World J Urol (1998) 16: 205–211

L. A. Baker · J. P. Gearhart

The staged approach to bladder exstrophy closure and the role of osteotomies

Abstract Since the 1970's, the staged reconstruction of bladder exstrophy has yielded consistent surgical success. The Johns Hopkins Hospital approach begins with early pelvic ring approximation with abdominal wall, bladder, and posterior urethral closure. Within the first 72 hours of life, the malleable pelvis can sometimes be approximated without osteotomies. Beyond this age, the author's prefer a combined vertical iliac and horizontal innominate osteotomy. Second, we typically perform the epispadias closure at 1 year of age. A modified Cantwell-Ransley technique is performed, usually yielding an increase in bladder capacity and very satisfactory results. In the last phase, the modified Young-Dees-Leadbetter continence procedure along with transtrigonal/cephalotrigonal ureteroneocystostomies are performed when the urethra is catheterizable, the bladder capacity is 60cc or greater, and the child will participate in a postoperative voiding program (typically 4–5 years of age). This applied approach usually results in a continent, voiding patient with pleasing external genitalia and preserved renal function.

Whereas it was once deemed "impossible to restore the bladder" (H.J. Jewett, patient communication, 1957) in patients with exstrophy, now, with contemporary management, this profound anomaly has successfully been reconstructed. While some controversy continues concerning not only the timing but also the techniques of reconstruction, the staged reconstruction of the exstrophy patient, as performed at the Johns Hopkins Hospital, has proven to withstand the test of time, yielding acceptable renal preservation rates and continence [11, 18, 34, 40, 45]. In this review, the current strategy of staged reconstruction and the application of osteotomies in this reconstruction will be delineated. Management options in the exstrophy reconstruction failures will also be addressed.

L. A. Baker · J. P. Gearhart (✉)
Brady Urological Institute, Marburg 1, 600 N. Wolfe St.,
Johns Hopkins Hospital, Baltimore, MD 21287, USA

Staged exstrophy reconstruction

The staged approach to exstrophy reconstruction consists of early bladder and posterior urethral closure, later epispadias repair, and finally bladder neck reconstruction with an antireflux procedure. This approach can yield a secure bladder and abdominal wall closure, urinary continence without renal compromise, and reconstruction of a cosmetic penis with good sexual function. Others have advocated a single- or two-stage approach to reconstruction with good preliminary results [7, 15, 19] but the numbers are limited. However, the risk of complications is significant for any one stage and, clearly, one complication could jeopardize other aspects of the repair. This staged approach has been recommended and performed at our institution since the mid-1970s and long-term results seem to justify this approach.

Stage 1: Initial early exstrophy closure

With rapid referrals and, in some cases, prenatal diagnoses [26], neonates with bladder exstrophy should be evaluated for surgical reconstruction promptly. At stage 1 of exstrophy reconstruction, the surgical objectives include: (1) approximation of the pelvic ring, (2) closure of the bladder and posterior urethra inside the pelvic ring, and (3) closure of the abdominal wall.

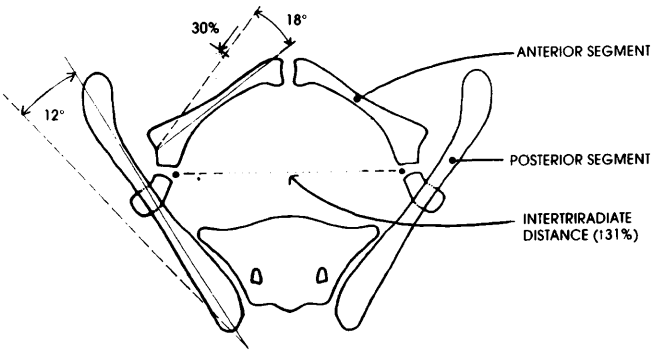


Fig. 1 The anatomy of the normal bony pelvis is seen in transverse view. Superimposed are the deviations observed in the pelvis of classic bladder exstrophy patients. In the posterior segment, each half is externally rotated 12°. The acetabulae are retroverted, yielding an increased intertriradiate distance. In the anterior segment, each half is externally rotated 18° and is on average 30% shorter

Approximation of the pelvic ring

The anatomy of the bony pelvic ring in classic exstrophy has been defined by Sponseller et al. using CT scan reconstructions [30, 49]. There is a 12° external rotation of the innominate bones on the sagittal axis, retroversion of the acetabula, and the public bones are on average 30% shorter with an 18° external rotation at the junction of the ischial and iliac bones [49] (Fig. 1). This yields the wide public symphyseal diastasis.

It has become clear that approximation of the open pelvic ring eases abdominal wall closure and diminishes the rate of bladder dehiscence and abdominal wall dehiscence [19, 34, 45]. This therefore allows the construction of an intrapelvic urethra and reapproximates the pelvic floor musculature, likely contributing to long term continence [1, 18, 45]. Additionally, in females, osteotomy may reduce the likelihood of uterine prolapse [3, 45]. Therefore, pelvic ring reapproximation is useful at initial bladder closure as well as at later stages of reconstruction if satisfactory reapproximation was not achieved intially.

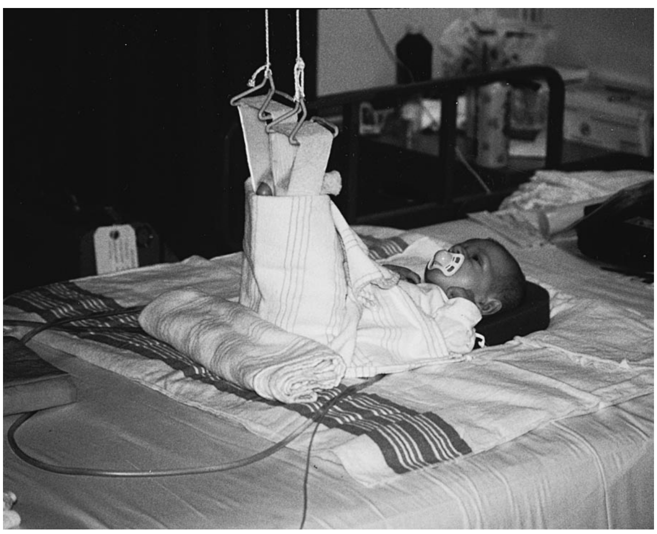


Fig. 2 Patient seen with an external fixator and in Bryant's traction

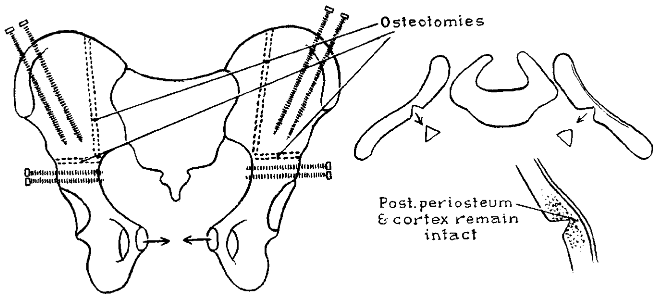


Fig. 3 Osteotomy sites for combined vertical iliac and transverse innominate osteotomies showing the placement of intrafragmentary pins

Pelvic closure in the neonate younger than 48–72 h old can be achieved without osteotomies due to the effects of maternal relaxin; immobilization is achieved by modified Bryant's traction for 3–4 weeks (Fig. 2). However, beyond this age or at this time if the pelvis is not sufficiently malleable, osteotomies are performed at the time of initial closure. An interesting predicament for the surgeon is the situation of the newborn with a large bladder template. In this case, with a bladder having great potential for later continence, the public diastasis will be wider and require osteotomy regardless of when closure is attempted. While the authors have performed posterior iliac osteotomies, anterior innominate osteotomies or public ramotomies at initial closure with success, a combined approach of vertical iliac osteotomy with horizontal innominate osteotomy (Fig. 3) has recently been used in over 68 patients at our institution with good results [30]. Femoral nerve palsy is a possible complication which must be monitored. However, with gradual tightening of the fixator, this complication has not been seen in the last 36 procedures. These osteotomies are secured by intrafragmentary pins, external fixation (4 weeks for newborns; 6–8 weeks for older patients), and light Buck's traction for 2–4 weeks.

Exstrophy closure

The initial decision as to whether a bladder template is amenable to closure is currently based on subjective data. Even a small bladder template, if distensible and contractile, can enlarge to a useful size once closed. However, if an examination under anesthesia reveals a small (< 5 cm^3) acontractile, nondistensible bladder patch, an attempt should not be made to close this bladder. While ureterosigmoidostomy has proven useful in this group of patients [39], our preference is to wait and reexamine the child at 4–6 months of age under anesthesia. If at later evaluation the bladder remains inadequate, a nonrefluxing colon conduit is used to divert the urine along with the abdominal wall closure and epispadias repair. This can be converted at a later age to

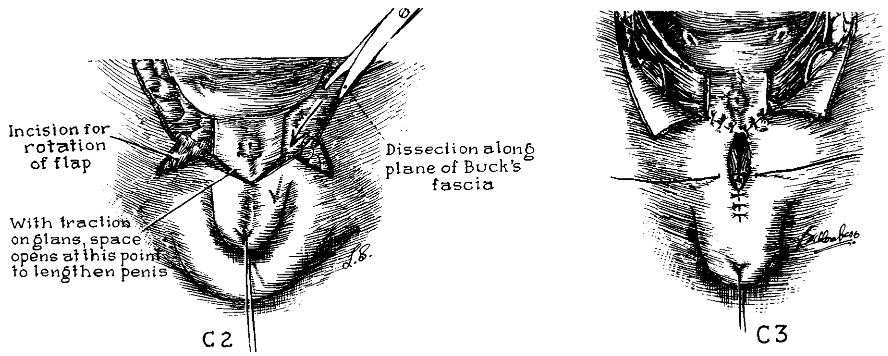


Fig. 4 Steps in primary bladder closure following osteotomy or without osteotomy in the newborn younger than 72 h age. *C2* Following bladder and posterior urethral mobilization, lateral skin incisions are made into the thick, healthy paraexstrophy skin; *C3* flaps of skin are rotated and anastomosed to the posterior urethral plate

a continent diversion or anastomosed to the rectosigmoid.

If the bladder template is amenable to closure, early exstrophy closure is advantageous for multiple reasons. Socially, for the family, a prompt closure begins the road toward normalcy. In addition, early closure saves the bladder from prolonged exposure which can lead to such histological changes as acute and chronic inflammation, squamous metaplasia, cystitis glandularis and cystitis cystica, and muscular fibrosis [2, 46]. Functionally, it is likely that this results in a bladder with low capacity and poor compliance [29]. Ongoing research at our institution has shown that the newborn exstrophy bladder is "immature" when compared to control newborns, having fewer small nerve fibers [43], less smooth muscle, and a three-fold increase in type III collagen content [41]. While it is unclear whether these changes are a part of the primary pathology or secondary to the lack of bladder cycling in utero, it is conceivable that prompt closure could also "mature" the bladder by restoring bladder cycling. Similarly, recent clinical data from the Mayo Clinic has verified the importance of immediate postnatal exstrophy closure; infants closed before 7 days of age required fewer bladder augmentations to achieve eventual continence [44].

The surgical technique of the midline closure of the bladder, posterior urethra, symphysis, and fascia has been previously described [21]. However, a few caveats that can add to surgical success follow. Inguinal hernias, seen in up to 82% of males, should be surgically repaired at the time of initial exstrophy closure [10]. If the child has severe chordee and a short urethra that inhibits attempts at penile lengthening, an incision of the urethral plate may be necessary. Management of this is best assessed after extensive mobilization of the bladder and prostatic plate from the rectus fascia, the pubic bones, and the inferior ramus of the pubis. Once radical division of the urogenital diaphragm fibers from the posterior urethra/bladder neck area is accomplished, the prostatic urethra can be displaced posteriorly into the pelvis. Division of the anterior attachments of the crura and the suspensory tissue of the penis then displays the gap to be bridged between the prostatic plate and the penile plate. While this has been reconstructed after the manner of Johnston or Duckett, paraexstrophy skin flaps should be used with great caution. The authors have noted a 40% complication rate associated with their use and significant comorbidity [24]. This lack of urethral plate length can be managed by dividing the prostatic plate distal to the verumontanum in a V-shaped fashion. After corporal mobilization and midline reapproximation, the penile urethral plate is fashioned from a lateral rotational flap generated after a single lateral incision into the paraexstrophy skin (Fig. 4). Less tissue redundancy and dissection is therefore necessary. Paraexstrophy skin flaps are unnecessary in female exstrophy closures and are associated with a very high complication rate [6].

In all cases of initial closure, suprapubic tubes and ureteral stents are placed and urethral tubes/stents should not be used. Additional factors that are important to the success of the initial closure include pelvic immobilization and fixation, adequate pain control, prevention of abdominal distention, and postoperative antibiotics [34, 42]. Adequate urethral caliber is assured prior to removal of the suprapubic tube at 4 weeks. The status of the upper tracts is documented by ultrasound prior to discharge and is followed by ultrasound at 3 months and every 6 months to 1 year.

The successfully closed child is continued on prophylactic antibiotics, for essentially all have vesicoureteral reflux. Between the ages of 1 to 3 years, yearly cystograms under anesthesia are performed to assess the degree of reflux and, more importantly, to assess the growth of the bladder. By this age, it is hoped that the capacity will achieve 50 to 60 cm^3.

Stage 2: Epispadias repair

Epispadias repair should result in a cosmetic, straight functional penis with a urethra capable of catheterization if necessary. The modified Cantwell-Ransley epispadias repair has been the preferred technique at our institution since 1988, being performed typically between the age of 1 and 1.5 years [28, 37]. This repair offers a straight urethra with a 15% fistula rate at 3 months while simultaneously incorporating a chordee repair [28]. Performing the epispadias repair prior to bladder neck plasty provides a gradual increase in outlet resistance with the added benefit of enhancing bladder capacity [17].

In preparation for this repair, the following questions must be addressed: (1) Would preoperative stimulation of penile growth with testosterone benefit the repair? (2) Is penile lengthening useful at this time? and (3) Is the current posterior urethral meatus ideal, that is, without and/or not prone to stricture?

Most of our male patients undergo testosterone stimulation before epispadias closure. Testosterone enanthate in oil (2 mg/kg) is administered at 5 and 2 weeks prior to epispadias closure. The decision as to the need for penile lengthening can then be made after the response to testosterone has been observed. Penile lengthening can almost always be achieved at this time by division of all remnants of the suspensory ligament and scar tissue as well as further release of the crura from the inferior pubic rami. It is surprising how much of this tissue is intact at the onset of the epispadias repair. In some situations, further urethral lengthening may require free skin grafts, buccal mucosal grafts, ureteral grafts or pedicle skin flaps [33, 50]. These same maneuvers can be used to repair the scarred or stenosed posterior urethra.

Postoperative care includes bladder antispasmodics, broad-spectrum antibiotics and removal of the urethral catheter at 2 weeks. Long term experience with over 125 patients with the modified Cantwell-Ransley repair finds a conical glans, a straight penis and urethra below the corporal bodies with an acceptable complication rate.

Stage 3: Bladder neck plasty with or without Osteotomies

A continence procedure is indicated when (1) the urethra is stricture-free and capable of catheterization if necessary, (2) under anesthesia, the bladder capacity has achieved a minimum of 60 cm^3, and (3) the child is of the maturity to desire continence and to participate in the postoperative voiding program. This is typically around age 4–5 years. The modified Young-Dees-Leadbetter bladder neck plasty [36] and the transtrigonal/cephalotrigonal bilateral ureteral reimplantation [8, 9] are the surgical techniques employed at the Johns Hopkins Hospital. Again, it is necessary to reassess whether osteotomy might stabilize the intersymphyseal bar and improve continence at the time of bladder neck reconstruction. It is important to completely free the bladder neck area at this time so that urethropexy can be achieved. This may require excision of a portion of the intersymphyseal bar for visual access.

Urine is drained via bilateral ureteral stents and a suprapubic tube for 3 weeks. The urethra is calibrated with a soft 8-Fr. catheter and voiding trials are begun with the suprapubic tube in place after the urine has been sterilized. If no urine is passed, cystoscopy and urethral stenting may be required for a short period. A bladder readjustment period may span several months before day and subsequently night continence is achieved.

Combined exstrophy and epispadias closures

In the event of a significantly delayed primary closure or an initial bladder closure failure, a simultaneous closure of the exstrophy bladder and the epispadias can be performed. The advantages to this approach include one less anesthetic exposure and increasing outlet resistance to stimulate bladder growth. Again, in the scenario, the combined horizontal innominate and the vertical iliac osteotomies are necessary for a secure bladder, abdominal wall, and posterior urethral closure and can allow transposition of the urethra to beneath the corpora with some dissection. This combined approach of simultaneous exstrophy and epispadias closures has been performed in 17 patients at this institution with comparable results (i.e. fistula rate, bladder neck reconstruction rate, augmentation rate, and continence rate) to age-matched patients who underwent the classic staged approach after failed initial closure [31]. However, this is only necessary in select patients.

Outcomes of staged exstrophy reconstruction

Accumulation of the data from several series of staged reconstructions reveals the following conclusions:

1. Early exstrophy closure, only if in conjunction with pelvic ring approximation, results in a higher rate of continence achieved without augmentation; delayed closure, especially if without osteotomies, resulted in more bladder augmentations [34, 44].
2. Paraexstrophy skin flaps are at high risk for complications; the use of such flaps should be minimized in the male and is unnecessary in the female [24].
3. Bladder capacity under anesthesia, prior to bladder neck plasty, is the most important single predictor of eventual urinary continence [25]. A recent review of our 21 years of experience with 60 consecutive exstrophy closures found that 72% are dry and voiding urethrally without augmentation or clean intermittent catheterization [40].
4. In the Hopkins experience, the Cantwell-Ransley epispadias repair results in a straighter penis and urethra but is associated with a 15% fistula rate at three months [28].
5. In adult exstrophy men, all experience normal erections and 75% have satisfactory orgasms. Fertility is still an issue, however, with only 63% having antegrade ejaculation and few pregnancies achieved [5].

Exstrophy reconstructive failures

Failed initial closure

At the primary closure, failures can manifest as bladder dehiscence, bladder prolapse with obstruction, neourethral stricture and obstruction. It is prudent to consider referral of these complex management situations to an exstrophy center. Dehiscence, which may be precipitated by incomplete approximation of the pelvic ring, inadequate pelvic immobilization, wound infection, abdominal distention, or urinary tube malfunction [34, 42], necessitates a 6-month recovery period prior to a second attempt at closure. A tension-free closure with osteotomy and immobilization are important factors in both an initial and any subsequent closures [29]. Unfortunately, the chance of obtaining an adequate bladder capacity for bladder neck plasty and eventual continence, following multiple reclosures, is markedly diminished [20, 23, 29]. Similarly, bladder prolapse is considered a failure and will require bladder reclosure/revision. Neourethral stricture is most often associated with the paraexstrophy skin flap use [24]; pubic suture reaction and erosion or urethral stents may contribute in this problem. This diagnosis may be somewhat subtle; however, warning flags consist of urinary tract infections, detectable bladder volumes on ultrasound, bladder stones, and prolonged dry periods. While all closed exstrophy bladders have vesicoureteral reflux, upper tract deterioration is the ultimate fate of significant outlet obstruction. At this point, the management options include upper tract diversion (bilateral cutaneous ureterostomies or diversion into bowel conduit, which might be incorporated into augmentation or continent diversion at a later date), urethral dilation/incision, or open urethroplasty with or without osteotomies as indicated [3, 21]. Clearly, if renal function is compromised, the choice must achieve unquestionable free drainage for a period of time to allow the upper tracts and the kidneys to fully recover. No further bladder neck or urethral reconstruction should be performed until the posterior urethral stricture is clearly repaired and free drainage has been achieved.

Failure to gain bladder capacity

Despite a satisfactory initial bladder and posterior urethral closure, some bladders never attain sufficient capacity to act as functional bladders. It has become clear that multiple bladder closures, bladder prolapse, dehiscence, bladder calculi, recurrent infections, and vesicostomy have a negative impact upon the potential of the exstrophy bladder [16]. Bladder augmentation is recommended in this situation. If the bladder neck and/or urethra are problematic, a catheterizable abdominal stoma with or without bladder neck plasty or transection is performed with the augmentation [3, 21].

Failed bladder neck reconstruction

If urinary continence, defined as a 3-hour dry interval, is not achieved within 2 years of bladder neck reconstruction, this is considered a failure. Some success has been seen in repeating a Young-Dees-Leadbetter repair if the bladder neck is patulous and the bladder capacity is adequate [22]. The majority of bladder neck failures require eventual augmentation or a continent diversion [27]. Either the bladder neck is transected proximal to the prostate with a Mitrofanoff substitution or a continence procedure is performed, such as artificial sphincter [13, 32] or collagen injection [4].

Delayed urinary continence has been reported at the onset of puberty in some males and has been attributed to prostatic growth [41]. By MRI, the prostate of

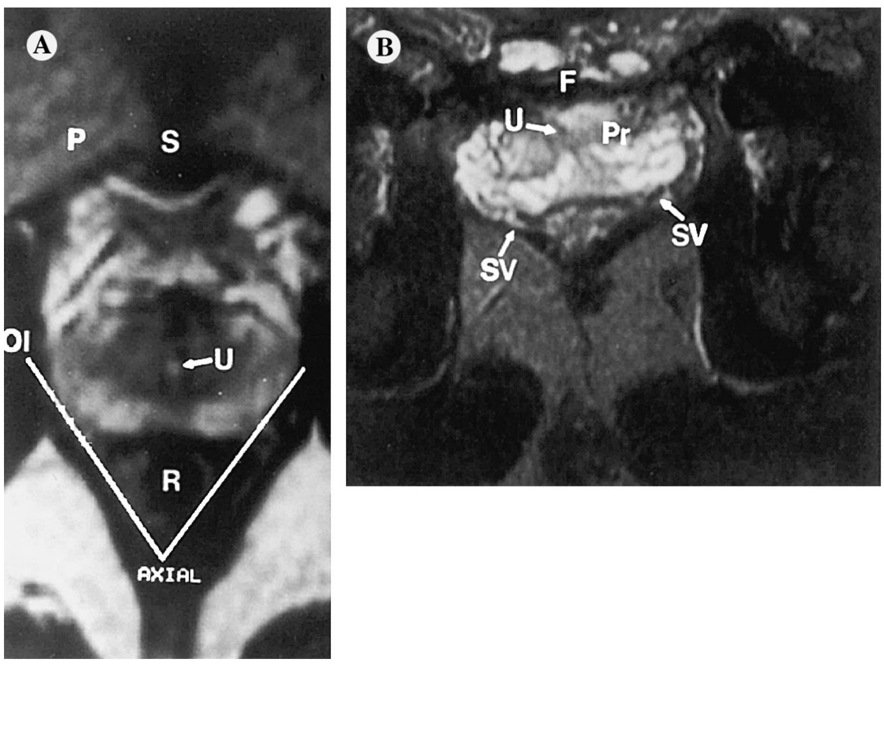
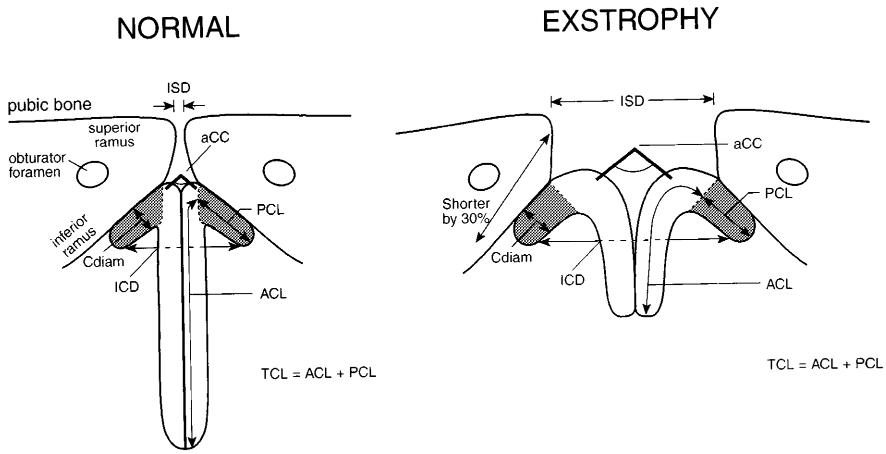


Fig. 5 Axial T2-weighted images through the mid-prostate gland. A 22 year-old normal individual demonstrates the usual relations between the components of the puborectalis sling (54°); B 30-year-old classical exstrophy patient demonstrates the altered relations between the components of the splayed puborectalis sling (109°) (*F*, fibrous band; *OI*, obturator internus; *P*, bony pubis; *Pr*, prostate gland; *Sf*, symphysis; *SV*, seminal vesicle; *R*, rectum, *U*, urethral)

Fig. 6 Penile and pelvic measurements in normal men and patients with exstrophy (*ISD*, intersymphyseal distance; *ACC*, corpora cavernosa subtended angle; *Cdiam*, corpus cavernosum diameter; *PCL*, posterior corporeal length; *ICD*, intercorporeal distance; *ACL*, anterior corporeal length; *TCL*, total corporeal length)



exstrophy patients (Fig. 5) is clover-shaped and absent anteriorly while its mean weight, maximal cross sectional area, and volume are normal [25]. Therefore, it is doubtful that growth of this abnormally configured prostate can impact upon urinary continence.

Failed genital–urethral reconstruction

The most common complication of Cantwell-Ransley epispadias closure, urethrocutaneous fistula formation, was seen in 15% of patients at 3 months postoperatively [28]. Urethral tortuosity with difficult catheterization and strictures are uncommon with this repair.

At an older age, unsightly penile scars and a short phallus may prompt further surgical intervention. Scar excision can be closed in a plastic fashion if penile skin is available; otherwise, flaps or full-thickness skin grafts can be used [21]. Freeing all scar tissue and suspensory ligament tissue can maximize penile length. A dorsal dermal corporal graft [51] or ventral corporal plication and rotation of the Cantwell-Ransley type [28, 38] may additionally help lengthen as well as correct any chordee. However, it must be recognized that the exstrophy penis, when compared to age and race-matched controls, is congenitally deficient in anterior corporeal tissue as assessed by MRI (Fig. 6). The posterior corporeal segments, attached to the inferior public ramus, are the same length as the controls. Therefore, overly aggressive attempts at lengthening the penis may only result in corporeal denervation and devascularization without additional lengthening [48].

Conclusion

Forty years ago, bladder exstrophy was considered a hopeless state, which could not be reconstructed. As delineated above, the staged surgical management of exstrophy has evolved, through much work and frank experimentation, into a precise scheme. Clearly, urinary continence can be achieved with renal preservation and the external genitalia can be fashioned to be functional as well as cosmetic by implementing this multi-stage approach. Other approaches such as single-stage bladder closure and epispadias repair in the very young child await the test of time as far as status of the upper tracts, ability to gain sufficient capacity for bladder neck reconstruction, and long-term continence results are concerned.

References

1. Aadalen RJ, O'Phelan EH, Chisholm TC, McParland FA Jr, Sweetser TH Jr (1980) Exstrophy of the bladder: long-term results of bilateral posterior iliac osteotomies and two-stage anatomic repair. Clin Northup 151: 193–200
2. Ben-Chaim J, Gearhart JP (1996) Current management of bladder exstrophy. Techn Urol 2: 22–33
3. Ben-Chaim J, Gearhart, JP (1997) An update on the current management of bladder exstrophy. In: Ball TP Jr, (ed) AUA update series, Vol. XVI. American Urological Association, Houston, pp 146–151
4. Ben-Chaim J, Jeffs RD, Peppas DS, Gearhart JP (1995) Submucosal bladder neck injections of glutaraldehyde cross-linked bovine collagen for the treatment of urinary incontinence in patients with the exstrophy/epispadias complex. J Urol 154: 862–864
5. Ben-Chaim J, Jeffs RD, Reiner WG, Gearhart JP (1996) The outcome of patients with classic bladder exstrophy in adult life. J Urol 155: 1251–1252
6. Ben-Chaim J, Jeffs RD, Gearhart JP (1997) Urethrovaginal fistula as a complication of female bladder exstrophy closure. J Urol, Submitted for publication
7. Canning DA (1996) Bladder exstrophy: the case for primary bladder reconstruction. Urology 48: 831–834
8. Canning DA, Gearhart JP, Peppas DS, Jeffs RD (1993) The cephalotrigonal reimplant in bladder neck reconstruction for patients with exstrophy or epispadias. J Urol 150: 156–158
9. Cohen SJ (1975) Ureterozystoneostomie – eine neue Antirefluxtechnik. Akt Urol 6: 1
10. Connolly JA, Peppas DS, Jeffs RD, Gearhart JP (1995) Prevalence and repair of inguinal hernias in children with bladder exstrophy. J Urol 154: 1900–1901
11. Connor JP, Lattimer JK, Hensle TW, Burbige KA (1988) Primary closure of bladder exstrophy: long-term functional results in 137 patients. J Pediatr Surg 23: 1102–1106
12. Culp DA (1964) The histology of the exstrophied bladder. J Urol 91: 538–548
13. Decter RM, Roth DR, Fishman IJ, Shabsigh R, Scott FB, Gonzales ET Jr (1988) Use of the AS800 device in exstrophy and epispadias. J Urol 140: 1202–1203

14. Duckett JW (1977) Use of paraexstrophy skin pedicle grafts for correction of exstrophy and epispadias repair. Birth Defects: Orig Art Ser 13: 175–179
15. Fuchs J, Gluer S, Mildenberger H (1996) One-stage reconstruction of bladder exstrophy. Eur J Pediatr Surg 6: 212–215
16. Gearhart JP (1991) Failed bladder exstrophy repair: evaluation and management. Urol Clin North Am 18: 687–699
17. Gearhart JP, Jeffs RD (1989) State-of-the-art reconstructive surgery for bladder exstrophy at the Johns Hopkins Hospital. Am J Dis Child 143: 1475–1478
18. Gearhart JP, Jeffs RD (1989) Bladder exstrophy: increase in capacity following epispadias repair. J Urol 142: 525–526; discussion 542–543
19. Gearhart JP, Jeffs RD (1990) Complications of exstrophy and epispadias surgery. In: Smith RB, Ehrlich RM (eds) Complications of urologic surgery, 2nd edn. W.B. Saunders, Philadelphia, p 569
20. Gearhart JP, Jeffs RD (1991) Management of the failed exstrophy closure. J Urol 146: 610–612
21. Gearhart JP, Jeffs RD (1998) Exstrophy-epispadias complex and bladder anomalies. In: Walsh PC, Retik AB, Stamey TA, Vaughan ED Jr (eds) Campbell's textbook of urology, 7th edn. W.B. Saunders, Philadelphia, pp 1939–1990
22. Gearhart JP, Canning DA, Jeffs RD (1991) Failed bladder neck reconstruction: options for management. J Urol 146: 1082–1084
23. Gearhart JP, Peppas DS, Jeffs RD (1993) Complications of paraexstrophy skin flaps in the reconstruction of classical bladder exstrophy. J Urol 150: 627–630
24. Gearhart JP, Peppas DS, Jeffs RD (1993) The failed exstrophy closure: strategy for management. Br J Urol 71: 217–220
25. Gearhart JP, Yang A, Leonard MP, Jeffs RD, Zerhouni EA (1993) Prostate size and configuration in adults with bladder exstrophy. J Urol 149: 308–310
26. Gearhart JP, Ben-Chaim J, Jeffs RD, Sanders RC (1995) Criteria for the prenatal diagnosis of classic bladder exstrophy. Obstet Gynecol 85: 961–964
27. Gearhart JP, Peppas DS, Jeffs RD (1995) The application of continent urinary stomas to bladder augmentation or replacement in the failed exstrophy reconstruction. Br J Urol 75: 87–90
28. Gearhart JP, Sciortino C, Ben-Chaim J, Peppas DS, Jeffs RD (1995) The Cantwell-Ransley epispadias repair in exstrophy and epispadias: lessons learned. Urology 46: 92–95
29. Gearhart JP, Ben-Chaim J, Sciortino C, Sponseller PD, Jeffs RD (1996) The multiple reoperative bladder exstrophy closure: what affects the potential of the bladder? Urology 47: 240–243
30. Gearhart JP, Forschner DC, Jeffs RD, Ben-Chaim J, Sponseller PD (1996) A combined vertical and horizontal pelvic osteotomy approach for primary and secondary repair of bladder exstrophy. J Urol 155: 689–693
31. Gearhart JP, Mathews R, Taylor S, Jeffs RD (1997) Combined bladder closure and epispadias repair in the reconstruction of bladder exstrophy. J Urol, in press
32. Hanna MK (1981) Artificial urinary sphincter for incontinent children. Urology 18: 370–373
33. Hendren WH (1979) Penile lengthening after previous repair of epispadias. J Urol 121: 527–534
34. Husmann DA, McLorie GA, Churchill BM (1989) Closure of the exstrophic bladder: an evaluation of the factors leading to its success and its importance in urinary continence. J Urol 142: 522–524; discussion 542–543
35. Johnston JH (1974) Lengthening of the congenital or acquired short penis. Br J Urol 46: 685
36. Jones JA, Mitchell ME, Rinks RC (1993) Improved results using a modification of the Young-Dees-Leadbetter bladder neck repair. Br J Urol 71: 555
37. Kajbafzadeh AM, Duffy PG, Ransley DG (1995) The evolution of penile reconstruction in epispadias repair: a report of 180 cases. J Urol 154: 858
38. Koff SA, Eakins M (1984) The treatment of penile chordee using corporeal rotation. J Urol 131: 931
39. Koo HP, Avolto L, Duckett JW, Jr (1996) Long-term results of ureterosigmoidostomy in children with bladder exstrophy. J Urol 156: 2037–2040
40. Lakshmanan Y, Peppas DS, Gearhart JP, Jeffs RD (1997) Bladder exstrophy: a twenty-one year experience with functional reconstruction in 88 consecutive patients followed from birth. J Urol, Submitted for publication
41. Lee BR, Perlman EJ, Partin AW, Jeffs RD, Gearhart JP (1996) Evaluation of smooth muscle and collagen subtypes in normal newborns and those with bladder exstrophy. J Urol 156: 2034–2036
42. Lowe FC, Jeffs RD (1983) Wound dehiscence in bladder exstrophy: an examination of the etiologies and factors for initial failure and subsequent success. J Urol 130: 312–315
43. Mathews R, Wills ML, Perlman EJ, Gearhart JP (1997) Neural innervation in the newborn exstrophic bladder: an immunohistochemical study. [Abstract] Am Acad Ped Annual Meeting
44. McMahon DR, Cain MP, Husmann DA, Kramer SA (1996) Vesical neck reconstruction in patients with the exstrophy-epispadias complex. J Urol 155: 1411–1413
45. Oesterling JE, Jeffs RD (1987) The importance of a successful initial bladder closure in the surgical management of classical bladder exstrophy: analysis of 144 patients treated at the Johns Hopkins Hospital between 1975 and 1985. J Urol 137: 258–262
46. Peppas DS, Tchetgen M, Lee BR, Jeffs RD, Gearhart JP (1997) A quantitative histological analysis of the bladder in classical bladder exstrophy in various stages of reconstruction utilizing color morphometry. J Urol, Submitted for publication
47. Ritchey ML, Kramer SA, Kelalis PP (1988) Vesical neck reconstruction in patients with epispadias-exstrophy. J Urol 139: 1278–1281
48. Silver RI, Yang A, Ben-Chaim J, Jeffs RD, Gearhart JP (1997) Penile length in adulthood after exstrophy reconstruction. J Urol 157: 999–1003
49. Sponseller PD, Bisson LJ, Gearhart JP, Jeffs RD, Magid D, Fishman E (1995) The anatomy of the pelvis in the exstrophy complex. J Bone Joint Surg (Am) 77: 177–189
50. Thomalla JV, Mitchell ME (1984) Ventral preputial island flap technique for the repair of epispadias with or without exstrophy. J Urol 132: 985–987
51. Woodhouse CR (1989) Reconstruction of the epispadiac penis in adolescents. Prog Pediatr Surg 23: 165