

## Advanced Analysis of Bladder Diary

CSM February 10, 2012 Chicago, IL  
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### Course objectives:

1. Determine global and nocturnal polyuria
2. List possible reasons for polyuria
3. Fully assess a measured volume bladder diary.
4. Determine when patients need further medical intervention based on bladder diary results

### Bladder diary research team (BDRT) 2003 to 2006

- Alfred Coats – Life Tech Houston, TX
- Linda Brubaker, Mary Pat FitzGerald, Kimberly Kenton – Loyola Medical Centre Chicago, IL
- Cindy Amundsen, George Webster – Duke University Medical Center Durham, NC
- Ananias Diokno, William Tissot – Beaumont Hospital Detroit, MI
- Linda Cardoza, Mathew Parsons, Maria Vella – King's College Hospital London, UK

### This lecture will focus on

- Clinical use of the bladder diary
  - Documentation of patient's status before, during and after treatment
  - To develop treatment plan
  - Educate and training the patient
- In the male and female adults in an outpatient setting

### Psychometrics (Parsons 2010)

- FVC have been shown to be a valid and reliable tool for assessment of micturition patterns (Larsson 1988, Brown 2002, Wyman 1988)
- Test-retest reliability – high to moderate
- Vavg (average or mean voided volume) has the best intra-individual reliability and may be the best measure for outcomes
- Not reliable for
  - Quantity of urine loss
  - Diagnosis discrimination between urge UI (UUI) and Stress UI (SUI)

### Types of records (Haylen 2010 – Appendix one IUGA and ICS definitions )

- Frequency volume chart (FVC or FV chart)
  - Volumes voided
  - Time of each micturition
  - Day and night, for at least 24 hours
- Bladder diary
  - Volumes voided
  - Time of each micturition
  - Incontinence episodes and degree of UI (urinary incontinence)
  - Fluid intake
  - Degree of urgency

### Information from bladder diary

- Subjective
  - Intensity of the desire to void
  - Leakage occurrence, type and amount
  - Pad usage and type
- Objective
  - Fluid type and amount
  - Micturition pattern

### Sensations of the bladder (Wyndaele 2008 great summary article)

- Physiologic
  - Sensation of micturition
  - Sensation of bladder filling
- Pathologic
  - Urgency
  - Pain
- Sensations of micturition
  - Usually free of sensation
  - Some people can feel: passing urine, opening sphincter
  - “If voiding is postponed for a long time then the beginning of the void is usually associated with urethral discomfort and a vague suprapubic pain lasting several minutes.”
- Sensations of bladder filling
  - Empty bladder – immediately after void, no sensation
  - First sensation of filling – slight pressure, not constant, lasts for a few seconds, vague, lower pelvic region, 40% of cystometric capacity
  - First desire to void – “consistent sensation which persuades a person to seek a place to void”, lower abdomen, can be easily delayed, gradually build sensation, 59% of cystometric capacity
  - Strong desire to void - with a full bladder, “constant almost uncomfortable sensation in perineal region or urethra”. Can be deferred only a short time and if not emptied will progress to pain due to over distention.

### Bladder sensory symptoms (Haylen 2010)

- *Normal* - no desire to void is felt when bladder volume is small. As volume increases, the desire to void begins gradually, is felt intermittently and is weak.
- *Increased bladder sensation* – complaint that desire to void occurs earlier and is more persistent. Differs from urgency in that it is possible to postpone.
- *Urgency* – complaint of a sudden compelling desire to void which is difficult to differ
- *Reduced bladder sensation* – complaint that desire to void occurs later despite awareness of bladder filling.
- *Absent bladder sensation* – complaint of absence of both filling sensation and desire to void.

### A healthy bladder – a consensus statement (Lukacz 2011)

- “A healthy bladder ... stores urine without discomfort at low pressures with intermittent signals of filling.”
- “When necessary, an individual should be able to defer voiding without leakage.”

### Desire to void

- 15 healthy females (De Wachter 2011)
  - Considering all voids
    - 65% occurred without desire to void
    - 9.5% made with strong desire to void related to postponing void
  - Higher sensation of fullness = higher voided volumes
  - FVC with record of sensation of bladder fullness are useful in evaluating bladder sensations
- Starkman 2008 great summary article
- OAB cannot be diagnosed without urgency, therefore urgency is key symptom and must be documented
- “Precise causation of urgency remains elusive despite intensive investigation”
- Two types of urgency (De Wachter 2010, Blaivas 2009)
  - An intensification of normal desire to void – 69%
  - Appears without warning (on / off switch) / a different sensation – 29%
  - Different sensation or a different pathology and will it respond differently to different treatments?
- Urodynamics
  - Theory - urgency is secondary to involuntary detrusor contraction
  - In reality urodynamics shows
    - High pressure detrusor contractions with very little sensation
    - Complaint of debilitating urgency with very little rise in detrusor pressure
- “Urge” is easy to confuse with “urgency” and ICS suggest not using the word “urge” – instead use “desire or need to void”

### Convenience void (CV) (Honjo 2010)

- “JIC” = just in case
- Void without desire or sensation of bladder fullness.
- Bladder is emptied for social reasons such as exercises, leaving the house, going to bed.
- 310 females: 15.5% OAB, 84.5% Normal

Age	Occurrence of CV
40s	30%
50s	24%
60s	21%
70s	10%

### Documenting quantity and quality of bladder sensations

- A single score encapsulating all qualities of urgency may not be possible.
- Starkman 2008 provided 7 different scales and some testing of the scales
- Most are called urgency scales but are really scales of bladder sensation
- Recording should include measure of
  - Frequency
  - Intensity
  - With respect to surrounding circumstances
  - Ability to defer
  - Duration of warning time

De Watcher 2003, Honjo 2010

	Description
Grade 0	No bladder sensation
Grade 1	Sensation of bladder filling without desire to void – void can be easily delayed for more than 60 minutes
Grade 2	First desire to void - void can be easily delayed for more than 30 minutes
Grade 3	Strong desire to void - void cannot be delayed for more than 15 minutes
Grade 4	Urgent desire to void - void cannot be delayed for more than 5 minutes
Grade 5	UUI

Studies which include bladder sensation (Starkman 2008)

- 3 levels of urgency situations listed from most to least
  - Waking, rising, latch-key
  - Running water, cold weather
  - Fatigue, worry
- Patients with OAB – < 50% of voids associated with urgency

Documentation of leakage

- Bladder diary is not reliable for (Parsons 2010)
  - Quantity of urine loss
  - Diagnosis discrimination between urge UI (UUI) and Stress UI (SUI)
- Number of pads used and size of pads – this may also not be reliable
  - Anxiety about possible large leak may result in using pad larger than really needed
  - Anxiety and misinformation about leak may lead to using pads longer than needed
  - Patient may change pad just for freshness (such as first AM and last PM)
  - Patient may wear panty liners always – vaginal discharge
- Leakage frequency – low frequency leakage
  - 25% of patients recorded fewer than 0.3 UI per day on a 3 day diary (Kenton 2006)
  - 34.5% of patients failed to record UI on 3 day diary (BDRT)
- Size of leaks (no research on this scale)
  - Leak volume - It is nearly impossible to measure the amount of urine leakage (wetness in your pad or underpants). Please try to label the approximate size of each wetness. Please change your pad each time it is wet so you can tell the size of the next wetness.
  - 1 = damp – just a few drops
  - 2 = wet – 15 to 50% of the pad is wet
  - 3 = soaked – more than 50% of the pad is wet
- Activities which precipitate leakage – movement versus urgency
  - Description of leak – it is important to note the circumstances surrounding the leak. Please check mark one of these boxes for every wetness / leak recorded.
  - Felt leak with activity – urine came out during a sneeze, cough, laugh, lift, bend, run, exercise, or any other movement or activity
  - Felt leak with strong urge – felt a strong or desperate need to urinate and could not hold it back. This includes leaks which occurred during walking to the bathroom with a strong urge.
  - Wetness discovered – went to the bathroom and found wetness but do not know when it occurred.

- Urinary Incontinence symptoms (Haylen 2010)
  - *Stress urinary Incontinence* (SUI)
  - *Urgency urinary Incontinence* (UUI)
  - *Mixed urinary Incontinence* (MUI)
  - *Nocturnal enuresis* – complaint of UI during sleep
  - *Postural urinary Incontinence* – complaint of UI with change of posture. It is unclear whether this is related to SUI or UUI
  - *Continuous urinary Incontinence*
  - *Insensible urinary Incontinence* – complaint of UI where patient was unaware of how it occurred
  - *Coital urinary Incontinence* – complaint of UI during intercourse, can be further subdivided into UI with penetration or orgasm
- Urinary Incontinence conditions (Homma 2008)
  - *Reflex UI*
  - *Functional UI*
  - *Overflow UI*

#### “Wetness discovered”

- Reasons for wetness discovered
  - Decrease sensation
  - Decreased awareness
  - Wetness is not urine
- Fluids that may cause wetness in the perineal area
  - Urine - Insensible urinary Incontinence
  - Sweating
  - Vaginal or penile discharge
- Pyridium test – phenazopyridine Hydrochloride – Colored urine test (Harvey 2010)
  - Patient takes Pyridium (or over the counter Azo Standard) BID for 3 days and brings used pads into clinic for assessment
  - High sensitive – if leakage is present it will be detected
  - Low specificity - due to high false positive, Pyridium left on the skin after voiding and wiping
  - “minimal, non-clinically significant loss of urine in normal women”
  - Nearly 100% of self-reported continent women stained after exercise
    - Mean staining area 2.66 mm (0 to 11 mm range)
    - Despite difficulties with test authors felt it was helpful in detecting extra urethra UI
- Pad tests (Harvey 2010)
  - Pad is weighted and patient wears the pad(s) for 24hrs bringing all pads in the be weighted after
  - 24 hour pad test in normal – 1.3g, 2.6g, average of 3.1g range 0-9g
  - This test suggests using greater than 1.3g as a positive test.
- Vaginal discharge (Stewart 2002)
  - Exact amount of normal vaginal discharge is unclear
  - Older texts state “There is a constant small amount of vaginal discharge ”
  - Amount has been estimated by weighting tampons
    - Average 1.55g to 1.89g per day
    - Secretion greatest on day 14 – ovulation – 1.98g
    - Least on day 7 and 26 – 1.37g

## Proper fluid intake (Mayo 2004)

Fluid need depend on

- Health / illness
  - Increased fluid need
    - Fever
    - Vomiting
    - Diarrhea
    - UTI / stone
    - Pregnancy and breastfeeding
  - Decreased fluid needs
    - CHF
    - Kidney, liver, adrenal disease
- Exercise
  - Amount of need depends on: –
    - Length of exercise
    - Intensity of exercise
    - How much you sweat
  - Consider sports drinks to replace sodium
  - It is possible to over hydrate – hyponatremia
- Environment
  - Higher fluid intake needed
    - Hot, humid weather due to sweating and fluid loss through skin
    - Indoor heated air due to fluid loss through skin
    - Altitude above 8,200 ft due to increased urine production and increased respiration rate

## Average healthy adult living in a temperate climate

- Replacement method
  - Urine loss = fluid intake
  - Food accounts for about 20% of fluid intake (480 ml or 2 c)
- 8x8 rule
  - Take in 8 eight oz glasses per day = 1900 ml
  - No scientific data to support this
- Dietary recommendations
  - The Institute of Medicine and ADA
    - Men 3000 ml (13 c)
    - Women 2200 ml (9 c)
  - US food science board recommends ½ oz per pound per 24 hrs (Lukacz 2011)
    - 120 pounds = 7.5 c
    - 160 pounds = 10 c
    - 200 pounds = 12.5 c
  - Pregnancy – 2300 ml ( 9.5 c)
  - Breast feeding – 3100 ml (13 c)
  - Exercise more than 1 hr – need to increase fluid intake 400 to 600 ml (1.5 c to 2.5 c)

Yogurt 125ml = 100 ml  
 Pudding 150 g = 100 ml  
 1 grape fruit = 180 ml  
 ¼ melon = 200 ml  
 Watermelon and  
 Tomatoes are 90% water

### Thirst

- Thirst is not a good measure of need
  - You may be dehydrated and not thirsty
  - You can be fully hydrated and still thirsty
- Not a good idea to let thirst alone guide fluid intake
- Drink enough so you rarely feel thirsty
- Urine output should be colorless or slightly yellow

### Timing of Fluids

- Should be evenly spaced throughout the day
- Strong relationship between evening fluid intake, nocturia, and nocturnal voided volume (Griffiths 1993)
- Decreasing fluid intake after 7 PM may decrease nocturnal UI (Tomlinson 1999)

### Evidence for fluid amount recommendations

- Fluid intake over 2,400 ml (80 oz) or under 1,500 ml (50 oz) can contribute to UI (Tomlinson 1999)
- Fluid intake over 3700 ml - associated with voiding > 10 x/ day and 2 x/ night, higher UI rates as compared to 2400 ml. (Lukacz 2011)
- Decreasing fluid intake does decrease frequency, urgency, and UI in patients with OAB (Switinhbank 2005)

### Primary polydipsia

- Excessive water intake, no specific levels are given
- In normal patients the kidneys can usually process large volumes of fluid without difficulty if spread over a long time (Diamond 2004, Gilbert 1976)
- Excessive water intake in combination with abnormal renal function, uncontrolled diabetes, psychosis, and syndrome of inappropriate antidiuretic hormone (SIADH) can result in hyponatremia (Diamond 2004, Gilbert 1976)
- Most commonly occurring in patients with schizophrenia or other psychiatric illnesses – 4 to 6 liters per day (Rae 1976, Vieweg 1986)
- Other case reports
  - To avoid drug detection - 5 gallons in a few hours (Diamond 2004, Klonoff 1991, Tilley 2011, Gardner 2002)
  - Patient – physician miscommunication in preparation for pelvic ultrasound (Christenson 1985, Gopal 2000)
  - During strenuous exercise (Garigan 1999)
  - Related to treatment of dehydration in an athlete – 5 liters of saline IV and 3 liters of water by mouth in 5 hours (Herfel 1998)
- Hyponatremia is an electrolyte disturbance due to sodium loss or fluid excess (Herfel 1998)
  - Symptoms include – disorientation, coma, seizures, focal neurological defects, cerebral edema (HA), death

### Type of Fluid Intake / irritants

- Caffeine
  - Caffeine results in significant increase in detrusor pressure (Creighton 1990)
  - Decreasing caffeine (less than 2 cups) may decrease UI (Tomlinson 1999, Burgio 2010)
  - RCT decreasing caffeine (less than 100mg) significantly decreased UI in combination with PFM exercises. (Bryant 2000)
  - Decreasing caffeine intake has no significant effect on leakage, frequency, urgency, or QOL (Swithinbank 2005; Bird 2005)
  - A multivariable analysis showed no association between coffee drinking or alcohol consumption and UI (Brown 1996)
  - US Food and Drug Administration lists more than 1000 over-the-counter drugs containing caffeine (Newman 2004)
- Alcohol
- Nicotine: smoking is associated with increased SUI symptoms and cessation can decrease the symptoms (Pearson 1992; Bump 1994)
- Carbonated beverages
- High acid and high oxalate containing foods can be irritating, especially in patients with painful bladder syndrome
- Artificial sweeteners (Newman 2007)

### Localizing urinary dysfunction (BDRT)

- Upper urinary tract - Urine production rate (may be related to urinary frequency )
  - Global polyuria
  - Nocturnal polyuria
- Lower urinary tract – bladder storage and emptying
  - Low bladder capacity (may be related to urinary frequency )
  - UI episodes
  - Urinary retention

### 24 hour urine output – V24

- Loss of body fluid (Mayo 2010 , Wikipedia 2011)
  - Insensible fluid loss
    - Cannot be easily measured
    - Sweat, breathing, BM, secretions
    - 500 to 1000 ml per day
    - Feces – 100 ml fluid per day
    - Vaginal secretions – 50 ml fluid per day
  - Urine
- No real agreement on what is normal V24
- Many clinicians use average 1500 ml to 2000 ml
- Recent research to establish norms V24 varied between
  - 600 ml to 2500 ml (Fallis 2005)
  - 725 ml to 4500 ml males (Tissot 2008)
  - 734 ml to 3150 ml females (Amundsen 2007)
  - BDRT scales include 1000 to 3500 ml
  - Means calculated by scatter plots from BDRT data 1250-1900 ml
- Most agree that under 600 ml or 700 ml is too low

- There is not much agreement on what is too high (see below)
- Urine production rate varies
  - 1 ml/min to 20 ml/min (Fallis 2005)
  - Average 0.7 ml/min to 2.1 ml/min
  - Average 6.1 ml/min (Heesakkers 2003)
- Urine volume is related to (Fallis 2005, Heesakkers 2003)
  - Fluid intake
  - Rate of renal circulation
  - Amount of water lost through other routes
    - Hyperventilation
    - Fever
    - Vomiting
    - Burns or wounds
  - Blood pressure
  - Status of glomeruli – related to antidiuretic hormone and circadian fluctuation
  - Medications such as diuretics

#### Global polyuria

- Excessive V24 urine production - often no value is given
- Most common parameters cited – over 2500 ml to 3000 ml per day
- Psychiatric patient with polydipsia syndrome produce V24 of 4934 to 9884 ml (Vieweg 1986)
- Standardization document – over 40 ml/ kg of body weight; V24 > 2.8 liters of urine in a 70 Kg (154 lb) female (Haylen 2010)

Patient's weight	V24
132 lbs	2460 ml
154 lbs	2829 ml
176 lbs	3240 ml
198 lbs	5940 ml ???

- Causes of global polyuria (Weis 2011 , Laureanno 2010 )
  - Diabetes mellitus (type 1 and 2)
  - Diabetes insipidus (pituitary and renal)
  - Polydipsia (psychogenic, dipsogenic, iatrogenic)
  - Secondary nephrogenic due to lithium or electrolyte disturbance such as hyperkalemia, hypokalemia
  - Secondary to medications such as diuretics

#### “Bladder diary day”

- Starts – time of getting out of bed to start the day
- Ends – last void of the night – the one before you get up out of bed to start the day

#### V24 - Total 24 hour urine volume

- Add all volumes voided in 24 hrs starting with the second void of the day and including the first void of the following day
- Average 1700 ml per 24 hrs
- Range 1250 ml to 2500 ml

#### F24 - Total 24 hour frequency

- Count number of voids in 24 hrs starting with the first morning void
- Voiding frequency is related to (Gulur 2011)
  - Rate of urine output – F24 Increases with increasing V24 (BDRT)
  - Reservoir capacity of the bladder – F24 Increases with age (BDRT)
  - Lower urinary tract sensation
  - Psychological response
- “epidemiological studies suggest that the normal micturition rate is approximately 8 micturitions per day and 1 or fewer episodes at night” (Lukacz 2011)
- Traditionally 7 voids per day is thought to be the upper limit of normal F24 (Haylen 2010)
- F24 should be adjusted for age, sex, and 24 hour urine volume (BDRT)
  - Female F24 =  $4.25 + 0.00012V24 + 0.015age$  (Amundsen 2007)
  - Male F24 =  $2.9 + 0.001V24 + 0.04age$  (Tissot 2008)
- Average 7 voids per 24 hrs
- Range 5.3 to 8.5 voids per 24 hrs

#### Vavg – average voided volume (also called functional bladder capacity)

- V24/F24
- Circadian rhythms – smaller voided volumes = early in afternoon as compared to early AM, late evening, and night time. (Orlke 2010)
- Vavg includes convenience voids
- Honjo 2010

	5,709 voids	Mean voided volumes
Grade 0	7.1%	141ml
Grade 1	14%	185ml
Broad CV	21%	170ml

- Vavg should be adjusted for age, sex, and 24 hour urine volume (BDRT)
  - Female Vavg =  $105.8 + 0.09V24 - 0.35 age$  (Amundsen 2007)
  - Male Vavg =  $150.8 - 1.5 age + 0.106V24$  (Tissot 2008)
- Vavg - Volume per void (BDRT)
  - Increases with increasing V24
  - Decreases with age
- Research shows a variety of Vavg – 330 ml, 382 ml, 400 ml (Gray 2011)
- “normal functional bladder capacity in adults ranges from 300 to 400 ml” (Lukacz 2011)
- Average 250 ml per void
- Range 180 ml to 385 ml per void

#### Unmeasured voids

- Ideally the patient would measure all voids in a continuous 3 day period – especially if nocturia is a concern.
- Practically this might not be possible
- If the patient is in a location where it is not possible to measure they will place a check in the box – Do not guess
- In this case Vavg would be calculated by adding all measured volumes and dividing by the number measured
- This number can then be inserted into the diary at each check mark for other calculations

Vmax – maximum voided volume (also called diary bladder capacity)

- List single largest volume voided
- Vmax increases with increased V24 (BDRT)
- Average 500 ml
- Range 400 ml to 750 ml
  
- Cystometric capacity – intra-vesicle volume at the end of a filling cystometrogram. (Gray 2011)
- Can be higher or lower than functional bladder capacity.
- Generally 300 to 600 ml
- Cystometric bladder capacity is not a substitute for functional bladder capacity
- Vmax (maximum voided volume) – significant positive correlation to cystometric bladder capacity. (BDRT)

Vmin – minimum voided volume

- Single lowest volume voided
- It is much more variable and less reliable than Vavg and Vmax
- Recommend not using Vmin in clinical or research data collection

Day voiding intervals

- Minimum day voiding interval - Single smallest daytime voiding interval
  - Like Vmin may not be reliable due to CV / BM
- Maximum day voiding interval - Single largest daytime voiding interval
  - Related to V24, age, Vmax, CV, circadian rhythms
- Average day voiding interval
  - Calculated per day
  - List each day voiding interval
  - Total them all /day time frequency – 1
  - Used as a starting point for bladder training
- Voiding interval - approximately every 3 to 4 hours based on volume of liquid consumed (Lukacz 2011)
- In older patients voiding interval is smaller – every 2 to 3 hrs, due to smaller bladder capacity

Other considerations

- Urinary retention / elevated post void residual (PVR)
  - Suspect retention if voiding occurs at one hour intervals with high volumes
  - For example 3:00 PM 150 ml, 4:00 PM 350 ml
  - It is not probable that the patient created 350 ml of urine in one hour
  - It is more probable that he did not empty fully at 3:00
- Relationship of leaks to voids
  - Patient may need to void more frequently if the UI occurs after a long period of no voids
- Relationship of desire to void to size of void
  - Often there is not a relationship with small voids occurring on high desire and large voids occurring on low desire
- Relationship of irritant intake to UI or urgency
  - Look for urgent void or UI within 1 to 2 hours of intake of irritating fluids

### Type of UI

- Patients with DO have (Parsons 2007)
  - Higher F24
  - Lower Vavg
  - More urge related leaks
  - Lower volume per leak
  - Same number of leaks
- Patients with urodynamic SUI
  - Almost 60% c/o urgency and 40% c/o UUI (Parsons 2007)
  - SUI group could be divided into 2 groups (BDRT)
    - Normal bladder capacity – expected clinical picture of SUI
    - Low bladder capacity – looks like OAB except UI occurs with activity.
- Conclusion –separation between SUI and UUI may not be completely possible or reliable with the FVC alone.

### Vn - nocturnal urine volume

- Add up all voided volumes included in after the patient retires for the night to before the patient leaves the bed for the day - includes only voids preceded and followed by sleep and the first void on getting out of bed for the day
- Voided volumes at night are on average 1/3 larger than Vavg (Laureanno 2010)
- Varies greatly (470 ml to 1020 ml) and affected by many factors
- Not reliable in evaluating nocturnal polyuria

### Fn - Frequency of night time voids

- Count number of voids from after the patient retires for the night to before the patient leaves the bed for the day - includes only voids preceded and followed by sleep
- Nocturia - is the complaint of interruption of sleep 1 or more times because of the need to urinate. Each void is preceded and followed by sleep (Haylen 2010)
- Great variety of prevalence reported in the literature 28.4% to over 80% (Fiske 2004)
- Clinically significant nocturia - Based on the degree of bother - 2 or more episodes. (Fiske 2004, Weiss 2011)
  - Mild – two nocturia
  - Moderate – three nocturia
  - Severe – four or more nocturia
- AUA 2007 = nocturia is urinating 2 or more times per night. (Levkowicz 2011)
- Meta-analysis (43 articles) 2 or more voids per night = definition of nocturia (Weiss 2011)
  - Men 20-40 = 2-17%, Women 20-40 = 4-18%
  - Men over 70 = 29-59%, Women over 70 = 28-62%
  - Higher in African Americans
- Age related changes (Parsons 2007)
  - 18 - 49 yo = more women have nocturia
  - 50 – 59 yo = equal women and men
  - 60+ yo = more men have nocturia
  - Conclusions
    - With aging - day production ↓ and night production ↑
    - Fn increases with age

Main causes of nocturia (Udo 2011, Weis 2011, Van Kerrebroeck 2002)

- Global polyuria
- Nocturnal polyuria
  - Obstructive sleep apnea (often associated with obesity)
  - Excessive evening fluid intake
  - Peripheral edema / third spacing of fluid into the legs caused by (Laureanno 2010)
    - CHF
    - Low blood volume
    - Venous stasis
    - High intake of salt
  - Idiopathic
  - Circadian defect in secretion of AVP – arginine vasopression
  - Autonomic disease (Gulur 2011)
  - Hepatic failure / chronic kidney disease
- Decreased bladder capacity
  - Reduced functional bladder capacity
    - Extrinsic compression from tumors
    - Bladder pain syndrome / IC
  - Bladder outlet obstruction
    - BPH
    - Elevated PVR – uterine fibroids, POP, urethral stricture
  - Detrusor overactivity
    - Nocturnal DO
    - OAB – 80% of pts with OAB report nocturia (antimuscarinics may not help)
    - Neurogenic bladder
  - Other
    - CA of bladder prostate or urethra
    - Bladder or ureteric calculi
    - Urogenital aging – estrogen deficiency
    - Learned voiding dysfunction
- Primary sleep disorders
  - Insomnia
  - Sleep apnea
  - Periodic leg movements
  - Narcolepsy
  - Arousal disorders – sleepwalking, nightmares
- Other potential factors
  - Medical disorders – cardiac failure, COPD, endocrine disorders
  - Neurological conditions – Parkinson’s disease dementia, epilepsy
  - Psychiatric conditions – depression, anxiety
  - Chronic pain disorders
  - Alcohol or drug use
  - Medications – corticosteroids, diuretics, beta-adrenergic antagonists

## Predictors of nocturia (Weiss 2011)

Men	Women
Most common predictors <ul style="list-style-type: none"> <li>• Urgency</li> <li>• BPH</li> <li>• Sleep disruption - snoring</li> </ul>	Most common predictors <ul style="list-style-type: none"> <li>• Urgency</li> <li>• Obesity</li> <li>• Sleep disruption - snoring</li> </ul>
Secondary associations <ul style="list-style-type: none"> <li>• Hx of prostate CA</li> <li>• Antidepressant use</li> </ul>	Secondary associations <ul style="list-style-type: none"> <li>• CAD</li> <li>• Diabetes</li> </ul>

## Types of nocturia

	Night frequency	Night urine production
Low bladder capacity	High	Normal
Nocturnal polyuria	High	High

## NPi - Nocturnal polyuria index

- $V_n/V_{24} \times 100$
- Nocturnal polyuria - is present when an increased proportion of the 24 -hour output occurs at night. (Haylen 2010, Van Kerrebroeck 2002)
  - NPi > 20% young adults
  - NPi > 33% for those over 65 yo
- This measure does not consider amount of time sleeping
- BDRT charts report much higher NPi in normal 34% to 50%

## Pn/P24 - Night / 24 hr production rate ratio

- Age adjusted relative night urine production is the best measure of nocturnal polyuria (BDRT)
- Number of minutes sleeping - Count total number of minutes from getting into bed for the night to getting out of bed for the day
- Pn - Night urine production rate =  $V_n / \# \text{ minutes sleeping}$
- P24 - 24 hour urine production rate =  $V_{24}/1440$
- Night / 24 hr production rate ratio =  $P_n/P_{24} \times 100$
- Above 105% and 155% = nocturnal polyuria

## NCBi - Nocturnal Bladder Capacity index (Burton 2011)

- $F_n - (V_n / V_{max} - 1) = \text{NBCi}$
- Measure of small nocturnal bladder capacity
- NBCi does not need to be adjusted for age or V24 as others do.
- NBCi over 1.3 is significant and over 2 is highly significant
- $F_n > 3$  = usually small bladder capacity.
- $F_n < 1$  = usually not small bladder capacity
- Should calculate NBCi if  $F_n$  is between 1 and 3
- Diagnostic significance is undecided.

## Conclusion of BDRT research

- Large overlap between normal and abnormal suggests it may be more useful to report measurements as a percent of reference population rather than normal or abnormal

## References

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## Appendix 1 – IUGA and ICS Standardization Document

Haylen BT, et al. An International urogynecological association (IUGA)/ International continence society (ICS) joint report on the terminology for female pelvic floor dysfunction. *Int Urogynecol J* 2010 21:26.

### Types of charts

- Frequency volume chart (FVC)- this records the volumes voided as well as the time of each micturition, day and night, for at least 24 hours
- Bladder diary - this records the times of micturitions, and voided volumes, incontinence episodes, pad usage, and other information such as fluid intake, the degree of urgency, and the degree of incontinence

### Information from frequency volume chart

- *Daytime frequency*- is the number of voids recorded during waking hours and includes the last void before sleep and the first void after waking and rising in the morning.
- *Nocturia* - is the number of voids recorded during a night's sleep: each void is preceded and followed by sleep.
  - Night time frequency is a term used by some to denote all voids from the time to go to bed with the intention of sleeping (not including the last PM void) till getting up out of bed with the intention of rising (not including the first AM void) this would include any voids that occur after retiring but before sleeping and after waking but before rising for the day. (Homma 2008)
- *24-hour frequency* - is the total number of daytime voids and episodes of nocturia during a specified 24-hour period.
- *24-hour production* - is measured by collecting all urine in 24 hours.
- *Maximum voided volume* - highest voided volume recorded
- *Average voided volume* - summation of all volumes voided divided by the number of voids
- *Polyuria* - excessive urine excretion resulting in frequent micturition. It is defined as the measured production of more than 2.8 liters of urine in 24 hours in a woman weighing 70 kg (about 155 pounds) = over 40 ml/kl.
- *Nocturnal urine volume*- is defined as the total volume of urine passed between the time the individual goes to bed with the intention of sleeping and the time of waking with the intention of rising. It excludes the last void before going to bed but includes the first void after rising in the morning.
- *Nocturnal polyuria*- is present when an increased proportion of the 24hour output occurs at night.  $\text{Nocturnal voided volume} / \text{total 24 hr voided volume} \times 100$ . Over 20% young adults, over 33% for those over 65 yo

Please note these definitions are based on patient's complaint and may not represent actual occurrence.

### Voiding symptoms

- *Hesitancy* - is the complaint of a delay in initiating micturition
- *Slow stream*- is the complaint of a urinary stream perceived as slower compared to previous performance or in comparison to others
- *Intermittency* - is the complaint of urine flow that stops and starts one or more times during voiding
- *Straining to void* - is the need to make an intensive effort to initiate or maintain the urinary stream
- *Spraying (splitting) of urinary stream* - is complaint of the occurrence of a spray or a split stream instead of one discrete stream

- *Feeling of incomplete (bladder) emptying* - is the complaint that the bladder does not feel empty after micturition.
- *Need to immediately re-void* - complaint that further micturition is necessary soon after passing urine
- *Post micturition leaking*- is complaint of UI after completion of micturition
- *Position dependent micturition* - the complaint of the need to assume a certain position to start voiding or improve bladder emptying (such as leaning backward, forward or semi standing)

#### Bladder storage symptoms

- *Increased daytime urinary frequency* - complaint that voiding occurs more during waking hours than deemed normal by the woman. Many professionals have a problem with this definition as the exact frequency seems to be dependent on several factors. In general it is thought to be less than 7 times
- *Nocturia* complaint of interruption of sleep one or more times because of the need to urinate- possibly different from night time frequency
- *Urgency* – complaint of a sudden compelling desire to void which is difficult to differ
- *Overactive Bladder syndrome (OAB)* – urinary urgency , usually accompanied by frequency and nocturia, with or without UI, in the absence of UTI or other pathology

#### Bladder sensory symptoms

- *Normal* - no desire to void is felt when bladder volume is small. As volume increases, the desire to void begins gradually, is felt intermittently and is weak. It is felt continuously when strong at larger volumes. (Homma 2008)
- *Increased bladder sensation* – complaint that desire to void occurs earlier and is more persistent. Differs from urgency in that it is possible to postpone
- *Reduced bladder sensation* – complaint that desire to void occurs late despite awareness of bladder filling. Is bladder filling different from desire to void? (Homma 2008)
- *Absent bladder sensation* – complaint of absence of both filling sensation and desire to void.

#### Urinary Incontinence symptoms

- *Stress urinary Incontinence (SUI)*
- *Urgency urinary Incontinence (UUI)*
- *Mixed urinary Incontinence (MUI)*
- *Nocturnal enuresis* – complaint of UI during sleep
- *Postural urinary Incontinence* – complaint of UI with change of posture. It is unclear whether this is related to SUI or UUI
- *Continuous urinary Incontinence*
- *Insensible urinary Incontinence* – complaint of UI where patient was unaware of how it occurred
- *Coital urinary Incontinence* – complaint of UI during intercourse, can be further subdivided into UI with penetration or orgasm

#### Urinary Incontinence Conditions (Homma 2008 Int J or Urol 15;3543)

- *Reflex UI* – urine passage as an autonomous micturition reflex of the sacral micturition center
- *Functional UI* - UI caused by impairments of function
- *Overflow UI* – UI associated with urinary retention

## Appendix 2 – Logistics of Bladder Diary completion

### Duration

- Varied widely – 1, 2, 3, 7, continuous day
- 3 day diary showed highly reliable (CCC 0.86) for number of UI episodes (Groutz 2000)
- Dairy fatigue is possible especially on longer diaries (7 day) but may be necessary for research
- Training may require continuous bladder dairy however these are usually less detailed and only include the information needed for the patient to learn
- Recommended duration is 3 days (Palnaes 1998, Tincello 2007)
- Patients unable to complete a 3-day diary have less success with treatment (Kincade 2001)

### Instructions

- Mailing bladder diaries (Parsons 2010)
  - Diary instructions mailed to patients = 32% completion
  - Addition of an letter describing the important of the dairy = 75.5% completion
- Dairy completed with written instructions correlate to diaries completed after individual instructions (Robinson 1996)
- BDRT research was completed with FVC mailed to patients – 10% rejection rate
- Lower completion of FVC in patients with POP and non-Caucasian patients (Heit 1996)

### Instructions to the patient - suggest verbal instructions include the following (BDRT, Burgio 2010))

- Motivation
  - Emphasis the importance of completing the diary accurately
  - Consider providing a clipboard with attached pen – increases the importance of the information
- Be clear on how to fill out the form - Provide clear definitions of terms including urge and leak
- Emphasis the important of recording all urination and leaks during the day and night
  - Provide space for measures volumes and check box for unmeasured voids (avoids guessing the volume)
- Warn of forgetting events if not recorded immediately
  - This is the most commonly cited difficulty with the diary
  - Ask patient to carry the dairy with them at all times
  - Tell them it is OK to get it dirty
- Make sure they understand “diary day” is from wake up to wake up on the following day
- Collection device
  - Demonstrate the method of using the collection device
  - Use “typical” voiding position (sitting for women, standing or sitting for men).
  - Provide a measuring vessel or nun’s hat – preferably with 25 ml increments

### Optimize bladder diary data (BDRT)

- Professional appearance of the diary
- Provide boxes with plenty of room
- Have a separate page for each day so wake up and bed times are always entered on the page
- Intake on a separate piece of paper – intake and output occur in different rooms
- Include a labeled example of the diary
- Include your contact information so patient can call you with questions
- Take interest in the diary when it is returned

### Appendix 3: Bladder Diary Instruction

1. Write in the specific time  
Circle "wake up time" and "bed time"

2. Record the amount of urine in the toilet in ml. If you cannot measure – place a √ in the box

6. Record the amount and type of fluid you

Specific time	Volume of void in ml or √	Desire to void 0 to 4	Leak volume 1 to 3	Felt leak with activity	Felt leak with strong urge	Wetness discovered	Drink type/ amount
5 AM							
6 AM 6:30	350	2	1	√			10 oz coffee
7 AM							16 oz water
8 AM 8:15	150	1					
9 AM 9:30	√ BM	1					
10 AM							
11 AM 11:45	200	3	2		√		12 oz soda

3. Desire or sensation to void  
0 = none  
1 = mild  
2 = moderate  
3 = severe  
4 = urgent

4. Leak volume  
1 = damp  
2 = wet  
3 = soaked

5. Make a check in one of these boxes for every leak recorded

## Appendix 4 Bladder Diary Analysis

Patient's name \_\_\_\_\_ Age \_\_\_\_\_ Male \_\_\_\_\_ Female \_\_\_\_\_

### Day bladder pattern

	Patient's value	Norms	Interpretation
V24			
F24			
Vave = V24/F24			
Vmax			
Max day voiding interval			
Total of day voiding intervals		-----	
Ave day voiding interval per day = Total of day voiding intervals / day time frequency - 1			

### Night bladder pattern

	Patient's value	Norms	Interpretation
Vn			
Fn			
$NPi = Vn/V24 \times 100 = \%$			
# of minutes sleeping		-----	
$Pn = Vn/\text{min asleep}$		-----	
$P24 = V24/1440$		-----	
$Pn/P24 \times 100 = \%$			
$NBCi = Fn - (Vn/Vmax - 1)$			

### Fluid

	Patient's value	Norms	Interpretation
Total fluid intake		9 c female, 13 c male	
Irritant intake		-----	

### Leakage type per \_\_\_ days

SUI \_\_\_\_\_

UII \_\_\_\_\_

Discovered \_\_\_\_\_

Number of pads \_\_\_\_\_

Type of pad \_\_\_\_\_

### Leak volume per \_\_\_ days

1 \_\_\_\_\_

2 \_\_\_\_\_

3 \_\_\_\_\_

### Desire to void per \_\_\_ days

0 \_\_\_\_\_

1 \_\_\_\_\_

2 \_\_\_\_\_

3 \_\_\_\_\_

4 \_\_\_\_\_

### Possible impairments

- Global polyuria
- Daytime frequency – increased, decreased, normal
- Diary bladder capacity – low or normal
- Day voiding interval – low or normal
- Bladder sensation – normal, increased, decreased, absent
- Leakage types
- Nighttime frequency – increased, decreased
- NP<sub>i</sub> – nocturnal polyuria, normal
- P<sub>n</sub>/P<sub>24</sub> ratio – nocturnal polyuria, normal
- Night time bladder capacity – low, normal