Intra-abdominal pressure measurement during ultrasound assessment of women with stress urinary incontinence: a novel model[1]

Aferição da pressão intra-abdominal durante avaliação ultra-sonográfica de mulheres com incontinência urinária de esforço: um novo modelo

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ABSTRACT

Purpose: To determine the influence of intra-abdominal pressure on the ultrasonographic evaluation of the urethrovesical junction (UVJ) and proximal urethra (PU) in women with stress urinary incontinence (SUI). **Methods**: This is a prospective cross-sectional study undertaken at the Urinary Incontinence Research Unit (UIRU) of the Universidade Federal de Pernambuco (UFPE). Thirty-six women complaining of SUI underwent perineal ultrasound assessments of the UVJ and PU having the bladder barely empty (< 50 ml of urine) with simultaneous measurement of the intra-abdominal pressure (IAP). An ALOKA ultrasound machine with a 7 MHz vaginal probe was used for the assessments. In order to measure the IAP, an Uromaster MPX616 urodynamic equipment, connected to a 10Fr rectal catheter with a pressure sensitive baloon, was used. **Results**: The participants' mean age was 46.4 ± 10.2 years. On maximum straining, the mean IAP was 99.3 ± 51.8 cmH_20, varying from 7 to 193 cmH_20, and the median was 99.5 cmH_20. Twenty-eight of 31 patients with UVJ hypermobility (90.3%) easily showed it with an IAP over 40 cmH_20. There was no significant association between the mean IAP measurements on maximum straining and the parameters studied. The IAP did induce a significant elongation of the proximal urethra length over 14 mm up to a cut-off over 80 cmH_2O, most likely to increase urethral resistance and pressure profile, thus avoiding urine leakage. However, all 19 women with such a characteristic already presented so with an IAP > 40 cmH_2O. **Conclusion**: There is no need to measure IAP routinely on perineal ultrasound assessments of the UVJ and PU in women with SUI having a barely empty bladder.

Key words: Urinary Incontinence, Stress. Ultrasonics. Bladder Disease. Urethra.

RESUMO

Objetivo: Determinar a influência da pressão intra-abdominal na avaliação ultra-sonográfica da junção uretrovesical (JUV) e uretra proximal (UP) em mulheres com incontinência urinária de esforço (IUE). **Métodos**: Este é um estudo de corte transversal prospectivo realizado na Unidade de Pesquisa em Incontinência Urinária (UPIU) da Universidade Federal de Pernambuco (UFPE). Trinta e seis mulheres queixando-se de IUE foram submetidas a aferições ultra-sonográficas perineais da JUV e UP com a bexiga praticamente vazia (< de 50 ml de urina) simultaneamente a medições da pressão intra-abdominal (PIA). Para tal foi utilizado um aparelho de ultra-som ALOKA com um transdutor vaginal de 7MHz. Com o intuito de medir a PIA, utilizamos o equipamento de urodinâmica Uromaster MPX616 conectado a um catéter retal de 10Fr com um balão sensível à pressão. **Resultados**: A idade média das participantes foi de 46,4 ± 10,2 anos. No esforço máximo, a média de PIA foi de 99,3 ± 51,8 cmH_20, variando de 7 a 193 cmH_20, e a mediana foi de 99,5 cmH_20. Vinte e oito de 31 pacientes com hipermobilidade da JUV (90,3%) facilmente a revelaram com uma PIA acima 40 cmH_20. Não houve associação significativa entre a média de PIAs aferidas no esforço máximo e os parâmetros estudados. A PIA na realidade induziu a um alongamento significativo do comprimento da uretra proximal acima de 14 mm até um ponto de corte acima de 80 cmH_2O, muito provavelmente para aumentar a resistência e características pressóricas uretrais, assim evitando a perda urinária. Entretanto, todas as 19 mulheres com tais características já as apresentavam com uma PIA > 40 cmH_2O. **Conclusão**: Não há necessidade de se aferir rotineiramente a PIA nas avaliações ultra-sonográficas da JUV e UP em mulheres com IUE com a bexiga praticamente vazia.

Descritores: Incontinência Urinária por Estresse. Ultra-Som. Doenças da Bexiga. Uretra.

Introduction

Urinary incontinence is a common problem affecting women. It leads to devastating socio-economic, professional and family inconveniences. People are living longer, having better access to information and more and more women are seeking medical help due to stress urinary incontinence (SUI). In 1998, approximately 135,000 women had inpatient surgery for SUI in the United States[1]. In European countries such as France, Germany, Italy, Spain and in the UK, SUI is highly prevelent, being diagnosed in as many as 80% of incontinent women[2]. Other studies also reported a high prevalence of SUI in women with urinary incontinence (50%)[3,4].

Studies of health economics on SUI revealed a substancial increase in expenditures both throughout the diagnostic work-up, particularly at the expenses of invasive investigations such as urodynamic testing, and treatment. Moreover, despite Valsalva leak point pressure being described as helpful in the diagnosis of SUI, it appears to be of minimal benefit in predicting the outcome of innovations in treatment such as the distal urethral polypropylene sling procedure[5].

In 1998, the average direct medical cost of SUI was US$ 5,642 and the indirect workplace cost of SUI was US$ 4,208[6]. Another study showed that the total healthcare expenditures in the year prior to the initial SUI diagnosis were approximately half of those in the following year (US$ 4,478 versus US$ 9,147)[7]. The total direct cost for treatment of SUI in the United States was about $0.5 billion in 1991[8].

It urges that a standard protocol for evaluation of women with SUI, both before treatment, aiming at tailoring the best clinical or surgical modality, and thereafter for follow-up and possible prognostic purposes, be defined by a gynecological, urological and urogynecological panel of experts. Meanwhile, we decided to study the influence of abdominal pressure during Valsalva's maneuver on pelvic floor responses of women with SUI based on perineal ultrasound assessments of the urethrovesical junction (UVJ) and proximal urethra (PU).

Methods

This is a prospective cross-sectional study undertaken at the Urinary Incontinence Research Unit (UIRU) of the Universidade Federal de Pernambuco (UFPE). It aimed at investigating, in women with SUI, the influence of intra-abdominal pressure (IAP) on the main urinary continence parameters assessed by perineal ultrasound with the patient in the dorsolithotomy position having a barely empty bladder (< 50ml of urine). The study protocol was reviewed and approved by the local Ethics Committee before any participant was enrolled. Potential volunteers were selected from women with SUI complaints, without a previous surgery involving the bladder or urethra, referred to the UIRU. All participants, after signing in the informed consent form, answered to a detailed questionnaire tailored to urogynecological symptoms and underwent a thorough physical examination foccused on urogynecological and neurological signs of abnormalities. Patients with complaints of urinary urgency underwent urodynamic testing and the ones diagnosed with urge incontinence were excluded from the study. Patients with neurological problems were also excluded. All had normal results for urinalysis and urine culture. We used an ALOKA ultrasound machine with a 7 MHz convex vaginal probe for perineal or transvulval assessments simutaneously with measurements of the IAP at maximum strain during Valsalva's maneuver. For this purpose, we used a 10Fr rectal catheter with a pressure sensitive baloon in place connected to a Uromaster MPX616 urodynamic equipment.The study parameters were as follows: the vertical (VUVJ) and horizontal (HUVJ) urethrovesical junction movements, the proximal urethra length (PUL) and the urethropubic distance (UPD). The measuments described here are the distances between the anterior margin of the UVJ and the inferior border of the pubic symphysis applied to vertical and horizontal UVJ movements. Also, the distances between the anterior margin of the UVJ and the point in the urethra where a horizontal line from the inferior border of the pubic symphysis meets the urethra (PUL), as well as the horizontal distances between the inferior border of the pubic symphysis to the urethral middle point (UPD). All measurements, the values on maximum straining minus the ones at rest, were taken 3 times by a single ultrasound specialist and the mean recorded. The chi-squared test was described as the Yates corrected number. In a 2 X 2 table with a cell contaning less than 5, we always described the 2-tailed Fisher´s exact test for the P-value. The level of significance considered in the present study was a P-value ≤ 0.05.

Results

A total of 36 women enrolled in the study. Their mean age was 46.4 ± 10.3 years, varying from 25 to 69 years with a median and mode of 46.5 and 44 years, respectively. Among them, 12 (33.3%) had mild SUI, 13 (36.1%) had moderate SUI and 11 (30.6%) had severe SUI. On physical examination, 15 (41.7%) did not have cystocele, another 15 (41.7%) had first degree cystocele, 5 (13.9%) and 1 (2.8%) had, respectively, second and third degree cystoceles. A summary of the main characteristics of the study population is found in Table 1.

There was no association between the mean BMI and IAP ($P > 0.80$) or the degree of SUI ($P = 0.15$). The impact of IAP during maximum strain on VUVJ movements in women with SUI is illustrated in Figure 1. An increase of over 60 cmH_2O led to a mean increase of 1.1 mm in the VUVJ movement ($P = 0.81$) and of 0.3mm, 0.5mm and 0.9mm, respectively, in the HUVJ movement ($P = 1.0$), PUL ($P = 0.90$) and UPD ($P = 1.0$). The higher the IAP the lesser the number of women presenting UVJ hypermobility (a vertical movement of the UVJ beyond 9 mm), as shown in Table 2. Actually, among the 31 women with UVJ hypermobility, 28 (90.3%) easily showed it with an IAP over 40 cmH_2O. This percentage decreased to 51.6% with recorded pressures over 100 cmH_2O for only 16 patients presented UVJ hypermobility under such high pressures, but again this difference was not significant ($P = 1.0$). Hence, our data suggest that women with SUI presenting UVJ hypermobility show it on perineal ultrasound without much effort, a simple increase of 40 cmH_2O in the IAP seems to be enough.

It was interesting to observe that 3 (9.7%) women with UVJ hypermobility presented it with an IAP lower than 40 cmH_2O. On the other hand, none of the women without UVJ hypermobility turned out to present it during maximum straining, in addition to that, 40% of them produced IAPs over 100 cmH_2O. Therefore, in women with SUI without UVJ hypermobility, there seems to exist a balance between the IAP and the reaction of the pelvic floor muscles, so that what was not meant to happen would not be changed due to increased pressures.

Then we became interested in analysing this phenomenon stratified by the degree of SUI. The descriptions of mean intra-abdominal pressures and vertical UVJ movements according to the degree of SUI are found in Tables 3 and 4, respectively.

The effects of increased IAPs on perineal ultrasound measurements of the PUL are depicted in Table 5. All 19 women with a PUL on strain over 14mm showed it with an IAP over 40 cmH_2O. So the same reasoning for the VUVJ movement applies here - there is no need to monitor IAP during perineal ultrasound assessments of the PUL.

When it comes to the analyses of the influence of intra-abdominal pressure on UPD changes over 4mm and HUVJ movements over 3mm, the likelihood of these happening also decreased with increasing IAPs, although these phenomena were not significant (P > 0.13).

TABLE 1 - Measurements of variables of interest from the study population.

	Mean ± SD	Minimum	Maximum	Median	Mode	P-value
BMI	28.3 ± 4.2	21.3	35.9	28.2	21.3	< 0.000001
No. of vaginal deliveries	2.5 ± 2.0	0	8	2	1	< 0.000001
IAP (cmH_2O)	99.3 ± 51.8	7	193	99.5	102	< 0.000001
VUVJ movement (mm)	16.0 ± 6.8	4	35	17	17	< 0.000001
PUL change (mm)	14.3 ± 5.1	4	23	15	18	< 0.000001
UPD change (mm)	3.8 ± 5.9	-11	12	5.5	8	0.0007
HUVJ movement (mm)	3.1 ± 1.0	-13	17	3	2	0.004

BMI = body mass index. IAP = intra-abdominal pressure. VUVJ = vertical urethrovesical junction. PUL = proximal urethra length. UPD = urethropubic distance. HUVJ = horizontal urethrovesical junction. SD = standard deviation.

TABLE 2 - The impact of IAP on women with SUI presenting UVJ hypermobility (a vertical UVJ movement over 9 mm) as assessed by perineal ultrasound with a barely empty bladder.

IAP (cmH2O)	No. of women with a VUVJ movement > 9mm	Relative risk	P-value
> 40	28	1.51	0.13
> 60	23	1.11	0.60
> 80	20	1.16	0.29
> 90	18	1.11	0.64
>100	16	1.07	1.00

TABLE 3 - Distribution of IAP measurements on perineal ultrasound of women with a barely empty bladder according to the degree of SUI.

Intra-abdominal pressure measurements (cmH2O)					
SUI degree	Mean ± SD	Minimum	Maximum	Median	Mode
1	97.8 ± 50.3	20	182	93.5	20
2	91.2 ± 48.6	7	186	94	7
3	110.4 ± 59.6	28	193	118	28

$\chi^2 = 0.67$ P = 0.71

TABLE 4 - Behavior of the vertical UVJ movement on perineal ultrasound with a barely empty bladder according to the degree of SUI.

Vertical UVJ movement (mm)					
SUI degree	Mean ± SD	Minimum	Maximum	Median	Mode
1	17 ± 7.7	5	35	17	11
2	16.3 ± 6.3	4	33	17	17
3	14.5 ± 6.5	5	26	16	17

$\chi^2 = 0.65$ P = 0.72

TABLE 5 - The impact of IAP on PUL of women with SUI as assessed by perineal ultrasound with a barely empty bladder.

IAP (cmH2O)	No. of women with a PUL change > 14mm	Relative risk	P-value
> 40	19	?	< 0.02
> 60	17	3.27	< 0.02
> 80	15	2.39	< 0.05
> 90	13	1.73	0.19
>100	12	1.71	0.18

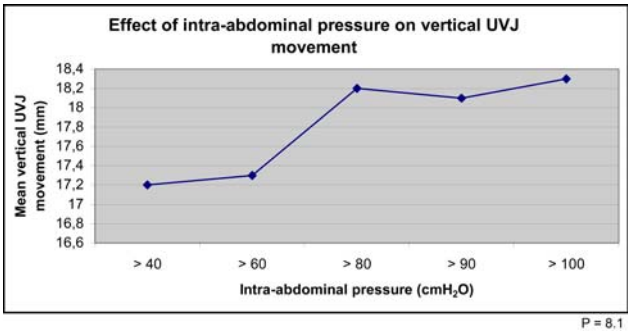

FIGURE 1 - The behavior of the VUVJ movement according to increased levels of IAP on perineal ultrasound assessments with a barely empty bladder.

Discussion

In analogy with our work, a recently published study involving women, slightly younger and slimmer than our population, with a mean age and BMI, respectively, of 33 ± 9 years and 24 ± 6, described a mean urethral retro-resistance pressure, which is the pressure required to achieve and maintain an open sphincter, of 112.6 ± 39.2 cmH_2O in women without SUI and of 69.9 cmH_2O in symptomatic SUI patients[9]. These findings corroborate ours in that the mean IAP in women with genuine SUI was 99.3 ± 51.8 cmH_2O, over the urethral retro-resitance pressure of women SUI and lower than the value described for women without SUI.

As depicted in Figure 1, women who exerted a higher IAP during Valsalva's maneuver had a minor tendency toward longer VUVJ movements, even though this difference was numerically very small (1.1 mm) and statistically not significant (P = 0.81). The same was true to the other parameters assessed. Therefore, the increase in IAP during Valsalva's maneuver does not significantly affect the main parameters involved in female urinary continence as assessed by perineal ultrasound with a barely empty bladder. In other words, during perineal ultrasound assessments of the UVJ and PU, it is not necessary to routinely monitor IAP for its influence on these measurements is not significant (P > 0.80). This is very important to emphasize given that the simpler, the lesser invasive, the more comftable the method of assessment, the more reliable and applicable the results will be. The literature is vast on examples supporting this argument, including a study showing that the simple presence of an intravaginal electrode, even without any stimuli whatsoever, improved the functional urehral profile length, the maximum urethral closure pressure, and areas of the urethral pressure profile similarly to what would happen if an electrical stimulation was applied[10].

Our findings suggest, as shown in Table 2, that women with SUI associated with UVJ hypermobility would present it, while straining, without much effort in 90.3% of cases. What is more, the stronger women with SUI pushed during straining the lower the likelihood of her presenting UVJ hypermobility. This is a paradox as we initially thought that the higher the intra-abdominal pressure the higher the likelihood of UVJ hypermobility in women with SUI. Then one could argue that most likely this is due to the fact that the ones with more severe degrees of SUI would push less in order to avoid involuntary leakage. However, our findings comparing the means, medians, minimum and maximum values also showed that this is not true because the more severe the SUI the stronger the women pushed, even though the lesser it was the VUVJ movement recorded, as shown in Tables 3 and 4. In line with these observations regarding the VUVJ movement, a study described a significant inverse correlation between the degree of SUI and Valsalva's maneuver as well as cough leak point pressures[11]. Nevertheless, similar studies with larger sample sizes should be encouraged to clarify this issue further for these differences were not statistically significant in the present study (P > 0.70). These pieces of evidence point out to the fact that, in spite of the severity of the SUI, women do push as much as they can on straining. Also, that the increased IAP might trigger an involuntary mechanism of pelvic floor muscle contractions directed to trying and maintaining the UVJ on a higher position to avoid urinary leakage. As a matter of fact, based on behavioral construct, women learn to consciously pre-contract the pelvic floor muscles before and during increases in abdominal pressure, such as coughing and other physical activities, to prevent leakage and end up contracting the pelvic floor muscles automatic[12].

What is more motivating is that intercostal muscle electromyography, a non-invasive measurement that can replace intravesical or intra-rectal determinations to quantify the forces during straining, reflects the real intra-abdominal pressure[13] and could well be used in further research.

The effect of increased IAPs on the PUL changes over 14 mm was more significant than the ones on the other study parameters. As illustrated in Table 5, the higher the IAP the lesser the number of women and the likelihood of a PUL becoming longer than 14mm because all 19 patients with such a characteristic showed it with an IAP > 40 cmH_2O. Hence, again, a minimum effort while strainnig was enough to produce the expected response. Therefore these findings

emphasize that there is no need to rotinely monitor IAP during such assessments. Even with an IAP cut-off over 80 cmH_2O, there was a more than 2-fold increased likelihood of the woman to present a PUL over 14mm and this difference was statistically significant ($P < 0.05$). So the naturally acquired mechanisms of pelvic floor muscle adaptation secondary to increased IAPs not only appear to act maintaing the UVJ slightly higher but, most importantly, it seems that they work jointly to elongate the PU, as a priority, thus facilitating an increase in the urethral resistance and pressure profile. Indeed, the pelvic floor muscles, part of the trunk stability mechanism, contribute to urinary continence. Their function is interdependent with other muscles of this system and they can have their tonic activity triggered by abdominal muscle action[14].

Conclusion

The increases in IAP in women with genuine SUI during perineal ultrasound assessments with a barely empty bladder did not significantly influence the VUVJ movement. It did induce a significant elongation of the PUL over 14 mm up to a pressure cut-off point over 80 cmH_2O, most likely to increase urethral resistance and pressure profile, thus avoiding urine leakage. However, all 19 women with such a characteristic presented so with an IAP > 40 cmH_2O. Therefore, we conclude there is no need to monitor IAP during perineal ultrasound assessments of the UVJ and PU having the patient a barely empty bladder (< 50 ml).

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