrenergic receptors)
    c. somatic control of the EUS and pelvic floor skeletal muscle (important for continence) is derived from the pudendal nerve (S2,3,4)



4. Afferent pathways:

    a. Information from the bladder and urethra reaches the dorsal root ganglia of the lumbar and sacral spinal cord through the pelvic and hypogastric

nerves (and plexi)
b. Information from the EUS and muscles of the pelvic floor travels in the pudendal nerve to the sacral spinal cord
c. Afferent nerves in the bladder and urethra respond to distension, chemical changes in the urine and substances released by the urothelium

Incontinence:

1. inability to prevent loss of urine from the bladder or the involuntary loss of urine from the bladder
2. 50% of nursing home residents and 15-30% of women over 65 are affected, but it is never normal
a. 85% of patients with urinary incontinence (UI) are women
3. complications include: depression, embarrassment, restricted activities, isolation, infection, falls, fractures and sleep disturbances
4. incontinence can be caused by many things including: pelvic muscle weakness, urethral sphincter incompetence, bladder irritation, fecal impaction, medications or neurological disease
5. risk factors: increased age, female gender, post-menopause, pregnancy, genitourinary surgery, infection, spinal cord injury, CNS diseases and chronic illness
6. transient incontinence can occur in 1/3 of elderly patients in the community and 1/2 of those who are hospitalized
- causes include: medications (e.g. diuretics, hypnotics, a agonists), CHF, UTI, delirium restricted mobility, fecal impaction, atrophic vaginitis, urethritis

Classification of Incontinence:

A. Overflow Incontinence:

a. loss of urine due to chronic urinary retention or secondary to a flaccid bladder, usually due to an obstructive (e.g. BPH, stone) or neuropathic lesion (e.g. spinal damage, diabetes mellitus, or transient after anesthesia)
b. common in men with BPH and uncommon in women
c. patients do not feel the urge to urinate and the bladder fails to ever empty completely, instead small amounts of urine leak continuously
d. other symptoms include nocturia, inability to void when the urge is felt, weak urinary stream and postvoid dribbling

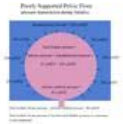
B. Total Incontinence:

a. the involuntary loss of urine at all times and in all positions
b. causes are neurological, post-surgical, after childbirth or due to pelvic disease
c. damage to the nerves may occur due to spinal deformities (e.g. spina bifida), spinal trauma, diseases (e.g. ALS, MS) or pelvic surgery
d. pelvic trauma of any cause may result in total incontinence due to nerve damage, scar tissue formation around the urethra, or fistula formation
e. in females the most common cause is repeated surgery for stress incontinence and in males total incontinence is most commonly seen after radical prostatectomy
f. treatment depends upon the cause but some possibilities include: urinary diversion, suburethral sling in females, artificial sphincter or muscle transplant

The two most common types of UI are stress incontinence and urge incontinence (these will be the focus of this seminar).

C. Stress Incontinence:

a. loss of small amount of urine with increased intraabdominal pressure without detrusor contraction
b. usually seen in middle aged women (with repeated vaginal deliveries) with weak pelvic floor and poor support for the vesicourethral sphincteric unit
a. the important supportive structures in the pelvic floor include: muscle (e.g. levator ani), fascia and ligaments
c. in a normal pelvic floor the vesicourethral sphincteric unit is well supported and the upper part of the urethra remains within the pelvis, this allows increases in intraabdominal pressures during straining to be equally distributed to the bladder and urethra ? the increased forces squeezing the bladder are counteracted as those same forces compress the urethra
d. incontinence results when the support fails and the urethra falls outside the pelvis so the intraabdominal forces act only on the bladder



Causes:

1. hypermobility of the vesicourethral segment owing to pelvic floor weakness impairs the efficiency of the sphincteric musculature ? failure to equally distribute intraabdominal pressures over the bladder and sphincter

a. normally when the patient strains the increased intraabdominal pressure is forced on the bladder wall, but because the urethra is found in the same compartment it is subjected to the same force so it is pressed closed
b. if it falls outside the abdomen it no longer pressed shut on exertion so the increased force only acts on the bladder wall and urine can escape from the urethra

2. intrinsic sphincter deficiency can be caused by multiparity and obstetric or pelvic surgery that results in weakened anterior vaginal muscle support of the bladder neck and urethra

a. in men intrinsic sphincter deficiency may be secondary to EUS damage after prostate surgery

D. Urge incontinence:

1. this is the most common pattern of incontinence affecting the elderly
2. precipitous loss of urine, preceded by a strong urge to void and an inability to reach the toilet, with increased intravesical pressure and detrusor contraction, usually at a low vesical volume
3. typical features are detrusor instability with a normal sphincteric component, normal anatomy and no urethral hypermobility
4. causes may be neurologic, idiopathic or due to inflammatory conditions affecting the bladder
5. specific examples of causes include: acute cystitis, upper motor neuron lesions (e.g. MS, stroke), Parkinson's disease or bladder cancer

History:

When taking a history from a patient with incontinence it is first crucial to rule out treatable or life threatening causes for the incontinence. One of the most common treatable causes may be a UTI, so questions regarding symptoms of dysuria, urgency, frequency, fever, and suprapubic pain are important to include. A pelvic mass may also contribute to incontinence so questions should be asked to investigate a history consistent with a pelvic malignancy. Questions to focus on should surround 1. history of a malignancy, 2. dyspareunia, 3. gynecological history (e.g. abnormal bleeding, regular check-ups…), 4. constitutional symptoms.

Other areas that may be addressed during the history:

1. Onset: during pregnancy, postpartum, after surgery or trauma
2. Frequency/severity/amount: number of pads used, voiding diary

    a. a small amount of urine usually is seen in overflow incontinence or outlet incompetence, and moderate flow in detrusor overactivity

3. Patterns: nocturnal, diurnal
4. Precipitants: cough, medications, position changes
5. Associated symptoms: straining, incomplete emptying, dysuria
6. Medical conditions: cancer, diabetes, neurologic disease, surgeries, radiation, BPH, UTI, prolonged labor, trauma, hypertension, CHF, medications
7. Living conditions

Symptom	Urge Incontinence	Stress Incontinence
Incontinence with sneeze, cough, lifting…	NO	YES
Nocturia?	YES	NO
Ability to delay void?	NO	YES
Daytime Frequency?	Often	Normal
Dysuria?	NO	NO
Quantity of urine?	Often substantial	Usually much less (i.e. not full bladder contents)

Physical:

1. this should include a brief psychiatric and neurologic evaluation
2. assess the abdomen: look at flanks, check for masses, check for bladder distention after voiding and check for any signs of fluid overload (e.g. polyuria)
3. Neurologic: check for perineal sensation and fecal impaction, check the bulbocavernosus reflex, anal sphincter tone and prostate
4. Pelvic: this is necessary for women

    a. must rule out pelvic malignancy
    b. perform with bladder empty to check organs and perform with bladder full to check for prolapse, cystocele, rectocele or incontinence
    c. look for atrophic vaginitis, masses, muscle laxity
    d. internal sphincter weakness can be assessed by asking the patient to cough while supine ? leakage of urine suggests outlet incompetence

5. Q-tip test: this may be used to evaluate urethral mobility (hypermobility can lead to stress incontinence)

    a. insert a cotton swab through the urethra into the bladder and note any changes in the angle of the swab with the patient straining
    b. a change of 30-40 degrees suggests excessive urethral movement

6. Stress testing: assesses for stress-induced leakage when the bladder is full

    a. have the patient relax and then ask the patient to cough or strain once

        i. instantaneous leakage is typical of stress UI
        ii. delayed leakage is typical of stress-induced detrusor overactivity

Work-up:

1. urinalysis, urine culture
2. ultrasound – looking for hydronephrosis, bladder distention, pelvic mass
3. postvoid residual volume – catheterize patient 5 minutes after urination, a large residual volume may indicate obstruction or hypotonic bladder
4. urodynamic studies – evaluates the physical structure and nerve function of the bladder and pelvic muscles with radiographic visualization of lower urinary tract > it is the most precise diagnostic tool available to evaluate problems of micturition

    a. cystometrogram – test of bladder and nerve function that is usually done

        i. valuable for the differentiation of stress, urge and mixed

incontinence
ii. small catheter is passed into the bladder and the bladder is filled with carbon dioxide
iii. it gives information about the size flexibility and sensitivity of the bladder

b. leak point pressures and urethral pressure profiles evaluate the function of the sphincter muscles - stress incontinence will show low urethral closure pressures, most demonstrable with a full bladder

c. electromyography can be included in the test to evaluate the state of contraction of the sphincter
d. video urodynamics is a highly specialized test included only in special circumstances

Treatment:

Stress incontinence:

1. patients with minimal stress incontinence may respond well to biofeedback/exercises or drugs whereas those with moderate or severe incontinence will probably require surgery
2. the most common cause of stress incontinence in older women is urethral hypermobility

a. it may be improved by: weight loss, physical maneuvers or Kegel exercises (voluntary contractions of the pubococcygeus muscles)
e.g. some women use vaginal cones to help strengthen the pelvic muscles

3. Pharmacologic:

a. a adrenergic agonists or tricyclic antidepressants are used to increase the internal sphincter tone and bladder outflow resistance (e.g. pseudoephedrine)
b. topical estrogen cream has been shown to increase tone and blood supply to the urethral sphincter muscles

4. can use periurethral bulking injections (teflon, collagen), and pessaries for females
5. for male can use penile clamps or sheaths
6. for women, surgery to:

a. elevate the bladder neck and bring the proximal urethra back into the abdomen (1 year success rate is 80-95%)
e.g. Burch suspension of anterior vaginal wall to Cooper's ligament
b. create a suburethral sling with fascia or a synthetic substance to compress the urethral sphincter

i. this has a similar success rate as bladder neck elevation

> complications of the above surgical procedures include: UTIs, urge incontinence and urinary retention

c. insert an artificial, inflatable urethral sphincter (most often performed in men)

Urge incontinence:

1. if urine culture is positive, treat the UTI with antibiotics
2. Timed voiding – using the patients voiding diary the physician helps them formulate a voiding schedule so the patient can urinate at a volume that is below the level that causes incontinence
3. Bladder training – biofeedback and Kegel exercises help the patient resist the sensation of urgency, postpone urination and urinate according to timetable
4. Pharmacologic:

a. antispasmodics to keep bladder from contracting (e.g. oxybutynin) – relaxes the bladder smooth muscle
b. anticholinergics to decrease bladder contractions (e.g. propanthaline, tolterodine)

> Oxybutynin and tolterodine are the most commonly used medications for urge incontinence and have minimal side effects (e.g. dry mouth, constipation), but cannot be used by patients with narrow angle glaucoma

c. tricyclic antidepressants (e.g. imipramine) – inhibit the bladder smooth muscle but have more significant side effects than oxybutynin and tolterodine