Etiopathogenesis, diagnostics and history of surgical treatment of stress urinary incontinence

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Urinary incontinence represents involuntary urine leakage into the urethra. This pathological condition represents a major medical, social and hygienic problem.

The paper presents risk factors for development of the disorder, as well as diagnostic methods applied in evaluation of the female patients. Chronological review of diverse surgical techniques used in treatment of stress urinary incontinence reported in the published scientific papers is also presented. Review of the literature data was also performed. Sling procedures with application of suburethral loops have been used since the beginning of the last century in treatment of this disorder. Surgical treatment of stress urinary incontinence is applied when conservative treatment fails to give any effects according to strictly defined indications. During the last 100 years, surgical techniques have undergone different improvements and the results have also been significantly improved.

Key words: stress urinary incontinence, surgical treatment of SUI, background.

INTRODUCTION

Urinary incontinence represents involuntary urine leakage to the urethra. This disorder represents major medical, social and hygienic problem. It appears in both female and male patients, and even in children. Complexity of the problem necessitates a multidisciplinary approach (urologist, gynecologist, neurologist, physiatrist, pediatrician, pediatric surgeon) to diagnosis and therapeutical choice.

Four types of urinary incontinence are recognized:
1. Stress urinary incontinence
2. Urinary urge incontinence
3. Overflow
4. Functional urinary incontinence

Stress urinary incontinence (SUI) is a special type of the urinary incontinence appearing as a result of the sudden increase in intraabdominal pressure (sneezing, laughter, heavy weight lifting). The disorder has been subject of studies and treatment for the long period of time. Between 25 and 30% of women suffer from the urinary incontinence. Out of that number, 50% has stress urinary incontinence (SUI) while 25% has mixed incontinence (stress and urge)¹.

ANATOMY

In 1994, DeLancey published “hammock theory” stipulating that the posterior vagina provides support to the urethra, which is compressed against it in the course of the increase in intraabdominal pressure. Sudden increase in intraabdominal pressure causes pubococygeal muscle contractions. The contraction leads to stretching and stiffening of the vaginal portion beneath the urethra, which enables closure of the urethral sphincter⁵. The surrounding structures are highly important for supporting of the urethra positioned in this way. Pubourethral ligament is fixed on one side to the middle part of the urethra and to the lower side of the public bone on the other, thus preventing urethral descent, providing its support together with the pubourethral muscle, which is a part of the levator ani muscle. These two structures together represent middle urethral complex. Dysfunction or loss of the support of the above-mentioned complex is presently considered responsible for onset of stress urinary incontinence in women. Pubocervical fascia, which is a part of the endopelvic fascia, adhering to the arcus tendineus of the pelvic fascia provides great fibrous support in women⁶. Two arcus tendinuses are tension structures located on the both laterals sides of the urethra and vagina, traveling from the interior side of the pubic bone all the way to the spina ischiadica. Arcus tendineus acts as hanging bridge ropes providing necessary support in securing the urethra on the posterior vaginal wall. Musculature of the pelvic floor comprises levator ani muscle, which bears the pelvic content weight and prevents stretching of the ligamental support under the influence of intraabdominal pressure. Levator muscle is composed of three parts: pubourectal muscle, pubococygeal muscle and iliococygeal...
gical muscle. On its anterior side, levator ani muscle creates an opening which represents the urogenital hiatus through which vagina and urethra pass, while anal hiatus is placed on the anterior side, through which terminal portion of the colon passes. Constant pelvic flood muscle tone is also the result of type I muscle fibers and it compresses the urethra and anterior vaginal wall against the pubic bone ramus thus closing the hiatus.

Functional innervation of the small pelvis is necessary for optimal support to the small pelvic organs (parasympathetic innervates smooth muscles of the urinary bladder, sympathetic innervates urinary bladder neck and urethra, while external urethral sphincter is innervated by the pudendal nerve). This peripheral innervation originates from the sacral spine (S2-S4). All the above-mentioned parts of the peripheral nervous system are controlled by the central nervous system. Absence of the central nervous system control leads to incontinence and involuntary leakage of urine. Each type of the small pelvic denervation may influence continence. Thus, in women who had had multiple vaginal deliveries presence of certain degree of denervation was evidenced by electromyography, and they more frequently suffer from stress urinary incontinence. Other factors that may lead to certain degree of denervation include: surgical procedures in the small pelvis, radiotherapy and certain neurological conditions such as spina bifida and muscle dystrophy.

PATHOPHYSIOLOGY OF STRESS URINARY INCONTINENCE

In order to maintain continence in women, intrauterine pressure must exceed the bladder pressure both at rest and in situations when intraabdominal pressure is increased. The mechanisms controlling the urinary continence include the following complex: normal functions of the peripheral and central nervous systems, urinary bladder wall, urinary bladder, urethral and pelvic floor muscles. Dysfunction of the lower urinary tract may be the result of dysfunction of any component of the above complex. The urethra has certain mechanisms which keep it closed and impermeable for the urine except during the act of voiding. The former includes mucosal secretion itself, which increases the pressure within the urethral lumen, which is controlled by estrogen. Moreover, consistency of the urethra itself greatly contributes to continence. The smooth muscles extending from the urinary bladder neck, distributed into longitudinal and circular fibers participate in urethral closure. Additionally, urethra has two sphincters: internal sphincter composed of striated muscles and external urethrovaginal sphincter. In all its length, the urethra lies on the anterior vaginal wall, firmly adhering to the pubocervical fascia, making a mild turn in its proximal part at the level of urethrovaginal transition, below the pubic bone. At this location, a portion of the pubocervical fascia, known as pubourethral ligament is separated.

In static disorders of the internal female genital organs, urethral hypermobility develops as a result of the impaired supporting mechanism. In case of the increased intraabdominal pressure, urinary bladder neck and proximal urethral descend, which causes uneven distribution of pressure on the urethra. Urinary bladder pressure overpowers urethral pressure, which results in involuntary leakage or urine. Urethral hypermobility is a result of disturbance of the normal anatomy of the vagina and pelvic floor, and such a disorder is usually initiated in the course of vaginal delivery to be further exacerbated with age and hypoestrogenic status in menopause. The final result of the events is rotation and descending of the proximal urethra significantly below its normal retropubic position, which eventually results in onset of SUI.

In 1988, Olsson and Blaivas presented a new classification of SUI, in which weakness of the internal urethral sphincter was for the first time implied as a cause of incontinence, in absence of any defect in the mechanism of vaginal support. It was named SUI type III, distinguishing it from types I and II, which are associated with urethral hypermobility. This type III is frequently described as internal sphincter deficiency (ISD). All the above mentioned points out to the importance of the internal urethral sphincter which is controlled by the pudendal nerve. Typical patient with internal sphincter deficiency also has low urethral occlusive pressure and funnel-shaped widening of the proximal part of the urethra. The most common causes of this type of incontinence are ischemia secondary to pelvic and vaginal surgical procedures, multiple surgeries in the small pelvis leading to firm scars, denervation in patients suffering from neurological conditions or injuries caused by radiation therapy. For this reason, ISD represents the most severe form of SUI. Isolated ISD as a cause of incontinence is rare, and it appears more commonly in combination with urethral hypermobility.

RISK FACTORS FOR ONSET OF STRESS URINARY INCONTINENCE

Vaginal delivery has already been mentioned as a predisposing factor for onset of SUI. If the incontinence develops during pregnancy, it has the tendency to reverse during puerperium, however it may reappear during each subsequent pregnancy, deteriorate progressively and become a significant problem. The prevalence of stress incontinence is significantly higher among multiparous than among nulliparous women and it may be associated with the number of pregnancies. Viktrup and collaborators evidenced that out of 278 women, 30% develop stress urinary incontinence within 5 years after delivery. Vaginal delivery leads to partial denervation of the pelvic floor in primiparous women, however electromyographic evidence suggests that reinnervation occurs in 80% of cases. Multiparity, prolonged second stage of delivery (>30 minutes), application of a forceps, high birth weight (>4 kg) and third degree perineal tear are important risk factors for pudendal nerve injuries. Changes in quality of the connective tissue that provides support to the small pelvic organs may lead to stress urinary incontinence. Predisposing factors for changes in the connective tissue quality are age and changes of the hormonal milieu. There is also a special form of SUI with intrinsic sphincter dysfunction. Namely, anatomic relations are not disturbed but sphincters are not functioning (ISD). The reason most commonly lies in the ischemia of the pelvic floor caused by previous surgical procedures, radiation, multiparity or underlying neurological conditions.
Sphincter denervation is the underlying cause in all these conditions. Association between sphincter denervation and SUI is studied in detail on animals.

Chronic increase in intraabdominal pressure represents another risk factor. This group of patients will include those with obstruction, chronic obstructive pulmonary disease as well as individuals occupationally exposed to excessive physical strain.

METHODS USED IN DIAGNOSIS OF STRESS URINARY INCONTINENCE

Different diagnostic questionnaires, tests and examinations are used in detection of SUI. They may be divided in three groups: subjective, semi-objective and objective. Subjective information is obtained from history. Semi-objective information are obtained from voiding diary, pad test and different questionnaires. Objective information is obtained by physical examination, laboratory tests, radiological and ultrasonographic examinations, urodynaminc testing and cystoscopy.

The first and essential step in evaluation of SUI is taking history. The history should be detailed with particular attention paid to previous diseases and surgeries, particularly those performed for the same problem. Some diseases may have either direct or indirect influence on the voiding act disorder, such as diabetes mellitus, cerebrovascular insult, herniated disc, etc. Information on medicinal products used by the patient is also necessary, since some of them may affect sphincter and urinary bladder detrusor and thus cause retention, pollakiuria, incontinence or nocturia. The history may be supplemented by special questionnaires (IsiQ). Positive answers to specially formulated questions in these questionnaires may lead the physician to focus his/her further clinical evaluation appropriately. Such questionnaires may be used during the follow-up period after the surgical procedure for assessment of subjective success of the surgical procedure and detection of adverse effect that may appear.

Voiding diaries are useful and accepted methods in assessment of severity of incontinence and assessment of success after the intervention. The patients are asked to enter the information on the volume and frequency of fluid intake as well as volume and frequency of urine output over the period ranging from 1 to 7 days. Three-day diary is most commonly used in the practice. Urinary incontinence episodes and situations in which they appear are entered in the diary.

Having in mind the fact that stress incontinence only infrequently develops as insolated problem in women, as well as that it is associated with static disorder in two thirds of cases, gynecological examination is necessary. Gynecological examination is performed in dorsal lithotomy position, while maximal intraabdominal pressure is achieved by coughing or Valsalva maneuver. In this way static disorders may be evidenced in the anterior segment manifested by cystoceles of different grades; in the central segment when uterine cervix/vaginal apex sliding toward the hymenal plane; and in the posterior segment, when it is manifested as rectocele of different grades. Additionally, gynecological examination is necessary to rule out other pathological processes in the small pelvis. Rectal examination is also highly important for detection of pathological conditions in the small pelvis and fecal impactions that may lead to urinary incontinence, particularly in elderly female patients.

Urinary (and fecal) incontinence may be only the symptoms of an underlying neurological disease. Neurological examination should include evaluation of the mental status, sensory and motor functions of the lower extremities as well as examination of the lumbar sacral neurological function. Neurological lumbar sacral examination should include assessment of the following: 1) pelvic floor muscle strength, 2) anal sphincter tone at rest, 3) voluntary anal contraction, 4) perineal sensitivity. It is particularly important to examine sacral ligaments of the spine from the second to the fourth one containing important neurons associated with voiding act.

Certain diagnostic tests may be performed in the course of the physical examination that will facilitate diagnosis of SUI. These tests include Q-TIP, pad testing and stress testing.

Q-TIP test evidences urethral mobility. It comprises placing of a cotton-tipped swab into the urethra up to the urinary bladder neck level and measuring of the axis changes upon increase of the intraabdominal pressure. The test is performed with the patient in gynecological position. Angle between the swab and horizontal plane in the relaxed position is first measured. Thereafter, the patient is asked to cough and the new angle is measured. While the test is performed, it is highly important to assure that end of the swab is not in the middle urethra or in the urinary bladder, since this may cause false low measurement results. It was accepted for the angle greater than 30 degrees upon maximum strain to be considered abnormal, and the angle reaching up to 72 degrees was reported in women with marked SUI.

Perineal pad test is used to evidence presence and quantity of the urine leakage. The test is performed by asking the patient to place a pad and keep it for the certain period of time. Thereafter weight of the pad is measured. During the test, usual everyday activities of the patient should be mimicked. It is recommended for the test to last one hour and in case that the results are not representative, it should be extended for another hour. As for the interpretation of the results, it should be stressed that measured quantity of the fluid up to 1 g may be attributed to measurement error, perspiration and vaginal discharge. Phenazopyridine hydrochloride (Pyridium®) is occasionally used for evidencing of incontinence with pad test. Pyridium turns the color of urine into red-orange thus enabling easy identification of the involuntary urine leakage.

Stress testing is a simple and widely accepted method. Urinary bladder of the patient must be filled before commencement of the test. The patient is asked to void and thereafter urinary catheter is placed and residual urine is measured. At the same time, a sterile urine sample may be obtained for urine culture, if not performed before. Thereafter, filling of the urinary bladder is initiated using the communicating vessels principle (infusion system connected to catheter on one side and elevated bottle with sterile fluid on the other). The moment when first sensations in the urinary bladder are felt as well as maximum capacity of the urinary bladder should be re-
corded. Thereafter, the catheter is removed and the patient is asked to cough first in lying and then in upright position. Urine loss appearing simultaneously with coughing is a reliable indicator of SUI. If the urine leakage is observed without coughing, other type of incontinence or excessive detrusor sensitivity should be considered.

Laboratory tests should be also considered in evaluation of SUI. Urine analysis and urine culture should be performed before all the above-mentioned functional tests. Infection of the lower urinary tract with all its numerous irritating symptoms frequently represents the underlying cause of the symptoms of urinary incontinence. In such cases, treatment of the infection will relieve all the above mentioned symptoms. Blood tests (urea, creatinine, glycemia, Ca) should be considered in patients suspected as having compromised renal function or polyuria (without diuretics). Routine cytological examination of the urine is not recommended and it should be performed only in the selected cases.

It is not always easy to make difference between urethral descent and cystocele, which are frequently coexistent, upon physical examination. Lateral cystogram in the relaxed position and upon voiding may determine which of the above two pathological condition is in question. Videocystography is also occasionally used in diagnosis since it enables dynamic assessment of the anatomy and function of the urinary bladder base and urethra during retrograde filling of the bladder as well as during voiding. Videocystography is used in complex problems associated with urinary incontinence.

Urodynamics is a relatively old method used in diagnosis or voiding act disorders and it was initially applied back in 1935. Urodynamic testing is performed by two catheters, one placid in the bladder and the other in the rectum. Both catheters measure pressure changes during bladder filling and emptying. Based on the obtained data and different formulae we can get the information on the specific disorder of the lower urinary tract. The role of urodynamics in diagnosis of SUI is controversial. Some authors believe that women must be subjected to urodynamic testing before surgical treatment, while the other believe that urodynamic testing is not necessary in presence of sufficient evidence suggestive of SUI.

METHODS USED IN TREATMENT OR STRESS URINARY INCONTINENCE

Treatment may be either conservative or surgical. Conservative treatment includes strengthening of the pelvic floor muscles, local application of estrogen creams, medicamentous therapy (alpha-adrenergic agonists) and application of the occlusive urethral rings.

The objective of each surgical intervention intended at resolution of SUI is restoration of normal position and support to vesicourethral segment, which usually lead to positive resolution of SUI. Intrinsic sphincter mechanisms are restored as soon as the anatomical abnormalities are corrected.

SURGICAL TREATMENT STRESS URINARY INCONTINENCE – HISTORY REVIEW

Review of literature data using PubMed search option enabled us to find more than 900 bibliographic units, out of which 100 was included in the analysis using the selection criterion. Other source, such as textbook published by Campbell at al., as well as individual in extenso papers were also included in the analysis. After further selection more than 35 major references, including reviews and original papers as well as chapters from books were retained.

Sling procedures with suburethral loops have been applied in treatment of SUI since the beginning of last century. Different surgical techniques and materials have been applied over the last hundred years. Von Giordino was the first to describe this procedure in 1907 at the surgical convention in Paris. At the time, the procedure was performed exclusively transabdominally. Not only that the technique was demanding but the applied slings were short, they produced tension and consequential urethral obstruction. The concept of intermittent self-catheterization was also known at the time. In 1910, Goebel described the first muscle sling with application of m. pyramidalis while modification made by Frangenheim comprised utilization of m. rectus and m. pyramidalis strips. Frangenheim modified the technique in 1914, while Stoeckel further modified the technique in 1917. He used fibers of m. rectus. Other muscles in the vicinity of the bladder neck (m. adductor femoris, m. gracilis, m. levator ani, m. rectus femoris, m. gluteus) were also used. In 1941, Aldridge described a sling made of m. rectus abdominis fascia. Two strips of the rectus fascia sutured along the mid-line below the urethra in the form of a loop were used. In 1958, suspension on the sacrospinal ligament according to Burch was described and used for surgical treatment of the vaginal wall prolapse over the prolonged period of time. The first transvaginal needle suspension was described by Pereyra in 1959. This type of needle urethropexy was subjected to more than 20 modifications within an effort to improve surgical results and reduce complications including those made by Raz, Gittes and Stamey. Stamey procedure was the first to use cystoscope for precise placement of sutures. This procedure is indicated for correction of SUI in absence of significant cystocele. Colposcystourethropexy or Tanagho procedure was described in 1976. The surgery assures fixation of the anterior-lateral wall of the proximal vaginal third to the Cooper’s ligament with two sutures placed on the both sides, which enables for vesicourethral segment to be returned in its normal position. The approach for colposcystourethropexy is provided through suprapubic incision and it required prolonged recovery period. Procedure failure rate was above 50%, which indicates search for the procedure that would enable better results.

Sling procedures are relatively old technique in resolution of SUI. Since 1960, slings have been used for resolution of recurrent SUI after one or more unsuccessful surgeries as well as within reconstructive procedures.
Currently, suburethral sling procedures may be roughly classified to those performed at the level of the urinary bladder neck and those performed at the middle part of urethra. The slings may be made of biological material and placed at the level of the proximal urethra and urinary bladder neck or made of synthetic material and placed at the level or proximal or middle urethra. Autologous graft is usually taken from the fascia lata or rectus abdominis fascia, allograft is obtained from the cadaveric donor while xenograft is biological material of animal origin. Ulmsten et al. published in 1996 a paper on use of tension-free vaginal tape (TVT) in treatment of urinary stress incontinence. The tape was placed in the middle urethral region, at the site of junction of pubourethral ligament and urethra with an aim to restore pubourethral ligament function. The procedure was performed for the first time in Serbia in 1998 at the School of surgical urology in Pirot. The first transvaginal correction of the small pelvis organ using “Prolift” system is described by Fattion in 2007, while the first result was reported in Serbia by Ignjatovic in 2008.

Biological indifference of Prolene was used for tapes made of this material. The procedure was based at the time on the stress testing performed by the end of intervention in order to avoid excessive urethral tension. However, the time has shown that application of the method was associated with numerous immediate surgical complications, such as urinary bladder perforation, injuries of the small pelvis blood vessels, intestinal and ilioinguinal nerve injuries. Delorm published in 2001 a paper presenting alternate method of placement of suburethral tape through both obturator foramina thus avoiding retro pubic space and at the same time complications associated with pelvic organ injuries. The tape is placed below the middle urethra, to be passed behind the inferior ramus of the public bone, through the obturator foramen from outside to inside. De Leval presented in 2003 the next modification of the sling procedure, passing the tape through the incision made on the vagina from the inside to outside using a special guide, and also passing it behind the inferior ramus of the public bone through the obturator foramen. Tension-free sling introduced by Trabucco has been used since 2004. The third generation of tension-free slings described by Neumann and Debodianc has been used since 2008. The idea was for slings to be as short as possible and to cross over the smallest possible number of anatomic structures. Additionally, they had to provide sufficient support to urethra and assure optimal continence.

Improvement of minimum invasive procedures in early 1990s led to introduction of laparoscopy in surgery and consequently, the first laparoscopic retro pubic colosuspensions. Potential advantages of the laparoscopic approach in comparison to the classical surgical procedures include better visualization of the retro pubic space, shorter hospitalization and faster recovery. Disadvantages of the approach include long suturing skill learning curve, technical complexity, etc. This type of surgery indeed has its place in the wide range of surgical modalities available for treatment of SUI.

Different synthetic materials, which are inert and non-resorbable have been used for sling procedures. Mersilene is a polymer type which is the first used artificial material.

Other sling materials are: Gore-tex, Nylon, Prolene, Teflon, Marlex, Silastic

CONCLUSION

1. Surgical treatment of SUI is applied when conservative therapy fails to provide effects and it is based on the strictly defined indications.

2. Surgical treatment has been the subject of numerous improvements and modifications and the same trend may be expected to be continued.

3. One of the major objectives of improvement is accomplishment of minimum invasiveness with small number of complications

4. The materials used are also improved

SUMMARY

ETIOPATOGENEZA, DJAGNOSTIKA I ISTORIJAT
HIRURŠKOG LEČENJA STRES URINARNE INKONTINENCE

Urinarinkontinencijapredstavljanenovoljnegubitak urina na uretru. Ovapatologija predstavlja velikimedicinski, socijalni i higijenski problem.


Poslednjih 100 godina operativne tehnikesu prošle kroz brojnausavršavanja, a i rezultatiznačajnopoboljšani.

Ključne reči: stress-urinarna inkontinencija, hirurško lečenje SUI, istorijat.

REFERENCES


