

## A Novel Midline Scroto-perineal Approach Facilitating Innervation Preserving Sphincteroplasty and Radical Corporal Detachment for Reconstruction of Exstrophy-epispadias

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| <b>OBJECTIVE</b>            | To report a novel surgical approach for single-stage repair of exstrophy-epispadias, with the specific aim of innervation, preserving sphincteroplasty corporal detachment for penile lengthening and ischio-pubic ramotomy for Linia-alba approximation.  |
| <b>MATERIAL AND METHODS</b> | Twenty-five classic exstrophy with compliant bladder plate and 10 incontinent epispadias patients were selected. Preoperative magnetic resonance angiogram of urogenital diaphragm showed triangular space between ischio-cavernosus, bulbo-spongiosus, and transverse-perinei muscles containing sphincteric branch of perineal artery indicating the course of sphincteric nerve. Bladder plate was mobilized. Through a midline scrotal septal and transverse incision along the base of urogenital triangle, the urogenital diaphragm was exposed. Corpora were separated from the urethral plate while preserving the glanular continuity and innervation to striated urethral sphincter, using muscle stimulator and nerve integrity monitor. In the subperiosteal plane along the ischio-pubic rami, the corpora were detached. Repair included ureteric reimplantation; anatomic reconstruction of bladder, bladder neck, urethra, and striated sphincter; corporo-glanuloplasty; ischio-pubic ramotomy; and abdominal closure. Assessment included surgical problems, cosmetic satisfaction, erectile function, continence, and upper tract status at 2-year follow-up. |
| <b>RESULT</b>               | There was no corporal loss. Postoperative complications included 4 perineal suture line infections, 11 peno-pubic fistula, and 1 adhesive intestinal obstruction. Erectile function was good in 33 patients. Penile length was gratifying in 25. Of 28 patients, 20 (71.4%) had dry interval of two hours. Dimercaptosuccinic acid study demonstrated upper tract scarring in 2 patients.  |
| <b>CONCLUSION</b>           | This approach facilitates innervation preserving sphincteroplasty and precise restoration of anatomy to near normal without operative accidents because of wide exposure gained, improving the functional and cosmetic results. UROLOGY 78: 668–674, 2011. © 2011 Elsevier Inc.  |

Despite numerous advances in surgery of exstrophy bladder, its anatomical reconstruction without operative accidents remains a challenging problem. Several techniques for single-stage and multistage repair for exstrophy bladder have been reported to fulfill the aims of restoration of anatomy and functional capability with preservation of the upper tracts.<sup>1-13</sup>

On the basis of the concept of surgical anatomy of urogenital diaphragm in exstrophy,<sup>14</sup> we report a novel midline scrotoperineal approach for single-stage repair of exstrophy-epispadias, with an endeavor to improve the

functional and cosmetic results and reduce operative accidents. This approach offers wide exposure of urogenital diaphragm and its muscles for precise identification and reconstruction of the external urethral sphincter, with preservation of its innervation to exploit its function. It also facilitates the exposure of the entire length of the ischiopubic ramus for radical yet safe corporal detachment in subperiosteal plane for corporoplasty and penile lengthening. Using the same approach, ischial tuberotomy with superior pubic ramotomy is performed for closure of the pelvic ring and abdominal wall defect.

### MATERIAL AND METHODS

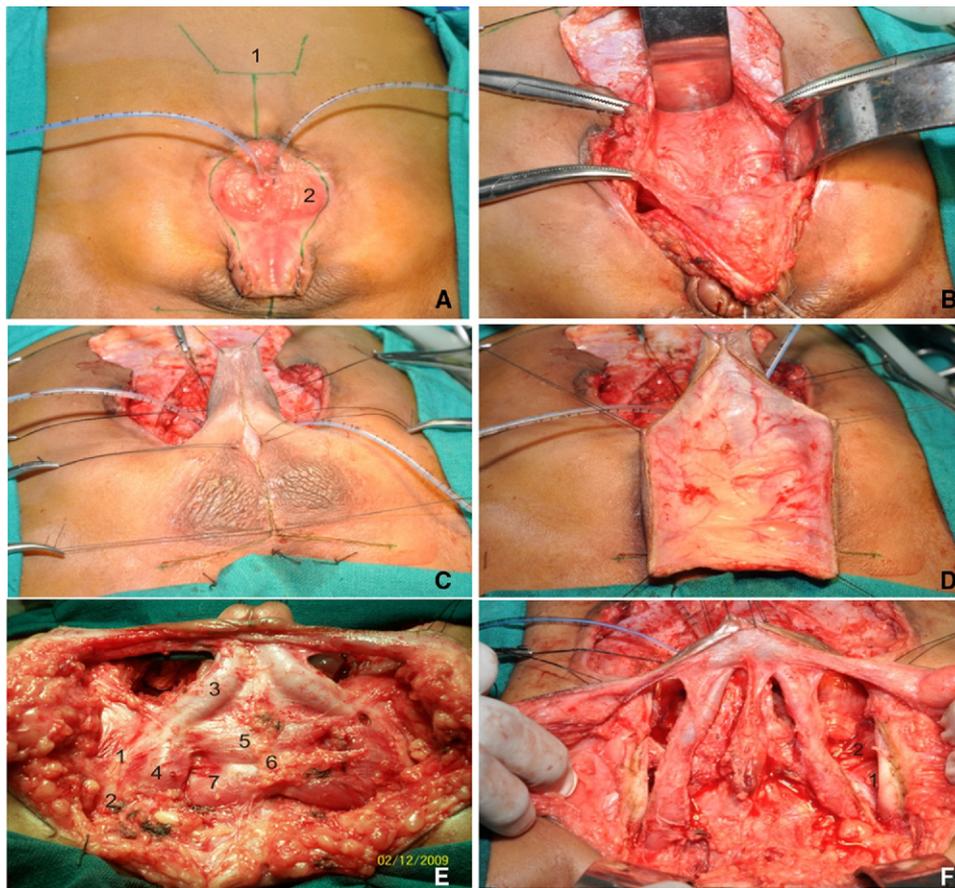
#### Patient Selection and Work-Up

From 2004–2010, 25 males aged 6 weeks to 17 years (mean,  $4.69 \pm 5.28$  [SD] years) with classic exstrophy bladder with compliant bladder plate and enough space for ureteric reim-

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Submitted: October 6, 2010, accepted (with revisions): December 29, 2010



**Figure 1.** (A) Green lines indicate the incision lines. Trapezoid skin flap (1) has been marked at the level of transtuberular line. Incision is carried along the margins of the bladder (2) and urethral plate up to the tip of glans. (B) After raising the trapezoid flap, the linea alba was incised vertically to enter the extraperitoneal plane, and the bladder was mobilized up to the intersymphyseal band. The vas deferens converging toward the base of the bladder can be seen. (C) For the scrotoperineal approach, from the middle of the shaft of the penis to the base of the urogenital triangle, median raphe is incised. A horizontal line across the ischial tuberosity is also incised. (D) Ventral penile skin, dartos, and scrotal septum are bisected in midline avascular plane up to the fascia covering the bulbospongiosus and corpora. (E) Bisected hemiscrotum and penoscrotal skin with dartos were retracted laterally to expose the ischiopubic ramus (1), ischial tuberosity (2), ventral surface of the corpora (3), ischiocavernosus (4), bulbospongiosus (5), perineal body (6), and superficial transverse perineal muscles (7). (F) Corpora have been separated from the midline urethral plate. Toward the posterior corporal segment, the plane of dissection was kept very close to the ischiocavernosus muscle. Radical corporal detachment is completed in the subperiosteal plane along the ischiopubic borders. Fibers of the obturator internus (1) and levator ani (2) are also seen.

plantation, and 10 incontinent males with epispadias with adequate bladder capacity were selected. Nine patients with small edematous bladder plate with numerous polyps and inadequate space for ureteric reimplantation were excluded.

Preoperative workup included general and upper tract assessment with computed tomography of the pelvis for planning of osteotomy and magnetic resonance angiogram for muscles and vessels of the urogenital diaphragm. Surgery was done under general anesthesia with epidural catheter placement.

## THE SURGICAL TECHNIQUE

The surgical technique was conceived and executed by the first author.

### Position and Draping

The patient was placed in the supine position over a folded towel, with mild elevation of the pelvis and thighs in a semi-abducted position. Below the level of the epigastrium to the

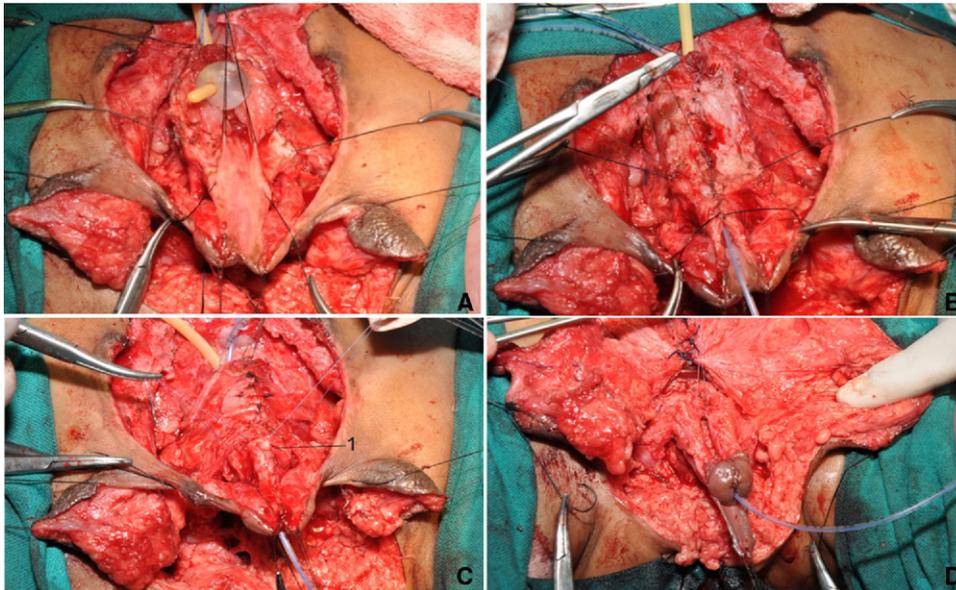
midthigh, the whole body was prepared and isolated in a sterile draped field with draped lower limbs included in sterile field. The rectum was packed with povidone iodine gauze and the anal region was draped separate from the operative field.

### Incision and Mobilization of Bladder Plate

The procedure began with raising of the trapezoid flap for umbilicoplasty and access to extraperitoneal plane.<sup>15</sup> The margin of the bladder plate and urethral plate were incised up to the tip of the glans using fine-needle tip cautery (Fig. 1A). The bladder was mobilized up to the intersymphyseal band in the extraperitoneal plane (Fig. 1B).

### Exposure of Urogenital Diaphragm

Using fine-needle tip cautery, skin and subcutaneous tissue along the base of urogenital triangle from ischial tuberosity of one side to other side was incised (Fig. 1C). From the middle of shaft of the penis to the base of the urogenital triangle, skin



**Figure 2.** (A) Excision of triangular mucosal patch at the bladder neck is completed, leaving a wide posterior urethral plate, lifted up in fine stay sutures ready for tubularization. (B) Closure of the bladder neck and bladder in 2 layers along with reconstruction of posterior urethra. Tubularization of the anterior urethra is in progress. (C) After construction of the bladder and urethra, the external urethral sphincter (1) was identified and anchored on the dorsal aspect of the neourethra. Anchoring sutures have been placed through external urethral sphincter and urethra on both sides ready for approximation. (D) Mobilized corpora are approximated in midline dorsal to neourethra, which is transposed ventrally.

along the median raphe of penis and scrotum, scrotal septum, and subcutaneous tissue was incised precisely at the midline through the visible avascular plane up to the level of fascia covering the bulbospongiosus and ischiocavernosus and the transverse perinei muscles (Fig. 1D).

Bisected hemiscrotum, penoscrotal skin, and dartos were retracted laterally to expose the ischiopubic ramus, ischial tuberosity, ventral surface of the corpora covered with Buck's fascia, ischio cavernosus, bulbospongiosus, perineal body, and superficial transverse perinei muscles (Fig. 1E). For bloodless operative field, prior control and division of the posterior scrotal artery is mandatory and emerges from the triangle between the bulbospongiosus and ischiocavernosus and the transverse perinei muscle as one of the terminal branches of the perineal artery. Now an open, panoramic view of the urogenital diaphragm is seen for further precise dissection. Using a muscle stimulator, all of the muscles are identified. Lateral penile skin is undermined between the plane of the penile dartos and Buck's fascia to establish the continuity between abdominal and perineal access (Fig. 1E).

### Corporourethral Separation

On the ventral surface of the penile shaft, over the corpora, Buck's fascia is vertically incised along the line parallel to the midline corpus spongiosum. In the plane between the tunica albuginea laterally and incised Buck's fascia medially, the anterior segment of the corpora is separated away from the midline urethral plate. Distal glanular attachment of the corpora, urethra, and spongiosum are preserved (Fig. 1F).

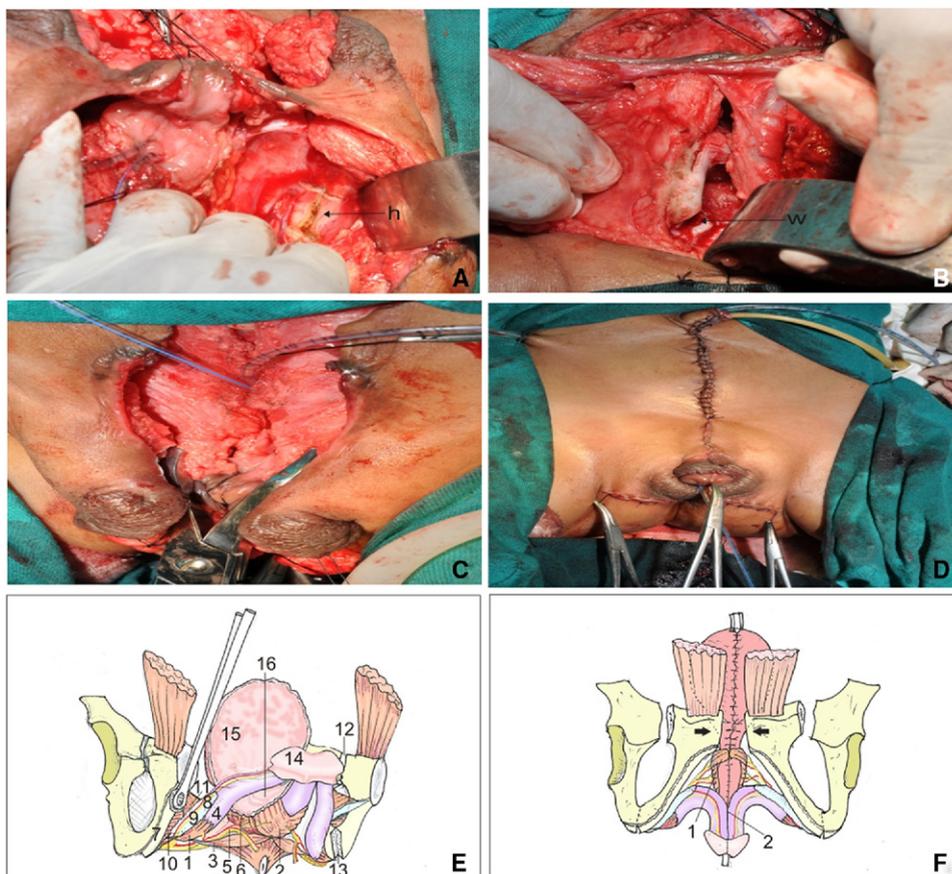
Proximally, the posterior segment of the corpora is separated, keeping the plane of dissection close to the ischiocavernosus muscle and the tunica albuginea of the corpora to avoid injury to the sphincteric branches of the perineal artery and nerve, which are running in the triangle between the bulbospongiosus

and ischiocavernosus and the transverse perinei muscles. At this point, a nerve integrity monitor was used to spare branches of the perineal nerve extending to the bulbospongiosus and external urethral sphincter. As we separate the proximal corpora from the proximal urethral plate, the deep transverse perinei muscle and contractile striated urethral sphincter can be identified cephalad to the bulbospongiosus muscle using a muscle stimulator (Fig. 1F and Fig. 2C).

### ISCHIO PUBIC CORPORAL DETACHMENT

The anterior segment of the corpora was released by dividing the intersymphyseal band very close to the pubic bones until we reached the point where the corpora were intimately adhered to the pubic ramus. Beyond this point, the anterior edge, ie, the subcutaneous edge of the ischiopubic ramus, which is already exposed via the scrotoperineal approach, is cleared of fibrofatty tissue. With needle-tip cautery, the periosteum along the anterior edge of the ischiopubic ramus is incised to the ischial tuberosity. The periosteal incision is extended across the medial edge of the pubic bone. Now the corpora are ready to be detached from the subperiosteal plane. A blunt downward push through a roll of gauze mounted on the sponge holder keeping the force toward the ischiopubic ramus in the subperiosteal plane will safely separate the corpora down up to ischial tuberosity, exposing the shining bare bone and the medial surface of the ischial tuberosity (Fig. 1F and Fig. 3E).

The ureters are reimplemented and the triangular mucosal patch from the bladder neck is excised, leaving the mid-



**Figure 3.** (A) View from the head end of the patient after completion of dissection of bladder and urogenital diaphragm, showing the pelvic surface of the right superior pubic ramus and the H-shaped incision on the periosteum for reflection of the periosteal flap and superior pubic ramotomy (h). (B) Perineal view of the medial surface of the right ischial tuberosity after completion of subperiosteal radical corporal detachment. A small wedge of bone has been removed (w). (C) Pubic bones held between the jaws of a patella approximator are gradually approximated in midline for linea alba approximation and closure of the pubic ring. (D) Appearance after completion of skin closure. (E) Schematic diagram to show some of the technical points of the procedure. Wide exposure of the urogenital diaphragm with exposure of triangle among the ischiocavernosus (1), bulbospongiosus (2), and supf. transverse perinei muscle (3) facilitates to keep the plane of dissection close to the ischiocavernosus and corpora (4) to preserve the branches of the perineal nerve (5) supplying the bulbospongiosus and the external sphincter muscle (6). Periosteal incision along with the anterior edge of the ischiopubic ramus (7) and subsequent detachment of the corpora in the subperiosteal plane with mounted swab preserves the neurovascular bundle (8) running along the inner edge of the ischiopubic ramus. With this maneuver, some periosteum (9) is detached to lie on the corpora, exposing the fibers of the obturator internal muscle (10) and the pubic part of the pubococcygeus muscle (11), which is not detached from the obturator fascia. Sites of superior pubic ramotomy (12) above the obturator foramen and wedge osteotomy of the pelvic surface of the ramus of ischium at its junction with the body of ischium (13) are also shown. Glans (14), bladder (15), veru montaneum and posterior urethra (16). (F) Diagram to show the scheme of completed repair. External urethral sphincter with intact innervation, anchored to the tubularized urethra (1). Radical corporal detachment and midline approximation over the tubularized urethra (2) offers apparent penile lengthening, and with wedge resection, the pelvic surface of ramus of the ischium with pubic ramotomy facilitates closure of the pubic arch resembling the closing of an open book.

line mucosal strip equal to the width of the posterior urethral plate continuous with the bladder mucosa above and the urethral plate below (Fig. 2A).

With placement of cystostomy and ureteral catheters exiting through the umbilicoplasty, and a Silastic urethral stent through the neo-external urethral meatus, the urethra was tubularized with 6-0 interrupted polyglycolic acid sutures and the first layer bladder closure with 5-0 polyglycolic acid sutures. Exposed detrusor at the bladder neck area was also approximated with 2

layers of interrupted sutures without double-breasting. The detrusor of the bladder was closed as the second layer (Fig. 2B).

The external urethral sphincter, visible and confirmed with muscle stimulation, was anchored to the dorsal aspect of the tubularized urethra on both sides with 1 or 2 interrupted sutures (Fig. 2C and Fig. 3F). A nerve integrity monitor was used to test its preserved innervation.

Mobilized corpora were approximated in the midline over the tubularized urethra, which was transposed ven-

tally, and glansplasty was completed in 2 layers with 6-0 polyglycolic sutures (Fig. 2D and Fig. 3F).

## ISCHIO PUBIC OSTEOTOMY AND ABDOMINAL DEFECT CLOSURE

Through the abdominal wall defect, in the extraperitoneal plane, the pelvic surface of the superior pubic ramus was approached. Above the obturator foramen, an H-shaped incision was made incising the periosteum over the superior pubic ramus. The upper and lower flaps of the periosteum were raised and, with a curved hemostat, a subperiosteal plane was developed around the superior pubic ramus (Fig. 3A).

With support of the curved hemostat passed subperiosteally around the superior pubic ramus, the bone was cut. The exposed medial surface of the ischial tuberosity was also cut, removing a narrow wedge of bone. The periosteum on the lateral aspect of the ischial tuberosity was left intact (Fig. 3B and Fig. 3E).

After completing the superior pubic ramotomy and the ischial tuberosity on both sides, the pubic bone was gradually approximated over a period of 30 minutes using a patella approximator. Thus, closure of the pelvic ring was achieved (Fig. 3C and Fig. 3F). The retro pubic space was drained and the linea alba approximated in midline.

Skin closure was completed with umbilicoplasty, abdomino-puboplasty, and penile skin approximation with creation of penopubic and penoscrotal angles and scrotoperineal closure (Fig. 3D).

Intraoperative and postoperative antibiotic cover was maintained. Analgesia through epidural catheter was maintained for 5–7 days. In the postoperative period, patients were nursed in the supine position without limb immobilization or traction. Ureteric catheter drainage was maintained for 14 days and cystostomy drainage for 21 days, followed by cystostomy catheter clamping and voiding trial.

## RESULTS

Thirty-five patients underwent repair with the technique described. The osteotomies were done in 21 patients with classic exstrophy and 4 patients with incontinent epispadias. There was no mortality, no corporal loss, no bladder dehiscence, or major operative complications. The outcome was analyzed using the following parameters: (1) Operative accidents/difficulties and time taken to complete the repair, (2) early postoperative complications, (3) late complications, (4) esthetic appearance, (5) erectile function, and (6) continence and upper tract status.

1. *Intraoperative difficulties and accidents, time taken to complete the repair:* Time to complete the procedure from incision to last stitch varied from 5–9 hours with a mean operative time of 7 hours. The procedure in infants was less time-consuming compared with older children and adolescents. While we searched for the

superficial transverse perinei in 1 patient, inadvertent injury to the anal canal occurred, which was identified and repaired without any later sequela. In another patient who had associated ventricular septal defect, intraoperative pulmonary edema was noted and managed by the anesthetist.

The superficial transverse perinei was found to be absent in 3 patients and was detected with difficulty in one. During corporo-urethral separation, partial oblique tear of the urethral plate occurred in 2 patients but were repaired without problem. Radical corporal detachment was performed in the precise plane in 33 patients.

In creating a subperiosteal plane across the ischiopubic ramus, initial difficulty in reaching the bone was experienced in all owing to variable thickness of the periosteum along the ischiopubic border; but once the periosteal incision was deep enough to strike the bone, there was no difficulty in corporal detachment in 33 patients. Difficulty in corporal detachment was experienced in the 2 oldest patients because of inadequate incision of the periosteum, but the mistake was identified and corrected. Corporo-urethral separation in a precise plane below the Buck's fascia was uneventful in 27 patients, but bleeding from the corpus spongiosum repeatedly blocked the view of plane in 8 patients. Transaction of mobilized urethral plate to create penoscrotal hypospadias was necessary in 2 patients.

The continuity of lateral penile skin was accidentally disrupted from glans in one. Deliberate subcoronal transaction of lateral penile skin was done in 7 patients for subsequent dorsal relocation. Reverse advancement of a flap of inner preputial skin was done for ventral shaft cover.

2. *Early postoperative complications:* postoperative superficial wound infection was the most common complication, which occurred at the perineal suture line in 4 patients; at the penopubic region in 14 patients, with dehiscence of penopubic junction in one; and dehiscence of umbilicoplasty in 4 patients. Two of these infections were caused by fungal contamination.

There was no case of bladder dehiscence. Postoperative adhesive intestinal obstruction occurred in 1 patient but resolved with conservative treatment. Epididymo-orchitis occurred in 1 patient. Transient discoloration and crust formation of the dorsal penile skin occurred in 3 patients.

3. *Late complications:* penopubic dehiscence led to recurrent dorsal chordee in 1 patient, and hypertrophied keloid scar at penopubic region was noted in one. Multiple bladder stone formation and graveluria was seen in 2 patients. Infraumbilical midline ventral hernia without pubic dehiscence occurred in 1 patient.

4. *Esthetic appearance of repair and penile length:* in 9 patients of incontinent epispadias and 16 classic exstrophy, reconstructed appearance of anterior abdominal wall and penile length was gratifying (Fig. 4A). In 1 in-



**Figure 4.** (A) Preoperative appearance of 17-year-old unrepaired classic exstrophy bladder. (B) Esthetic appearance six months after repair.

continent epispadias with recurrent dorsal chordee and 4 patients without osteotomy, the penile length was not satisfactory with penopubic dimple and partially buried penis. In 5 other patients, penile length was satisfactory.

5. *Erectile function:* in 2 patients erection could not be recorded and there was no definite history of morning erection. In the remaining 33 patients, a definite history of morning erection with increase in penis size was recorded.
6. *Voiding pattern, continence, and upper tract:* all patients passed urine at a 5–10-minute interval immediately after clamping the cystostomy catheter, but gradually after a month the frequency decreased with progressively increasing dry interval. Penopubic urine leak stopped in all patients. Assessment of continence was done by noting the period of dry interval and episodes of bed-wetting.

After two years of reconstruction, 28 patients could be evaluated for continence. Thirteen classic exstrophy and 7 incontinent epispadias were dry for more than 2 hours without upper tract dilatation. Of these, 11 who were >5 years old developed midstream holding capabilities and

could attend classes without urine leak. Two of these patients are awaiting hypospadias repair.

One incontinent epispadias and 1 classic exstrophy with good bladder capacity still experience leaking at the bladder neck and are awaiting revision bladder neck surgery. Of the remaining 6 classic exstrophy, 2 patients had small-capacity bladder with reflux and renal scarring seen on dimercaptosuccinic acid scan, and augmentation cystoplasty was done. Four classic exstrophy have unsatisfactory continence, day and night wetting, and unpredictable leaking at 45-minute to 1-hour interval. Two of these patients had bladder stones. Upper tracts are preserved. Urodynamic study revealed detrusor instability.

## COMMENT

In 1906, Trendelenburg stated that despite severe pathologic defects, all of the structures necessary for continence are present.<sup>16</sup> Therefore, precise anatomic reconstruction in patients with compliant bladder plate should be associated with good functional outcome. Several good techniques for anatomic reconstruction have been reported in the literature by Jeffs,<sup>1</sup> Kelly,<sup>2</sup> Mitchell and Baglil,<sup>5</sup> Grady and Mitchell,<sup>7</sup> Baka-Jakubiak,<sup>9</sup> Rosch et al,<sup>10</sup> Bharti et al,<sup>11,12</sup> and Caione et al,<sup>8,13</sup> but these techniques did not give enough consideration to the anatomy of urogenital diaphragm with specific sphincteric reconstruction with preserved innervation.

Although nonspecific approximation of periurethral muscle around the tubularized urethra has been reported by Caione et al<sup>8,13</sup> the technique to specifically approach the external sphincter preserving its innervation has not been reported. The advantage with our technique is that without destroying the nerve supply of the striated urethral sphincter, it is possible to dissect and reconstruct it without significant operative accidents. Development of the capability of midstream holding in patients who have had this repair technique, with an overall 70.1% continence rate, indicates the advantage of innervation preserving sphincteroplasty.

Another clear advantage with this technique is that this approach guides the surgeon from less distorted normal anatomical planes to the field of abnormal pathology. Therefore, despite apparent massive dissection, operative accidents are almost negligible, even in 2 major crucial maneuvers of reconstructive surgery of exstrophy-epispadias—Corporo urethral separation and radical corporal detachment.

Because the entire field of the perineal surface of urogenital diaphragm is exposed with this approach, it is quite easy to separate the anterior corporal segment from the midline urethral plate and spongiosum by dissection through the well-defined plane between Buck's fascia and tunica albuginea without injuring the urethral plate or neurovascular bundle. The separation of the posterior corporal segment and ischiocavernosus muscle from the posterior urethra without injuring the bulbospongiosus, external urethral sphincter, and deep transverse perinei

muscle is facilitated by exposure of the triangle containing the perineal artery and nerve.

The most serious complication of corporal separation from the ischiopubic rami is loss of corpora because of injury to the neurovascular pedicle running on the lateral aspect of the corporal body, which has been reported in literature.<sup>17-20</sup> In our experience of 35 cases, despite radical corporal detachment, there is no corporal loss or ischemic injury to glans because of the following reasons: (1) Wide exposure of urogenital diaphragm offers the facility to incise the periosteum along the anterior edge of the ischiopubic ramus up to the ischial tuberosity so at the time of corporal detachment, there is no diversion from subperiosteal plane causing uncontrolled accidental tear. The possibility of injury to corporal vessels are remote because we know from study of the course of the dorsal penile artery in exstrophy runs along the inner edge of the ischiopubic ramus deep to the perineal membrane before leaving it to lie on the lateral aspect of corpora<sup>14</sup> (2) Entering the subperiosteal plane from the anterior edge of the ischiopubic ramus and maintaining the same plane for corporal detachment with blunt roll of gauze dissection eliminates the possibility of injury to neurovascular bundle. Because of this, we have never encountered the complication of corporal loss despite radical corporal detachment to gain apparent penile lengthening with tension-free midline approximation of the corpora.

With this approach, access created for bladder plate mobilization is used for superior pubic ramotomy. With the scrotoperineal approach, after radical corporal detachment, the medial subperiosteal surface of the ischial tuberosity is exposed for ischial tuberotomy. Combined superior pubic ramotomy and ischial tuberotomy facilitate the closure of the pelvic ring similar to the closing of an open book. The pubic ramotomy alone was described by Frey<sup>21</sup> but combining it with wedge ischial tuberotomy makes the pelvic ring closure easier and more effective. Because the axis of weight bearing lies posterior to the osteotomy sites, immobilization is not required because there is no destabilization.

Combination of these factors leads to successful bladder repair, abdominal wall defect repair, functional urethral sphincter reconstruction and penile lengthening procedure, and quick recovery with overall satisfying functional and cosmetic results.

The necessity to make an inverted T incision in the perineum with division of posterior scrotal vessels and nerves, and the need to perform additional perineal dissection is perhaps the only disadvantage of this technique. This disadvantage is suitably compensated by the ability to perform precise dissection in visible tissue planes without operative accidents, which leads overall to very satisfying results.

## CONCLUSIONS

The important advantage of the surgical technique is the wide exposure of morbid pathology facilitating precise restoration of anatomy to near normal without operative accidents, which contributes to good cosmetic and functional results.

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