Surgery for Incontinence

16

Emilio Merlini

16.1 Definition

Urinary incontinence is defined by the International Children's Continence Society (ICCS) [1] as an "uncontrollable leakage of urine. It can be continuous or intermittent."

Continuous incontinence means constant leakage of urine, and it is almost always associated with a malformation of the urinary tract like bladder or cloacal exstrophy, epispadias, neuropathic bladder, ectopic ureters, and urogenital sinus or with an iatrogenic or traumatic damage to the sphincter mechanisms. Intermittent incontinence means leakage in discrete amounts that can occur during daytime and/or nighttime and, in most cases, represents a functional phenomenon that doesn't require surgical repair.

Pseudoincontinence is a continuous urinary leakage associated with normal micturition and a normal bladder development; it is found only in females and it is due to an ectopic ureter draining outside the domain of the urinary sphincter. In most cases the ureter belongs to the upper pole of a complete duplex kidney and drains either in the genital tract or in the urethra, distal to the sphincteric area.

E. Merlini
Division of Pediatric Urology, Regina Margherita Children's Hospital, Citta' Della Salute e Della Scienza Di Torino, Torino 10100, Italy
e-mail: emilio.vittorio.merlini@gmail.com

16.2 Pathophysiology

Urinary continence is generally attained between 2 and 3 years of age in normal children, and it consists in the capability of voluntary controlling micturition, both postponing and starting it under cortical control [2].

Normal micturition requires intact neural pathways linking the central and peripheral nervous system with the bladder/sphincter complex and a bladder of adequate capacity, contractility, and compliance and a functioning sphincter.

Voluntary micturition is under neural control by several cortical areas and by the pontine micturition center that coordinates the sensitive afferences from the bladder and proximal urethra and the efferent output to the motoneurons in the sacral portion of the spinal cord.

Disruption of these fine neural control mechanisms is responsible for urinary incontinence observed in congenital and acquired neuropathic bladder [3].

The bladder is meant to store and expel urine at low pressure and at proper time and place; to obtain this result the bladder must have an adequate compliance and capacity for age, without overactive contractions.

In a newborn, the bladder, capacity is approximately 30 ml and it increases to approximately 300 ml in teenagers. A practical rule to estimate normal bladder capacity for age is 30 ml X (age in years +1). Compliance is rather complicated to calculate in children as no reliable normal values

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are available in literature. A rule of thumb is that detrusor pressure should not exceed 10 cm H_2O at bladder capacity.

Normal bladder capacity and compliance and the absence of involuntary phasic contractions during filling are necessary conditions to obtain continence, while a small, fibrotic, low-compliance, or overactive bladder will never allow storing enough urine at low pressure.

An intact bladder outlet is the second necessary condition for continence; bladder outlet includes the bladder neck and proximal urethra that, together, may be regarded as a single unit acting as a sphincter. There is no anatomically distinct striated and smooth sphincter, but, rather, a mixture of smooth and striated muscle with elastic fibers extending from the bladder neck to the membranous urethra in males and to mid-urethra in females and creating a high-pressure zone that has sphincteric function [4].

Several factors contribute to the maintenance of a normal pressure in the sphincteric area: Intrinsic factors include smooth and striated muscle tone and contractility and elastic fibers of the bladder neck and urethral wall.

Extrinsic factors comprise the transmission of abdominal pressure to an adequately long portion of the urethra located within the abdomen and structural support of the posterior urethra and bladder neck by the perineal diaphragm and muscles. An intact perineal diaphragm counteracts the tendency of bladder and urethra to slip outside the abdominal cavity because of the abdominal pressure and provides a sound structure against which the urethra is compressed with increasing abdominal pressure.

In many conditions causing incontinence in children, most of the factors promoting continence are inadequate or absent.

16.3 Clinical Conditions Associated with Structural Incontinence

The conditions associated with structural incontinence, i.e., caused by anatomical factors, can be classified as:

1. Conditions characterized by a congenital anomaly of the bladder and/or urinary sphincter:
   - Exstrophy complex (epispadias, bladder exstrophy, cloacal exstrophy, and exstrophic variants)
   - Bilateral ectopic single ureters
   - Congenitally short urethra, generally associated with a urogenital sinus malformation
   - Anomalies of the urethra and bladder, mainly incontinent duplication of the bladder and/or urethra
   - Incontinent ureterocele
2. Conditions with deficient neural supply to the bladder and sphincters:
   - Congenital or acquired neurogenic bladder
3. Acquired conditions:
   - Iatrogenic injury to the urethral sphincter
   - Posterior urethra trauma and stenosis

The treatment of these conditions differs according to the various causes; this chapter will deal only with the procedures required to reinforce the bladder outlet when this is defective.

16.4 Preoperative Evaluation

A thorough preoperative evaluation is necessary, and both upper and lower urinary tract must be assessed together with renal function and average daily urinary output.

Incontinence can be multifactorial and be caused by insufficient bladder neck and/or by insufficient bladder capacity and/or compliance; therefore, the main diagnostic problem is to evaluate the responsibility of every single structure involved in the process of keeping a child dry. In other words, it is necessary to understand if incontinence is purely an effect of a weak bladder outlet or if a concomitant bladder dysfunction is a cofactor. In such case, a concomitant bladder augmentation is needed at the time of bladder outlet surgery.

Clinical evaluation with a voiding diary, a 4 h observation protocol together with a video urodynamic test, is generally sufficient to evaluate the lower urinary tract. Video urodynamic in particular is an indispensable tool, showing, at the same time, the anatomy of the bladder, bladder neck, and urethra and the pressure at which urine leaks together with the dynamics of the posterior urethra.

To perform a correct and useful video urodynamic investigation, because of leakage around standard urodynamic catheters, occlusion of the bladder outlet with a balloon catheter is needed to judge bladder capacity, contractility, and compliance, while leak point pressure is evaluated with the balloon deflated.

Inadequate bladder outlet resistance can be assumed if the leak point pressure is under 30–40 cm H_2O and the bladder neck is open on fluoroscopy, while if bladder capacity is less than 50–60 % than expected for age and compliance less than 2 cm H_2O per ml, most probably the bladder needs to be augmented at the time of bladder outlet surgery [5].

16.5 Principles of Surgical Treatment of Incontinence

No single procedure, with the exception of artificial sphincters, is able to recreate a sphincteric mechanism working exactly in the same manner as native sphincters, that is to assure continence and volitional voiding to completion at will. Most of the procedures can provide either "continence" for a limited period of time, generally 3 h (the so-called social continence), coupled with volitional voiding or "dryness," which means that children are dry for a limited period of time but require clean intermittent catheterization (CIC) to empty their bladder. Preoperative evaluation and the choice of the surgical procedures must take into account factors influencing the ultimate outcome of the procedure: need for CIC, intellectual capabilities of the patient, manual dexterity, and availability of a motivated caregiver to assist the patient in CIC. In general, most neuropathic bladders are already being treated with CIC and they continue after continence procedure, while patients with exstrophy or epispadias generally are not on CIC preoperatively, and they and their parents need a very clear explanation that after the procedure, especially if associated with bladder augmentation, patients may need to empty their bladder with CIC, most likely through an appendicovesicostomy.

16.6 Surgical Procedures

Procedures aiming at increasing bladder outlet resistance can be divided into:

1. Urethral lengthening and tightening procedures, aiming at creating a long and narrow tube out of the trigone (Young–Dees–Leadbetter, Mitchell procedure, and modifications)
2. Construction of a flap mechanism that progressively increases its resistance as the bladder fills
3. Suspension and external compression of the urethra (slings, artificial sphincter)
4. Injection of bulking substance within or around the urethral wall
5. Closure of the bladder neck

16.6.1 Urethral Lengthening Procedures

The first procedure for "bladder neck reconstruction" was initially described by Young in 1922 and later modified by Dees in 1949 and Leadbetter in 1964 [6] who added ureteral reimplantation moving the ureters in a more cranial position. It is popular for treatment of incontinence in exstrophy-epispadias population where continence rates between 70 and 86 % have been reported in large series [7], while its use in neuropathic bladder has not gained a vast popularity, and only few reports of its success rate in this subset of incontinent population are available in the literature [8].

The procedure starts (Fig. 16.1) with the patient lying supine with his back hyperextended to facilitate bladder exposure. The bladder wall can be reached through a midline incision or a modified Pfannenstiel with midline longitudinal opening of the abdominal fascia and rectus muscles.

The anterior bladder wall is incised in the midline starting at the beginning of the urethra.

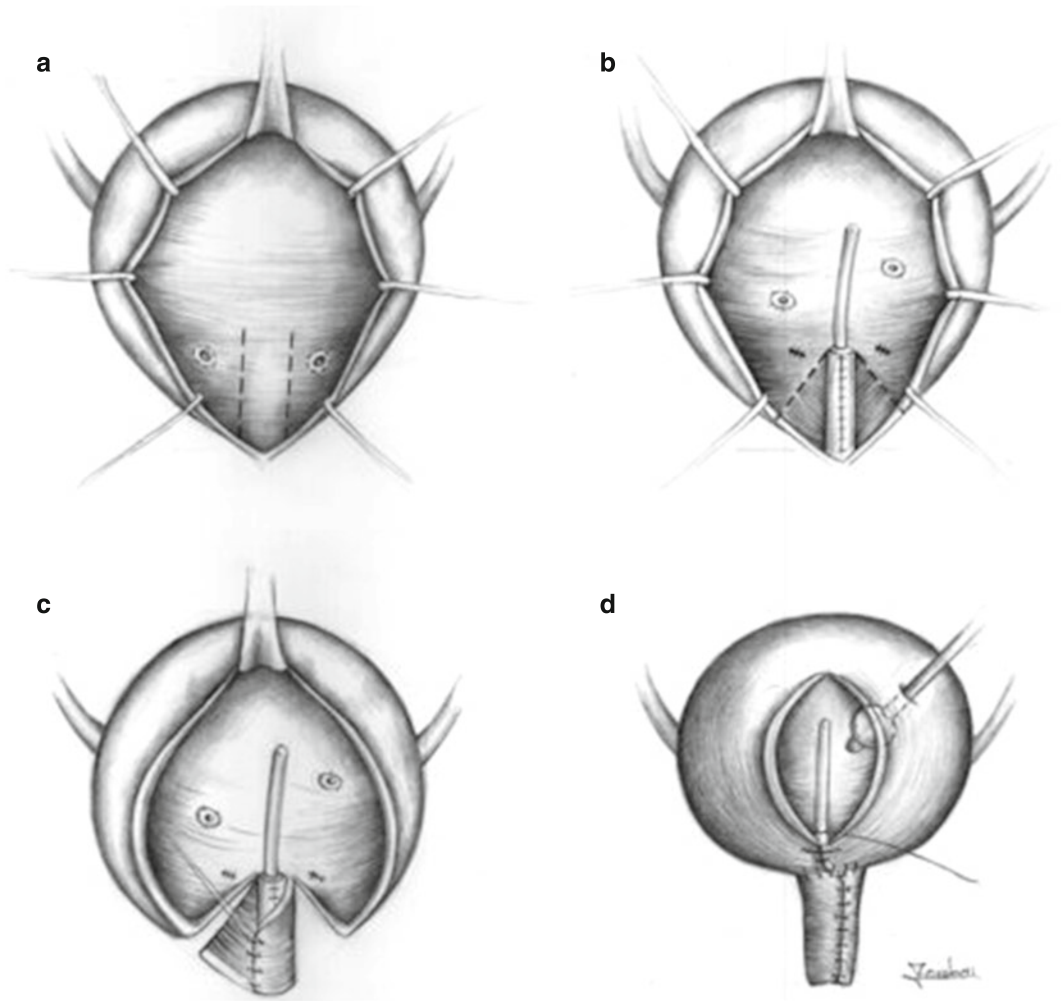

Fig. 16.1 Bladder neck repair according the Young-Dees Leadbetter procedure . The bladder is open vertically (**a**) and a longitudinal strip is outlined on the trigone, in continuity with the posterior wall of the urethra . (**b**) Ureters are reimplanted, cephalad, in a cross trigonal fashion. The mucosal strip is tubularized around a soft multiperforated stent (8 or 10 Fr.) and the mucosa lateral to the tubularized strip is removed, leaving two detrusor triangles. (**c**) A horizontal incision is carried out at the junction between the denuded detrusor flaps and intact bladder wall. The two muscular flaps are wrapped around the mucosal tube in a "pants over vest" fashion, to create the new posterior urethra and bladder neck. (**d**) a suprapubic catheter is inserted and the bladder is closed vertically.

A longitudinal strip 12–14 mm wide and 3–4 cm long is outlined in the trigone, in continuity with the posterior wall of the urethra, reaching the level of the ureteric orifices. It is of utmost importance that the longitudinal strip starts as far as possible in the proximal urethra to avoid the hourglass deformity responsible for many failures of YDL technique. The ureters are dissected and reimplanted cephalad in a cross-trigonal fashion. The mucosal strip is then tubularized in the midline, over an 8 or a 10 Fr. catheter with reabsorbable sutures to create a long and narrow mucosal tube. The mucosa lateral to the tubularized strip is then removed, creating two denuded detrusor triangles. In the original technique, a horizontal incision is carried at the junction between denuded and intact detrusor, creating a muscular flap that is wrapped around to cover and reinforce the new urethra. A similar maneuver is carried on the other side, creating a second flap that is sutured to the first one, covering the urethra in a pants-over-vest fashion. Some

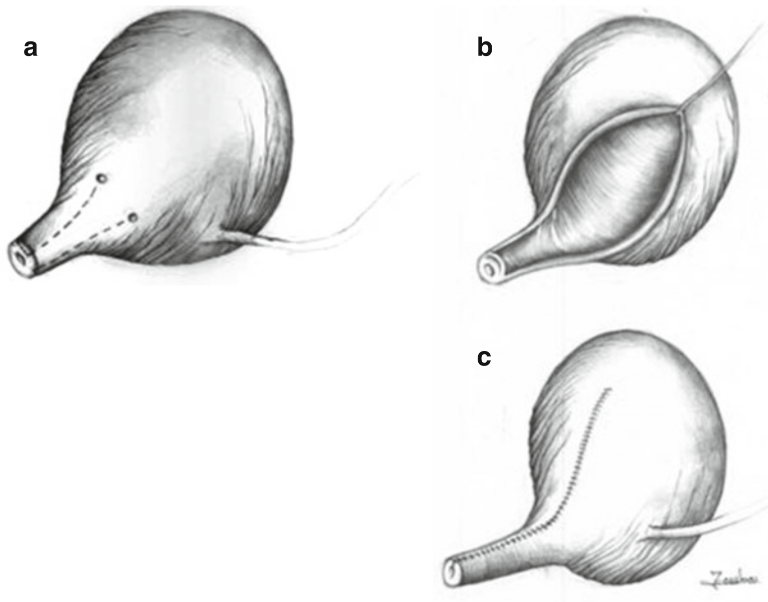

Fig. 16.2 Mitchell's bladder neck repair. (**a**) A transverse incision is carried out on the anterior aspect of posterior urethra and is extended cranially along the posterior lateral wall of the urethra and bladder, creating a (**b**) triangular flap of anterior urethral and bladder that is incorporated in the bladder. (**c**) The urethral strip is tubularized around an 8 or 10 Fr. catheter, creating a long and narrow urethra.

modifications of this step have been described: Gearhart does not cut horizontally the muscle and he wraps the two muscular flaps around the urethra, making only multiple limited incisions in the free edge of the muscle, in order to elongate the flaps [9]. The bladder is then closed in two layers; the outer muscular layer and the bladder neck are suspended to the undersurface of the pubic symphysis to maintain the bladder neck and proximal urethra in an intra-abdominal position buttressing it against the pubic bones to improve continence. We leave a short and soft stent in the reconstructed posterior urethra for a week, while urine is drained by a suprapubic Foley catheter that is kept open for 10–12 days and then clamped and released until normal voiding habits are resumed. Generally some months after surgery are necessary to achieve social continence and day continence precedes nighttime continence.

This procedure has been modified by some authors, Mollard and Koff [10, 11] among them, keeping the basic principle of elongating the posterior urethra and adding fixed resistance at the bladder outlet.

In 1993 Jones and Mitchell returned to Young's original concept of creating a long and narrow tube using the trigone muscle, without adding additional muscular support [12].

The procedure (Fig. 16.2) starts with a transverse incision on the anterior aspect of the posterior urethra, as distal as possible, extending approximately for half of the circumference; the incision is extended proximally on both sides of the urethra and bladder up to the ureteric orifices, outlining a posterior strip of muscle and mucosa, 1.5 cm large. The ureters are reimplanted. Then the strip is tubularized around an 8 or a 10 Fr catheter with a running reabsorbable suture, creating a long and narrow tube. The bladder is closed vertically in the midline. The main advantage of this procedure is that it provides excellent continence rate, sacrificing only a minimal portion of bladder capacity. Recently, Mitchell has described a further improvement in continence rate after bladder neck repair, using a demucosalized muscular flap and wrapping it around the reconstructed urethra.

These procedures are mainly used in the exstrophy–epispadias group, and the reported success rate, that means dry night and day for at least 3 h and voiding normally through the urethra, goes from 60 to 70 % in most series[13]; another 25 % may become continent after bladder augmentation. The YDL and variations have their main role in creating continence, allowing, in many cases, spontaneous voiding; if voiding is not an issue, like in most neuropathic bladders, already on CIC to empty the bladder, other continence procedures may be chosen. Nevertheless, even if the child is voiding before treatment, clinical experience and urodynamic evidence tend to show that creation of a fixed resistance at the bladder outlet, coupled with transection of nerves running around the bladder neck, a densely innervated area, in few years causes progressive detrusor insufficiency with increasing postvoiding residuals, making CIC, often coupled with bladder augmentation, inevitable.

16.6.2 Construction of Flap Mechanism

Another philosophy for obtaining continence is the use of a flap valve mechanism; the Kropp and Pippi Salle procedures belong to this group, where continence is obtained at the expense of the capacity of spontaneous voiding.

The Kropp procedure has been described by Kropp and Angwafo in 1986 [14]. The operation consists in tubularizing an anterior bladder wall flap and reimplanting it submucosally in the posterior trigonal area, creating a one-way valve mechanism, following the principles of the antireflux procedures for the ureters. In the original procedure, the tubularized bladder together with the urethra was completely detached from the bladder, which made CIC very difficult in the majority of patients; later the procedure was modified leaving the posterior wall of the urethra in continuity with the trigone, in part obviating the difficulties in catheterization. This procedure requires CIC for emptying the bladder because the continence mechanism increases with the intravesical pressure; therefore, spontaneous micturition is impossible.

The anterior bladder wall and proximal urethra are exposed, and a vertically oriented rectangular strip, 5–7 cm long and 2–2.5 cm large, is outlined on the anterior bladder wall. The base of the strip coincides with the bladder neck. The bladder is opened and both ureteric orifices are catheterized. The junction between the trigone and the bladder neck is identified, and the mucosa and superficial muscle are incised carrying this incision upward to join the two longitudinal incisions. If needed, the ureters are reimplanted in a more cephalad and lateral position to give space in the midline, and the anterior bladder wall strip is tubularized in one layer, starting precisely at the bladder neck and continuing upward. A 6 cm. long submucosal tunnel is then developed in the trigone staying exactly in the midline; the tunnel must be large enough to accommodate easily the bulky detrusor tube that is pulled through the submucosal tube, carefully, not to tear the fragile trigonal mucosa.

The opening of the new urethra is secured to the bladder wall with interrupted sutures, and the anterior bladder is closed around the new bladder neck at the base of the neourethra.

The Kropp procedure gives good results in terms of dryness, approximately over 80 %, but, unfortunately, most of the patients experience severe problems with catheterization of the new urethra. Moreover, the tubularized anterior wall is quite bulky and difficult to reimplant in the posterior bladder wall.

The majority of these patients require bladder augmentation at the time of the Kropp procedure or later because of the loss of bladder volume due to the use of the anterior bladder wall.

Pippi Salle developed a bladder outlet repair for incontinence, creating a new urethra, composed of both anterior and posterior bladder flaps [15].

The procedure (Fig. 16.3) starts with exposure of the anterior bladder wall, then a wide-based, full-thickness, 5 cm long, longitudinal anterior bladder wall flap is developed with a tongue of mucosa extending beyond the distal border of the full-thickness flap. A narrow (1 mm) strip of mucosa is then removed from the lateral margins of the flap, leaving a denuded area of detrusor muscle. After catheterization of the ureters, two longitudinal parallel incisions, 1 cm apart, are carried out in the posterior wall mucosa. The anterior strip is sutured in two layers to the posterior one. The redundant bladder mucosa in continuity with the anterior strip is folded back to cover the intravesical neourethra, facilitating bladder closure. Lastly, the bladder wall is closed in the midline, paying attention not to exert too much compression over the anterior wall flap.

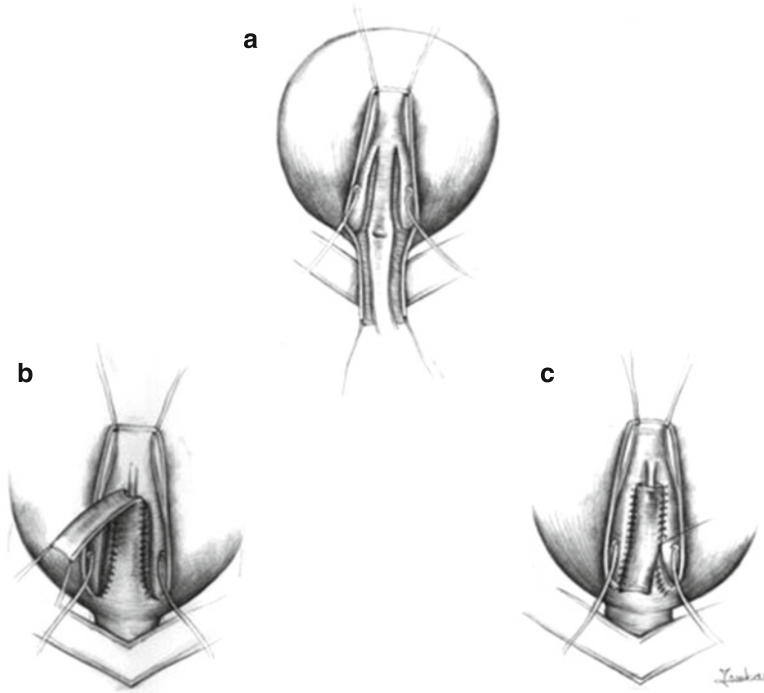

Fig. 16.3 Pippi Salle anterior bladder wall flap. (**a**) A 5 cm. long longitudinal flap of anterior bladder wall is developed; a narrow lateral strip of mucosa is removed from the flap and two vertical, parallel incisions are carried out on the trigonal mucosa. (**b**) The anterior flap is sutured in two layers to the posterior one, creating an intravesical "tube", (**c**) that is covered with the bladder mucosa. The anterior bladder wall is then closed in the midline.

The success rate of this procedure ranges from 72 to 94 %; combining all the reported patients, the success rate in achieving continence is 80 % (44 out of 55) with 16 % experiencing difficulties in catheterization.

16.6.3 Suspension and External Compression of the Urethra

16.6.3.1 Suspension

In the past, bladder neck suspensions have been very popular for the treatment of female incontinence. Marshall–Marchetti–Krantz or Burch suspension [16, 17] in association with bladder augmentation has obtained an immediate success rate around 70–80 %, but this success rate seems not durable in time, and, therefore, these procedures have been mostly abandoned in favor of periurethral slings.

McGuire and Lytton [18] popularized the concept of using a strip of isolated rectus fascia, passed beneath the bladder neck and sutured to the anterior rectal fascia at the insertion of the muscles on the pubic bones.

The slings obtain the result of elevating the bladder neck and compressing it on the posterior and lateral portions of its circumference; they find their main indication in the treatment of incontinence in neuropathic bladders, and the best results are obtained in females, even if their use is popular also in males. Children with bladder exstrophy and epispadias are best served by alternative procedures because slings may erode into the urethra, probably because the quality of tissue is poor in this group of patients.

Children with neuropathic bladder who are unable to stay dry with CIC and maximal medical management of bladder dysfunction are good candidates for sling; other good candidates are those who are incontinent after posterior urethra injury or iatrogenic injury to the sphincteric mechanism.

The evaluation of the candidates to a sling procedure must be very careful, taking into account several aspects: the detrusor responsibility in causing incontinence, the planned method of bladder drainage after surgery, the need for a continent stoma, and, finally, whether a bladder augmentation may be necessary.

It's unusual that the detrusor of a neuropathic bladder is completely normal; even in patient with apparent areflexic detrusor, it may show hyperreflexia after having increased the bladder outlet resistance; therefore, detrusor function must be assessed with careful urodynamics, in order to evaluate the need for a bladder augmentation at the time of the sling.

In general, patients undergoing a sling procedure are already catheterizing themselves, but after positioning of the sling, and especially in males, catheterization may become more difficult or even impossible, so providing a catheterizable abdominal channel may be a sensible adjunct to the procedure, mainly in wheelchair-bound children who, generally, prefer to catheterize through an abdominal continent stoma.

The sling may be constructed with rectus fascia or sometimes in fat children; it can be harvested from the fascia lata, making abdominal closure easier [19]. Decellularized porcine submucosa, SIS, has shown long-term good efficacy, while synthetic materials tend to erode into the urethra [20].

Also allografts, using cadaveric fascia lata, have given good results, favorably comparing with autologous rectus fascia.

The periurethral space may be developed transvaginally in adult women or in adolescents, while in male and young girls an anterior retropubic approach is more adequate. The procedure starts with incising the endopelvic fascia, close to the bladder neck, and developing a plane between the urethra and the vagina in female and seminal vesicles in males, cautiously spreading the blades of a right angle clamp. Great care should be used not to damage the bladder neck anteriorly or the rectum or vagina posteriorly. Once the space is obtained, an umbilical tape is threaded around the bladder neck, and when an adequate space is created, the sling is positioned, avoiding compression of the ureters. Because the sling tends to curl, it is stabilized with few stitches that keep it flat and adherent to the bladder neck. If the child is on CIC through an abdominal stoma, the sling can be tightened as much as possible to obtain a good continence, but if the child needs to catheterize himself through his urethra, it is necessary to check repeatedly the ease of catheterization during the positioning of the sling.

Lottman et al. [21] has described a midline retrovesical approach to the bladder neck that is useful mainly in neuropathic bladder. After careful detachment of the peritoneum from the bladder dome, the space between the posterior wall of the bladder and the anterior wall of the vagina in females or seminal vesicles in males is cautiously developed, remaining strictly in the midline and leaving the ureters laterally. Once the bladder neck is identified, a right angle is passed laterally on each side, so creating a space around the bladder neck, where the sling can be pulled through in the same way as described before.

The sling can also be crisscrossed in the midline, thereby exerting 360° compression on the bladder neck; this modality seems to be more effective in males. Even more effective is the tapering of the bladder neck associated with placement of a crisscrossed periurethral sling [22] (Fig. 16.4).

16.6.3.2 External Compression of the Bladder Neck

External compression of the bladder neck or urethra can be fixed or variable; fixed compression is obtained by means of fascial or synthetic wraps placed around the bladder neck, while variable compression is achieved using the artificial urinary sphincter.

Fixed External Compression

Walker et al. [23] described a procedure to wrap and compress the bladder neck using a strip of rectus fascia, with good results; Bugg and Joseph [24] added the suspension of the wrap to the pubic bone. A vascularized myofascial flap made of rectus muscle and fascia, wrapped around the bladder neck and suspended to the pubic bone, has been reported by Kolligian and Firlit [25] with good results in a small series of patients.

The use of synthetic material to create a wrap around the bladder neck has been generally fraught with a high complication rate due to the erosion of the cuff into the urethra, and the overall experience is limited in children. Some devices have given good results like the urethral constrictor described by Lima et al. [26] who reported 100 % continence rate in 42 patients.

Recently, a new device for the treatment of urinary incontinence in males has been proposed;,

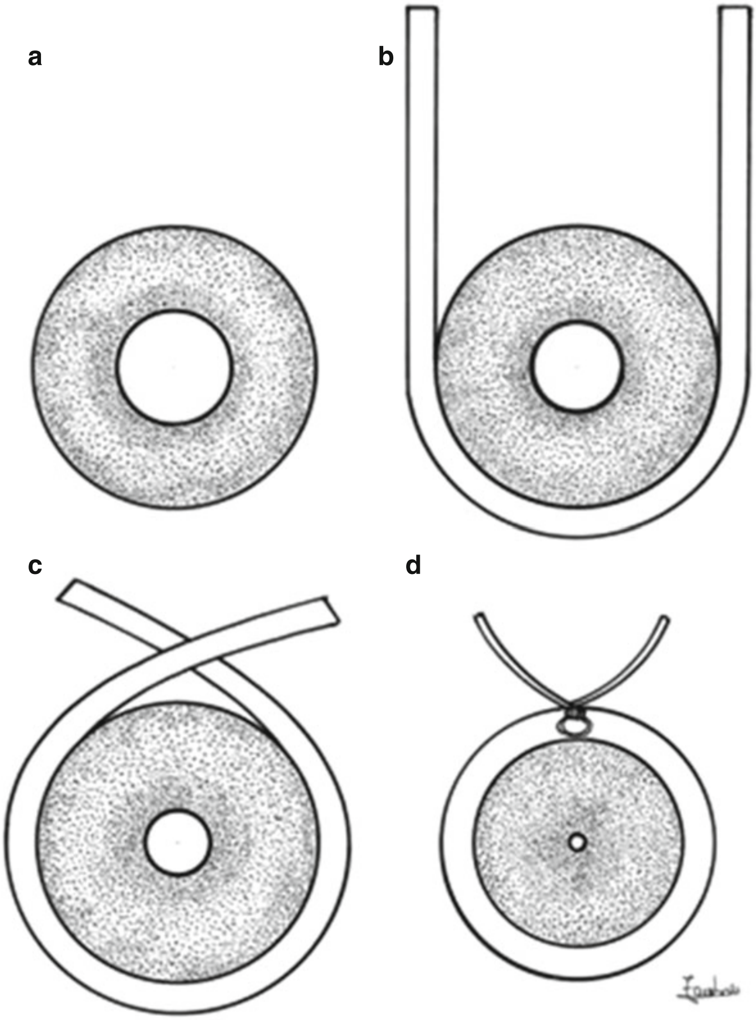

Fig. 16.4 Suspension and external compression of bladder neck (**a**, **b**) The sling compresses the posterior and lateral walls of the bladder neck. (**c**, **d**) The sling can be crisscrossed in the midline, exerting a 360° compression over the bladder neck (cinch) and can be suspended to the undersurface of pubic bones increasing its efficacy

it is a polypropylene male perineal sling, called "InVance®" (American Medical Systems Inc., Minnetonka, MN), that has been used successfully in adults to treat postprostatectomy incontinence, with low morbidity and a low complication rate [27]. The device consists of a polypropylene mesh that is secured to the descending pubic ramus bilaterally with titanium screws; the sling tension is adjusted to exert maximal pressure over the bulbar urethra. The experience in pediatric age is still limited.

The AdVance® (American Medical Systems Inc., Minnetonka, Mn) transobturator male sling has been recently employed to treat adolescent males affected by neuropathic incontinence with a 65 % success rate [28].

Variable External Compression: Artificial Urinary Sphincter

Variable compression over the bladder neck or urethra is provided by the artificial urinary sphincter, described by Scott in 1972 [29], and repeatedly modified and made more reliable in order to obviate the once frequent mechanical problems. The newest model (AMS 800) has a mechanical failure rate of 7.6 % and a nonmechanical failure rate of 9 % in a series of 184 adults with a mean follow-up of 40.8 months [30]. In children the long-term (7–10 years) survival rate is approximately 80 % in most reported series [31].

The sphincter is a mechanical device comprised of three components: an inflatable cuff that can be positioned around the bladder neck

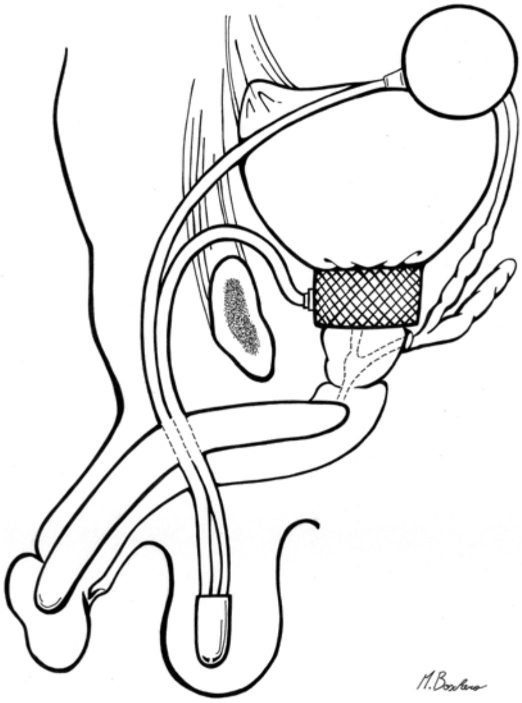

Fig. 16.5 AMS 800 Artificial urinary Sphincter. See text for description

or posterior urethra or around the bulbar urethra, a pressure-regulating reservoir balloon, and a control pump. In children the bladder neck is the preferred site of placement of the cuff; usual minimal age for placement is 6 years in boys and 8–9 years for girls. After placement the sphincter should be kept deactivated for approximately 1 month to prevent erosion.

The pressure-regulating balloon maintains the cuff inflated, exerting a constant pressure around the urethra, generally between 61 and 70 cm H_2O; the pump, located within the scrotum in boys and in the labia majora in girls, can be squeezed manually; this maneuver empties the cuff and the patient can void or catheterize himself or herself. Then the cuff fills again in approximately 3 min. The sphincter can be deactivated pressing a button located in the pump (Fig. 16.5).

The main indication for artificial sphincter placement is neurogenic incontinence in a patient with a stable and compliant bladder who can void spontaneously; in the past it was feared that intermittent catheterization could cause erosion of the urethra, but now it is clear that CIC can be performed safely even in these patients, provided that the cuff is deflated. Ability to void spontaneously can deteriorate with time, and Gonzales has reported that 74 % of patients, followed for a mean of 8 years after sphincter placement, ultimately required CIC [32].

Selection of the patients is extremely important because patients who had previous bladder neck surgery are poor candidates for artificial sphincter, and patient with a hyperreflexic, hypocompliant bladder is at risk of deterioration of the upper tract and persisting incontinence. A careful video urodynamic evaluation with bladder neck occlusion is needed before a child is selected for an implant. Unfortunately at least 20 % of patients will undergo progressive detrusor dysfunction after sphincter placement, and, currently, no test can predict who will undergo these changes. Approximately 30 % of patients require bladder augmentation with the bowel either as a simultaneous or later procedure [33]. Bladder augmentation, especially if performed simultaneously with sphincter placement, may increase the risk of infection of the device.

The most frequent complications requiring sphincter removal or substitution are mechanical malfunction, erosion of the urethra, and infection of the device. The last two complications generally preclude the possibility of implanting a new sphincter.

16.6.4 Injection of Bulking Substances

Several substances both organic and synthetic have been injected under the mucosa of the bladder neck or around the bladder neck to improve continence. Politano et al. popularized the injection of Teflon paste in adults and children with an 86 % success rate [34]; the use of this substance was later abandoned because of concerns about its safety and migration to other organs.

Organic material like autologous fat or chondrocytes was proposed but early abandoned because of their inefficacy, probably due to reabsorption. More successful was the use of X-linked bovine collagen that gave variable results, better in the exstrophy–epispadias group than in neuropathic bladders. Bomalski et al. reported a 22 % cure rate of incontinence with another 54 % improved in 40 children followed for a mean of 4.5 years [35]. Concern exists about long-term degradation of collagen with progressive worsening of continence.

Synthetic materials in use nowadays include polydimethylsiloxane (Macroplastique®) and dextranomer/hyaluronic acid copolymer (Deflux®). Macroplastique is composed of particulate silicone; Guys et al. [36] have reported a continence rate of 33 % and improvement of 14 % after one or more injections of this substance in 49 children affected by neurogenic bladder. Some concerns have been recently raised because of possible migration of smaller particles [37].

Deflux is widely used for treatment of vesicoureteral reflux; Lottman et al. [38] have reported a 50 % success rate (cure or substantial improvement) in children affected by severe urinary incontinence.

Injection is generally performed transurethrally, using a cystoscope with a 5 Fr. working channel; the bulking substance is administered in two or more sites at the bladder neck until a good mucosal apposition is observed. Any further instrumentation or catheterization of the urethra should be avoided in the following days in order to avoid dislocation or extrusion of the injected substance.

The injection can be performed also in an antegrade fashion; this is particularly useful when the bladder neck has already undergone prior surgery and identification of the proper injection site is difficult. Antegrade vision of the bladder neck helps in a more accurate placement of bulking material.

In our experience the use of injectable material for continence has proved helpful to gain additional continence after a partially successful urethral lengthening procedure, but it has proven useless as a single procedure in case of structural bladder neck incompetence.

Conclusions

Treatment of structural urinary incontinence in children remains very challenging, and surgery should be offered to the patients only if all the available medical options have failed. Patients and their families must be very motivated and psychologically ready to face less than perfect results. The percentage of failures, reoperations, and complications must be stated clearly and honestly to give the patient and family the possibility of giving a really informed consent. If augmentation is planned together with a continence procedure, it must be explained very clearly that the patient will never void normally in the future and he or she will be bound to intermittent catheterization for the rest of his/her life. These patients and their families need a long-lasting emotional support.

Once patients and family consent to perform a continence procedure, the patient needs to be studied thoroughly and, if necessary, repeatedly until a very clear anatomical and functional picture of the situation is obtained, and then the most appropriate procedure for that particular patient can be chosen. Despite accurate preoperative evaluation, after increasing the bladder neck resistance, the detrusor will deteriorate in a high percentage of cases, causing a less efficient micturition with increasing postvoiding residuals, upper urinary tract changes, and recurrent incontinence. These cases need to be identified early because they need further surgery to create a bladder reservoir at low pressure that can be emptied with intermittent catheterization. Therefore, patients need an accurate lifelong follow-up. The field of incontinence surgery is evolving with the introduction of new injectable substances and artificial devices that will contribute in making this surgery less invasive; anyhow the principles for obtaining continence remain always the same: a low-pressure reservoir of adequate capacity, enough resistance at the bladder outlet, and the possibility of emptying the bladder easily and reliably.

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References

1. Neveus T, Von Gontard A, Hoebeke P et al (2006) The standardization of terminology of lower urinary tract function in children and adolescents: report from the standardization Committee of the International Children's Continence Society. J Urol 176:314–324
2. Neveus T, Sillen U (2013) Lower urinary tract function in childhood; normal development and common functional disturbances. Acta Physiol 207:85–92
3. Yoshimura N, De Groat WC (1997) Neural control of the lower urinary tract. Int J Urol 4:111–125
4. Blaivas J, Romanzi L, Heritz D (1998) Urinary incontinence: pathophysiology, evaluation, treatment overview and nonsurgical management. In: Walsh P, Retik A, Vaughn E, Wein A (eds) Campbell's urology. W. B. Saunders, Philadelphia, pp 1007–1036
5. De Badiola F, Castro-Diaz D, Hart-Austin C et al (1992) Influence of preoperative bladder capacity on the outcome of artificial sphincter implantation in patients with neurogenic sphincter incompetence. J Urol 148:1493–1495
6. Leadbetter GW (1964) Surgical correction of total urinary incontinence. J Urol 91:261–264
7. McMahon DR, Cain MP, Husmann DA et al (1996) Vesical neck reconstruction in patients with the exstrophy-epispadias complex. J Urol 155:1411–1413
8. Donnahoo K, Rink R, Cain M et al (1999) The use of the Young-Dees-Leadbetter bladder neck repair in patients with neurogenic incontinence. J Urol 155:1411–1413
9. Geahrart J, Jeffs RD (1998) Exstrophy-epispadias complex and bladder anomalies. In: Walsh P, Retik A, Vaughn E, Wein A (eds) Campbell's urology. W.B. Saunders, Philadelphia, pp 1939–1990
10. Mollard P (1980) Bladder reconstruction. J Urol 124:525–529
11. Koff SA (1990) A technique for bladder neck reconstruction in exstrophy: the cinch. J Urol 144:546–549
12. Jones J, Mitchell M, Rink R (1993) Improved results using a modification of the Young-Dees-Leadbetter bladder neck repair. Be J Urol 71:555–561
13. Chan DY, Jeffs RD, Gearhart JP (2001) Determinants of continence in the bladder exstrophy population after bladder neck reconstruction. Urology 57:774–777
14. Kropp K, Angwafo F (1986) Urethral lengthening and reimplantation for neurogenic incontinence in children. J Urol 135:533–536
15. Salle J, De Fraga J, Amarante A et al (1994) Urethral lengthening with anterior bladder wall flap for urinary incontinence: a new approach. J Urol 152:803–804
16. Marshall V, Marchetti A, Krantz K (1949) Correction of stress continence by simple vesicourethral suspension. Surg Gyn Obstet 88:509–518
17. Burch J (1961) Urethrovaginal fixation to Cooper's ligament for correction of stress incontinence, cystocele and prolapse. Am J Obstet Gynecol 81:281–290
18. Mc Guire E, Lytton B (1978) Pubovaginal sling for stress incontinence. J Urol 119:82–84
19. Govier FE, Gibbons RP, Correa RJ et al (1997) Pubovaginal sling using fascia lata for the treatment of intrinsic sphincter deficiency. J Urol 157:117
20. Kobashi KC, Dmochowski R, Mee L et al (1999) Erosion of woven polyester pubovaginal sling. J Urol 162:2070
21. Lottmann H, Traxer O, Aigrain Y, Melin Y (1999) Posterior approach to the bladder for implantation of the 800 AMS artificial sphincter in children and adolescents: technique and results in eight patients. Ann Urol 33:357–363
22. Herschorn S, Radomski S (1992) Fascial slings and bladder neck tapering in the treatment of male urologic incontinence. J Urol 147:1073–1075
23. Walker D III, Flack CE, Hawkins-Lee B et al (1995) Rectus fascial wrap: early results of a modification of the rectus fascial sling. J Urol 154:771
24. Bugg CE, Joseph DB (2003) Bladder neck cinch for pediatric neurogenic outlet deficiency. J Urol 170:1501–1503
25. Kolligian ME, Palmer LS, Cheng EY, Firlit CF (1998) Myofascial wrap to treat intractable urinary incontinence in children. Urology 52:1122–1127
26. Lima SV, Araujo LA, Vilar FO (1997) Further experience with the periurethral expander : a new type of artificial sphincter. Br J Urol 80:460
27. Athanasopulos A, Kostantinopoulos A, Mc Guire E (2010) Efficacy of the InVance male sling in treating stress urinary incontinence: a three year experience from a single centre. Urol Int 85:436–442
28. Groen LA, Spinoit AF, Hoebeke P et al (2012) The advance male sling as a minimally invasive treatment for intrinsic sphincter deficiency in patients with neurogenic bladder sphincter dysfunction: a pilot study. Neurourol Urodyn 31:1284–1287
29. Scott FB, Timm GW (1974) Treatment of incontinence by an implantable prosthetic urinary sphincter. J Urol 112:75
30. Elliott D, Barrett D (1998) Mayo Clinic long term analysis of the functional durability of the AMS 800 artificial urinary sphincter: a review of 323 cases. J Urol 159:1206–1208
31. Hafez A, McLorie G, Bagli D, Khoury A (2002) A single-center long-term outcome analysis of artificial urinary sphincter placement in children. BJU Int 83:1120–1131
32. Gonzalez R, Merino F, Vaughn M (1995) Long term results of the artificial urinary sphincter in male patients with neurogenic bladder. J Urol 154:769–770
33. Barrett D, Parulkar B, Kramer S (1993) Experience with AS 800 artificial sphincter in pediatric and young adult patients. Urology 42:431–436

34. Vorstman B, Lockhard J, Kaufman M, Politano V (1985) Polytetrafluoroethylene injection for urinary incontinence in children. J Urol 133:248–250
35. Bomalski M, Bloom D, Mc Guire E et al (1996) Glutaraldehyde cross-linked collagen in the treatment of urinary incontinence in children. J Urol 155:699–702
36. Guys JM, Breaud J, Hery G et al (2006) Endoscopic injection with polydimethylsiloxane for the treatment of pediatric urinary incontinence in the neurogenic bladder: long term results. J Urol 175:1106–1110
37. Henly DR, Barrett DM, Wieland TL et al (1995) Particulate silicone for use in periurethral injections: local tissue effects and search for migration. J Urol 153:2039–2043
38. Alova I, Margaryan M, Bernuy M et al (2012) Long term effects of endoscopic injection of dextranomer/hyaluronic acid based implants for treatment of urinary incontinence in children with neurogenic bladder. J Urol 188:1905–1909