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Original Article

Vaginographic Examination of the Pelvic Floor

J. O. L. DeLancey
Department of Obstetrics and Gynecology, University of Michigan Medical Center, Ann Arbor, Michigan, USA

Abstract: In women with genital prolapse, damage to the pelvic floor muscles, fasciae, and ligaments leads to characteristic changes in the shape and position of the vagina. This observational study was undertaken to determine how these changes can be used to document damage to individual pelvic floor structures. Resting and straining radiographs in the standing position with barium in the vagina were made of 23 women with normal and 31 women with abnormal support, and correlated with anatomic studies of 23 cadavers. These studies demonstrate that the downward sagging of the upper vagina seen in frontal radiographs reflects a failure of the cardinal–uterosacral complex. Loss of the lateral indentations in the lower vagina indicates loss of the constricting effects of the levator ani. In lateral radiographs the levator plate's inclination can be measured. The distance between the pubic symphysis and anterior perineal body indicates the levator ani muscles' closure of the vagina. A line from the lower pubic symphysis to the ischial spine represents the location of the arcus tendineus fasciae pelvis. The distance between this line and the anterior vaginal wall indicates the status of the pubocervical fascia and its attachment to the arcus. With these observations, the vaginogram can be used to examine the status of the fascial and muscular supports of the vagina. It offers a research tool for the study of individual parts of the supportive system, and can be applied to such questions as the frequency of damage to muscles, fasciae or ligaments in recurrent prolapse.

Keywords: Bead-chain cystourethrogram; Genital prolapse; Radiography; Vaginal prolapse; Vaginography

Correspondence and offprint requests to: Dr John O. L. DeLancey, Associate Professor, Director, Division of Gynecology, D2234 MPB Box 0718, 1500 E. Medical Center Drive, Ann Arbor, Michigan 48109-0718, USA.

Introduction

There is a large body of observations concerning the anatomic changes seen with genital prolapse [1–9]. There have been few scientific studies, however, that test hypotheses about changes that occur in the normal structural anatomy in these patients. One of the problems encountered in designing studies of women with prolapse has been the paucity of simple clinical research techniques that provide data concerning the status of specific parts of the genital support system.

The shape and location of the vagina depends upon its connections to the pelvic walls through the endopelvic fasciae, and also upon its closure and support by the levator ani muscles [10]. Certain changes in vaginal topography reflect changes in specific portions of the supportive system, in much the same way that failure of a tent support leads to a specific change in the tent's shape and appearance. The following observational study was performed to define the anatomic structures responsible for specific characteristics of vaginal shape and position, and to assess how changes in individual anatomic supports are reflected in vaginal topography.

Materials and Methods

Radiographic observations were performed during bead-chain cystourethrograms and voiding proctograms following standard techniques for bead-chain cystourethrography and vaginography [11]. Ten milliliters of the barium paste used for esophageal studies were injected into the vagina using a 50 ml catheter-tipped syrine, and then distributed with a gloved finger to assure complete coating of the vaginal wall. A bead-chain was placed in the urethra after 250 ml of bladder contrast had been instilled. Radiographs were made both with the woman at rest and straining in the standing position with her feet 16 in apart. In instances where the outline of the vagina was obscured by the bladder on frontal radiographs, postvoid films were made. When the levator plate was not visible on lateral films, 30 ml of barium paste were placed in the rectum to help define it. More recently, in 10 patients these static films have been supplemented with fluoroscopic examination to view the mobility of the vagina during straining, pelvic muscle contraction, and at rest.

These studies were made of 54 women ranging in age from 26 to 82 years (average 53.4 years) and parity from 0 to 9 (average 3.6) who presented for evaluation of urinary complaints or genital prolapse. Fifteen had undergone hysterectomy and 9 had recurrent prolapse. The type of support problems present based on clinical examination are shown in Table 1. Women listed as having clinically normal support were those who had urinary symptoms but normal support on both supine and standing pelvic examination performed specifically to assess support.

Full pelvic dissections in 10 fresh and 12 embalmed cadavers ranging from 33 to 80 years of age were made, emphasizing the examination of vaginal support and shape, as seen on the radiographic images. Four cadavers had previously undergone hysterectomy. These dissections were supplemented with examination of serial cross-sections of the pelvic portion of a 33-year-old nulliparous cadaver, cut at 6 mm intervals in the axial plane.

Anatomic investigations were correlated with the radiographic images in several ways. Specific dissections were undertaken to define the structures that determined the shape of the vagina and its position relative to the pelvic bones. This helped explain the normal position and shape of the vagina, as well as the change in its location, an appearance that occurred in patients with prolapse. Palpable structures such as the levator ani muscles were identified on examination, a radiopaque marker was placed on them, and an X-ray exposure taken. This allowed for both confirmation of the radiographic appearance of the structures and delineation of their boundaries. For the cardinal and uterosacral ligaments, which are not palpable in their entirety, as well as for the arcus tendineus fasciae pelvis, dissection established the origin of these supports relative to bony landmarks visible in radiographs. The points at which these ligaments attach to the genital tract were established by dissection.

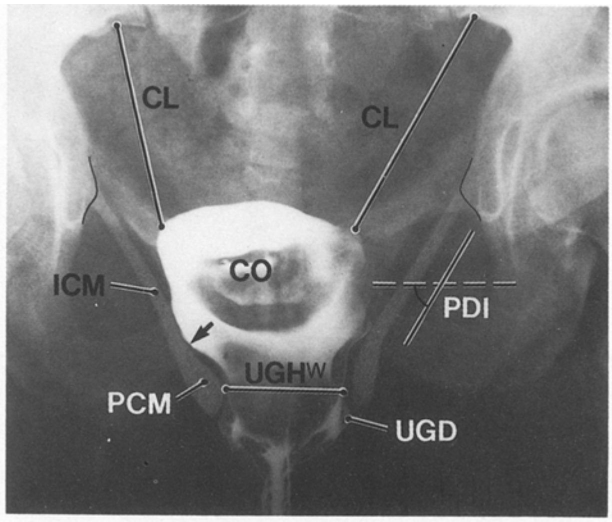
Table 1. Support in patients undergoing vaginographic examination

Clinical normal support	23
Abnormal support	31*
Uterine prolapse	4
Vaginal prolapse	4
Cysto/urethrocele	26
Rectocele	10
Pulsion enterocele	6

*Some patients had more than one defect.

Results

In frontal projection the vagina has an expanded upper portion, with a narrower constricted portion below (Figs 1 and 2). The upper vagina, which extends



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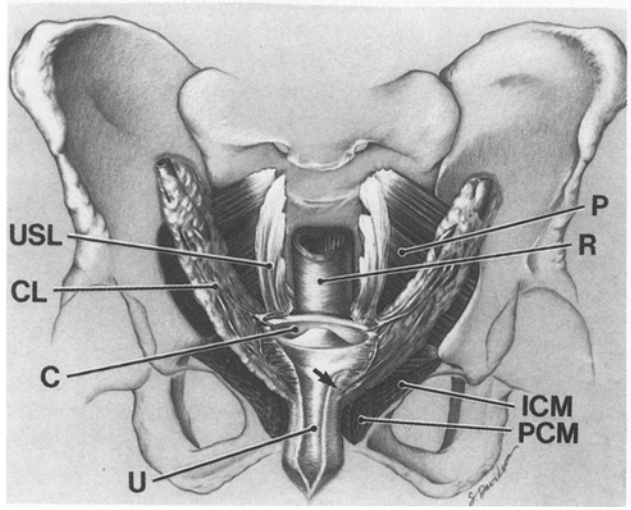

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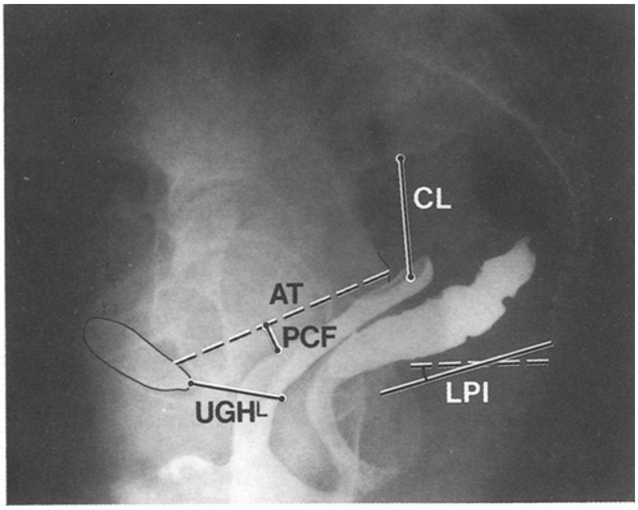
Fig. 1. a Frontal radiograph of the pelvis with barium paste in the vagina. NB: A line with a dot at each end indicates the distance spanned by the indicated structure (e.g. CL) while those ending in a single dot point to the structure (e.g. PCM). **b** Support structures: frontal view. The levator ani has been cut in the coronal plane lateral to the vagina. The shape of the vaginal wall is shown to correspond to its radiographic appearance, showing the impression of the cervix (C) and urethra (U) on the vaginal lumen. Abbreviations used in this and subsequent figures: AT, arcus tendineus fasciae pelvis; C, cervix; CL, cardinal ligament; CO, cervical os; CX, cervix; E, enterocele; ICM, iliococcygeus muscle; LP, levator plate; LPI, levator plate inclination; OI, obturator internus muscle; P, piriformis muscle; PCF, pubocervical fasciae; PCM, pubococcygeus muscle; PDI, pelvic diaphragm (levator ani) inclination; R, rectum; U, urethra; USL, uterosacral ligament; UGD, Urogenital diaphragm; UGH^L, urogenital hiatus length; UGH^W, urogenital hiatus width; V, vagina.



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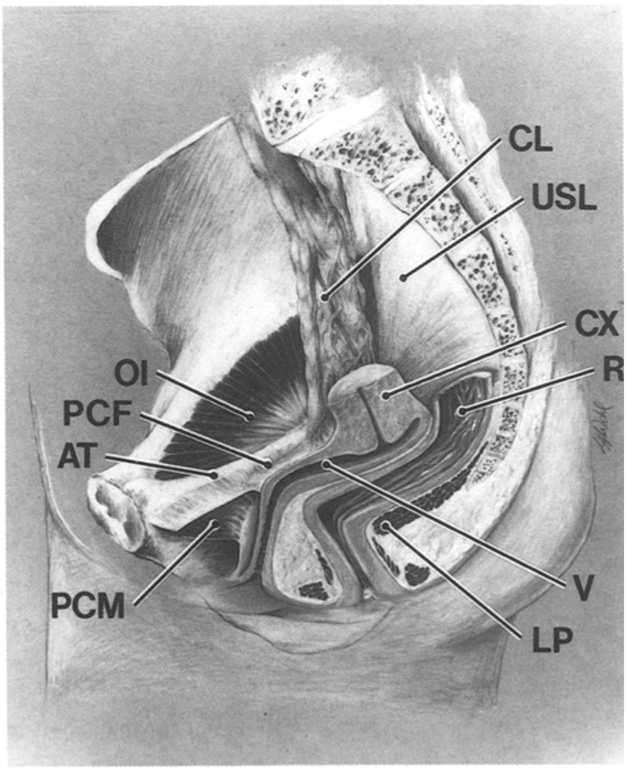

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Fig. 2. a Lateral radiograph of the opacified vagina and rectum. **b** Support structures: lateral view. The bladder, urethra and uterine corpus have been removed from this diagramatic sagittal section to reveal the attachments of the vagina.

laterally beyond the limits of the cervix, is suspended in the pelvis by the caudal portion of the cardinal–uterosacral ligament complex. These ligaments attach the cervix and upper vagina to the pelvic wall in the area of the greater sciatic foramen. When these suspensory fibers are damaged, the cervix and/or the upper portion of the vagina prolapses downward, away from the greater sciatic foramen (Figs. 3 and 4), and fall below their normal position at the level of the ischial spine. This may be present unilaterally and affect only one side

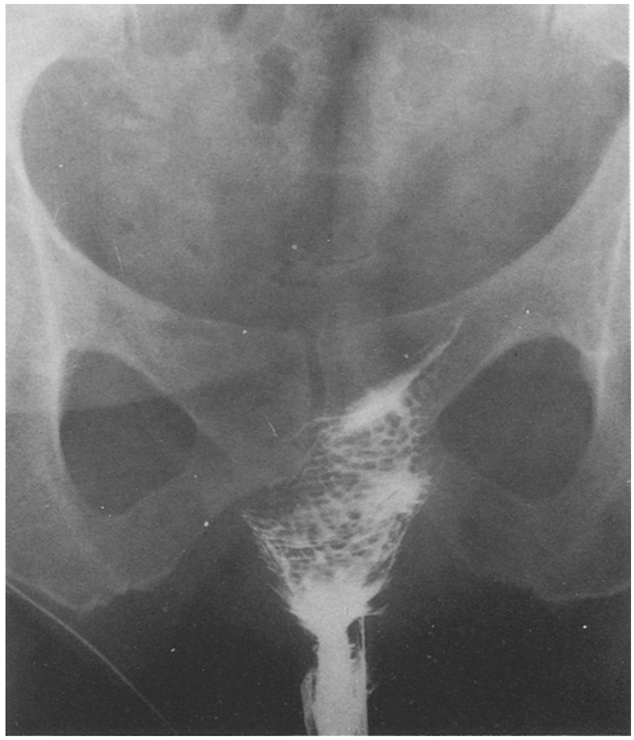

Fig. 3. Frontal radiograph of a patient following hysterectomy, demonstrating isolated loss of support from right cardinal–uterosacral ligament.

(Fig. 3) or may occur symmetrically, leading to downward descent of the cervix and/or vaginal apex (Fig. 4).

At the transition between the wide upper vagina and the narrow lower vagina, it is attached to the pelvic walls by the pubocervical and rectovaginal fasciae (see below). The constriction in the vagina below this point represents the effect of the levator ani muscles (pubococcygeus portion) on the vagina as they pass along either side of the vaginal canal (Fig. 1b). The distance between the two sides of the vagina in this region indicates the width of the urogenital hiatus in the levator ani muscles, which is usually one-third of the bituberous diameter. The small symmetrical protrusions in the lateral borders of the vaginal image below the caudal margin of the levator ani represent the level of the urogenital diaphragm (now properly called the perineal membrane) (Fig. 1a). These mark the lower border of the levator ani muscles, and represent the lateral traction of the transverse vaginae muscle and the smooth muscle contained in the perineal membrane. In addition, it is also possible to see the actual muscles themselves in most women (Fig. 1) because of the difference in radiodensity between ischiorectal fat and the levator muscles.

Lateral radiographs reveal additional information. The uterosacral portion of the cardinal–uterosacral ligament complex originates from the second, third and fourth sacral vertebrae and inserts into the cervix and upper vagina (Fig. 2), connecting them to the site of origin of these fibers. The degree to which this portion

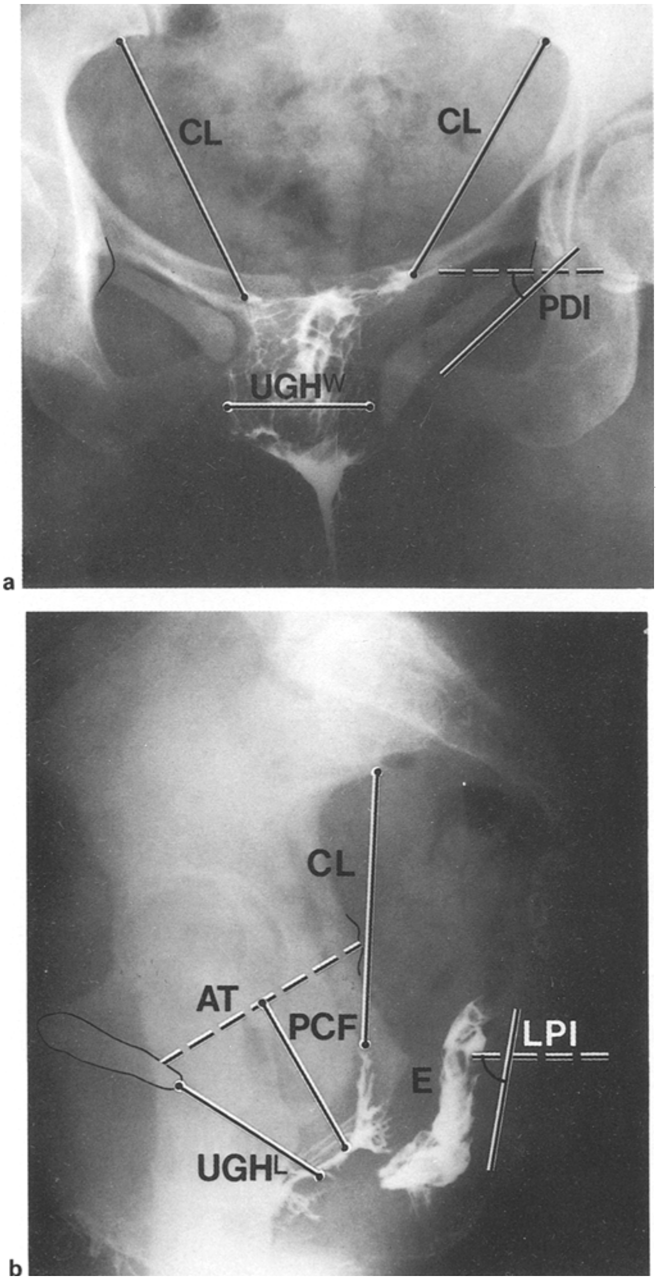

Fig. 4. Radiographs of a woman who had previously undergone vaginal hysterectomy and colporrhaphy and has recurrent prolapse. **a** Frontal resting view demonstrates widened hiatus from asymmetric loss of levator ani. **b** Lateral straining radiograph with the levator plate almost vertical, the pubocervical fascia's support is defective, an enterocele (E) is visible, the hiatus is widened, and the cardinal ligaments are elongated.

of the suspensory mechanism has failed is assessed on lateral radiographs by examining this distance, and can also be evaluated by comparing the location of the vaginal apex or external cervical os to the level of the ischial spine (Fig. 2), where the cervix or vaginal apex normally lies.

The mid-portion of the anterior vaginal wall is attached to the pelvic wall by the pubocervical fascia at the arcus tendineus fasciae (Fig. 2b). The arcus originates at a point 1 cm above the inferior edge of the pubic symphysis and ends at the ischial spine. A line drawn between these points establishes its position on a lateral radiograph (Fig. 2a). The amount of downward displacement of the vaginal wall due to failure of the pubocervical fascia that has occurred with a cystocele can be assessed by measuring the distance between the normal insertion of the vagina at the arcus tendineus fasciae pelvis and the most dependent part of the anterior vaginal wall (Fig. 3), and is normally about one-fourth to one-fifth the length of the arcus tendineus.

The levator ani muscles pull the rectum and vagina towards the pubic bones, closing the urogenital hiatus. The anterior–posterior diameter of the hiatus can be assessed on lateral radiographs as the interval from the posterior border of the symphysis pubis and the anterior border of the perineal body (Fig. 2a). It can be compared with the length of the outlet (from pubic symphysis to the tip of the last sacral vertebra), and is usually one-third to one-fourth of this latter distance.

The midline aponeurosis in the levator ani muscles between the anus and coccyx is known at the levator plate. Its downward slope, below the horizontal, can be assessed in one of two ways. The interface between the levator plate and rectum is usually visible on lateral radiographs (Fig. 2), and the angle between this shadow and the horizontal can be measured. When this is not visible, the addition of barium to the rectum, whose posterior wall is attached to the plate, allows the inclination of the levator plate to be assessed.

Discussion

This report describes a research technique that can be used to examine the status of both the fascial and the muscular supports of the vagina. By correlating individual aspects of vaginal shape with the anatomic structures responsible for them, it makes simultaneous assessment of damage to these two different tissue types possible. These radiographic studies supplement knowledge gained from cadaver dissection that provides detailed information about the location and attachments of structures such as the levator ani, but which fails to reflect normal topography because the pelvic floor muscles become flaccid at death, causing the pelvic floor to sag unnaturally [12–14].

Vaginography satisfies the crucial requirement that it can be performed in the standing individual, allowing structures to carry their normal weight loads, and can be done with the woman straining so as to reveal any weakness that may not be apparent when the individual is supine or resting. These latter considerations are difficult to satisfy with CT and MRI imaging, because they must be done in the supine position, and the long exposure times make study of the straining individual difficult at present. In addition, skeletal landmarks to which these structures attach are readily seen, and therefore allow the position of the vagina to be assessed relative to its supportive framework.

Previous studies have reported radiographic examination of the pelvis in women with prolapse, especially women with stress urinary incontinence [11,15,16]. It has also been used to study the depth and axis of the normal vagina [17,18], as well as genital prolapse [19,20] and enterocele [21]. Bethoux [19] and Lazarevski [20] have both made extensive radiographic studies of genital prolapse, and have demonstrated the ease with which the pelvic organs can be visualized. These previous studies have defined the topographic changes that have occurred in the pelvic organs. The present report extends the value of these studies to define the specific anatomic changes that are responsible for these alterations in vaginal shape and position.

The group of patients reported here is too small to use in defining exact normative values for these assessments. As more observations are made of women with normal and abnormal support this will easily be possible. The qualitative information provided in the results section is useful and provides sufficient information to make interpretation of these studies meaningful.

The anatomic observations in this study by themselves are not new. The suspension of the vagina and uterus by the pubocervical fascia [22], cardinal ligaments [23] and uterosacral ligaments [24] has been previously described, and is supported by the anatomic findings of the present study. We have not yet been able to find satisfactory anatomic landmarks to allow for assessment of the anatomic defects seen with rectoceles or enteroceles, and are currently evaluating methods to better understand these.

The importance of the levator ani muscles in pelvic support is receiving renewed interest [25]. These muscles have previously been studied by injecting radiographic contrast material [13], but this technique has not been widely used because of its discomfort. Vaginography provides a non-invasive way to assess the ability of the levator ani muscles both to maintain a closed urogenital hiatus and to maintain a normal levator plate. This should provide a functional assessment to correlate with much of the new research in electromyography of this region. Furthermore, it allows investigators to evaluate not only the muscular supports but also the integrity of the fibrous suspensory tissues at the same time, a critical issue in resolving the longstanding conflict of the relative importance of fibrous and muscular supports.

Despite our general success in treating women with problems of pelvic organ support, recurrent prolapse – and specifically vaginal prolapse – continues to occur. By documenting the status of the ligamentous and muscular supports, these studies can allow us to test hypotheses concerning the role of ligamentous failure and muscular damage. For example, it would allow us to address the question of whether women with recurrent prolapse are more likely to have a widened levator hiatus and vertical levator plate than women having their first repair. Finally, it could provide an objective way to quantify the degree of damage in a given woman, to help in assessing the effectiveness of different operations in comparable patients.

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EDITORIAL COMMENT: This paper demonstrates in a very graphic fashion the dynamic relationship between the vagina, the rectum, the bladder and the pelvic floor at rest and during stress in women who are being evaluated for urinary complaints. Overall, it is extremely well written and provides additional data and support to the current theories regarding the anatomy and the function of the pelvic floor as a unit. The investigator also correlated this with cadaver studies by further marking the levator ani muscles and then doing similar studies to demonstrate that what appear to be the levator ani muscles in the live subjects are truly representative. However, whether or not this technique will be applicable clinically remains unknown. Although defecography is currently being used to demonstrate rectoceles and enteroceles, there are those who feel that clinically these studies are unnecessary. However, as a research tool to demonstrate in a dynamic fashion the anatomical relationships in the normal and in the abnormal, this is a very interesting study. Also, it may be that in the future we will rely to some extent on this type of study to determine what procedures will need to be performed in the patient who presents with complete prolapse. It may also be a method of follow-up for those patients who have undergone extensive pelvic floor reconstruction.

Review of Current Literature

Leak Point of Incontinence: A Measure of the Interaction Between Outlet Resistance and Bladder Capacity

McCormack M, Pike J, Kiruluta G

Division of Pediatric Urology, Department of Surgery, Montreal Children's Hospital, McGill University, Montreal, Quebec, Canada
J Urol 1993; 150:162–164

A group of 48 spina bifida patients were divided into two groups depending on whether detrusor contractions were demonstrated. Six of the 14 areflexic patients and 7 of the hyperreflexic patients were wet in spite of conservative therapy for 2 years, consisting of intermittent catheterization and/or anticholinergic therapy. Leak point pressure and leak point volume were determined in all patients by measuring the bladder pressure and volume, respectively, at which leakage from the urethral meatus was observed during bladder filling. Leak point volume was 84 ml in wet hyperreflexic patients versus 155 ml in those who were dry. Leak point pressure did not show a difference. In the areflexic patients, leak point pressure was 30 cm of water in the wet patients versus 57 cm of water in those who were dry. Leak point volume did not differ in this group. Eighteen of the hyperreflexic patients had undergone augmentation enterocystoplasty and the only 2 that remained incontinent had a leak point pressure less than 40 cm of water, suggesting that outlet resistance should have been augmented as well. Of 7 areflexic patients having a procedure to augment outlet resistance, 2 failures had a leak point pressure less than 40 cm of water, suggesting that the augmentation was insufficient. Leak point pressure and volume may enhance accurate diagnosis and management in myelodysplastic patients.

Comment:

The authors point out that leak point pressure was described by McGuire to prognosticate the risk of upper tract deterioration in myelodysplastic children. The urethral sphincter apparatus becomes incompetent when the bladder pressure overcomes the outlet resistance. A grading of severity of incontinence in neurologically normal adult female patients can be made on the basis of the leak point pressure, i.e. that point at which bladder pressure overcomes the outlet resistance. This measure has generally been made by urologists, and most gynecologists have not understood the term. The severity of incontinence may be used in patient management and in postoperative assessment of improvement or cure. The measure of leak point volume can provide an assessment of functional bladder capacity which is useful for instructing patients in behavioral therapy techniques.

Anchor Fixation and Other Modifications of Endoscopic Bladder Neck Suspension

Benderev, TV

Mission Hospital Regional Medical Centre, Mission Viejo, and Division of Urology, University of California at Irvine Medical Center, Orange, California, USA
Urology 1992; 40:409–418

Fifty-three women with genuine stress incontinence and a hypermobile urethra underwent a modified endoscopic bladder neck suspension. The major change in suture placement was to use four entry points through the urethropelvic fascia on each side, and maximize the amount of tissue incorporated in the sutures. No vaginal incision was utilized but the suture was removed vaginally from the needle after the third pass, replaced on the fourth pass, and then brought to the abdominal entry site. Holes were drilled 2 cm lateral to the midline on either side of the pubic bone, an anchor was placed into each hole, and the sutures were tied down over the distal pulp of the index finger. Patients were followed by mail or phone contact. Four (8%) failed treatment and 7 (15%) complained of urgency incontinence.

Comment:

The main alteration in this technique is the capture of a large volume of tissue lateral to the urethrovesical junction by a multiple-pass technique. Also new is the use of an anchor system to fix the sutures in the pubic bone. The article does not justify the necessity of using new techniques for this endoscopic suspension, and the failures reported in other studies do not seem to be related to pull-through of sutures from the abdominal wall fascia. Theoretically it would be desirable to get as much tissue as possible at the urethrovesical junction. The main difficulty with this paper is the poor criteria for diagnosis and cure. There is no objective follow-up provided. The article is worth reading in order to understand the concepts of the new technique in suture placement.