WORKSHOP A7 — NON-INVASIVE ASSESSMENT OF BLADDER FUNCTION

Chair: Clive Griffiths, Ron van Mastrigt

OVERVIEW OF METHODS FOR NON-INVASIVE URODYNAMICS

Ron van Mastrigt, Rotterdam

Bladder function is presently assessed from measurements of pressure and flow rate made during voiding. These measurements are expensive, time consuming, and uncomfortable to the patient. Therefore, methods have been proposed to assess bladder function from non-invasive measurements. Traditionally it has often been proposed to diagnose obstruction on the basis of flow rate measurements alone. More recently, diagnostic methods based on the non-invasive measurement of bladder pressure, on the measurement of sound produced during voiding, and on imaging techniques have been described. It is to be expected that in the near future these methods will have a considerable impact on urodynamics. This overview presents a summary and analysis of the non-invasive urodynamic measurement techniques published to date.

THE PENILE CUFF — INTRODUCTION

Rob Pickard, Newcastle

The assessment and treatment of men with lower urinary tract symptoms (LUTS) is an important part of clinical urology. Currently symptoms are characterised and empirical treatment decided by severity and effect on quality of life together with basic urodynamic information obtained from a flow rate and residual urine. Precise urodynamic diagnosis and hence objective treatment decisions however require the measurement of bladder pressure during voiding. The penile cuff technique of measuring bladder pressure non-invasively has evolved over the last 25 years and is now at the brink of clinical application. The talks that follow describe this evolution and point the way forward to its widespread use in clinical practice.

THE PENILE CUFF — ORIGIN AND PHYSIOLOGY OF OCCLUSION TECHNIQUES FOR BLADDER FUNCTION MEASUREMENT

Mike Craggs, London

Threshold occlusion by pressurising a cuff placed around a compliant tube carrying fluid can be used to measure indirectly the driving pressure within the tube. This is the basis of non-invasive blood pressure measurement with a sphygmomanometer. Likewise, it has been shown that the pressure which must be applied to a water-filled cuff encircling the penis to stop micturition shortly after its onset can be used to monitor bladder function non-invasively: the utility of the method demonstrated objectively, for the first time in man, that the anti-muscarinic drug atropine could markedly reduce bladder (detrusor) contractions. This paper will discuss the origins of the penile occlusion technique for bladder pressure measurement and the physiological effects on detrusor pressure of stopping urine flow during voiding.

THE PENILE CUFF — DEVELOPMENT OF THE PENILE CUFF MEASUREMENT

Clive Griffiths, Newcastle

McRae et al described the use of an air filled cuff to measure bladder pressure in man (Neurourology and Urodynamics 1995, 14: 101-114). They inflated the penile cuff prior to commencement of flow and, when the subject was ready, gradually deflated the cuff until flow could start. The cuff was than rapidly deflated so that flow could continue without further interference. We developed this technique further: a cuff is applied to the penis but only after flow has commenced is the cuff inflated, in a controlled manner, until flow is just interrupted. This pressure is taken as a measure of the bladder pressure at interruption. The cuff is then rapidly deflated allowing voiding to resume and the inflation/ deflation cycle can be repeated, typically 2 or 3 times. We developed an electronic pneumatic control device that has subsequently been automated using feedback from the flow meter.

THE PENILE CUFF — DEMONSTRATION OF THE LABORATORY PROTOTYPE INSTRUMENT

Michael Drinnan, Newcastle

In the development of the penile cuff instrument we used a simple hydrodynamic model of the bladder and urinary tract. In this demonstration, the model allows the basic principle and operation of the instrument to be appreciated in real-time. Additionally, by including a simple model of the prostate, we will reproduce the typical patterns of flow versus cuff pressure seen in normal and obstructed subjects.

THE PENILE CUFF — CLINICAL TRIAL OF THE PENILE CUFF MEASUREMENT

Stuart McIntosh, Newcastle

In a study that began in August 2001, the 'cuff test' estimate of bladder pressure is being compared with the directly recorded value from simultaneous voiding cystometry ('the gold standard') in approximately 150-200 men with LUTS. The aims of the study are to validate the measurement, assess its reproducibility and reliability and to begin evaluating the clinical usefulness of this novel device in the classification of BOO.

THE PENILE CUFF — INDEPENDENT EVALUATION OF THE PENILE CUFF MEASUREMENT

Chris Blake, Bristol

In order to provide independent verification of the cuff measurement, we have recently begun a study at Bristol Urological Institute. By comparing the cuff measurement with simultaneous cystometry data, the aim of the study is to provide the first independent evidence for its efficacy. We will present the early results from this study.

THE PENILE CUFF — PATIENT ACCEPTABILITY OF THE PENILE CUFF MEASUREMENT

Wendy Robson, Newcastle

One key benefit of the new measurement is its simplicity. We will show a short video of the cuff in use, then present data on its acceptability as a practical clinical test, as reported by the patients themselves. Sister Robson has been responsible for applying the cuff in clinical practice since its first use 4 years ago.

THE CONDOM CATHETER — THEORY, PRINCIPLE AND VALIDATION

Johan Pel, Rotterdam

The external condom catheter consists of an incontinence condom connected to a tube, a valve and a pressure transducer. The condom is adjusted to the penis and taped with laboratory film to increase its stiffness. When a volunteer or patient voids in the condom, the flow rate through it is interrupted by closing the tube with the valve. During this interruption, the condom fills with urine and the pressure transducer measures the pressure rise until a maximum condom pressure is reached. In theory, this maximum condom pressure equals the bladder pressure when the bladder neck is open.

We tested this catheter in healthy volunteers and patients with LUTS. In the volunteers, we found that the condom pressure depended on the volume of the bladder at the moment of flow rate interruption. Thus, repeated interruptions in one voiding are necessary to correct for the volume dependence.

The patients first underwent an invasive PFS to quantify the urethral resistance. Then the condom and bladder pressure were simultaneously measured using a small catheter guided into the bladder via the condom. It was shown that the difference between the bladder and condom pressure correlated significantly with the urethral resistance. Furthermore, the relatively high abdominal pressures in some patients who strained during voiding were not reflected in the condom pressure. In those who did not strain, a simple clas-

sification strategy to separate non-obstructed from obstructed patients was found on the basis of a combination of maximum condom pressure and a separately measured maximum flow rate.
In the same group of patients, we found that for an accurate condom pressure measurement, the free flow rate should exceed 5.4 ml/s. Under that condition the condom is filled and pressurised so quickly that the risk of sphincter contraction or detrusor inhibition is small. To further reduce this risk, we developed a variable outflow resistance catheter. Using this new catheter, the outflow resistance can be step-wise increased to estimate the isovolumetric pressure in the condom without complete interruption of the flow rate. It can also be used to minimise the duration of the flow rate interruption by maintaining a small pressure in the condom, called a preload, during voiding. When voiding starts, a small outflow resistance is selected, to pre-fill the condom with urine. As a result, the pressure in the condom increases to a pre-load value. Superimposed on this pre-load, an isovolumetric pressure measurement is done. After each measurement, the pre-load outflow resistance is restored. The minimisation of the duration of the flow rate interruption again reduces the risk of sphincter contraction or detrusor inhibition. A secondary advantage of pre-loading the urethra before a pressure measurement is that it enables the investigator to monitor sphincter contraction (a sudden drop in condom pressure) or detrusor inhibition (gradual decrease of the pressure after interruption of the flow rate).

THE CONDOM CATHETER — PRACTICAL IMPLEMENTATION

Ron van Mastrigt, Rotterdam

For large scale application of the condom method for non-invasive bladder pressure measurement an integrated measurement set up was developed. It is based on the use of reusable domes that are attached to a reusable pressure transducer. The domes have three outflow ports, with different resistance and one inflow port to which a modified incontinence condom is attached. Disposable tubes attached to the outflow resistances can be closed by pneumatic valves. Valves and transducer are fixed on a standard rotating disc flow transducer. The valves are computer controlled.

THE CONDOM CATHETER — APPLICATION IN EPIDEMIOLOGICAL STUDY

John Huang Foen Chung, Rotterdam

825 healthy male volunteers aged 38-77 will be studied three times in five years to evaluate changes in the urinary bladder contractility secondary to age related prostatic enlargement. Presently the first of these three evaluations was completed in 105 men. Two pressure measurements were done in each man. As the second measurement was not systematically different from the first, there was no bias. The reproducibility was good and comparable to that of invasive pressure flow studies. Unexpected adverse events were mild and inherent to the subject's sensibility and vulnerability. It can be concluded that the condom method for non-invasively measuring the bladder pressure is very suitable for epidemiological studies.

THE CONDOM CATHETER — APPLICATION IN EPIDEMIOLOGICAL STUDY

Mark Spigt, Maastricht

In a large randomized controlled trial we will study the effects of an increased water intake (1.5 liter daily) in patients aged 55-75 years, with a moderate symptom score (IPSS 8-19). The rationale behind this intervention is the animal study observation that increasing the urine output may improve bladder function. On this basis we hypothesize that increasing the work load on the human bladder will also lead to an increase in bladder contractility. In addition, we will assess if improving the bladder contractility will lead to a relief of symptoms. We are currently recruiting our research population. We aim to include a total of 160 patients. At the conference we will present our experiences thus far in measuring bladder pressure non-invasively in our trial.

THE PENILE COMPRESSION MANOEUVRE

Maryrose Sullivan, Subbarao Yalla, Boston

We have evaluated the feasibility of using a penile urethral compression and quick release maneuver during urination as a potential non-invasive clinical screening tool in the evaluation of patients with voiding dysfunc-

tion and the diagnosis of prostatic obstruction. The penile compression-release maneuver was performed in adult men with symptomatic voiding dysfunction and in asymptomatic normal men by compressing the penile urethra for 2-3 seconds after the initiation of flow and quickly releasing the compression.
Our findings suggest that the magnitude of the flow rate change generated after the penile compression-release maneuver depends on the magnitude of the isometric detrusor contraction developed during penile urethral compression and on the conduit status of the outlet. In patients determined to have poor urinary flow rates, this non-invasive maneuver has been able to differentiate prostatic obstruction associated with normal detrusor contractility from other causes of low urinary flow rates. Despite these encouraging trends, further studies in a larger cohort are required to determine its potential clinical utility as a screening tool for diagnosing prostatic obstruction.

DIAGNOSIS OF URETHRAL OBSTRUCTION FROM NOISE RECORDING DURING VOIDING

Johan Pel, Rotterdam

It was previously shown that noise produced in the urethra during voiding can be measured at the perineum. This noise is related to the flow rate through the urethra, but its origin and relation to urethral resistance is undefined. It has been suggested that the recorded noise may be caused by turbulence in the narrowing of the urethra through the enlarged prostate. The aim of our present research is to develop a biophysical model of the urethra to study the relation between noise production and urethral resistance. The urethral model will be made using the Finite Element Method (FEM), an analysis method that allows the urethral contractile properties to be combined with the urethral geometry. To this end we measure contractile properties of small bundles of urethral muscle fibres. Furthermore, a rubber model consisting of polyvinyl alcohol cryogel is made, which will be used to mathematically describe the urethral geometry and to simulate flow through an obstructed elastic tube.