Urodynamic aspects of feminine urinary incontinence treated with slings


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Received 14 March 2010; accepted 18 June 2010
Available online 14 May 2012

Abstract

Objectives: Treatment of feminine stress urinary incontinence (SUI) with slings aims to supplement the function of the damaged ligaments, favoring the correct transmission of the tensions. Our objective is to determine which preoperative variables could predict the outcome of surgical treatment of SUI and to study the urodynamic changes produced by the surgery. Material and methods: 139 women (age $X = 61.7; \sigma = 10.88$) operated on due to SUI were studied retrospectively. In 118 cases (84.8%), sling techniques (TVT, TOT, TVT-Safyre, and REEMEX) were used. Clinical evaluation and complete preoperative video-urodynamics were made preoperatively and at 3 months of surgery. A statistical study (Fisher’s test, Wilcoxon, Friedman, Student’s $t$ and Pearson’s $r^2$) and analysis of multivariate logistic regression analysis by step elimination method were performed. Results: Post-operatively, the SUI ($p = 0.000$) and bladder hyperactivity syndrome decreased. The success percentages (urodynamic absence of SUI) for each technique were: TVT-Safyre (75%), TOT (73%), TVT (60%) and REEMEX (57%), without significant differences. Age (ROC cut-off: 61 years) was a prognostic factor of success ($p = 0.024$). Preoperative maximum flow ($Q_{\text{max}}$) (16 ml/s) constituted the only urodynamic parameter with a predictive value for success ($p = 0.026$). An open bladder neck was a risk factor for persistence of postoperative SUI (RR = 2.78). A significant decrease of the postsurgical $Q_{\text{max}}$ ($p = 0.017$) was verified, without increase of the post micturition residue or of the $W_{\text{max}}$. An increase of the postsurgical urethral resistance (UR) was also observed ($p = 0.004$). Conclusions: The pre-operative $Q_{\text{max}}$ is the most important urodynamic prognostic parameter in feminine SUI surgery, its normality being associated to a greater probability of cure of the incontinence. In the cases of decreased preoperative flow, use of slings that increase urethral resistance more (REEMEX) is not recommended. Hyperactivity of the preoperative detrusor does not significantly modify the results of surgery of the SUI.

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PALABRAS CLAVE
Incontinencia urinaria de esfuerzo; Slings; Urodinámica

Aspectos urodinámicos de la incontinencia urinaria femenina tratada con cabestrillos

Resumen
Objetivos: El tratamiento de la incontinencia urinaria de esfuerzo (IUE) femenina con cabestrillos, pretende suplir la función de los ligamentos dañados, favoreciendo la transmisión correcta de las tensiones. Nuestro objetivo es determinar qué variables preoperatorias pueden predecir el resultado del tratamiento quirúrgico de la IUE y estudiar los cambios urodinámicos que produce la cirugía.

Material y métodos: 139 mujeres (edad \( \bar{x} = 61.7; \sigma = 10.88 \)) intervenidas por IUE fueron estudiadas retrospectivamente. En 118 casos (84.8%) se utilizaron técnicas de cabestrillo (TVT, TOT, TVT-Safyre, REEMEX). Se realizó evaluación clínica y video-urodinámica completa preoperatoria y a los tres meses de cirugía. Se realizó tratamiento estadístico (test de Fisher, Wilcoxon, Friedman, t Student y \( \chi^2 \) Pearson) y análisis de regresión logística multivariante mediante método de eliminación por pasos.

Resultados: Postoperatoriamente disminuyó la IUE (\( p = 0.000 \)) y el síndrome de hiperactividad vesical (\( p = 0.001 \)). Los porcentajes de éxito (ausencia urodinámica de IUE) para cada técnica fueron: TVT-Safyre (75%), TOT (73%), TVT (60%) y REEMEX (57%), sin diferencias significativas. La edad (punto de corte ROC 61 años) fue factor pronóstico de éxito (\( p = 0.024 \)). El flujo máximo (Qmax) preoperatorario (16 ml/s) constituyó el único parámetro urodinámico con valor predictivo (\( p = 0.026 \)) para éxito. Un cuello vesical abierto fue factor de riesgo para la persistencia de IUE postoperatoria (RR = 2.78). Se comprobó disminución significativa de Qmax postquirúrgico (\( p = 0.017 \)), sin aumento del residuo postmecional ni de Wmax. También se observó aumento de URA (resistencia uretral) post-cirugía (\( p = 0.004 \)).

Conclusiones: El Qmax preoperatorio es el parámetro urodinámico pronóstico más importante en la cirugía de la IUE femenina, asociándose su normalidad a una mayor posibilidad de cura de la incontinencia. En los casos de flujo preoperatorio disminuido se desaconseja los cabestrillos que más incrementen la resistencia uretral (REEMEX). La hiperactividad del detrusor preoperatorio no modifica significativamente los resultados de la cirugía de la IUE.

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Introduction
Surgical treatment of stress urinary incontinence (SUI) aims the urethral pressure to be maintained above the bladder pressure, both at rest and during increases in pressure caused by increased abdominal pressure. With the objective of improving the results of the technique, and of minimizing the discomfort of the treatment, various models of tension-free sling which have appeared on the market have been used.

In order to know the factors that influence the outcome of the surgical treatment of the SUI, we face the difficulty of performing rigorous experimental studies, with objective approach such as determining whether a variable is related to the outcome of the different types of treatment described.

In this sense, the main objective of this work is to determine which preoperative variables can be used to predict the outcome of the surgical treatment of female SUI with the different suburethral sling techniques. The secondary objectives are to analyze: (a) if SUI surgery causes other changes in the filling phase of the lower urinary tract and, if so, whether there are predictive variables with respect to these changes; and (b) if SUI surgery leads to changes in the voiding phase of the lower urinary tract and, if so, whether there are predictive variables regarding these changes.

Material and methods
We performed a retrospective study on a cohort of 139 women of mean age 61.7 years (standard deviation: 10.88 years), undergoing incontinence because of presenting SUI. The patients were classified according to urethral hypermobility (52%) and cervical incompetence (4%).

The choice of the surgical technique has not been a variable possible to control, because it is a retrospective analysis of patients assigned to different services. The surgical techniques used are shown in Fig. 1. In 118 cases (84.8%) slings, which are the main study population, of different types, were used: TVT (30.9%), TOT (29.5%), REEMEX (15.8%), and SAFYRE (TVT) (8.6%) and Infast (2.2%).

The patients underwent a clinical examination before surgery and three months thereafter (evaluating the presence of SUI, overactive bladder syndrome, and symptoms of the voiding phase), and a complete video urodynamic study (prior informed consent), both of the filling and the voiding stages. A urethral profile was also performed in the postoperative period.

The data were recorded in an Excel® spreadsheet, and imported into the SPSS® software for statistical analysis. The statistical tests used were: Fisher's exact test for dichotomous variables, non-parametric Wilcoxon's test for two dependent categorical samples, non-parametric Friedman's test for more than two categorical dependent samples,
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Figure 1  Type of female SUI interventions performed.

Student’s ’t’ test for comparison of means for two dependent parametric samples, and Pearson’s chi-square test for independent categorical variables, and Student’s ’t’ test for comparison of means for two independent parametric samples. The significance level was set at bilateral p < 0.05. Bilateral p < 0.1 was considered a trend toward significance.

Finally, we performed a multivariate logistic regression analysis for predictive purposes, the dependent variable being persistent postoperative SUI, using the step elimination method in steps (step-way).

Results

The variation of the most significant symptoms after surgery is shown in Table 1. A significant decrease in the percentage of both clinical SUI and urodynamic SUI was observed, from 100% preoperatively to 25% postoperatively, this reduction being statistically significant (p = 0.000). With regard to the success of the different surgical techniques, there were no statistically significant differences between them (p = 0.443). The postoperative variation of the urodynamic variables is shown in Tables 2–4.

In the filling phase, 30% of the patients had symptoms of preoperative bladder overactivity. In the postoperative period, there was a statistically significant decrease in these symptoms (p = 0.001). Although we found more cases of detrusor overactivity postoperatively (36%) than preoperatively (30%), no statistically significant differences were detected (p = 0.493). In the postoperative period, there was diminished amplitude of the involuntary contraction (p = 0.013) and of the bladder capacity at which the contraction occurred (p = 0.000) in the patients with persistent overactivity after surgery. Ex novo overactivity appeared in 12% of the cases.

As for the voiding phase, there was a slight increase in the symptoms of the voiding phase, but only with a tendency to statistical significance (p = 0.072). We did find, however, a significant decrease in the peak flow in the postoperative period (p = 0.017) and in the peak flow percentile postoperatively (p = 0.001), as well as a significant increase in the UR increase (p = 0.004). No differences in the contractile power (W80-20) between the pre- and postoperative periods (p = 0.490).

The preoperative variables (Tables 5 and 6) that might be predictive of the outcome of the intervention were studied. The only variables that had statistical significance were age and preoperative urinary flow and, with a trend to significance, cervical incompetence. There was a significant relation between the absence of postoperative urodynamic SUI and age (p = 0.024). However, we observed that the patients with preoperative abnormal peak flow percentile (p < 50) have a greater risk of not healing (p = 0.045), and the same thing happens if the preoperative peak flow rate is decreased (p = 0.026). The patients with cervical incompetence also had a greater risk of not healing (p = 0.099), with a relative risk of 2.78. Neither the preoperative UR increase nor the power of the detrusor was predictive of the success or failure of the intervention.

The ROC curves were constructed for the variables with statistically significant predictive value for the cure of the SUI, age (Fig. 2) and preoperative peak flow (Fig. 3). For the peak flow, the ideal cut-off point was set at 16 ml/s and at 61 years for age, i.e., the patients aged over 61 years or with flow under 16 ml/s in the preoperative period were less likely to cure the incontinence after the intervention.

The only preoperative variable that was statistically significant for the disappearance of detrusor overactivity in the postoperative period was age, setting the ideal cut-off point by means of the ROC curve at 60 years (p = 0.020) (Fig. 4). We did not obtain any statistically significant relation between the different preoperative variables and the occurrence of the de novo detrusor overactivity. No Statistical significance between the preoperative variables and the postoperative peak flow reduction was not observed either, although the previous decreased Qmax almost reached statistical significance differences (p = 0.056).

The emergence of postvoid residue in the postoperative period was associated with the preoperative UR increase, those with higher UR increase having greater residue in the preoperative period (p = 0.029). A tendency to the residue was also shown in the patients with preoperative symptoms of the voiding phase (p = 0.063), in which TVT and REEMEX were placed (p = 0.080) and which had decreased preoperative Qmax (p = 0.065).

Finally, we also studied the relations between the postoperative, both clinical and urodynamic, variables. We found a significant relation between persistent postoperative clinical and urodynamic SUI (p = 0.001) and between postoperative urodynamic SUI and a lower closing pressure

Table 1  Postsurgical variation of symptoms.

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Statistical significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased SUI</td>
<td>p = 0.000*</td>
</tr>
<tr>
<td>Decreased overactive bladder syndrome</td>
<td>p = 0.001*</td>
</tr>
<tr>
<td>Increased filling phase symptoms</td>
<td>p = 0.072**</td>
</tr>
</tbody>
</table>

* Significant.
** Trend to significance.
### Table 2  Postsurgical variation of urodynamic variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Preoperative period</th>
<th>Postoperative period</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Q_{\text{max}}$ (ml/s)</td>
<td>23.39 (22.70)</td>
<td>19.02 (10.91)</td>
<td>0.017&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Postvoid residue (ml)</td>
<td>13.49 (42.82)</td>
<td>10.56 (35.3)</td>
<td>0.839</td>
</tr>
<tr>
<td>Voluntary contraction amplitude (cm H₂O)</td>
<td>27.58 (16.50)</td>
<td>16.12 (18.04)</td>
<td>0.013&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Voluntary contraction capacity (ml)</td>
<td>133.21 (81.54)</td>
<td>55.33 (75.61)</td>
<td>0.000&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>UR increase (cm H₂O)</td>
<td>10.14 (5.79)</td>
<td>12.30 (8.55)</td>
<td>0.004&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>W 80-20 (W/m²)</td>
<td>1.40 (3.22)</td>
<td>2.51 (10.31)</td>
<td>0.490</td>
</tr>
</tbody>
</table>

<sup>a</sup> Mean (standard deviation between brackets).
<sup>b</sup> Patients with pre- and postoperative overactivity.
<sup>c</sup> Significant.

### Table 3  Postoperative variation of urodynamic variables.

<table>
<thead>
<tr>
<th>Variable&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Preoperative percentage (%)</th>
<th>Postoperative percentage (%)</th>
<th>Significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUI</td>
<td>100</td>
<td>25</td>
<td>0.000&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Detrusor overactivity</td>
<td>30</td>
<td>36</td>
<td>0.493</td>
</tr>
<tr>
<td>Percentile $Q_{\text{max}}$&lt;sup&gt;b&lt;/sup&gt;</td>
<td>23</td>
<td>9</td>
<td>0.001&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> Presence of the symptom.
<sup>b</sup> P50.
<sup>c</sup> Significant.

### Table 4  Postoperative variation of urodynamic variables.

<table>
<thead>
<tr>
<th></th>
<th>Postoperative urodynamic results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal (%)</td>
</tr>
<tr>
<td>SUI (preoperative)</td>
<td>51.32</td>
</tr>
<tr>
<td>SUI and overactivity (preoperative)</td>
<td>30.30</td>
</tr>
</tbody>
</table>

on the urethral profile ($p = 0.025$). In contrast, none of the entities, such as detrusor overactivity, peak flow, the closing functional length (urethral profile), the UR increase, the transmission of pressures, were statistically significant among the patients with and without SUI postoperatively.

Regarding the voiding phase in the postoperative period, the presence of symptoms of the voiding phase was associated with the existence in the postoperative period of decreased peak flow ($p = 0.001$) and showed a trend toward significance in the patients with postvoid residue ($p = 0.058$).

The postoperative peak flow was greater when there was no overactivity ($p = 0.005$) and there was a tendency to UR increase and W80-20 higher when there was detrusor overactivity. The postoperative peak flow is inversely related to the postoperative UR increase ($p = 0.007$) and directly to the W80-20 ($p = 0.000$). There was a trend to statistical significance between the UR increase and the emergence of postvoid residue.

In the multivariate analysis, three variables associated to persistent postoperative SUI were found: age, peak flow,
and presence of bladder neck incompetence. In the step-way analysis, only one independent predictor of postoperative SUI was found: preoperative peak flow ($p = 0.0001$). Age was shown to be dependent on $Q_{\text{max}}$, decreased flow occurring at an older age.

## Discussion

The cure rate of our incontinence series and the decreased urodynamic SUI are similar to those described by other authors.\(^1\) Possibly, our series do not show better results when patients come from different teaching hospitals and it is an outcome of the learning curve, and when the indication has been established by clinical symptoms only. Although apparently TVT-Safyre and TOT showed better results, there was no difference of statistical significance. Other authors have shown no significant differences between different techniques.\(^2\)

Studying the clinical variables, both their relations to urodynamic parameters and their possible predictive value, in our study, we found a statistically significant relation between clinical and urodynamic SUI.\(^3\)

Age in our series appeared as a predictor of absence of SUI in the postoperative period of incontinence surgery. However, multivariate analysis determined that age is not an independent variable. Deutsch et al.\(^4\) also observe that age is a poor prognostic factor. However, in a multivariate analysis, Daneshgari et al.\(^5\) found that neither age nor body mass index, race, obstetric history, or hormonal status were risk factors for recurrence of incontinence after surgery.

The presence of overactive bladder syndrome was not proved as a prognostic factor of the result of incontinence surgery. There was no relation between symptoms of the voiding phase and the presence of postoperative urodynamic SUI either.\(^6\)

Regarding urodynamic findings, preoperative peak flow was the only urodynamic parameter with predictive value regarding the postoperative outcome.\(^7,8\) In addition, the multivariate analysis showed that it was the only independent predictor of the postoperative outcome. Although the peak flow rate depends on three factors (micturition

![Figure 2](image2.png)  
**Figure 2** Diagnostic yield curve of age with regard to healing of postoperative urodynamic stress incontinence.  

![Figure 3](image3.png)  
**Figure 3** Diagnostic yield curve of $Q_{\text{max}}$ with regard to postoperative urodynamic stress incontinence.
volume, urethral resistance, and bladder contractility), in our series, we found no relation among these three variables alone and postoperative urinary continence.

With regard to the video-urodynamic results, we found no differences in the outcome between cases with or without urethral hypermobility. In the literature, there are different opinions. To Fritel et al.,\textsuperscript{9} the presence or absence of urethral hypermobility is a predictive factor for the outcome of surgery; the greater mobility, the better result. Similarly, Meschia et al.\textsuperscript{10} report that the absence of hypermobility in the preoperative period is a poor prognostic sign. In contrast, other authors such as Minaglia et al.\textsuperscript{11} find no relation between postoperative hypermobility and the cure of urinary incontinence. In our series, the presence of an open bladder neck was a risk factor for persistent postoperative SUI. However, this difference was not fully significant, possibly due to the small number of women with open neck who underwent surgery.\textsuperscript{12}

In our series, we observed a significant relation between postoperative maximum urethral closure pressure (MUCP) and urinary incontinence. The patients with incontinence had a significantly lower MUCP. However, the length of the functional urethra showed no relation. Dörflinger et al.\textsuperscript{13} also found a relation between maximum urethral closure pressure and urinary incontinence.

After surgery, 50% of the patients with overactive bladder syndrome disappeared, while in 26% of the patients without prior overactive bladder syndrome it appeared after surgery (12% if we look at urodynamic detrusor overactivity). Overall, the net result was that the percentage of patients with overactive bladder syndrome decreased from 61 to 42%. Kulseng-Hanssen et al.\textsuperscript{14} observed the occurrence of de novo urge incontinence in 11% of patients operated on for TVT and found that women with mixed incontinence had worse postoperative outcome than those who only had SUI. Porena et al.\textsuperscript{1} suggest that patients undergoing TVT experienced more symptoms of the filling phase compared with those who underwent TOT. Overall, we observed an increase in the percentage of postoperative detrusor overactivity (30–36%). However, this change was not statistically significant.

Overall, the net result was that the percentage of patients with overactive bladder syndrome decreased from 61 to 42%. Kulseng-Hanssen et al.\textsuperscript{14} observed the occurrence of de novo urge incontinence in 11% of the patients operated on for TVT, and they found that women with mixed incontinence had worse postoperative outcome than those who only had SUI. Porena et al.\textsuperscript{1} suggest that the patients undergoing TVT experienced more symptoms of the filling phase compared to those who underwent TOT. Overall, we observed an increase in the percentage of postoperative detrusor overactivity (30–36%). However, this change was not statistically significant.

Osman\textsuperscript{15} compared anticholinergic treatment versus surgical treatment with pubovaginal sling or Burch in women with mixed incontinence, and they observed a higher percentage of disappearance of urge incontinence with surgery than with medical treatment, although urge incontinence appeared after the intervention in 20% of patients with prior isolated SUI. Ducket et al.\textsuperscript{16} observed a higher percentage of post-TVT detrusor overactivity in cases with decreased preoperative urinary flow, attributing it to an obstructive effect of surgery.

In our study, the only variable that significantly predicted postoperative disappearance of hyperactivity was the age of the patient. The patients younger than 60 years had a significantly better healing rate. With regard to the ex novo detrusor overactivity, we have not detected any predictive factor of its appearance. However, the literature has identified other factors such as detrusor pressure greater than 15 cm H2O during the filling\textsuperscript{17} or elevated preoperative flow acceleration\textsuperscript{18} in addition to age, previous surgery, or radiological evidence of urethral compression.\textsuperscript{19}

Another interesting aspect is the impact of the intervention on the voiding phase. In our series we observed a significant decrease in peak urinary flow with surgery. This observation had already been identified by other authors.\textsuperscript{20} Dolan et al.\textsuperscript{21} point that the decrease in peak flow is only observed in the patients in whom incontinence disappears after surgery, and this decrease in the peak flow is accompanied by an increased opening voiding pressure.

In our study, the postvoid residue did not increase after surgery, although a direct relation was found between the presence of postoperative postvoid residue with prior existence of symptoms of the filling phase and with preoperative peak flow. The strongest relation was established between the postoperative postvoid residue and the preoperative UR increase figure.\textsuperscript{22,23} The surgical technique used did show an influence on the appearance of the postvoid residue in our series, the residue being less with TOT and TVT-Safyre than with TVT and REEMEX.

Contractile power measured by the parameter W80-20 did not experience any change either. Groen and Bosch\textsuperscript{24} found that the patients with greater contractile power measured by the parameter WF tend not to require catheterization in postoperative incontinence surgery.

We think that although the urodynamic study is subject to revisions with regard to its indications in female SUI, it remains a useful tool to decide the treatment of this pathology.\textsuperscript{25} Furthermore, the introduction of new types of

![Graph](image-url)
less invasive slings is necessary to consider the importance of a long-term urodynamic evaluation of this condition, allowing us to better understand the functional evolution of the patients and to better predict the risk of failure of the surgery.16,27

Conflict of interest

The authors declare that they have no conflict of interest.

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23. Yang AC, Chen MC. The correlation between preoperative voiding mechanism and surgical outcome of the tension-free vaginal tape procedure, with reference to quality of life. BJU Int. 2003;91:502–6.