Pediatric bladder function development, urodynamic evaluation and treatment

W41, 16 October 2012 14:00 - 17:00

Start	End	Topic	Speakers
14:00	14:05	introduction	• Jian Guo Wen
14:05	14:30	The bladder development and urine production as well as pathophysiology of enuresis in children	• Soren Rittig
14:30	14:55	The urodynamic evaluation of bladder dysfunction in children: indications, technique, interpretation.	• Jian Guo Wen
14:55	15:20	Dysfunctional elimination syndrome in children – diagnosis and treatment	• Jens Christian Djurhuus
15:20	15:30	Discussion	All
15:30	16:00	Break	None
16:00	16:25	Neurogenic bladder dysfunction and surgical treatment in children	• TM Jorgensen
16:25	16:50	Epidemiology and treatment strategies for enuresis in China	• Jian Guo Wen • Wei Ping Zhang
16:50	17:00	Discussion	All

Aims of course/workshop

This workshop will introduce the knowledge of bladder development, bladder dysfunction and urodynamic evaluation. Also the details of the evaluation of paediatric bladder dysfunctions by video urodynamics studies and voiding pattern from more than five hundreds Chinese newborns will be discussed. The experiences of diuresis and natriuresis in healthy children and treatment for refractory daytime urinary urge incontinence from Denmark, the diagnosis and treatment experience of enuresis from China will also be shared. We hope this workshop will increase the diagnosis and treatment knowledge on paediatric bladder dysfunctions urodynamic evaluation.

Educational Objectives

More than 100,000 Chinese urologists, paediatrics, gynaecologists and anorectal surgeons, nurses and technicians, need the knowledge on paediatric bladder dysfunction. It is an excellent chance for them to share the knowledge of diagnosis and treatment experience of bladder dysfunction from Denmark and China during the ICS meeting 2012 in China. Paediatric bladder dysfunction is a common disease. The first section will demonstrate some typical paediatric bladder dysfunction and its urodynamic evaluation. The second section will show video urodynamic study (VUD) in evaluating these diseases. Besides, studies about voiding pattern in many kinds of newborns in China will be introduced. Enuresis is a global intractable complaint in children. In the third and fourth sections, the different experience of enuresis in epidemiological survey, diagnosis and treatment between the developed and developing countries will be shared. Finally, treatment experience of neurogenic bladder in China will be shown.

W41 Pediatric bladder function development, urodynamic evaluation and treatment

Tuesday, 16 October, 2012 14:00 - 17:00

Chair: **Jian Guo Wen** China

Speaker 1: **Jens Christian Djurhuus** Denmark,

Speaker 2: **Soren Rittig** Denmark,

Speaker 3: **Wei Ping Zhang** China,

Speaker 4: **TM Jorgensen** Denmark

Level: **Advanced; Length: 180 minutes; Category: Pediatrics**

Schedule:

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14:00	14:05	Introduction	Jian Guo Wen
14:05	14:30	The bladder development and urine production as well as pathophysiology of enuresis in children	Søren Rittig
14:30	14:55	The urodynamic evaluation of bladder dysfunction in children: indications, technique, interpretation.	Jian Guo Wen
14:55	15: 20	Dysfunctional elimination syndrome in children – diagnosis and treatment	Jens Christian Djurhuus
15:20	15:30	Discussion	All
15:30	16:00	Coffee Break	None
16:00	16:25	Neurogenic bladder dysfunction and surgical treatment in children	Troels Munch Jørgensen
16:25	16:50	Epidemiology and treatment strategies for enuresis in China	Wei Ping Zhang and Jian Guo Wen
16:50	17:00	Discussion	All

Aims

This workshop will introduce the knowledge of bladder development, bladder dysfunction and urodynamic evaluation. Also the studies of voiding pattern from more than five hundred Chinese newborns will be discussed. The experiences of diuresis and natriuresis in healthy children and treatment for refractory daytime urinary urge incontinence from Denmark, the neurogenic bladder dysfunction and surgical treatment, and the alternative treatment experience of enuresis in China will also be shared. We hope this workshop will increase the diagnosis and treatment knowledge on pediatric bladder dysfunctions urodynamic evaluation.

Educational Value

More than 100,000 Chinese urologists, pediatrists, gynaecologists and anorectal surgeons, nurses and technicians, need the knowledge and experience on evaluating and managing pediatric bladder dysfunction. It is an excellent chance for them to share the knowledge of diagnosis and treatment experience of bladder dysfunction from Denmark and China during the ICS meeting 2012 in China. In the first part, basic concept on bladder development, pathophysiology of enuresis, indication and routine technique of pediatric urodynamics will be introduced to the audience, which may offer a novice understanding of bladder function and its evaluation. In the second part, speakers will focus on the treatment aspects of pediatric bladder dysfunction. This part will features the surgical treatment of neurogenic bladder and Traditional Chinese Medicine and acupuncture treatment of enuresis.

Ⅰ **Introduction**

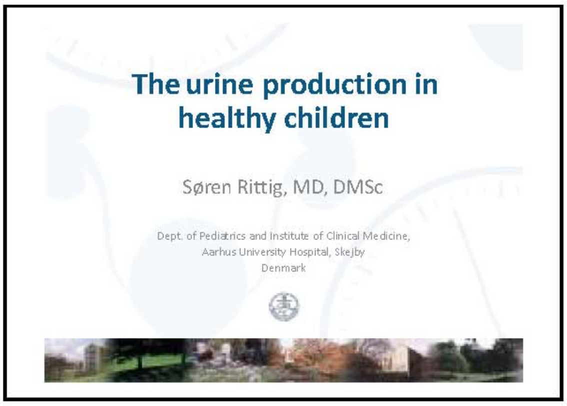
JG Wen, MD, PhD, Professor
Pediatric Urodynamic Center, The First Affiliated Hospital of Zhengzhou University China

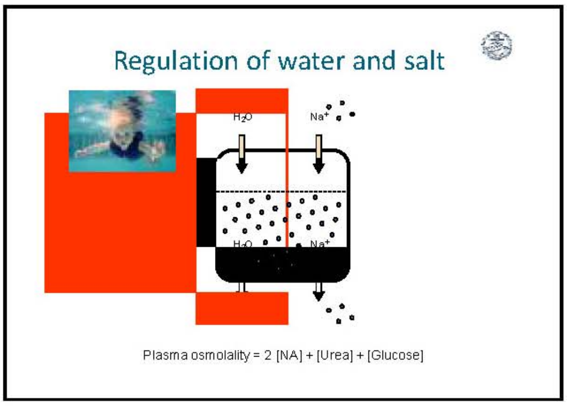
This workshop will introduce the knowledge of bladder development, bladder dysfunctions and their urodynamic evaluation. The details of voiding pattern observation in more than five hundreds Chinese newborns will be discussed. Treatment of neurogenic bladder and enuresis is a global intractable complaint in children. The experiences of diuresis and natriuresis in healthy children and treatment for refractory bladder dysfunction as well as surgical treatment of neuorgenic bladder from Denmark, the diagnosis and treatment experience of enuresis from China will also be shared. We hope this workshop will increase the diagnosis and treatment knowledge on pediatric bladder dysfunctions urodynamic evaluation. Not only urologists, but also pediatrists, gynaecologists and anorectal surgeons, nurses and technicians need these knowledge. ICS Beijing provide an excellent chance for them to share the knowledge of diagnosis and treatment experience of bladder dysfunction from Denmark and China.

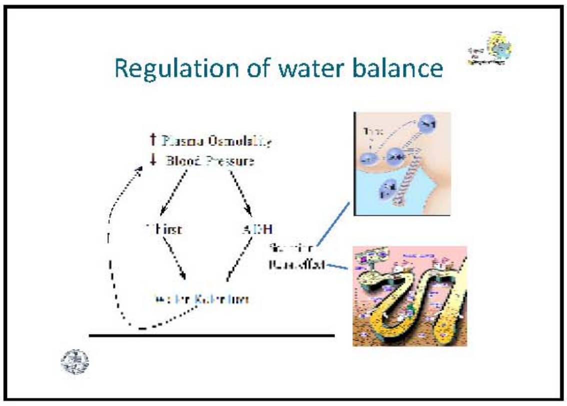
Ⅱ The bladder development and urine production as well as pathphysiology of enuresis in children

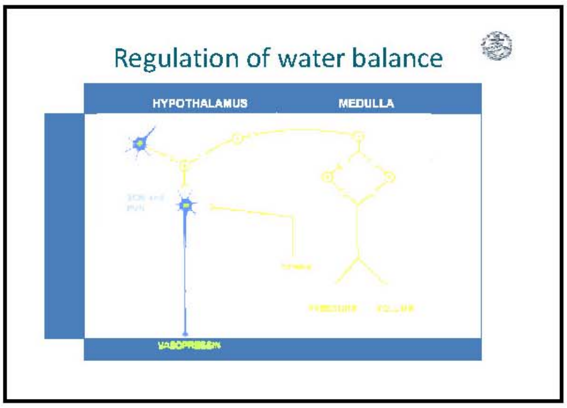
S Rittig, MD, PhD, Professor,
Department of Pediatrics, Aarhus University Hospital, Skejby, Denmark

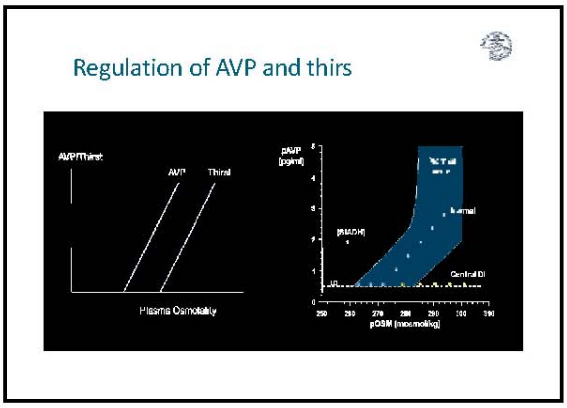
1. The urine production in health children



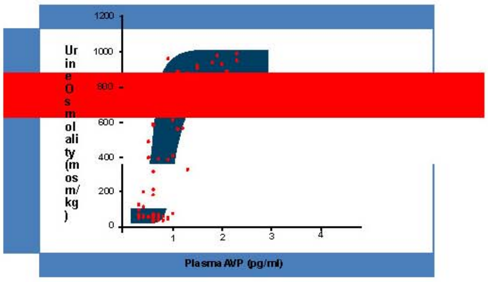




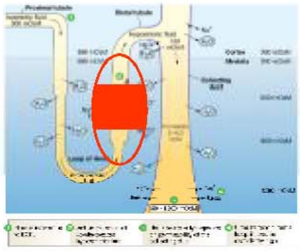




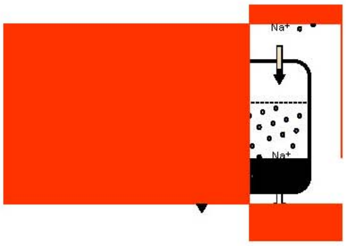
Renal sensitivity to AVP - antidiuresis



The renal regulation of water balance

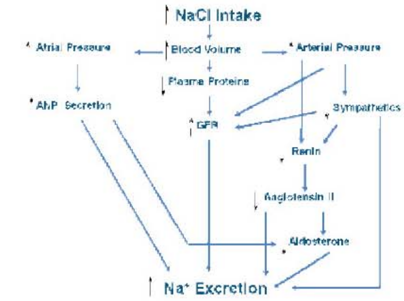


Regulation of water and salt

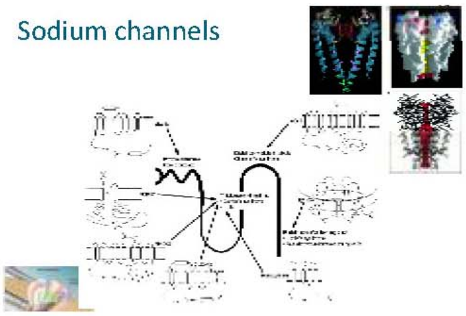


Plasma osmolality = 2 [NA] + [Urea] + [Glucose]

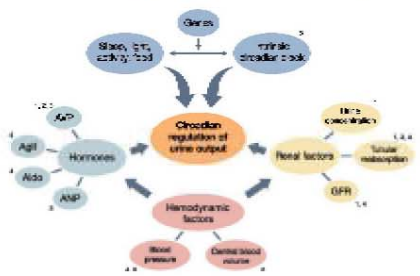
Regulation of Sodium balance



Sodium channels



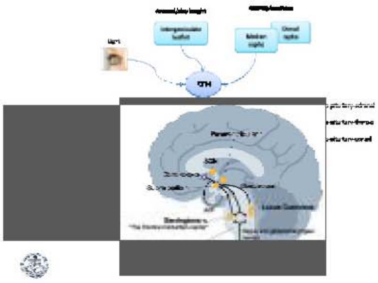
Circadian regulation of urine output



What is circadian rhythm?

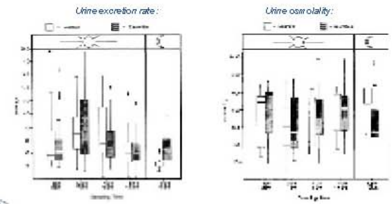
1. Circa (around) - diem (one day); (in humans 24.2 h).
2. First demonstrated by Androsthenes, 4. century BC: "leaf movements of the tamarind tree".
3. John Wren "Herbal Treatise", 1632: Described the daily flows of the four humours - fluids that were considered to govern human nature: 'Blood reyneth 6 h from 9 o'clock in ye night till 3 in the morne; cholic from 3 in the morne till 9; melancholy from 9 till 3 in the even; flegme from 3 till 9 o'clock in the night'.
4. Day-to-night rhythm of diuresis known since 1859 (Roberts).
5. In 1997 mammalian clock genes was discovered leading to a paradigm shift in the understanding of circadian rhythms.

Circadian rhythm regulation



Circadian regulation of urine output

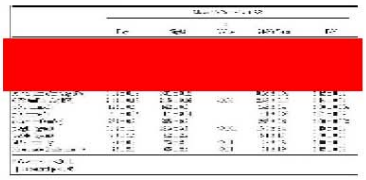
N=11 healthy children
Age 12-17 (mean 13.9 yrs)
Girls=6



Rittig et al, Am J Physiol, 256: F664-671, 1989.

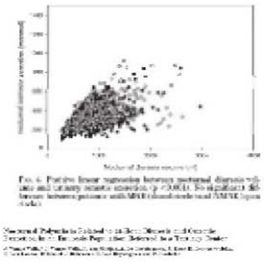
Circadian regulation of urine output

N=10 healthy children
Age 9-17 (mean 13.2 yrs)
Girls=4



Rittig et al, J Urol, 176: 774-780, 2006.

Circadian regulation of urine output



Strong correlation between nocturnal urine volume and:
- Nocturnal osmotic excretion
- 24 h osmotic excretion

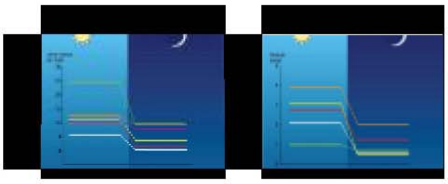
Indicates role of nutritional intake

Ontogeny of water transport

- Urine diluting capacity fully developed during fetal life.
- Full urine concentrating capacity develops during first 1-2 years of age.
- Most renal water transport occurs through water channels.
- Many mammalian renal AQPs have been shown to be differentially expressed during development.

Circadian regulation of urine output
- Age 5-9 days

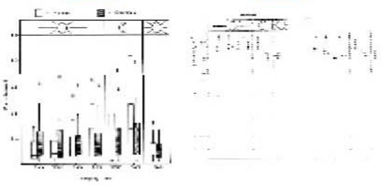
Urine volume *Sodium excretion*



Mahler et al, unpublished

Circadian regulation of urine output
- AVP and ANP hormones

Plasma AVP: *Plasma ANP:*



Rittig et al, Am J Physiol, 256: F664-671, 1989. *Rittig et al, Scand J Clin Lab Invest, 51:209-217, 1991.*

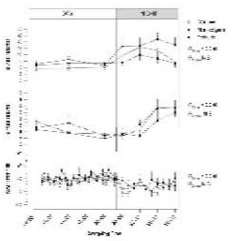
Circadian regulation of urine output
- AgII, Aldosterone and blood pressure

N=10 healthy children
Age 9-17 (13.2 yrs)
Girls=4

Plasma AGII:

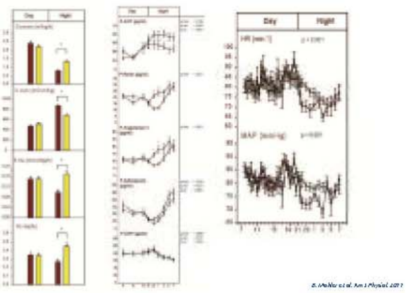
Plasma Aldosterone:

Blood pressure:



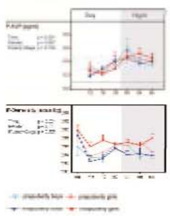
Rittig et al, J Urol, 176: 774-780, 2006.

Sleep influences nocturnal urine output

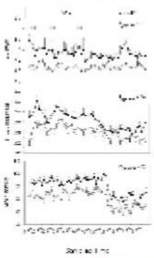


Age and sex related changes in p-AVP

N= 39, age 7-15 yrs



N= 39, age 7-15 yrs

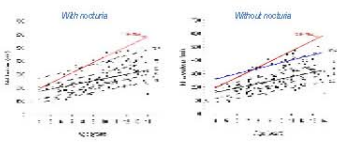


Mahler et al, PhD Thesis. *Rittig et al, unpublished.*

Circadian regulation of urine output

N=148 healthy children
Age 3-15 (mean 9.6 yrs)
Girls=62

With nocturia *Without nocturia*



Conclusions:
1. Higher N-Uvol during nights with nocturia (6.5 % of all nights).
2. Nocturnal polyuria definition proposed: N-Uvol > 20 x (age + 9) (ml).

Conclusions

- In healthy children urine output is undergoing circadian rhythm:
  - Reduced urine output during night
  - Reduction in both free water and osmolar excretion
  - Related to significant rhythms in regulating hormones (e.g. AVP)
  - Related to sleep, circadian clock and blood pressure dip
- The circadian regulation of urine output in children is undergoing changes with age without gender differences
  - Attenuated rhythm of AVP
  - No rhythm in free water excretion after puberty
  - Continued rhythm of solute excretion

Collaborators

[redacted]

Aarhus University Hospital
Søren Rittig
Jens Hunsballe
Henriette Schaumburg
Frank Schmidt
Anne Omedson
Thorsten B Mathiesen
Kostas Kamperis
Søren Hagstrøm
Birgitte Mahler
Charlotte Siggaard
Jane H. Christensen
Mia Faerch
Rene F. Andersen
Helene Kvistgaard
Wendy Bower
Casper Jessen
Luise Borch
Lene H Tauris
Marie Schrøder
Karen Alstrup
Jane H. Knudsen
Troels M Jørgensen
Jens C Djurhuus

Research Unit for Molecular Medicine
Niels Gregersen

Institute of Human Genetics
University of Aarhus
Lars Bolund
Thomas Corydon

The water and salt research centre, Univeristy of Aarhus
Søren Nielsen
Jørgen Frøkiær

Institute of Human Genetics
University of Copenhagen
Hans Eiberg

Dept. of Pediatrics
Ghent University Hospital
Belgium
Johan vande Walle

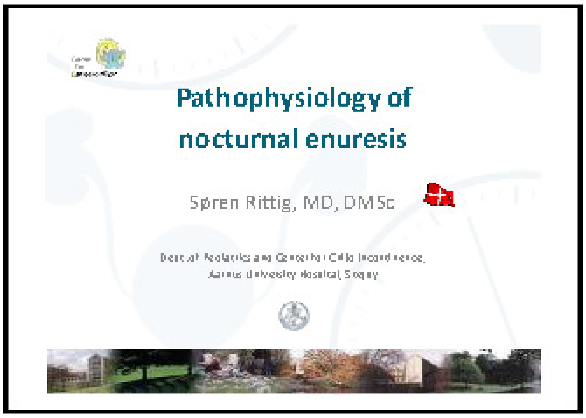
Dept. of Pediatrics
Bratislava University Hospital
Slovakia
Laszlo Kovacs
Eva Radvanska

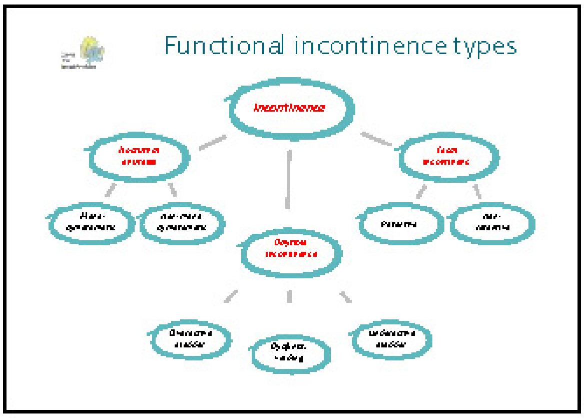
Dept. of Pediatric Urology
Hong Kong University
CK Yeung

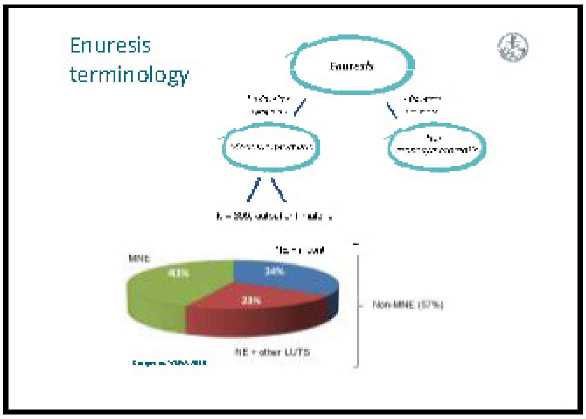
Dept. of Endocrinology
Northwestern University
Chicago IL, USA
Gary L. Robertson

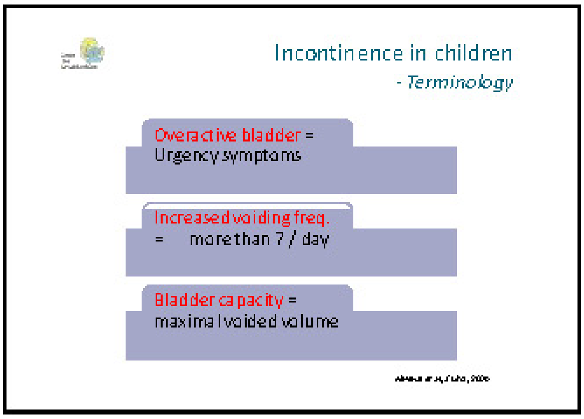
Dept. of Psychiatry
Saarland University Hospital
Germany
Alexander von Gontard

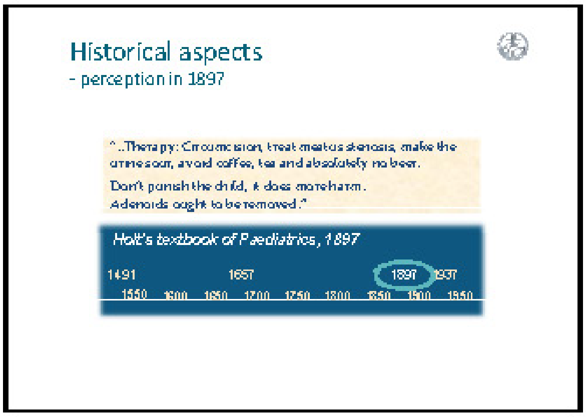
2. Pathophysiology of nocturnal enuresis

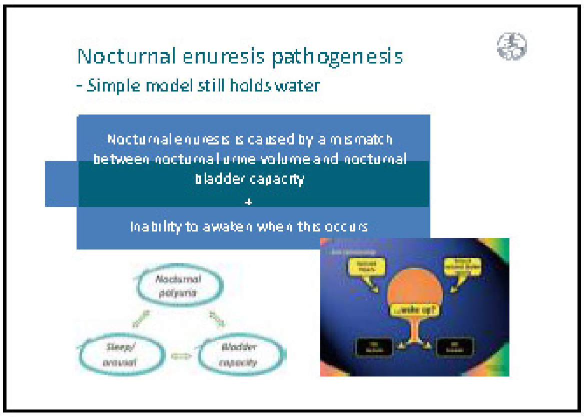






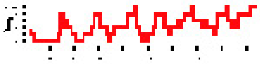






Sleep EEG and Nocturnal Enuresis

- *Nørgaard et al, 1989 (uncontrolled):*
  Sleep EEG is normal (manual scoring). Enuresis occurs in all sleep stages.
- *Hunsballe et al, 1997 (controlled):*
  No difference in EEG by manual scoring. Tendency to more delta band energy (computer).
- *Neveus et al, 1999 (uncontrolled):*
  Enuresis occurs predominantly in nonREM sleep. No correlation between enuresis events and EEG.



Arousal and Nocturnal Enuresis

- *Kirk et al, 1996:*
  Normal children are also unable to wake up when the bladder is overfilled.
- *Wolfish et al, 1998:*
  61% of normal children are unable to wake up to acustic stimuli (120 dB).
  Fewer enuretic children (9 vs. 39%) are able to wake up to acustic stimuli.
- *Yeung et al, 2010:*
  "Our results suggest an interaction between bladder overactivity and brain arousability" (i.e., a "bladder-brain dialogue").

dDAVP and sleep

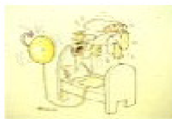
- dDAVP does not cross the blood-brain barrier (?)
- No significant differences in sleep parameters between dDAVP responders and non-responders
- No change in sleep EEG during dDAVP nights
- Patients on dDAVP do not have increased nocturia
- Patients on dDAVP are more difficult to awaken

Controversies:

- Antidiuretic effect in nephrogenic DI patients ?
- Effect on Startle reflex ?

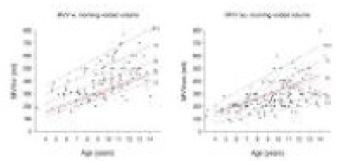
Alarm treatment and sleep

- App. 30% converts from enuresis to nocturia.
- The majority of patients sleep throughout the night!
- Alarm treatment increases nocturnal FBC in non-polyuric patients.
- Alarm treatment has no effect on sleep pattern.



Bladder capacity and enuresis

Bladder capacity and enuresis

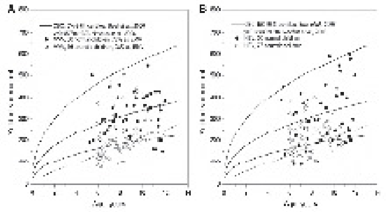


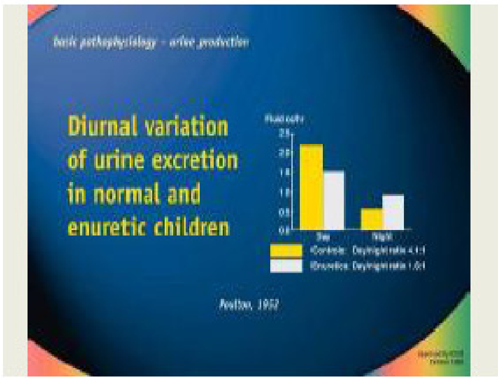
Normal bladder capacity:
Maximal voided volume (MVV).
Koff's formula: EBC = 30 * (age + 1) (ml)

Is correct only if first morning voided volume is disregarded!

Reduced < 65% (predictive value for poor dDAVP response)

Bladder capacity and enuresis





Nocturnal polyuria in enuresis

Home recording

- Diaper weights 1-2 weeks
- Night uvol =
  diff. diaper weight +
  nocturia volume +
  morning urine volume

Definition of nocturnal polyuria

How should we define nocturnal polyuria?

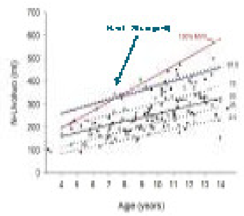
Definition based upon expected bladder capacity (ICCS, 2006).

Nuvol > 130 % of MVV

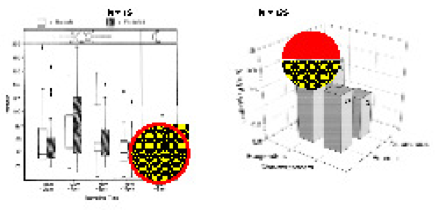
or

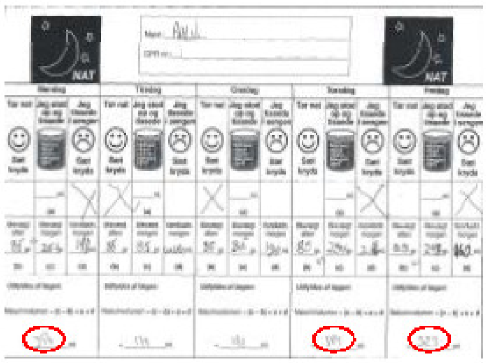
Population based definition.

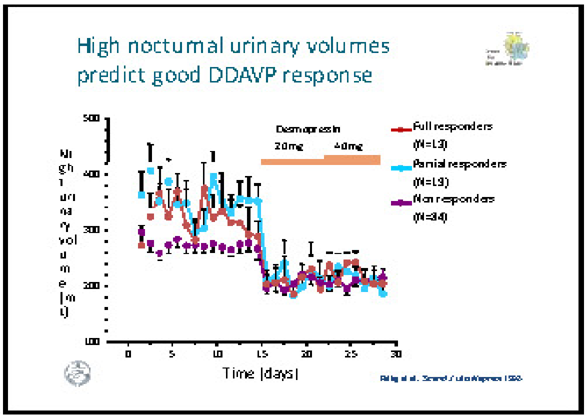
Nuvol = 20 x (age+9)

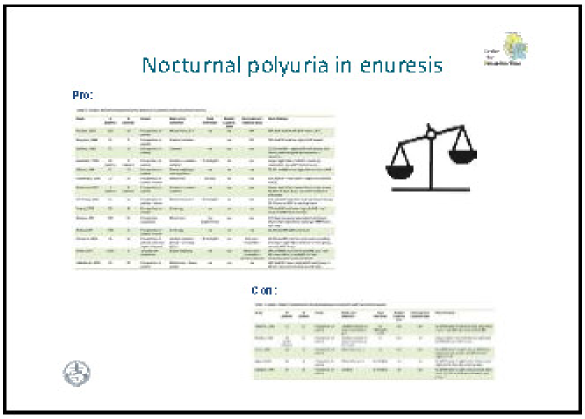


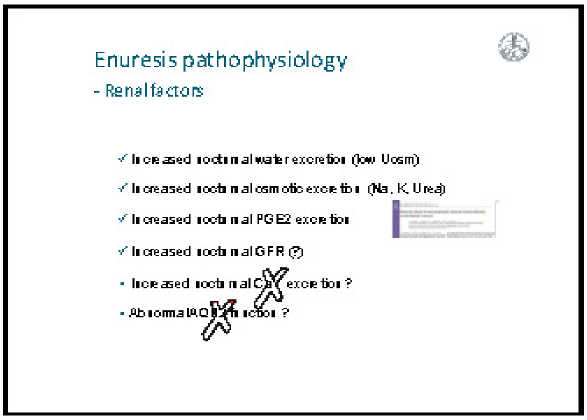
Nocturnal polyuria in enuresis

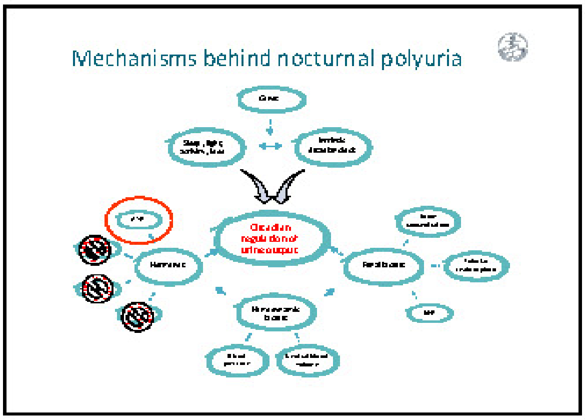


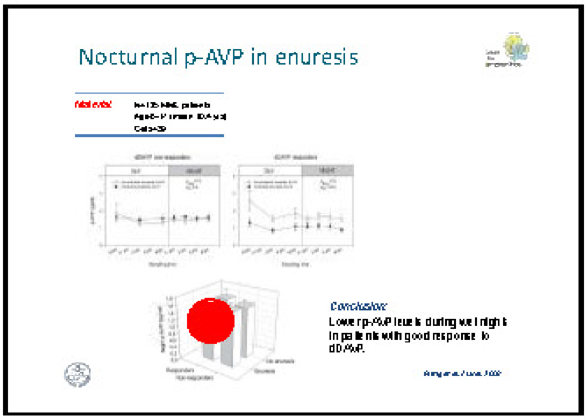


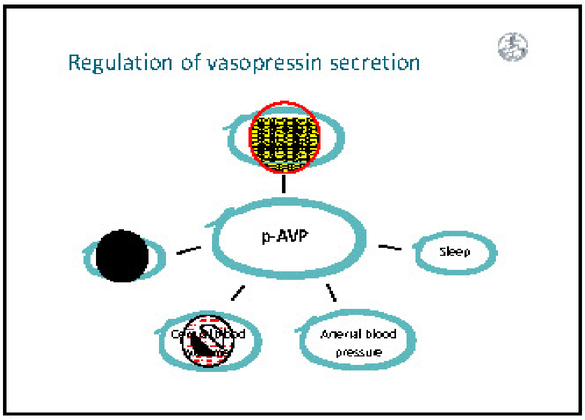

High nocturnal urinary volumes predict good DDAVP response
Desmopressin
20mg
40mg
Full responders
(N=13)
Partial responders
(N=13)
Non responders
(N=34)
500
400
300
200
100
0
5
10
15
20
25
30
Time [days]


Nocturnal polyuria in enuresis
Pro:
Con:

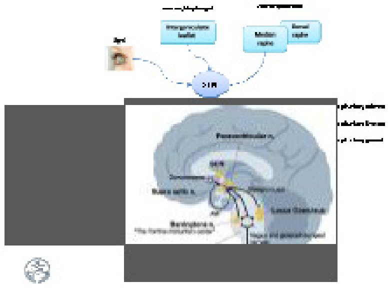

Enuresis pathophysiology
- Renal factors
✓ Increased nocturnal water excretion (low Uosm)
✓ Increased nocturnal osmotic excretion (Na, K, Urea)
✓ Increased nocturnal PGE2 excretion
✓ Increased nocturnal GFR (?)
• Increased nocturnal Ca excretion ?
• Abnormal AQP2 function ?


Mechanisms behind nocturnal polyuria
Circadian regulation of urine output

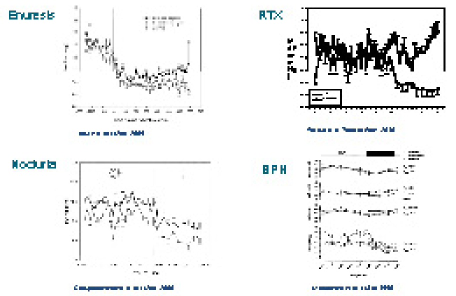

Nocturnal p-AVP in enuresis
Conclusion:
Lower p-AVP levels during the night in patients with good response to dDAVP.


Regulation of vasopressin secretion
p-AVP
Sleep
Arterial blood pressure

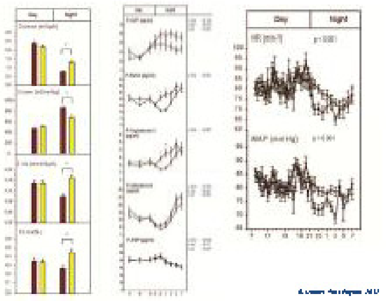
Circadian rhythm regulation
– could be the primary mechanism



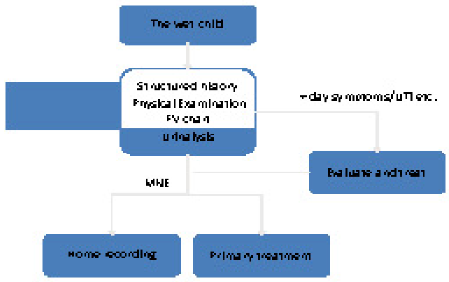
Nocturnal polyuria and blood pressure



Sleep deprivation causes polyuria

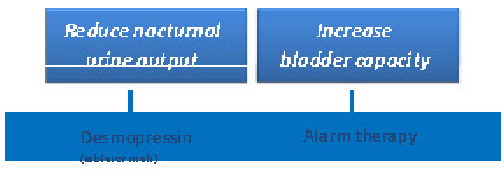


Enuresis evaluation strategy



Management of enuresis

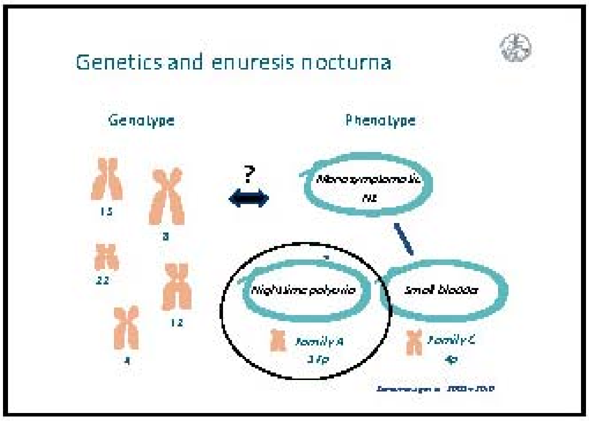
The simple patient (the responder):

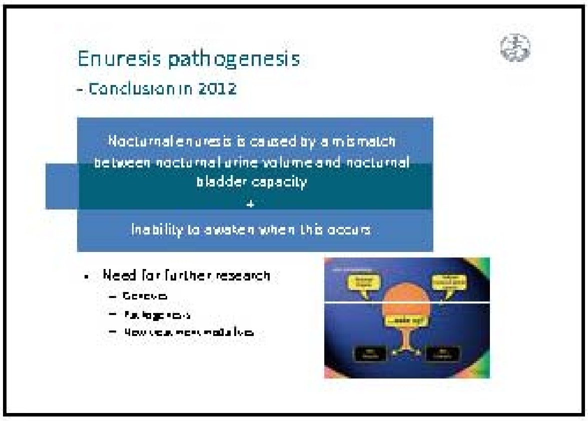


Genetics and enuresis nocturna

Chromosome	LOD-score	Marker	Study	OMIM
4p?	3.66	D4S2950	Eiberg 2001	
8q	-	D8S264	Eiberg 1995	
12q	4.2	D12S80	Dahl 1995 Arnell 1996 +1997	ENUR2
13q	3.55	D13S291	Eiberg 1995	ENUR1
	2.67	D13S263		
22q	4.51	D22S446 - D22S343	Eiberg 1999	ENUR3

- [illegible]
- Linkage to 13q, 12q, and 22q have been confirmed in independent families
- [illegible]


Genetics and enuresis nocturna
Genotype
Phenotype
15
8
22
12
4
?
Monosymptomatic
NE
Nighttime polyuria
Small bladder
Family A
13q
Family C
4p


Enuresis pathogenesis
- Conclusion in 2012
Nocturnal enuresis is caused by a mismatch between nocturnal urine volume and nocturnal bladder capacity
+
Inability to awaken when this occurs
• Need for further research

Ⅲ The urodynamic evaluation of bladder dysfunction in children: Indications, technique, interpretation.

JG Wen, MD, PhD, Professor
Pediatric Urodynamic Center, The First Affiliated Hospital of Zhengzhou University China

According to ICS, any investigation that produces information on the function of the urinary tract is part of urodynamic studies (UDS), including ①Voiding and defecation history, physical examination, voiding frequency charts and defecation diaries; ② uroflowmetry; ③ nonivasive static and dynamic ultrasonography; ④ pressure/flow/EMG study and video urodynamic study. It has become a common practice in the evaluation of infants and children with lower urinary tract symptoms (LUTS).

1 Indications for UDS

UDS are done to discriminate between those children with functional voiding problems, those with neuropathic bladders and those with anatomic anomalies who may need surgery. The invasive urodynamic studies is usually reserved for children for whom the outcome of such studies is expected to change the therapeutic regime.

The indications for the cases to receive UDS evaluation:
Increased post voiding residual (PVR) with no special explanation.
To diagnose the detrusor function such as unstable or over activity, detrusor areflexia, and detrusor – sphincter dyssynergia (DSD).
To investigate the effects of bladder dysfunction on the upper urinary tract.
To investigate the relationship between bladder function and its morphological changes as well as coexisting VUR, leakage or incontinence.
To investigate the relationship between bladder dysfunction with neurogenic abnormality or damage (spinal bifida, spinal injury, cerebral damage, etc), as well as any other disease such as diabetes, lateral sclerosis of spinal cord, urethral valve.
To follow up the results of pelvic and lower urinary tract operation and any other treatment procedures.

The most frequently confronted diseases that need to be considered for UDS:

A. Neurogenic bladder: Proper UDS is the cornerstone for guiding management of NBD, including an adequately sized, normally compliant bladder that can eliminate urine entirely in order to protect upper urinary tract.
B. Anorectal malformations: Children with such malformations are known to have associated spinal cord and genitourinary abnormalities. UDS is recommended in all patients with an anorectal malformation due to the possibility of NBD even without evidence of tethering or injury.
C. Voiding dysfunction, including urge syndrome and underactive bladder.
D. Vesicoureteric reflux (VUR)：Video-UDS could show when and how the VUR happed, as well as the grade of VUR.
E. Urinary incontinence. It is important to use UDS to distinguish the etiology of incontinence, such

as OAB, urethral sphincter incompetence, neurogenic bladder, and the methylene blue test during cystometry is used to distinguish the leakage of the ectopic ureter from that of bladder.

F. Recurrent urinary tract infection (UTI): The UTI could not be explained by routine examination.

G. Bladder outlet obstruction (BOO) and LUTS resistant to routine treatment.

2 UDS Techniques and parameters interpretation

2.1 Preparation before UDS

(1) Bowel or rectum preparation.

(2) History, physical and laboratory examination as well as voiding dairy. Three days voiding diary that monitors fluid intake throughout the day, the presence of UTI, questions establishing the bowel elimination pattern, and current voiding habits including how urine is expelled (voluntarily, spontaneously with Crede's maneuver or via a catheter).

(3) Ultrasonic evaluation of the upper urinary tract can give quick and simple anatomical information on duplicated systems, dilatation or scarring.

(4) The flowmetry (for the children capable to void to the flowmeter) provides the evidence for further invasive UDS.

(5) The dedicated and knowledgeable staff and explanation patiently is very important. Informing the procedure and aim of urodynamic study to the parents or guardian, and if possible trying to convince children to cooperate.

(6) Administration of sedative adequately (not anesthetics), and marking in the report if the child too afraid.

(7) After the child voids on the flowmeter the bladder is catheterized using a multi-lumen or microtransducer urodynamic catheter. Prior application of 1% lidocaine jelly or a liquid solution instilled into the urethra as a topical anesthetic may aid in catheter passage. The urodynamic evaluation approach should start as lenient as possible ending up in the majority of the cases with invasive investigations.

2.2 Non-invasive UDS

2.2.1 Uroflowmetry

Uroflowmetry is used in any child with bladder dysfunction, who is able to void. However, the children less than 2 year old and children with NBD are seldom able to void spontaneously. It is usually performed at the beginning of comprehensive UDS, or just before a catheter is inserted to drain the bladder to determine the residual.

The most frequent confronted voiding patterns in children are shown in Table 1. Not all children show smooth urine flow curve. In a health children survey (2004), 29.6% boys and 34.1% girls had staccato curve were observed in our study in 2004. It did not have effect on maximum flow rate, mean flow rate, and PVR.

Table-1. Voiding patterns on uroflowmetry

Voiding Pattern	Suspected Pathology
Bell-shaped curve	Normal sustained detrusor contraction
Tower	Overactive bladder
Plateau	Outlet obstruction
Staccato	Sphincteric overactivity during voiding
Interrupted	Acontractile/underactive bladder

Recently, Ozawa, et al. performed uroflowmetry in male children by an ultrasound Doppler probe. However, it is not applicable in newborns, because of their interrupted micturation and difficulty of device fixation.

Uroflowmetry is valuable in the assessment of voiding function for a wide range of urological conditions. The measured flow is affected by a number of factors including:
A. strength of detrusor contractility
B. presence of bladder outlet obstruction
C. adequacy of relaxation of the sphincter mechanisms
D. patency of the urethra
E. compensatory mechanisms such as abdominal straining

However, the maximum urine flow is accurate only when the volume is greater than 50% of maximum voided volume. The flow pattern in children is far more informative than the actual flow rate due to the ability of the detrusor in children to exert a strong contraction to overcome any outflow resistance. The shape of the curve can be indicative of detrusor function, degree of bladder outlet resistance and external urethral sphincter activity during voiding. Ideally uroflowmetry should be repeated 2 or more times to ensure that a consistent voiding pattern is exhibited. Combined with perineal patch EMG provides adequate information about the cause of the abnormal flow pattern and the post-void residual, and precludes further invasive testing.

2.2.2 Uroflowmetry with ultrasonography

Flow rate is a composite of both the function of the detrusor and that of bladder outlet/urethra. It is impossible to determine from a flow rate alone if voiding dysfunction is due to a detrusor pathology or bladder outlet/urethra pathology or from a combination of problems. Uroflowmetry combined with ultrasound could provide more information on voiding function.

2.2.3 Voiding volume and post voiding residual

Koff suggested that children bladder capacity can be estimated by equation 'age + 2'ounces, and validated it in 203 healthy children. In 1988, Hjalmas presented another equation that has been adopted by ICCS till now (expected bladder capacity [ml] = 30 + [age in years X 30]). There are no formulas used in newborn to predicate the bladder capacity or voiding volume although voiding volume is a good parameter to evaluate neonate bladder function. In our recent studies, 21 newborns with 778 times voiding were analyzed, which demonstrates that there are considerable changes in the voiding pattern between day 4 and day 14 of life. Voiding volume increases significantly with age and surges at day 4 and day 28 in full-term newborns. In contrast, although pre-term neonates show similar increase trend as full-term during 28 days after birth, they have only one surge at day 28. Full-term newborns have higher voiding volume than pre-term, while the former has less intermittent voiding. In term newborns the voiding volume (19.8±10.9) is significantly higher than that of preterm newborns. Recently, we recorded the number of voids per 12h (voiding frequency,**VF),** voiding volume (**VV:** ml), Post-void residual (**PVR**) in newborn (Table 2).

Table 2. VF, VV, PVR and its development in the newborns with age (mean ± SD)

____	VF(times) per 12 hours		VV(ml)/ per voiding time		PVR (ml)/ per voiding time	
age (days)/ group	pre-term	full-term	pre-term	full-term	pre-term	full-term
1	5.0±1.2	5.6±1.4	12.4±6.0	15.1±6.2	1.5±1.0	1.5±1.0
4	6.9±1.5##	6.4±1.6	12.3±6.4	23.4±10.3**/#	1.4±0.9	2.2±0.9*/#
7	9.6±2.1##	8.6±1.5##	13.3±8.5	23.3±9.8*	1.4±1.1	1.3±1.1#
14	10.9±1.7	8.3±1.9**	13.8±7.6	22.2±7.9*	1.2±1.0	1.4±0.8
28	8.7±1.1##	7.3±1.3*	21.2±6.9#	37.1±8.5**/##	1.4±0.9	2.2±0.8*/#

Note: * Comparing full-term with pre-term newborns at the same day age, $P < 0.05$; ** Comparing full-term with pre-term newborns with the same day age, $P < 0.01$.

Comparing voiding parameters in marked day-age with those in the former day-age in the pre-term group or in the full-term group, P < 0.05; # # Compare voiding parameters in marked day-age with those in the former one in the pre-term group or in the full-term group, P < 0.01.

PVR measurements are performed routinely by using formal ultrasonography or via bladder scanning devices which calculate the volume and generate a number without providing anatomical visualization of the bladder. The current recommendations are for examination of PVR after uroflowmetry with ultrasonography. Children with PVR of 5 to 20 ml should be re-exammed and successive values of greater than 20 ml are indicative of abnormal emptying. Voided volume and duration between the voids and PVR should be recorded. This attention to detail is necessary in children with hydroureteronephrosis or VUR in whom urine in the upper urinary tract might drain back into the bladder soon after voiding is complete. Changes in PVR may indicate a need for further invasive studies, especially in those who do not perform CIC.

2.2.4 Voiding pattern

It has been reported that interrupted (or incomplete) voiding as a result of lack of coordination between the bladder and the external sphincter can be often seen in infants, which causes elevated voiding pressures until the child reaches the age of 2 years old. Our team had similar findings and demonstrated that full-term newborns had more voiding volume and less interrupted micturation compared to preterm newborn indicating different developing stage of central nervous system.

3.3 Invasive Urodynamics

Cystometry, an invasive procedure, is used to determine bladder capacity, contractility, compliance, emptying ability and degree of continence. Video UDS allow real-time viewing the change of bladder function providing the insight into the diagnosis as well as accurate interpretation of the findings.

Passing an urodynamic catheter transurethrally allows for accurate assessment of the PVR as well as intravesical pressure at that volume of natural filling. Children with prior urethral surgery may require catheter placement via cystoscopy while under sedation before the study. A suprapubic catheter can also be inserted. Some believe the increased invasiveness of this maneuver is offset by the more physiological nature of voiding without a catheter in the urethra. If required, a 6Fr double lumen catheter is generally placed with the child under sedation 6 to 24 hours before the study. Children can be placed in the supine or sitting position. Previous study has proved that there was no significant difference in measurement outcomes based on variability of position.

Electromyography of the striated component of the external sphincter and pelvic floor musculature is an important parts of UDS, and most centers use a patch EMG electrode with a capacity of at least 1,000 Hz. Patch electromyography electrodes are placed on the perineum in the 3 and 9 o'clock positions, or a 24 gauge needle electrode is positioned perineally in boys or paraurethrally in girls. EMG needle electrodes can be used during cystometry to provide the most accurate information on individual motor units at rest, in response to sacral reflexes, and during bladder filling and emptying in patients with suspected or known neurological conditions.

3.3.1 Filling Phase.

(1) Filling media: Normal saline is the commonest media to fill the bladder although CO2 was used, and perhaps nowadays, it is still in use in few centers or hospitals.

(2) Filling rate: Bladder filling should be performed at a rate of 5% to 10% of the expected bladder capacity per minute with saline at a temperature of 21 to 37ºC. The rate of filling may have an effect on capacity, intravesical pressure and compliance. The expected bladder capacity can be calculated from the Hjalmas equation (expected capacity [ml] = 30 + [age in years X 30]). For children with myelodysplasia it can be calculated using the formula, 24.5 X age (years) + 62. In children who perform CIC it can also be estimated by the largest recorded volume drained from the bladder during the day for 3 to 4 days.

(3)Filling cycle: A minimum of 2 filling cycles should be performed during UDS once the child is as relaxed as possible. The first filling cycle is often artificial and incorrect. If the child has a neurogenic bladder and no sensation then a single filling may suffice. Filling should continue until the child has a strong urge to void or is uncomfortable, or micturition occurs, detrusor pressure is greater than 40 cm H2O, infused fluid volume exceeds at least 150% of expected capacity or the rate of leakage is greater than the rate of infusion. Some children with a much larger bladder may need additional filling to determine if they can initiate voiding only at these large volumes.

(4)Natural filling: Alternatively cystometry can be performed using the body's natural diuresis to fill the bladder, called natural fill cystometry or ambulatory urodynamics. In this setting the child is permitted to be mobile and more compatible with his/her own environment, and less psychological stress is involved. The results of natural filling cystometry have identified several differences compared to conventional filling. In children and adults, natural filling studies elucidate lower voided volumes, higher voiding pressures and a dampened increase of the pressure increase during filling. Increased sensitivity for the detection of detrusor overactivity has also been reported via natural filling cystometry.

3.3.2 Interpretation of filling phase parameters

Interpretation of UDS should be performed by a trained pediatric urologist, UDS nurse practitioner or other urodynamicist. It is best accomplished in real time while visualizing the study, and observing the patient's behavior and response during the micturition cycle. In children who are too young to describe what they are feeling, curling of the toes and tightening of the abdomen may be signs that the bladder is becoming uncomfortably full and voiding is imminent. Bladder storage function should be described in terms of bladder sensation, detrusor activity, bladder compliance and bladder capacity. Bladder sensation can only be ascertained in children who have been toilet trained or are old enough to understand and articulate various bladder sensations. Decreased or absent bladder sensation may be identified on UDS when greater than expected bladder capacity has been reached without a change in sensation.

(1) Detrusor function

Detrusor activity can be characterized as normal, overactive or underactive. Any amount of detrusor activity during filling should be considered pathological although some researchers treat it as normal in newborn or infants. The bladder should fill with only an incremental change in pressure, whether provoked or not. The term detrusor overactivity is used to describe any involuntary detrusor contraction greater than 15 cm H_2O from baseline during the filling phase. Detrusor underactivity may be noted when there is a poor, unsustained or nonexistent detrusor contraction during micturition accompanied by a larger than expected bladder capacity for age (greater than 150% of expected bladder capacity). This may result from chronic obstructive voiding due to neurogenic, functional or anatomical consequences.

(2) Bladder capacity

Bladder capacity and compliance pose some challenges for interpretation. Bladder capacity in children does not change in a linear fashion with age, although a linear formula is almost universally used to calculate capacity.

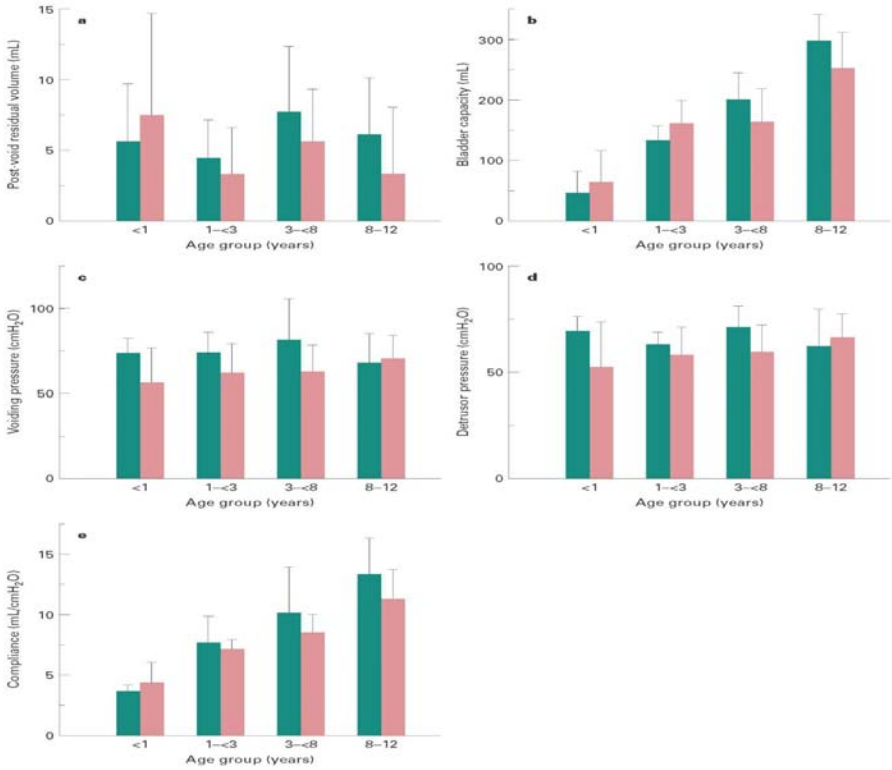


Fig. 1 The mean (sd) ,**a**, post-void residua urine volume, **b**, bladder capacity, **c**, maximum voiding pressure, **d**, detrusor pressure on voiding, and **e**, bladder compliance in male (green) and female (red) children of different age groups.

(3) Bladder compliance

Compliance measures the distensibility of the bladder wall during storage and is recorded in ml/cm H2O. Thus, a change in compliance should be adjusted not specifically to the child's age but to bladder capacity at that given measurement. Furthermore, there are no validated reference values for a safe compliance factor for children or adults. Accepted values of normal compliance are 10 cm H2O at capacity or more accurately 5% of the child's normal capacity per cm H2O, which is equivalent to 20 cm H2O at expected bladder capacity. In children with NBD it has been noted that overly rapid filling can exaggerate the increase in basic pressure resulting in poor compliance measurements compared to natural fill cystometry. Kaefer et al.compared physiological bladder pressures at PVR and at the same volume during filling for UDS, and noted that there was at least a greater than 5 cm increase in 63% of children.

3.3.3 Interpretation of voiding phase parameters

The study should not be considered complete until there is a spontaneous void in children who are capable of it. Voiding pressures in infants' tend to be higher than that in older children. Similarly, boys have higher median voiding pressures than girls, by about 5 to 15 cm H_2O. High voiding pressures with poor flow rates are indicative of anatomical or functional urethral obstruction. Functional obstruction is often the result of pelvic floor muscle contractions (registered and recorded on patch EMG) during voiding that may produce a staccato voiding pattern. A persistently low flow rate during voiding is more suggestive of an anatomical obstruction. It is also important to evaluate whether voiding pressure has been sustained throughout the entire contraction resulting in complete emptying of the bladder. EMG activity of the external urethral sphincter monitored by needle electrode should be carefully analyzed to determine if it has remained silent throughout voiding.

3.4 Ultrasound urodynamic study

The addition of ultrasound assessment is easy, requiring little specialized equipment and is non-invasive with no ionizing radiation, yet it provides a more thorough assessment of the lower urinary tract. The ultrasound cystodynamogram (USCD) combines ultrasound examination of the bladder with uroflowmetry will provide more detailed information on bladder structure and function than uroflowmetry alone. The full bladder is scanned using any form of ultrasound probe allowing adequate visualization of the bladder- providing an idea of the ”functional” bladder capacity. Three approach including superpubic, perineum and transrectum ultrasound is used according to different requirement of the study. Bladder wall thickness, bladder volume, diverticula, distal ureteric anatomy (presence of hydroureteronephrosis), intra-vesical pathology (carcinoma or calculi), bladder neck status (open or close), PVR are recorded by ultrasound. A significant difference between bladder wall thickness (BWT) in children with and without upper urinary tract dilation was founded (UUTD) in our previous study. The BWT correlated with the maximal amplitude detrusor overactivity, the detrusor leak point pressure and the maximal detrusor pressure during filling significantly. As a predictor of UUTD, BWT greater than 3.0mm had specificity of 79.4% and sensitivity of 90.9%, a positive prediction value of 76.9%.

3.5 Video UDS

Video UDS can significantly improve the diagnostic accuracy. The addition of video not only allows for real-time measurement of the exact detrusor pressure at the time of urinary leakage or VUR occurs, but also reveals the overall shape and contour of the bladder and bladder neck during filling and voiding. These images, saved to the patient's chart, are invaluable additional information for subsequent reexamination of test findings. Furthermore, in children with NBD and dynamic dysfunction, video can also identify simultaneous intrinsic sphincter deficiency which might have otherwise remained undetected.

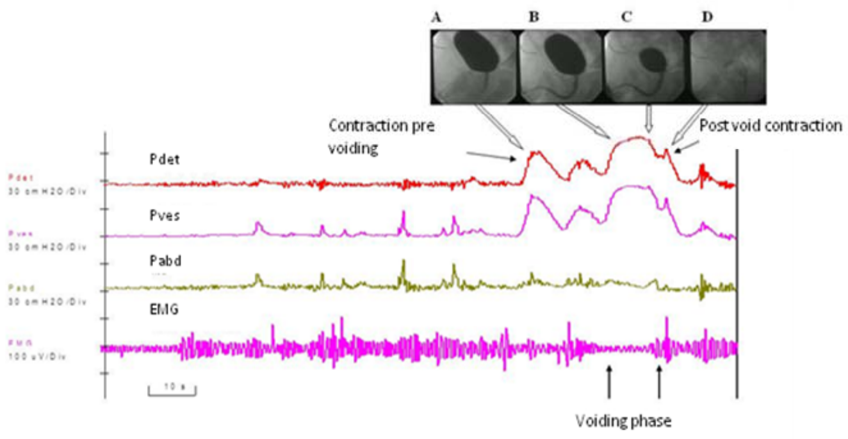


Fig.2. Video cystometry of a 2.5-month-old boy who did not cry during voiding showing synergic voiding (B,C) with two pre-voiding contrations (A); bladder neck opening during precontraction (A) and bladder emptied completely at the end of voiding (D) (Pdet detrusor pressure, Pves bladder pressure, Pabd abdominal pressure). The diluted urografin was used as media of filling bladder.

A more advanced level of interpretation of UDS findings is possible with concurrent video imaging. Visualization of the bladder and bladder neck during filling and of the urethra during voiding allows for the integration of all aspects of LUT function and improves characterization of the abnormality. Any abnormal EMG tracings or pressure changes can be visualized, confirming their reliability. However, videourodynamics has its disadvantages. The expensive, time-consuming, radioactive drawbacks all restrict its application in clinic.

3.6 The important steps improving the cooperation from the children

After putting the catheter in the bladder, keeping the children away from the examination room for a while if the child be agitated until him or her become quite.

(1) The toys could make child forget the examination;
(2) Eating or drinking is allowed during the examination.
(3) Sedation, such as diazepam, or local anesthesia, such as lidocaine glue, might considered if the child feel painful for the catherization.
(4) Two cycles of cystometry is necessary for children to make sure the result is repeatable.
(5) Older children, especially girls should respect their privacy as much as possible, such as evasive when urinating

4 Clinic application of urodynamic study

4.1 Neurogenic bladder

Neurogenic bladder-sphincter dysfunction (NBSD) is a common disorder in children, caused by neuropathic damage. The deterioration of the upper urinary tract (UUT) is a major cause of morbidity and mortality in children with NBSD. On the one hand, the dynamics and disturbances of the lower urinary tract of children differ from those in adults, most NBSD in children being due to abnormal spinal column development or myelodysplasia; on the other hand, there are continuous changes and development in NBSD with growth and maturation, particularly during the first few years of life. In addition, VUR is more likely in children with NBSD, as the antireflux mechanism of the vesico-ureteric junction is not mature in children, which contributes to upper urinary tract dilation (UUTD).

Although ultrasonography, IVU, renography, CT and MRI have been widely used to investigate NBSD and UUTD, each of these methods has its limitations. There was no clear correlation between the neurological damage level and incidence of sacral sparing in children with high-level myelodysplasia. Some children with a normal site of the conus medullaris had tethered-cord syndrome and abnormal urological symptoms. In addition, 75% of children with no urological symptoms of the tethered-cord syndrome were found to have abnormal urodynamic changes.

Urodynamic techniques specially designed for infants and young children have allowed a more accurate assessment of bladder-sphincter dysfunction in children. With the advent of video urodynamic monitoring of intravesical pressures and the morphological change of bladder, considerable progress has been made in understanding NBSD in children, especially the activities and coordination of the detrusor muscle and the external urinary sphincter during bladder filling and emptying. Current urodynamic tests have not only permitted an accurate delineation of the types of NBSD, but have also provided important prognostic clues for the better planning of follow-up surveillance studies, and contributed significantly to the improvement in NBSD management

In one of our studies, the selective use of urodynamic variables is valuable for predicting the risk of UUTD in children with NBSD. Decreased bladder compliance, and increased DLPP and ACD are the main urodynamic risk factors, and they reciprocally increase the occurrence and grades of UUTD. The grades of UUTD are compatible with increases in relative unsafe cystometric capacity, relative risk rate of cystometric capacity and urodynamic risk score.

Video urodynamics provides the "gold standard" evaluation of patients who have neurogenic bladder dysfunction. It has the advantage of pressure/flow cystometry while allowing simultaneous anatomical visualization of the bladder and urethra, thus providing information about bladder size and shape, the presence of vesicoureteric reflux, the competency of the bladder neck and the site of bladder outflow obstruction. Video urodynamics reduces the importance of simultaneous electromyography for diagnosing DSD.

4.2 Nonneurogenic neurogenic bladder (Hinman syndrome)

Hinman syndrome is a rare condition characterized by bladder outlet obstruction detected by clinical and urodynamic evidence at the level of the external sphincter, and the absence of any structural or neurological cause. Since 1973, several cases of this condition have been reported in older children. It is also referred to as occult neuropathic bladder or psychological non-neurogenic neurogenic bladder. Other pathophysiology has also been proposed, including a psychological model, pathologically severe form of dysfunctional voiding, and an undetected neurological lesion. This condition is very rare in the infancy period and is characterized by urodynamic evidence of an involuntary functional bladder outlet obstruction at the level of the external sphincter with no demonstrable neurological diseases. Prolonged detrusor overactivity in combination with pelvic floor overactivity may lead to detrusor-sphincter dyssynergia and finally to detrusor decompensation. Undetected neurogenic diseases with bladder maturation delay or unrecognized neurogenic bladder may be involved.

4.3 Primary vesicoureteral reflux

Primary vesicoureteral reflux (VUR) is the commonest congenital urinary tract abnormality in childhood, which is diagnosed mostly after an episode of urinary tract infection (UTI) or in a medical examination. Children with VUR, mostly in association with UTI, are at risk of developing renal scarring. Children with high-grade congenital reflux have also been shown to have abnormal bladder function in about half of the cases. This dysfunction was characterized by an overdistended bladder and incomplete emptying. And voiding dysfunction may also be responsible for the development of VUR in older children without congenital malformation of the UVJ. The dysfunction had a negative influence on spontaneous resolution of VUR, which did not improve despite treatment. With video-urodynamics study, both bladder function and the reflux grade can be obtained in one procedure. Proper management, i.e. invasive or non-invasive methods, could be chose according to the evaluation result of VUD.

4.4 Posterior urethra valve

Posterior urethral valve (PUV) is a common cause of lower urinary tract obstruction in male infants and the most common congenital cause of bilateral renal obstruction. PUV continues to be a significant cause of morbidity, mortality and ongoing renal damage in infants and children, leading to renal damage (renal hyperplasia and obstructive uropathy). Without proper and timely evaluation and treatment, the prognosis is very poor.

Obstruction in the posterior urethra causes progressive muscle thickening (hypertrophy and hyperplasia), trabeculation, and diverticular formation. By VUD, pediatricist may detect high intravesical pressure, increased residual urine, high pressure voiding, hyperreflexic bladder, and small capacity bladder with poor compliance, as well as the morphological changes of bladder, vesicoureteral reflux, or hydronephrosis.

4.5 Detrusor Overatctivity

Detrusor overactivity may or may not represent a clinically significant abnormality, depending upon the child’s age and voluntary response to the overactivity. Overactive contractions are considered to be normal in even in the face of a strong desire to void. This maturation usually occurs by 4 years of age, and often much earlier. Prior to maturation voiding is involuntary and usually to completion, as a result of a well-sustained detrusor accompanied by synergic relaxation of the urethral sphincter mechanism.

4.6 Anorectal Malformations

Children born with an anorectal malformation are known to have associated spinal cord and genitourinary abnormalities. Lesions are often characterized as high or low, depending on where the rectum terminates in respect to the levator ani pelvic floor muscle. NBD is common in children with anorectal malformations, from tethering of the spinal cord or iatrogenic injury during reconstructive surgery. The role and timing of UDS in these children have been debated in the past. Recent reports recommend initial UDS in all patients with an anorectal malformation due to the possibility of NBD even without evidence of tethering or injury. The abnormal patterns are an upper motor neuron lesion with detrusor overactivity with or without DSD, or a lower motor neuron lesion with an acontractile bladder with extensive sphincter denervation. Followup UDS are recommended in all children who undergo surgical repair, especially if they remain symptomatic postoperatively. The NBD can initially be clinically silent in younger children, but similar to myelodysplasia, it may be dynamic. Therefore, initial or repeat UDS should be performed at the first sign of change in bladder or bowel function

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Ⅳ **Dysfunctional elimination syndrome in children – diagnosis and treatment**

Jens Chr. Djurhuus, Head of Department, professor，
Department of Clinical Medicine, Aarhus University and Aarhus University Hospital， Denmark

Functional non-structural reasons for the wet child have a high prevalence. A large background study from Sweden showed two decades ago that daytime wetting in seven-year-olds amounted to approximately 3%, and that urgency was present in up one third of the seven-year-olds [1]. Signs of voiding dysfunction amounted to approximately 1%, whereas isolated night-time wetting was present in 7-8% if episodes occurring once a month or more were incorporated.

Since then epidemiological studies from all over the world have confirmed that there is a high prevalence of childhood wetting in every combination [2,3,4,5].

For a period of time it was speculated if there were cultural or ethnical differences in the prevalence of wetting. Initially, epidemiological studies showed that, example given in Hong Kong there was a low prevalence of enuresis but later this was alluded to the level of awareness of possibilities of treatment, so, today most studies concur with the initial prevalence studies[6].

Previously there was a tendency to believe that nature and non-interference could take care of most of the cases. There was also a tendency to prioritise psychological aspects of wetting. It is still accepted that approximately 15% of wetters are relieved spontaneously every year [7]. It is however also a fact that the most severe cases have a far more dim prognosis. In the final end in adulthood up to 1% of the population still have significant severe enuresis. Therefore, there is good reason to be aggressive both concerning diagnosis and treatment.

Diagnosis and treatment of bladder dysfunction and dysfunction elimination syndrome in children is a multidisciplinary and interdisciplinary task. It involves paediatrists, nephrologists and urologists, gastroenterologists, urotherapists and ultimately clinical physiologists, psychiatrists and psychologists. Any diagnosis and therapy strategy depend on the service, whether it is secondary or tertiary, where tertiary services have a tendency of having a large number of very complicated cases with a significant preponderance of children with psychological problems.

From the beginning it is important to emphasise that one of the major tools in dealing with these children is serendipity. A consistent treatment programme, which incorporates several modalities, has to be used, and it may take months to obtain the full effect of one treatment modality before eventually another one is instigated. It is also important to emphasise that invasive diagnostic measures, such as urodynamic investigations, should be reserved to an ultimate situation when everything else have failed and not only used as a diagnostic tool, but also in the treatment strategy.

The strategy for diagnosis and treatment, and the priority of the disciplines to be used, heavily depends on the referral profile, whether it is primarily from the primary sector and non-specified hospital services, or whether they are based on a tertiary referral centre.

According to the patient profile a service has to take care of a centre should be structured prioritising relevant disciplines. Key persons should be urotherapists, paediatric urologists and nephrologists, physiotherapists and urodynamicists. Typically, child psychiatrists and psychologists will be needed on a consultancy basis. However, in special settings with a special referral profile child psychiatry and psychology may be key disciplines, perhaps supplemented by neurophysiologists.

Through the last decades is has also become increasingly important to incorporate paediatric gastroenterologists since dysfunction elimination syndrome is very frequent and constipation has become a key symptom to address [8].

Dysfunctional elimination syndrome

The term dysfunctional elimination syndrome, which signifies the combination of urinary symptoms and signs of constipation, was originally introduced by Koff. How often this syndrome occurs in one's patient clientele depends on: 1) service profile, example given if there their preponderance is on the urology side or the gastroenterology side, but it is anyway rather frequent that children presented with wetting problems have an underlying constipation which has to be addressed first. Here the Rome III criteria is a valuable tool in assessing the constipation and its degree, and it is always relevant to have a specific history taking addressing the child's defecation habits.

It is still disputed if new psychiatric disorders have a prominent position in explaining voiding problems in children. There is no doubt that the presence of symptoms of attention deficit disorders plays a role. However, an in some large studies a high prevalence of night time wetting and daytime wetting has been found in children with ADHD.

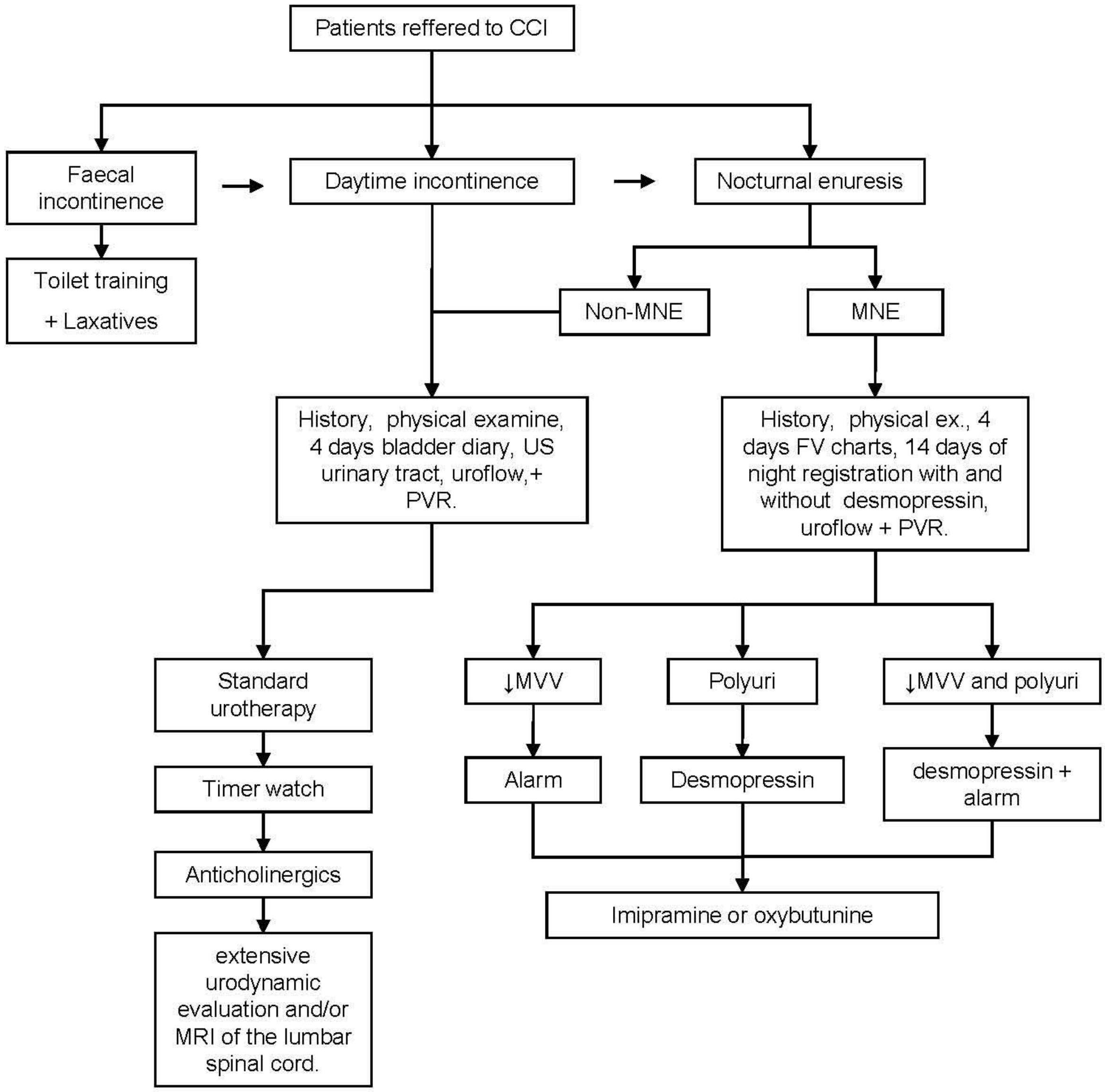
However, there is a general consensus about that addressing the symptomatology from a somatic point of view is very fruitful.

A strategic approach to the wet child

History

In our clinic we use a consistent approach according to figure 1. Patients are referred, they are subjected to a structured history taking to define the type of incontinence day time, night time, eventually accompanied by faecal incontinence.

Figure
1



We try to identify associated symptoms and risk factors addressing recurrent infections, constipation or psychosocial factors. Finally, we identify possible suspicion of neuropathic or anatomical disorders which need further evaluation.

Physical examination

In the physical examination it is important to examine the back for spine deformities, skin discolouration, dimples, hairy tuffs, subcutaneous lipomas, asymmetrical buttock and an oblique gluteal cleft. Then genitals are examined and the lower extremities are examined focusing on symmetry, muscular tone, the deep reflexes and anocutaneous reflex and finally gait. It is also important to evaluate the possible presence of constipation by identifying soiling, abdominal mass and doing rectal examination, respectively a ultrasound investigation.

Voiding diary

Then a voiding diary has to be obtained. Regardless of the nature of the complaints a voiding diary is the absolute prerequisite to initiate both the diagnosis process, but essentially also, especially in lighter cases and cases of monosymptomatic bedwetting, in the treatment process.

In our experience the child and parents' compliance with a completion of a voiding diary is very high. Moreover, the consistency and the reproducibility of the diagnostic test is fully satisfactory. It is our experience that handing out a tool for weighing pads is very important. The parents are instructed in how to fill out the diary, how to weigh the pads before bedtime and typically in the morning, and how to register fluid intake typically in the weekend.

The data which can be obtained from the voiding diary are voiding frequency where focus is on increased or decreased frequency. It is considered that increase frequency is more than eight voids per day [9]. A decreased number of voidings are considered if the frequencies are less than or equal to three per day.

The voiding diary also gives information about incontinence episodes, the number and the severity, and when fluid intake is measured information about normal or abnormal intake together with irrational timing can be identified. The normal intake is 25-30 ml/kg/day. Increase intake might signify hormonal disorders as in diabetes insipidus and increased intake might be a compensatory mechanism to an overactive bladder simulating postponement of voiding. Finally, the notification of urgency signifies the presence of overactive bladder.

Treatment based on a voiding diary dialogue

A voiding diary can be considered as a diagnostic tool as well as a tool for the initial steps in treatment. It is identified if the child suffers from monosymptomatic or non-monosymptomatic bedwetting [10] and if functional constipation is present.

Treatment

Constipation and faecal incontinence should be addressed. This is done by toilet training and laxatives. With our referral profile one in five children has a competent faecal disorder. Addressing the faecal disorder we have a success rate in relieving the wetting symptoms of approximately 20%. This is far less than what others have found, where up to 90% of the children are relieved. This is probably reflecting the referral profile.

If nocturnal enuresis is of the monosymptomatic type we use 14 days of night registration with and without desmopressin, a urine flow and a post volume residual. This identifies once again the functional bladder capacity whether polyuria is present and whether there is a combination. If the functional bladder capacity is low, then alarm clock treatment is instigated. If it is a case of polyuria, desmopressin is used and if it is a combination desmopressin and alarm can be used.

If day time incontinence is identified then standard urotherapy is instigated. Standard urotherapy comprises the explanation and the demystification of the disorder. Pedagogic instruction of the child in order to improve the child's perception of bladder function and structure and prober toilet posture is instructed together with a possible regulation of the fluid intake and voiding with regular intervals.

Standard urotherapy should be used for months. In our hands four months of standard urotherapy with repeated contacts results in that more than half of the children are dry.

If the child is still wetting then timer treatment or anticholinergic treatment is relevant. In our clinic we use timer as first choice together with standard urotherapy with rather significant success in that 70% of the children undergoing such a treatment becomes dry. On the other hand the same result is obtained when anticholinergic medication is employed.

Over a period of time of up to two years it is possible, in our hands, to cure 95% of the children. This is however based on a referral profile from general practitioners and paediatric departments. We seldom encounter malformations in the upper and lower urinary tract. Analysing 240 patients we only found three.

Urodynamic investigation

In children referred for day and night time wetting and where no physical deficiencies are eminent a urodynamic investigation is certainly no first choice. In our hands less than 10% of the children finally undergo a urodynamic investigation. When urodynamic investigation is indicated it is of paramount importance to emphasise that the urodynamic investigation has to be done in a way which allows possible future urodynamic investigations in the child. This means that the investigation has to felt as less invasive as possible, providing as much information as possible. We insert a super pubic catheter under slight anaesthesia or sometimes local anaesthesia. Together with a thin rectal tube it is then possible to identify the child's habitual behaviour in our hands typically for 24 hours but it can be extended even further. This natural filled extended monitoring can be used to identify possible staccato voiding and to instigate a bio feedback of the staccato voiding, but otherwise to identify if obstruction is present and how significant the overactive bladder is.

It has been substantiated that natural filled urodynamics reflect the voiding habits in normal volunteers, and that the maximal voided volume is equal to the systematic capacity using conventional urodynamics. It is our opinion that urodynamics in children preferably should be natural filled extended urodynamics.

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Neurogenic bladder dysfunction and their surgical treatment in children

TM Jorgensen

1 Introduction

The Neurogenic bladder encompasses a wide variety of presentations depending on the degree of lower urinary tract involvement and the interplay between bladder storage capability and sphincter function. No specific universal surgical procedure is suitable for everyone. Surgical management has to be tailored to each individual, based on careful consideration of urodynamic findings, medical history, age and presence of other disability. The mainstay of current NBD management is non-surgical with anticholinergics and CIC in the majority of children. A small subgroup who fails to respond to treatment may need to undergo surgery.

2 Attaining safe bladder storage pressure and capacity

2.1 Urethral dilatation

This procedure aims at lowering the pop-off pressure of a hostile neuropathic bladder by lowering DLPP to below 40 cm. H2O.

(1) Dilatation is carried out under general anesthesia using sounds up to 36 Fr in infants and Hegar dilators in those older than 6 to 8 years.

(2) It has been employed primarily in younger age groups.

(3) Technically, it is best suited for females. In males dilating the external sphincter using a balloon or by sounds is feasible via a perineostomy.

2.2 Vesicostomy

(8) This procedure has been useful in infants. Additionally, it can be considered if parents are non-compliant with CIC or where urethral catheterization is difficult.

(9) Vesicostomy is easily performed. Complications are minor and readily managed; they include bladder mucosal prolapse, stomal stenosis, stone formation and peri-stomal dermatitis.

(10) Vesicostomy effectively reduces bladder storage pressures to safe levels in NBD. It has been shown to effectively reverse hydronephrosis, VUR and to decrease the incidence of UTI.

(11) Although intended as a temporizing procedure in the majority, stomas can be left functional as a permanent solution in children who lack the mental acuity or social support to ensure reliable compliance with CIC8. Its greatest drawback is the inability to easily fit and maintain a collecting appliance over the stoma in older individuals.

2.3 Bladder augmentation

Enterocystoplast

Augmenting the bladder using segments of small intestine, colon or gastric patches represents the definitive method of creating a safe, low-pressure capacious organ for storage, albeit at the cost of incurring a multitude of short and long-term complications. Reported outcomes of enterocystoplasty have generally been favorable with respect to increasing bladder capacity, decreasing storage pressures and improving upper urinary tract drainage. Up to 90% achieve socially acceptable urinary continence with or without an additional bladder outlet procedure.

Notwithstanding, enterocystoplasty has potential serious implications, especially for children with an anticipated longer residual life span than adults because enteric tissue, although incorporated into the bladder, retains its absorptive and secretory properties. Mucus formation is especially bothersome as it tends to block catheters and requires regular irrigation, and may predispose to stone formation. The haematuria dysuria syndrome is a recognized entity following gastric augmentation, which is believed to be caused by acidic secretions from gastric mucosa. Additionally, reconstruction entails intraperitoneal surgery with its risks of subsequent adhesions, bowel obstruction and the need for lengthy postoperative hospital stays. Reports of surgical complications in up to 40% of patients are not unusual

Another long-term complication is stone formation (approximately 15% of augmented bladders). Long-term metabolic complications are also common, and are particularly worrisome in children as these may interfere with growth and development. Bowel resection may lead to malabsorption of vitamin B12 and chronic diarrhea, which may also impair normal development.

Hyperchloremic metabolic acidosis is the most common disturbance encountered, and may lead to demineralization of bone and stunted linear growth. Finally, there is the potential for malignant transformation in 0.6%, which is a serious and often fatal consequence of enterocystoplasty. Therefore these patients need to be followed indefinitely with regular cytology and endoscopy, starting 5 to 10 years after augmentation, although efficacy of these surveillance parameters has yet to be proven.

3 Autoaugmentation

The technique is appealing because it precludes the use of intestinal tissue.

(1) This technique involves partial detrusorectomy or detrusor myotomy, leaving the underlying mucosa intact and bulging, as a wide mouthed diverticulum, leading to an increase in bladder capacity and compliance.

(2) Conflicting outcomes and modest success rates in children with NBD has hampered widespread application of autoaugmentation.

(3) There have been discrepancies between studies, but it remains that autoaugmentation is a safe simple procedure with low morbidity that may avert the need for formal enterocystoplasty in a select group of children.

4. Increasing bladder outlet resistance

4.1 Fascial sling

The technique involves suspension of the bladder neck with an autologous fascial strip or artificial material secured to the rectus fascia or the pubic symphysis. It is believed the mechanism of action involves coaptation of the bladder neck due to traction, and/or elevation of the urethra to an intraabdominal position, which increases tension on the bladder neck with abdominal straining. In a review regarding slings in children with NBD, Kryger et al. found continence rates ranged between 40 – 100%. It is difficult to compare results as techniques and concomitant augmentation rates vary between studies. Complication rates are modest and include difficult catheterization and rectal injury.

4.2 Artificial urinary sphincters

In 1973 Scott introduced the artificial urinary sphincter (AUS). Reported continence rates after AUS implantation have been high with different series reporting success in 70 - 85%[26,27,28]. Many surgeons are reluctant to implant an AUS as it consigns patients to further revision surgery, and the potential risk of deterioration in bladder function and a concomitant deleterious effect on upper urinary tract drainage.

(1) However, with improved durability of newer models that have an average life span of about 8 years, revision rates have become less of an issue[27].
(2) The ideal patients for AUS implantation are post-pubertal males or females, who can void volitionally and empty the bladder completely[26]. It is important to recognize that CIC is feasible in patients with an AUS.
(3) Complications specific to AUS include altered bladder compliance, and worsening DO. This has necessitated bladder augmentation, in approximately 50%[27,28]. Removal of an AUS due to erosion, infection or mechanical malfunction occurs in at least 20%[27,28]. Revision rates for wear and tear have steadily been decreasing with ongoing refinements in AUS; the most recent long term experience with the AMS 800 AUS has a revision rate of 0.03 revisions per patient-year[28].

4.3 Bladder neck reconstruction

The optimal bladder neck procedure should increase bladder outlet resistance at minimal cost of decreasing bladder capacity, maintain easy catheterization and still allow some leakage at high pressure in order to protect the upper urinary tract. Different operative techniques with the aforementioned aims have been used with varying outcomes. The Young-Dees-Leadbetter bladder neck repair 9 has been employed primarily in treating incontinence associated with exstrophy-epispadias complex yielding continence rates of about 70 - 80% but it seems to have little success in children with NBD.

In conclusion, attaining safe bladder storage pressure and capacity, bladder augmentation and increasing bladder outlet resistance are the three main methods of surgical intervention for the congenital neuropathic bladder.

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Ⅵ Epidemiology and treatment strategies for enuresis in China

Wei Ping Zhang, MD, PhD, Professor
Department of Pediatric Urology, Beijing Children Hospital,
and
JG Wen, MD, PhD, Professor
Pediatric Urodynamic Center, The First Affiliated Hospital of Zhengzhou University China

The ICCS defines the enuresis (NE) as intermittent urinary incontinence in children sleep at night over the age of 5. It is categorized as monosymptomatic or nonmonosymptomatic. Monosymptomatic NE (MNE) occurs in the absence of any daytime lower urinary tract symptoms (LUTS), such as frequency, urgency, or daytime incontinence. Nonmonosymptomatic NE (NMNE) is more common; when a detailed history is obtained, the majority of children have at least subtle daytime symptoms. NE is also divided into primary nocturnal enuresis (PNE) and secondary nocturnal enuresis (SNE).

1. Epidemiology and predictor of marked enuresis

1.1. Epidemiology

It is well known that the overall prevalence of PNE, as well as prevalence of PNE in different age groups, is greatly varied in different countries, ranging from 2.3% to 25%. The prevalence of enuresis is inconsistent in different Asian countries, some studies shown that prevalence of PNE in Asia is lower than that in Western countries, but others not. We investigated a total of 11799 children aged 5–18 years old in mainland of china and found that overall prevalence of PNE was 4.07%，ranging from 11.83% in 5-year-old group to 1.21% in 15-year-old group, and the prevalence stabilized to approximately 1% in the group older than 15 years. There was no significant difference in prevalence of PNE between boys and girls in every age group although the PNE was found to occur more frequently in boys than in girls (4.57% versus 3.56%, $p = 0.01$). Totally, 47.69% of PNE occurred weekly, and 21.41% occurred daily.

Among all PNE cases, PNE associated with daytime urinary symptoms occurred in 21.17%, arousal dysfunction after enuresis occurred in 57.42% and positive family history was found in 22.87%. Only 6.08% of PNE cases had sought professional help, 49.15% families woke the child at night and / or restricted the child's fluid intake to avoid enuresis, and 44.8% families would rather wait for their child to mature. There was significant difference in the frequency of PNE, daytime symptoms, family history and PNE management but no significant difference in gender, inhabitation and arousal dysfunction between pediatric and adolescent groups. The episodic severity of PNE in the adolescent group was significantly higher than that in pediatric group ($p < 0.05$). Marked PNE was found in 1.46% of all children.

However, the prevalence of PNE in different age groups varies greatly in different countries. Byrd et al. reported in 1996 that the overall prevalence of enuresis in children aged 5–17 years in North America was 10.63%, 33% among 5 year olds, 18% among 8 year olds and 0.7% among 17 year olds. In Netherlands, the overall prevalence of enuresis in children aged 5 to 15 years was 6%, and 15% in the 5 to 6-year and 1%in the 13 to 15-year age group. In Africa, the overall prevalence of enuresis was 17.6% in children aged 6–12 years in southwestern Nigeria. In Asia, the prevalence of enuresis in children varies also in different countries. The overall prevalence of enuresis in children aged 7 to 12 years was 8%–10.6%, and declined with age from 10.3%–20.4% at 7 years to 3.3%–5.6% at 12 years in Malaysia and Korea. In Hong Kong, school children aged 4–12 years had a prevalence of enuresis was 3.5%. In Taiwan children aged 6–12 years showed that the overall prevalence of enuresis was 5.5%, and 9.27% of 7 years, 1.56% of 11 years.

Given the great cultural and economic differences between China and western countries, there are several possible reasons for the lower prevalence of bed-wetting in Chinese children. First, young children often sleep with their parents and have body contact with them throughout the night. When the child shows dysphoria due to bladder fullness, usually the mother immediately wakes up the child to void, which actually plays a role in helping establish the voiding reflex in children. In the United States or other western countries, however, infants generally sleep alone in his or her own bed. Secondly, breast-feeding for more than 6 months is common in China, and young children are often cared for by their grandparents rather than by outside day-care providers. Thirdly, fewer numbers of children in families because of family planning policy in China, may allow parents to pay more attention to their only child's behavior and development. First-born children have been reported to be at lower risk for NE than second- or third- born children. Finally, the diaper is not used after children begin to walk on their own, and they often are taken to feasible place to void in public areas in China. But the children from western countries usually use diaper longer, partly until preschool age, and they often micturate at any moment disregarding the surroundings. Though a recent study has noted that the age at which toilet training begins had no influence on the development of bladder control, many studies were still supportive that toilet environment and regular voiding with optimal posture might help develop normal bladder control and thus avoid bladder dysfunction at a later age. Last, but not the least, one major reason for different rate is the different definition of enuresis between the studies.

1.2 predictor of marked PNE

Four variables were found to be significant as predictors of marked PNE. They were age, inhabitation (rural or urban), arousal dysfunction, associated daytime symptom and family history. Among the 94 PNE cases with a positive family history, 53 were boys and 41 were girls. The percentages of positive family history from the male line, female line or both lines were respectively 67.92% (36/53), 22.64% (12/53) and 9.43% (5/53) in boys and respectively 70.73% (29/41), 21.95% (9/41) and 7.31% (3/41) in girls. Apparently positive family history of PNE was more frequently seen from the male line. However, there was no significant difference in the familial distribution between boys and girls ($p > 0.05$).

2.1 Evaluation before treatment

History

A careful history taking is fundamental to the evaluation of enuresis. Symptoms that suggest a low functional bladder capacity include urinary frequency and nocturia. Some children void with a normal frequency or even a reduced frequency and yet have a low functional bladder capacity; these children often do not drink appreciably during the day, and urinary frequency is evident only after a fluid load. Most children in the age range for elementary school can relate an accurate voiding history for school days.

An objective means of documenting voiding patterns is the **voiding diary**, which is especially useful when the history is not clear. A voiding diary kept by the parents should help to assess the times at which a child voids; the relationship between voiding and common events such as meals, breaks at school, and play activities; the occurrence of urgency or incontinence; and the volume voided (as often as is practical, and at least at common voiding times, such as on waking and after school). The history taking should include screening for **symptoms of cystitis or constipation**, since both conditions are associated with a reduced functional bladder capacity. Parents are often unaware of constipation in their child, and children in the age range for elementary school should be directly questioned about this problem. In one cross-sectional study of 277 children with enuresis, in which parental reporting of constipation was compared with a clinician's assessment, the prevalence of constipation reported was 14% and 36%, respectively. Keeping a 2 to 4-week calendar for bowel movements is helpful. The child should be instructed not to flush the toilet; the parent should record the time of movements and soiling, indicate whether the stool is soft or hard, and record the width.

A history of soaking absorbent disposable underpants suggests nocturnal polyuria, and in such cases, a history of **daily diet and fluid intake** is helpful. Many children do not drink appreciable amounts of fluids during the morning and early afternoon, especially on school days. These children often arrive home from school thirsty, and most of their daily fluid intake occurs during the late afternoon and evening, a pattern that favors nocturnal polyuria.

The physical examination should include palpation of the abdomen for stool, examination of the lower spine for cutaneous stigmata of spinal dysraphism (midline pigmentation or hair tuft, or a dimple above the cleft), assessment of the anal wink, and evaluation of the motor strength, tone, reflexes, and sensation in the legs for evidence of a neurogenic bladder. Children who have daytime urinary symptoms or who do not have improvement with therapy should be referred to a specialist.

Table Relevant patient history at the first consultation.

Areas of interest	Relevance
General health and development	
Growth, weight loss	Poor growth in renal failure. Malaise, nausea, weight loss etc in diabetes or kidney disease
Micturition and drinking habits	
Bedwetting frequency	Poor prognosis in very frequent enuresis
Previous dryness	Comorbidity (somatic or psychiatric) more common in secondary enuresis
Daytime incontinence: When? How often?	Urge incontinence should be treated before enuresis. Neurogenic or anatomic causes gives daytime incontinence more often than isolated enuresis
Urgency	Indicates detrusor overactivity
Weak stream, hesitancy, straining	These symptoms may indicate neurogenic bladder or malformation
Urinary tract infections	Indicates lower urinary tract dysfunction, neurogenic bladder or malformations, most commonly the former
Excessive thirst. Need to drink at night	Kidney disease, diabetes or habitual polydipsia. Desmopressin contraindicated.
Bowel habits	
Bowel movement frequency, stool consistency.	Low stool frequency and/or hard stools indicate constipation, which should be addressed before enuresis treatment can start
Faecal incontinence	This is most commonly caused by constipation.
Psychology	
Behavioral problems	If behavioural problems are severe they may need to be addressed concomitantly with enuresis therapy
How does the child view his/her enuresis?	The child who is not bothered by the enuresis may not be motivated for labour-intensive therapy

(From Neveus T. *Nocturnal enuresis – theoretic background and practical guidelines.* Pediatr Nephrol, 2011, 26:1207-1214.)

Laboratory testing and imaging studies

A urinalysis is warranted in all children to rule out urinary tract infection and glycosuria. A high specific gravity in a urine specimen obtained in the afternoon suggests low fluid intake during the day.

Ultrasonography of the pelvis is helpful in children with daytime symptoms and should be performed routinely as part of a specialty assessment. Ultrasound examination of the bladder, performed when the child feels the bladder is "full," can be used to estimate functional bladder capacity, which can be compared with norms for bladder capacity according to age. Ultrasonography can be used to assess the patient for a thick bladder wall and elevated residual urinary volume (>5 ml), both of which suggest NMNE. The use of transabdominal ultrasonography of the rectum to measure the transverse rectal diameter has reportedly been helpful in screening for constipation, but its use for this purpose has not been well validated.

2.2 Treatment

2.2.1 Non-Pharmacologic therapy

Behavioral therapy

The fundamental goal of behavioral therapy is the achievement of good bladder and bowel habits. For example, the child should be encouraged both to void frequently enough to avoid urgency and daytime incontinence and to have a bowel movement every morning after breakfast, before leaving for school.

Table. Recommendations for the Use of Behavioral Therapy.
Remove underpants and have child void in toilet at start of every day
Encourage child to avoid holding urine
Encourage voiding at least once every 2 hr, at least several times during school day, and often enough to avoid urgency and incontinence
Facilitate easy access to school toilets with a note to the teacher
Have child drink a liberal amount of water during morning and early afternoon hours, a total of at least 30 ml per kilogram of body weighty
Minimize intake of fluids and solutes after dinner unless child is participating in evening sports or social activities
Encourage a daily bowel movement, preferably after breakfast and before child leaves for school
Have child use optimal posture to relax pelvic-floor muscles, facilitating good emptying of bowelfj
Encourage the child to eat foods that soften stool and to avoid foods that harden stool
Encourage the child to engage in physical activity and discourage prolonged sitting in front of television or computer

(From Robson. WL. *Evaluation and Management of Enuresis*. N Engl J Med, 2009, 360:1429-1436)

Alarm therapy

The urine alarm works by using a moisture-sensitive switching system that, when closed by contact with urine, completes a small-voltage electrical circuit and activates a stimulus, such as a bell or buzzer, which is strong enough to cause the child to wake. If there is no improvement at 1 month, it is reasonable to discontinue therapy.

Acupuncture

Acupuncture is an alternative medicine that treats patients by insertion and manipulation of needles in the body. The earliest written record of acupuncture is found in the *Huangdi Neijing* (translated as The Yellow Emperor's Inner Canon), dated approximately 200 BC. Acupuncture typically incorporates traditional Chinese medicine as an integral part of its practice and theory. Being an integral part of traditional Chinese Medicine (TCM), acupuncture involves complex theories of regulation of five elements (fire, earth, metal, water, and wood), Yin and Yang, Qi, blood and body fluids. By stimulating various meridian points, disharmony and dysregulation of organ systems are 'corrected' to relieve symptoms and restore natural internal homeostasis. In European countries almost half the practitioners follow these non-TCM practices. The most notable difference is that these other approaches often are primarily acupuncture, and do not incorporate Chinese herbal medicine. The term "acupuncture" is sometimes used to refer to insertion of needles at points other than traditional ones, or to applying an electric current to needles in acupuncture points. Different variations of acupuncture are practiced and taught throughout the world. However, there is no anatomical or scientific evidence for the existence of qi or meridians, concepts central to acupuncture.

There are many reports on treatment of MNE with acupuncture all around the world, especially in China. The short term efficacy rate of mono-acupuncture therapy could reach over 90% in Wang Y research and many other Chinese reports as well. When combined with desmopressin, the long term (6 months) efficacy could reach above 80%.

However, there is still controversy over the efficacy of this traditional Chinese manipulation, and some system reviews have published and appraise its efficacy negatively. The mortal weakness of acupuncture is that nearly all studies in favor of acupuncture are poorly designed and lack of control groups.

According to the International Children's Continence Society standardization document (Nevéus et al., 2006), nocturnal enuresis falls into the two categories of monosymptomatic night wetting or enuresis accompanied by other symptoms of the lower urinary tract. The underlying aetiologies of these discrepant presentations mandate that the trialist separate children into these categories before testing an intervention and that the report of outcome be similarly specific. An ideal study of acupuncture in nocturnal enuresis would require children be sub-classified as discussed above and then further grouped according to the number of initial wet nights per week (i.e. symptoms severity) and the age strata. Clearly younger children who are wet less often will appear to respond more to intervention and influence the size of treatment effect. Outcomes reported during treatment should be clearly stated and post-intervention measures reported along with longitudinal follow-up data. These measures would provide a level of transparency currently not evident in many reports.

Another aspect of explanation to inconsistent result between Chinese and western might lies in the understanding of TCM. According to the concept of TCM, nocturnal enuresis can be differentiated into the following types:

Deficiency-cold in the kidney with insufficient kidney-qi: manifested by one, two or more involuntary urine discharge during sleep at night, accompanied with bright-white complexion, frequent urination and even cold limbs, aversion to cold, pale tongue proper, and deep slow and forceless pulse in severe cases;

Deficiency of qi of the spleen- and lung, and dysfunction of the bladder**:** manifested by involuntary frequent discharges of the urine small in amount during sleep, accompanied by bright- white complexion, mental fatigue, lassitude in the limbs, poor appetite, loose stool, pale tongue proper, slow or deep- thread pulse;

Damp-heat in the Liver Channel and pathogenic fire-heat arising internally: manifested by involuntary frequent discharges of scanty, dark and foul smell urine at night, accompanied with flushed face, vexation or sleep-talking, aversion to fatty and greasy food, thick and greasy or yellow and greasy tongue coating, taut and rapid pulse.

So different points of acupuncture and even different Chinese herbal will be administrated accordingly.

Main points: Shenmen (HT 7) and Weizhong (BL 40) were selected. With a #30-#32 filiform needle 1-2 cun in length, Shenmen (HT 7) was inserted superficially for 0.5 cun with the tip of the needle pointing upwardly. Usually the reinforcing method is adopted. Weizhong (BL 40) was inserted perpendicularly for 1 cun. The needles were retained for 28 minutes, during which one manipulation was performed. It is preferable that the treatment is given in the afternoon. And one course consists of 7 treatment sessions.

Fig 1. The Shenshu points on the back.

Fig 2. The ear points for acupuncture.

Modifications: For the type of deficiency-cold in the kidney with insufficient kidney qi, the kidney should be warmed and supplemented. Zhongji (CV 3), Shenshu (BL 23), Pangguangshu (BL 28) and Taixi (KI 3) were selected and needled with the reinforcing method.

For the type of deficiency of qi of the spleen and the lung, the spleen should be tonified and qi replenished, Qihai (CV 6), Taiyuan (LU 9), Zusanli (ST 36) and Sanyinjiao (SP 6) were taken and needled with reinforcing method.

And for the type of damp-heat in the Liver Channel, the damp-heat should be cleared away. Taichong (LR 3), Xingjian (LR 2) and Yanglingquan (GB 34) were selected and needled with the reducing method.

Sometime the ear points are used as an supplement, which also produces fairly great results.

Recently, there are two reports on laser acupuncture on nocturnal enuresis published, which shows the ardor on the potential acceptance of acupuncture as a routine therapy for nocturnal enuresis in the future. Karaman et al reported a positive result with efficacy rate of complete improvement (complete dryness) at 90-day (56.1%) and 180-day (54.4%). Nonetheless, Radvanska et al had no significant positive findings, whose study focused on the bladder reservoir function and nocturnal urine output, and only slightly increase in the average voided volume after acupuncture were recorded.

Traditional Chinese Medicines

Some Chinese herbal medicines are recorded with special effect in managing enuresis. Here we present some prescription.

Bushen yiyuan tang (decoction of reinforcing the kidney to benefit qi) includes Astragalus membranaceus, ephedra, cuscuta, Schisandra, fructus alpiniae oxyphyllae, psoralea corylifolia L, mantis egg-case, common macrocarpium fruit. And some other herbal material, such as Poria cocos, Chinese yam, Rubus idaeus and so on, can be added according to different health status of the patients. Combined with acupuncture will have excellent curative effect.

Suoqua tang (decrease of urine decotion) includes fructus alpiniae oxyphyllae, root of combined spicebush, common yam rhizome winged yan rhizome，common macrocarpium fruit, cherokee rose fruit. And researches show that this prescription has similar outcome compared to desmopressin (90% vs 86%), but lower recurrent rate than desmopressin after 3 months (4% vs 16%).

2.2.2 Pharmacologic therapy

Desmopressin

Desmopressin is a synthetic analogue of the pituitary hormone, arginine vasopressin. It exerts an antidiuretic effect through its action on the renal collecting tubule, and results in increased permeability to water reabsorption. When administered at bedtime, it helps to reduce nocturnal urine production with a beneficial effect on the symptom of enuresis in a large proportion (70%) of children with nocturnal enuresis.

Imipramine and Other Tricyclic Antidepressants

Imipramine (a tricyclic antidepressant) is one of the earliest medications used to treat bedwetting in children; however, its mechanism of action in nocturnal enuresis is uncertain. The beneficial effect of imipramine was initially attributed to its anticholinergic effects, but it has been recently shown that imipramine can be of help in children who have not responded to anticholinergic therapy. The reduction in the wet nights is modest, with cure rates in the range of 20%. The rate of relapse after discontinuing treatment is high. The major concern with the use of imipramine is the risk of potentially life-threatening side effects such as arrhythmias, heart blocks, and convulsions, although they have been rarely reported in the treatment of nocturnal enuresis. Given the availability of better treatment options (alarms and desmopressin), tricyclic antidepressants are now recommended as third-line treatment.

Oxybutynin and Other Anticholinergic Drugs

In some children, nocturnal enuresis is a result of nocturnal detrusor overactivity. Some have lower urinary tract symptoms in the daytime (non-monosymptomatic nocturnal enuresis) and others have nocturnal detrusor overactivity without daytime detrusor overactivity. In these children, anticholinergic medications are often indicated. Anticholinergic drugs can have a dual effect through their relaxing action on the smooth muscle of urinary bladder (which inhibits detrusor overactivity) and by increasing bladder capacity. In enuretic children with a small maximum voided volume who are refractory to therapy, the addition of anticholinergic medications to their treatment is particularly beneficial.

Conclusion

Bedwetting alarms remain the first-line therapy for primary nocturnal enuresis. Acupuncture is an alternative therapy, and with the use of laser, it is noninvasive, painless, short-term therapy with excellent prospects. Pharmacologic therapy should be used sparingly and with due diligence in children with nocturnal enuresis because of the risk of adverse effects. Desmopressin is the most common drug used in the treatment of nocturnal enuresis. It should be used if alarm therapy is not feasible or is ineffective, or as an adjuvant to alarm therapy. Anticholinergic agents such as oxybutynin or tolterodine should be used in children with detrusor over-activity.

Acupuncture and traditional Chinese herbs provided an alternative for the treatment of NE. However, its validation needs to be evidenced researches. To standardize the procedure and indications is necessary in the future.

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Notes

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