Bladder compliance what does it represent. Can we measure it, and is it clinically relevant?

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Abstract

Aims: to report the conclusion of the Think Thank on Compliance Discussions during the second ICI-RS meeting in 2010

Methods: During a three day meeting a group of specialists discussed compliance, what it represents, how it can be measured and if it is clinically relevant.

Results: Bladder compliance is the result of a mathematical calculation of volume responsible for 1 cm H2O pressure rise measured during a cystometric filling. It gives an indication on how the different mechanisms in the bladder wall react on stretching. There is a need of standardisation of measurement and suggestions for this are given in the text. Pitfalls are described and how to avoid them. There is a wide range of compliance values in healthy volunteers and groups of patients. Poor compliance needs to be defined better as it can have significant clinical consequences. Prevention and treatment are discussed.

Conclusion: If compliance is correctly measured and interpreted, it has importance in urodynamic testing and gives information relevant for clinical management.
Introduction

Compliance refers to the relationship of volume to pressure. In bladder function it can be calculated from a cystometric pressure/volume curve. Different experimental studies indicate that most probably different mechanisms are involved: a spinal parasympathetic reflex, an intrinsic reflex activity in the vesical plexus, inhibition from spinal cord, intrinsic mechanism of bladder muscle independent of the nervous system, pure muscular in the beginning of the bladder filling while further filling is registered neurologically and inhibition by spinal reflex occurs. As compliance is not influenced by anesthesia, transsection of roots or spinal cord, the volume/pressure relationship is unchanged during the period of spinal shock.

Smooth muscles of the bladder have specific length/tension correlations. Slow stretching gives almost no increase in tension, fast stretching tension increase and if stretching is stopped, tension goes down again. Fast shortening gives loss of tension which gradually comes back. Visco-elastic mechanisms through collagen between muscles play a role, plasto-elastic through the muscles themselves, while a “viscous” third part would explain that overdistension can give irreversible defects in the wall. During gradual filling of the bladder these three develop one after the other.

Physical factors influencing the value of compliance

The static modulus of elasticity is the ratio of the change of stress (in a body when subjected to a change of strain. In the three-dimensional the bladder the equivalent analogy is the change of intraluminal pressure (ΔP), when the volume is changed (ΔV). Although pressure and volume are not directly proportional to stress and strain, the general principles from the one-dimensional system may be extrapolated to a three-dimensional system. The inverse of this concept, the ratio ΔV/ΔP is called compliance and is a measure of distensibility. The changes of ΔV and ΔP are made when the system is at steady-state, i.e. when pressure and volume are stable.

With urodynamics the compliance of the bladder is generally measured when the system is not at steady state, i.e. when bladder filling is continuous. This would not be a problem if the bladder was a purely elastic organ as pressure changes would be instantaneous when bladder volume altered. However, this is not the case as the bladder exhibits stress-relaxation after a
rapid change of volume. In a viscoelastic system (fig 1) the transient response is greater if the rate of change of strain is greater, the thick black line shows the case for a purely elastic system. If measurements are made at steady-state the change of stress would be similar. However, if made before steady-state, the strain changes are different and also depend on the initial rate of change of strain. In non-steady state (vertical dashed line) the compliance would appear reduced, and more so if the filling rate was high. But at what rate may the bladder be filled so that viscoelastic properties do not falsely underestimate compliance? In a one-dimensional viscoelastic system, stress is measured as a function of strain changes. In a three-dimensional system such as the bladder, stress is interpreted as pressure and strain as volume, although again it is emphasized that these are not proportional transformations. The simplest model is to describe the tissue as a system of elastic springs and a viscous dashpot. One canonical form is shown in figure 2. The collection of two springs E1 and E2, along with a viscous dashpot (η), is called the Standard Linear Model. It describes best the equivalent model for muscle. The dashpot confers time-dependence to an instantaneous change of length (strain) with a time constant (τ) determined by the ratio η/E2. The objective of the model is to determine error during stretch (strain changes) at different rates and for different values of viscosity (η). This can be extrapolated to estimating errors in measurements of bladder compliance when filling at different rates, and with bladders of different rates of viscoelastic (stress) relaxation (different values of τ) and elastic constants, E1 and E2.

The analysis begins with the system E1, E2, η in figure 2 with a mathematical equivalent.

\[
\frac{d\varepsilon}{dt} (E_1 + E_2) + \frac{E_1}{\tau} \varepsilon = \frac{d\sigma}{dt} + \frac{\sigma}{\tau}
\]

For given values of ε and dε/dt the left hand term can be written as a constant, k, and equation 1 becomes a first order differential equation that can be solved by separation of variables.

\[
\sigma(t) = \exp\left(\frac{kt + \tau \ln\sigma(0)}{\tau}\right)
\]

where \(\sigma(0)\) is the value at t=0 (figure 1).

Equation 2 was solved for several values of τ ranging from 2 to 1000 s, encompassing the values observed in isolated detrusor muscle. The value of ε was set arbitrarily at 200
units and $\frac{dc}{dt}$ between 0.05 and 10 units s$^{-1}$. Important is the ratio of $\varepsilon$ and $\frac{dc}{dt}$ values, and the arbitrary units chosen here can be made equivalent to milliliters with no loss of generality. The relative magnitudes of $E_1$ and $E_2$ are important and will be varied as part of the analysis.

Figure 3A shows a solution of equation 2 for the stress generated in bladder tissue when ramp strains are imposed at different rates, as shown by the numbers next to the different curves – note the logarithmic scale of the y-axis. Stress is imposed more quickly as the rate of strain increases. Of more interest is figure 3B where stress is measured at the same imposed strain, applied at different rates, by analogy this is the same as the measured pressure when the same volume is introduced but at different rates. The different plots are for various values of $\tau$, but the general shape is the same, at lower strain rates the change of stress is less. Again by analogy to the hollow bladder, filling to the same volume but at a lower rate would increase pressure less. If the stress (pressure) value for a given strain (volume) change was used to estimate compliance, the value would be underestimated at high strain rates. When the filling rate is less than 1/s the change of pressure is not very dependent on filling rate. The same conclusion was reached over the range of $\tau$, from 2 to 1000 s. Finally figure 3C indicates a feature of the model that did alter the curves of figure 3B, namely altering the ratio of the two elastic components $E_1$ and $E_2$. As the $E_1/E_2$ ratio increased, the influence of strain rate was progressively increased. The y-axis in this plot shows the percentage increase of stress as filling rate increases, normalized to the value at the lowest rate. An increase of the $E_1/E_2$ ratio increased the deviation for the stress value at low rates and would successively underestimate the compliance.

The model indicates higher strain rates will progressively increase the error in measuring true compliance values. Of greatest significance is to estimate the proportional difference in the two elastic components. One way to achieve this is to estimate the ratio of the time-independent and time-dependent components of total stress when subjected to a rapid change of strain, which indeed been shown to increase in obstructed bladders$^{14}$. It will be useful to extend the model to a three-dimensional construct but this initial approach shows the approximate limits on urodynamic measurements that can estimate bladder compliance.

Measuring Compliance

How to measure compliance has no general agreement.
The ICS definition 2002\(^{15}\) states that compliance is calculated by dividing the volume change (\(\Delta V\)) by the change in detrusor pressure (\(\Delta p_{\text{det}}\)) (\(C = \Delta V / \Delta p_{\text{det}}\), expressed in ml/cmH\(_2\)O). Two standard points should be used: the start of filling and cystometric capacity or immediately before any detrusor contractions that will end the test by e.g. cause significant leakage. Papers predating the recommendation can not be expected to comply with it \(^{16}\). There are several things that need to be known to permit accurate compliance calculation and correct interpretation of the result.

**Filling medium**

Cystometry filling is mostly done with liquids which are not compressible, allow detection of incontinence and determination of leak point pressure, can permit fluoroscopy imaging. Gas cystometry, thought to be quicker and more hygienic\(^ {17}\), has mostly been discontinued because CO\(_2\) is compressible, not physiologic, may evoke artifacts and does not permit voiding studies.

The liquid used may influence bladder behavior. Detrusor overactivity can be enhanced by acidic solution (pH 3.5)\(^ {18}\) or decreased by alkaline solution (pH above 8.5)\(^ {19}\). At equal filling speed, solutions of extreme osmolarity did not alter the sensitive and motor urodynamic outcome \(^ {20}\). None of these studies referred specifically to bladder compliance.

The temperature of the filling solution is another controversial issue. Ice water was described to differentiate types of neurogenic bladders \(^ {21}\), but is not used for normal compliance measurement. The ideal liquid temperature should be similar to urine at body temperature \(^ {22}\). But infusion liquid at room temperature is widely accepted as comparable to those at body temperature.

**Filling rate**

The theoretical best filling rate would be achieved by diuresis \(^ {18}\). But ambulatory monitoring, with natural filling \(^ {23}\) is costly, time consuming and only used in some centers. A low compliance on standard cystometry was replaced by phasic detrusor contractions during ambulatory monitoring \(^ {24}\). The ICS 2002 standardization of filling rates was: slow fill - < 10 ml/min; medium fill 10< <100 ml/min; rapid fill > 100 ml/min. In clinical practice in adults, filling rates range from 10 ml/min to 100 ml/min, with predominance of 30-50 ml/min. The ICS guideline on Good Urodynamic Practices \(^ {25}\) states that a “good urodynamic investigation should be performed interactively with the patient”, implying that there must be a limit to the
filling rate. It also suggests that when pressure goes up, filling is stopped and the bladder pressure followed to determine whether a fall in pressure occurs (= accommodation test). If pressure drops, filling should only be restarted when the pressure has become stable for a while and at an appropriately lower rate (10 ml/min), to be increased to 20 ml/min if the pressure does not rise again. If no fall in pressure occurs after stopping the filling, then it is reasonable to assume that poor compliance is in fact present. It is recommended to standardize and report filling rate, but also to follow a standard protocol when poor compliance is suspected during filling cystometry.

Detrusor pressure measurement

The pressure measurement needs a pressure sensor placed into the bladder, usually transurethrally, and another sensor being placed rectally or vaginally (or through an abdominal stoma), to measure abdominal pressure \(^{26}\). Pressure development due to the action of the detrusor smooth muscle and bladder wall is made by subtracting abdominal from vesical pressure. Correct pressure measurement needs proper calibration, usually against atmospheric pressure with the zero reference level at the superior edge of the symphysis pubis. Many technical causes of artifact must be kept in mind\(^ {18}\): air bubbles, kinked tubing, blocked catheters, incorrect sensor placement, migration of the pressure catheters, rectal pressure variations by flatus and stools. Patient-related causes are lack of cooperation and constant body movements, presence of “pop-off” mechanism subtracting intra-vesical bladder pressure as diverticulum and reflux into dilated upper urinary tract.

Data is now available (Sullivan 2010, in press) that \(p_{\text{det}}\) at start is in the range -5 cmH\(_2\)O to +5 cmH\(_2\)O in 95% of patients. It is entirely reasonable that \(p_{\text{det}}\) could be negative, as it is a derived figure from two real pressures, and it is by no means obvious that \(p_{\text{ves}}\) should always be greater than or equal to \(p_{\text{abd}}\). This means that the difference in detrusor pressure (\(\Delta p_{\text{det}}\)) in the two cases illustrated in Fig 4(a) and (b) is the same in each case.

The ICS Standardisation of Terminology is clear that pressure measurement should be made while excluding any detrusor contraction and before any significant leakage. This means that when no leakage occurs and the detrusor pressure returns to its value before contraction, \(\Delta p_{\text{det}}\) can be calculated as in Fig 4 (c), using the pressure at bladder capacity. However, if a contraction results in significant leakage or the pressure does not fall to its previous level, as in Fig 4 (d), the final pressure and volume values should be taken at the point shown, before the contraction.
When the filling is performed on top of significant post-void residual urine, the situation is more complex. The pressure that would occur if the bladder was empty is not known, as shown in Fig 4 (e), so the compliance cannot be calculated in the standard way. However, if the bladder is drained to zero at the end of the test, the pressure can be monitored and the value when empty used to calculate compliance, taking the volume change as the voided volume added to the drained residual. This is illustrated in Fig 4(f).

**Bladder volume**

Volume is generally calculated between two points: at the start of filling and at either the maximal cystometric capacity or at the start of a detrusor contraction. But there are uncertainties and pitfalls (fig 5). Great care should be taken to ensure that the bladder is in fact empty before filling commenced, or at least the pre-filling volume should be subtracted from the total, otherwise again the change in volume during the test will be wrongly calculated. Normally, the infused volume is used to calculate compliance, as this is the figure measured alongside pressure during the filling phase of the test. However, also diuresis will occur during the test. The commonly given advice to come to a urodynamic evaluation with a full bladder for an initial uroflowmetry can cause real hyperdiuresis during cystometry and increase of the filling volume with up to 20%\(^27\). Thus the volume stated at the beginning and the end of the test may be wrong. Since we are concerned with the change occurring in volume, we only need to consider the amount that diuresis adds to filled bladder volume during the filling phase of the test (upper part of Fig 5). This should either be estimated or measured by post-void catheter drainage in order to get a correct value for compliance\(^27-28\). But also voiding data can be used as volume voided may differ from volume injected (bottom part figure 5) In all cases, an accurate calculation of volume can only be obtained by completely emptying the bladder both before and after the test.

Bladder filling in many patients continues until sensation of full bladder is reported, pain or severy urgency, not always related to important pressure alterations. Sensation can be influenced by many factors that will, indirectly, determine which volumes will be used for compliance measurement.

**Calculation of compliance**

In compliance calculation, the unit ml/cm\(H_2O\) is normally used. Reported as more useful has been ‘compliance cost’ – the cm\(H_2O\) rise for 100ml fluid infused – for two different stages of
filling, initial and terminal \(^2^9\), equivalent to ‘dynamic compliance’\(^3^0\), being the gradient of the pressure/volume curve at different points during the urodynamic test. Other new methods of measurement as Wahl’s dimensionless unit \(^3^1\) and sinusoidal pumping (inducing small repeated changes in bladder volume) (Cardozo, unpublished 1980), have not been cited since. Discounting of detrusor overactivity (DOA) and consideration of \(p_{\text{abd}}\) changes is generally recognized. For compliance calculation when the pressure change is zero different suggestions have been made. Harris \(^3^2\) recognizes such compliance as infinite and assigns the arbitrary compliance of 1000. Gilmour et al.\(^3^0\) used the smallest amount measurable on their apparatus, i.e. the measurement precision. Sandri et al\(^3^3\) made the value of compliance equal to the value of maximum cystometric capacity (MCC), assuming the pressure change to be 1 cmH\(_2\)O. If a valid \(p_{\text{det}}\) would be slightly negative at the start of a test, Sullivan (2010) proposes that the pressure increase (or 1 cmH\(_2\)O if less than 1) during filling could be adopted when calculating compliance. Given that the main concern when poor compliance is seen is the possibility of renal damage, it may be of value to consider the difference between \(p_{\text{ves}}\) and the ureteric pressure. If the latter is at all different from \(p_{\text{abd}}\), then a new method of calculating compliance will be needed. The pressure transmitted from the bladder to the kidney is likely to be affected by a number of factors, e.g. patient size and position, degree of vesicoureteric reflux and transmission of intra-abdominal pressure to the ureter and kidney. Additionally, it may be necessary to consider how to calculate compliance in the presence of significant vesicoureteric reflux or bladder diverticula. Also we should examine whether detrusor muscle biomechanics remain the same after DOA has occurred during filling.

Measurement of compliance in special conditions

During filling, the bladder can be considered a closed box pressure reservoir. Any fluid escape during filling will lower bladder pressure, jeopardizing correct calculation of bladder compliance. Determination of detrusor leak point pressure (defined as the lowest detrusor pressure at which urinary leakage occurs) is as important as detrusor filling pressure, as it may determine the natural evolution of a poor compliant bladder. Patients with a leak point pressure above 25-30 cm water are generally considered at risk for upper tract deterioration. Incompetence of the closure mechanisms leads to a low leak point pressure, which may falsely suggest safe low bladder pressures. Filling may be done with a Foley catheter to obstruct the outlet \(^3^4\). Other “pop-off mechanisms” as vesico-ureteral reflux or bladder diverticula may also lead to false favourable measurements of bladder compliance. In children with high grade vesico-ureteral reflux, a reduction of compliance up to 40% has been reported.
if reflux was prevented by ureteral occlusion. Accurate measurement of “true” bladder compliance could indicate if the detrusor pressure may become more elevated post surgery endangering the upper urinary tract. Vesico-ureteral reflux or bladder diverticula can adequately be diagnosed by video-urodynamics. But how to measure their effect on pressure during bladder filling is as yet not known.

The relationship between bladder compliance and urinary tract infection is unclear, but urine analysis is recommended to permit correct measurement. It has been shown that even asymptomatic bacteriuria can increase bladder sensation and thus a quicker reporting of filling sensations (Wyndaele thesis 1993). Presence of urinary tract infection may worsen a poor compliant bladder. High pressure is thought to diminish the natural uro-epithelial resistance, predisposing to infection. Successful lowering of bladder filling pressure certainly reduces the incidence of lower urinary tract infections.

Compliance figures

Some authors have studied compliance in groups of healthy symptom free and history free volunteers of different ages (Table 1). A study in 18 women (57±13 years old) with cystometrically demonstrated hypocontractile detrusor found compliance of mean 204±164 ml/cm H2O which after several days of treatment with subcutaneous injections of betanechol decreased to 80±54 ml/cm H2O and improved voiding. Data on compliance for large groups of patients (wyndaele thesis 1993) are given in table 2. They show wide variations in each group. This study also showed that compliance calculated between start of filing and first sensation of filling, from first sensation of filling to first desire to void and from first desire to void till strong desire to void were not statistically different. Compliance and reporting of cystometric filling sensation were strongly correlated.

It is obvious that compliance figures can vary widely in groups of healthy individuals and also in patients with voiding problems, which makes it difficult to define limits of normality. High compliance with no pressure changes noted during filling were shown not to be related to dysfunction in bladder motor function. Data are needed on reproducibility of compliance with repeated testing in the same individual, in order to determine how accurately changes in compliance induced by treatment can be measured.

The poor (“low”) compliant bladder
It is not surprising that values given for a low compliance bladder are not uniform. They vary from 10 ml/cm H$_2$O to 40 ml/cm H$_2$O. Kaufmann et al.$^{42}$ used 40 cm H$_2$O ‘bladder storage pressure’ at typical bladder capacity as the pressure level at which upper tract dilatation and subsequent renal impairment could be expected if appropriate management was not instituted. However, these values relate to children with myelodysplasia $^{43-44}$ and may not be relevant for adolescents and adults. Wahl et al.$^{45}$ state that a 6 cmH$_2$O pressure rise from empty to capacity should be considered as the normal pressure rise, regardless of bladder capacity, age, size and sex, with the implication that any pressure rise above this is poor compliance. However this related again to children. The influence of filling rate has been discussed above. Weld et al.$^1$ found a good indication of the importance of bladder management with compliance of >12 ml/cm H$_2$O in 75% of patients on intermittent catheterisation but only in 20% with indwelling catheters. A positive, statistically significant correlation with reflux, abnormal upper urinary tract and pyelonephritis, was found with compliance values of <10 and <12.5, but not with compliance values of 15 and >20 ml/cm H$_2$O. Thus the authors postulate a critical compliance value of 12.5 ml/cm H$_2$O. In the German speaking area in adults values below 10 indicate a poor compliance bladder, values between 10 and 25 are arbitrary and values >25 cm H$_2$O are regarded as normal.$^{47}$ Ghoniem et al.$^{48}$ divided compliance into an ‘initial’ and ‘terminal’ phase, when initially slow bladder pressure rise may change into a rapid pressure increase. The bladder volume at this “break point” has clinical importance. If the bladder is regularly emptied with intermittent catheterization before this point, the low compliance further has no major consequences (fig 6). Based on the concept of “dynamic compliance”, the characteristics of the bladder pressure curve must be correlated with the risk of upper tract damage in the individual patient. Conditions associated with a low compliance bladder are not fully understood. An association with DOA is widely reported.$^{49}$ However, Harding et al.$^{50}$ found in women without outlet obstruction DOA not predictive for poor compliance. The association with vesico-ureteric reflux is frequently mentioned. Within specific patient groups poor bladder compliance was associated with low bladder capacity, high bladder weight, recent retention episodes, low bladder wall blood flow and usage of indwelling catheters.$^{51-54}$

Patient groups at risk for low compliance

Neuropathic and paediatric patients are the groups most at risk for low bladder compliance in which pathophysiology, cause of the disease and the therapeutic possibilities of low
compliance were most studied. Low compliance may occur in the spinal reflex bladder as well as in the acontractile or hypocontractile detrusor, even when catherization is performed. Especially complete cauda equina lesions may be associated with low compliance in up to 55% of cases\textsuperscript{55}, requiring screening and strict surveillance\textsuperscript{56}. Shin et al.\textsuperscript{57} found a correlation in complete cauda equina lesions with a later onset of therapy, due probably to an increase in collagen after recurrent UTI and muscle hypertrophy induced by sympathetic nervous system overactivity\textsuperscript{58}.

Myelomeningocele patients are especially at risk during early childhood, puberty and the growth period\textsuperscript{42}. Boys are more at risk and a tethered cord, destabilized by growth, is another reason for low compliance.

The implantation of an artificial urinary sphincter is another risk factor. If low compliance is already present preoperatively a bladder augmentation is mandatory at the same time or before the implantation of the artificial bladder. However, even a normal compliant bladder may decompensate after sphincter implantation, obviously caused by the increase of sphincter resistance on a reservoir with limited properties.

Various therapeutic procedures have led to decrease of pressure and increase of compliance: simple urethral dilatation in children with myelomeningocele\textsuperscript{59}, posterior sacral root rhizotomy performed in the context of implantation of a Brindley stimulator\textsuperscript{60}. Also alphablockers in neurogenic bladders are able to improve bladder compliance\textsuperscript{61}.

Therapeutic considerations in a low compliance bladder

To differentiate between functional and structural low compliance a cystometry under spinal or general anaesthesia can be done. The functional low compliance should respond to pharmacological bladder relaxation with antimuscarinics and Botulinum toxin A.

Good studies in which the efficacy of antimuscarinics was evaluated in patients with neurogenic bladder dysfunction are lacking. In some studies the changes reported are not significant, despite statistically significant change in maximum cystometric bladder capacity and maximum detrusor voiding before and with antimuscarinic therapy, probably because of difficulties in evaluating the real compliance.

Botulinum toxin A, which most probably acts not only on the efferent but also on the afferent side of the micturition reflex is able to improve neurogenic bladder overactivity in adults and children. Some older paper also demonstrated a marked effect on bladder compliance in patients with a spastic spinal cord injury by using baclofen, an effect, which may be related to
relaxation of the striated sphincter, leading to decreased resistance and/ or a central neurological effect.

For the structural poor compliance, only surgery (bladder augmentation, bladder substitution) can change the situation.

Conclusions and recommendations

- Bladder compliance should be measured using the detrusor pressures at zero volume and end filling volume.
- At zero volume, \( p_{\text{det}} \) should be in the range -5 to +5 cmH\(_2\)O. For the purposes of compliance calculation, \( \Delta p \) should be the difference between this and the \( p_{\text{det}} \) at end of filling.
- In the presence of detrusor overactivity, \( p_{\text{det}} \) should be taken as the pressure between contractions or before the pre-voiding wave of detrusor overactivity.
- The bladder volume should be known accurately either because video studies were done and bladder emptying verified or by catheterization after voiding to measure post void residual and also measure the \( p_{\text{det}} \) as bladder volume decreases to zero.
- In patients who self-catheterize, the bladder should be emptied but in those with suspected poor compliance or neurological patients filling should commence after the patient has voided as much as possible, without removing their residual urine.
- The bladder should be filled at 50 ml/min as a standard if there is no reason to suspect poor bladder compliance. If poor compliance is suspected or expected (e.g. if the patient has upper tract dilatation) then filling should be at 20 ml/min.
- If poor bladder compliance is seen, then filling should be stopped, as per ICS guidelines.
- If there is no fall in \( p_{\text{det}} \) then filling should be restarted at 20 ml/min if earlier filling was at 50 ml/min, or at 10 ml/min if earlier filling was at 20 ml/min.
- If the \( p_{\text{det}} \) falls then filling can be restarted one minute after the fall in \( \Delta p_{\text{det}} \) has stopped, at the reduced filling rate noted above.
- The term ‘poor compliance’ should be used to describe a bladder with reduced values of compliance.
- When \( \Delta p_{\text{det}} \) is zero or negative, its value should be taken as 1 cmH\(_2\)O, making compliance equal to the volume change measured.
- Normal compliance at filling rates of \( \leq 50 \) ml/min should probably be a minimum of 40 ml/cmH\(_2\)O. But more studies are needed.
• Exact numeric values of compliance have limitations as in healthy volunteers and in patients with a same pathology very wide ranges of calculated compliance have been found.

• Many factors can influence the outcome of compliance measurement and should be taken into account: urinary infection, leakage, bladder diverticula, vesico ureteral reflux et al.