

Trauma/Reconstruction/Diversion

CADAVERIC ANATOMY OF PELVIC FRACTURE URETHRAL DISTRACTION INJURY: MOST INJURIES ARE DISTAL TO THE EXTERNAL URINARY SPHINCTER

VLADIMIR B. MOURAVIEV AND RICHARD A. SANTUCCI*

From the Prostate Centre, Vancouver General Hospital, Vancouver, British Columbia, Canada, War Surgical Department, Kirov Military Medical Academy, St. Petersburg, Russia, and Urology, Detroit Receiving Hospital (RAS) and Wayne State University School of Medicine (RAS), Detroit, Michigan

ABSTRACT

Purpose: The anatomy of posterior urethral distraction injuries is controversial. We present a cadaver study of posterior urethral distraction injuries. To our knowledge this is the first study that establishes that the most common location is distal to the external urinary sphincter.

Materials and Methods: We performed an autopsy review of 10 male patients with posterior urethral distraction injuries.

Results: Urethral disruption occurred distal to the external urinary sphincter in 7 of 10 patients. It appeared to occur when the anterior pelvic ring and urogenital diaphragm complex were displaced caudal and rostrally, tearing the urogenital diaphragm off of the urethra. The average inner mucosal defect \pm SD was 3.5 ± 0.5 cm, while the defect between the outer urethral layer (tunica of the spongiosum) was 2.0 ± 0.2 cm due to mucosal retraction. Simple and complex injuries could be observed, according to the clinical classification proposed by Turner-Warwick in 1989. Simple injuries had less significant dislocation of the symphysis, general maintenance of urethral continuity and slightly shorter mucosal distraction (3.3 cm). Complex disruptions had significant symphyseal dislocation, complete disassociation of the urethral ends (often with interposition of other tissues) and a slightly longer mucosal distraction (3.8 cm).

Conclusions: Posterior urethral distraction injuries appear to most commonly occur distal to the urogenital diaphragm, contrary to classic teaching. These injuries are on average between 3 and 4 cm, and they are more significant dorsal than ventral. They appear to occur as simple or complex injuries, mirroring the clinical findings seen in clinically simple and complex urethral strictures.

KEY WORDS: urethra, wounds and injuries, fractures, pelvis, anatomy

The anatomy of posterior urethral distraction injuries is a source of controversy. Older, classic teaching suggests that the prostatic urethra is torn off of the urogenital diaphragm at a location proximal to the striated urinary sphincter.^{1,2} Diagrams propounding this have been widely published (fig. 1). This proximal urethral injury is said to result in striated sphincter incompetence after urethral distraction injuries.³ However, more modern series have shown that urethrographically,⁴ urodynamically,⁵ cystoscopically⁵ and surgically⁶ injury appears to be distal to the striated sphincter in a majority of cases. The most modern texts are only recently describing this finding.⁷ To our knowledge this is the first report of autopsy evidence for a distal location of most posterior urethral distraction injuries, which should greatly bolster the believability of evidence previously determined by more indirect means.

Clinical evidence for a distal location of most urethral injuries has been previously published. Of the 17 continent

patients with posterior urethral distraction injury treated with perineal urethroplasty reported on by Andrich and Mundy the internal sphincter was cystoscopically visible proximal to the injury in 13 (65%).⁵ This was confirmable on urodynamics in 11 of the 17 patients (55%). The sphincter usually appeared 1 to 2 cm proximal to the urethroplasty scar.

Surgical data also support this assertion. During perineal approach urethroplasty for the repair of strictures resulting from posterior urethral distraction injury, Mundy maintained that 100% of 17 patients had injuries distal to the sphincter (fig. 2).⁶ Also, patients with urethral distraction injury usually have a visible verumontanum well proximal to the area of injury,⁸ further supporting the distal location of most urethral distraction injuries. However, despite these data many practitioners and groups persist in the belief that these injuries are posterior, that is proximal to the external sphincter.

To our knowledge autopsy data on the subject have been absent to date. Accordingly we began autopsy investigations in patients with posterior urethral distraction injury to prove or disprove the assertion that urethral distraction injuries occur distal to the sphincter.

Submitted for publication May 18, 2004.

* Correspondence: Urology, Detroit Receiving Hospital, 4160 John R., Suite 1017, Detroit, Michigan 48201 (telephone: 313-745-1712; FAX: 313-745-0464; e-mail: rsantucc@med.wayne.edu).

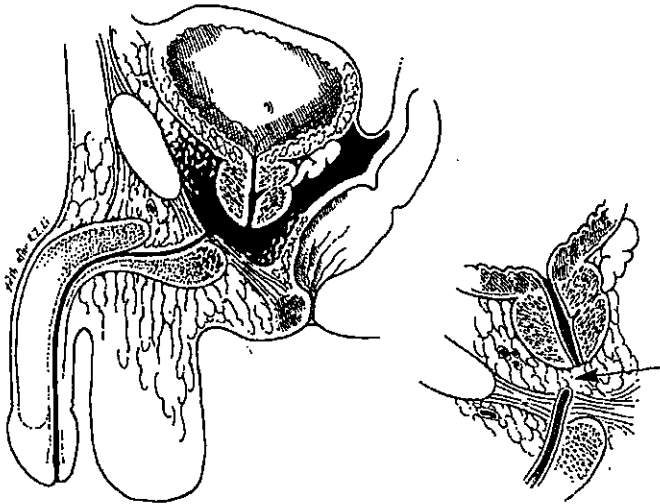


FIG. 1. Classic teaching suggested that urethra is torn proximal to urogenital diaphragm. This is likely incorrect in light of more recent understanding.

MATERIALS AND METHODS

We performed an autopsy study in 10 fresh male cadavers with pelvic fracture and posterior urethral distraction injuries who died of their multiple injuries. Average time from injury to death was 3 days. Specimens were obtained by en bloc evisceration of the anterior pelvic bones and viscera, including the urogenital diaphragm, urethra, bladder, penis and surrounding soft tissues. After precise visual inspection to determine the exact nature of gross tissue disturbances the intact urethra was removed. The external urethral surface was coated with India ink and fixed in 10% formalin solution for 24 hours. Microscopic preparations were stained with hematoxylin and eosin, and examined microscopically. The exact location and length of each urethral injury was noted and injuries were classified as simple and complex, as proposed by Turner-Warwick.³

RESULTS

Simple vs complex. Complete urethral disruption was found in 9 patients, while partial rupture was seen in 1. Of the complete disruptions there were 6 simple and 3 complex injuries. Simple injuries involved modest dislocation of the symphysis backward and upward, which was associated with the general maintenance of urethral continuity, and slightly shorter mean mucosal distraction \pm SD (3.3 ± 0.7 cm). Complex disruptions showed significant symphyseal dislocation, complete disassociation of the urethral ends (often with interposition of other tissues) and slightly longer mucosal distraction (3.8 ± 0.7 cm) (fig. 3). In each case the extent of external urethral distraction was less than the distraction of the urethral mucosa due to retraction of the mucosal tissues. Average retraction of the urethral mucosa was 1.9 ± 0.5 cm for simple injuries vs 2.0 ± 0.2 cm for complex injuries.

All patients had unstable pelvic fractures. The most frequent fracture was a bilateral pubic rami fracture (butterfly fracture) with associated dislocation of the pubosymphysis upward and backward (32% of cases).

Mechanism and location. The mechanism of urethral disruption appeared to be separation of the anterior pelvic ring (symphysis) together as a unit with the urogenital diaphragm. Backward and upward displacement of this unit tore the urethra off of the urogenital diaphragm, as described in 1980 by Pennal et al,⁹ at a location distal to the sphincter.¹⁰ The urethra appeared tightly adherent to the urogenital diaphragm, making the site of separation at the weaker proximal bulbar urethra more likely.

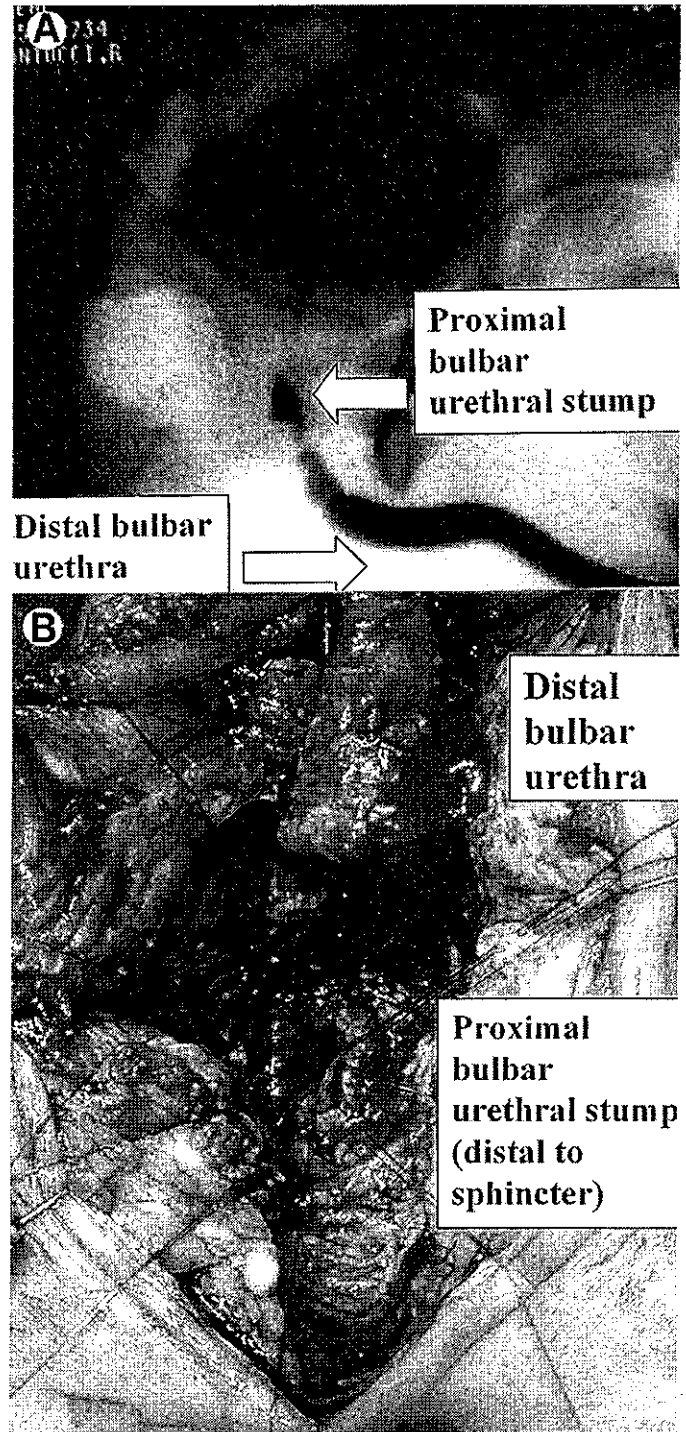
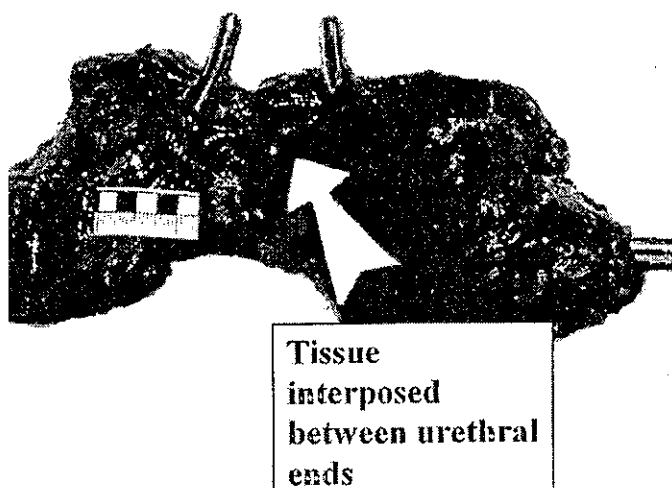


FIG. 2. Patient with previous posterior urethral distraction injury. A, retrograde urethrogram clearly shows injury distal to striated sphincter. B, intraoperative photograph reveals injury distal to striated sphincter.

In 7 of 10 cases urethral injury was distal to the membranous urethra. In 3 of 10 cases it involved the membranous urethra or was proximal to it (fig. 4). In 7 of 10 cases the urethral defect was greater on the dorsal than on the ventral urethra (fig. 5).

DISCUSSION

Location of injury. The existing literature appears adequately to establish that most posterior urethral distraction injuries occur distal to the striated sphincter using clinical

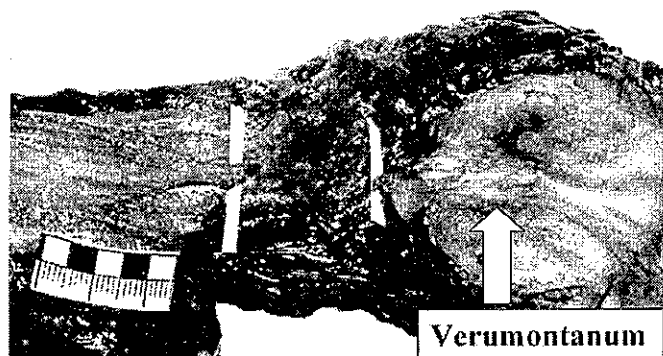


Tissue interposed between urethral ends

FIG. 3. Complex urethral disruption resulting in interposition of tissue between torn urethral ends. Arrow indicates significant tissue interposed between urethral mucosal ends, which are seen at point where each metal sound exits urethra. Such interposition might make early endoscopic realignment difficult or impossible. Outer tissue is inked, resulting in dark appearance.

observation.^{4-6,8} However, this concept is not yet universally embraced and to our knowledge we present the first direct observations using autopsy specimens to prove it. Other studies, such as a cystoscopic series of 17 patients with urethral distraction injury, showed an injury location distal to the sphincter in 65%,⁵ which correlates with our 70% rate.

It is not clear why the older theories that urethral injury occurs proximal to the sphincter have persisted. They were based on expert opinion but had little objective support.^{1,3} Despite this fact, they have proved difficult to topple even when supplanted by reliable data. Even now not all modern authorities support our conclusion. Koraitim reported on 145 patients with posterior urethral distraction injury and stricture that he believed clinically had fibrous processes involving rather than sparing the membranous urethra.¹¹ Colapinto and McCallum presented drawings that clearly depict a more proximal location for posterior urethral injuries.² Perhaps after healing and scarring the exact location of injury in these patients is too difficult to determine with certainty during urethroplasty or perhaps the urogenital diaphragm structures are not as consistent as we have believed and they are not easily identified.^{12,13} Nevertheless, we believe that the preponderance of evidence supports a more distal urethral location in the majority of patients. These autopsy data provide a powerful argument to bolster the assertions previously made using urethrography,⁴ urodynamics,⁵ cystoscopy⁵ and direct observation during surgery.⁶



Verumontanum

FIG. 4. Simple urethral disruption with urethral injury well distal to verumontanum. Paper strips indicate disrupted urethral ends.

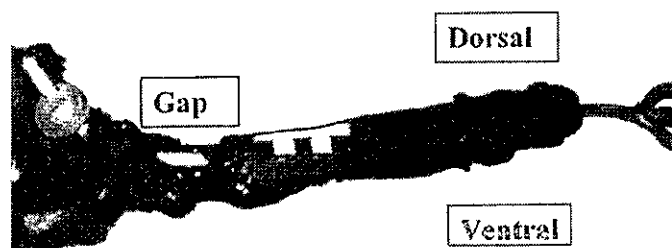


FIG. 5. Complete urethral disruption shows more significant mucosal gap dorsal than ventral. Note that urethral catheter is visible through large dorsal gap but it is not seen ventral.

The fact that 30% of urethral distraction injuries in this and other similar series⁵ were located proximal to the sphincter supports the admonition of many experts in the field that operations that may injure the internal (bladder neck) urinary sphincter should not be done in these patients because they may result in incontinence.^{14,15}

That is not to say that urethral injuries cannot occur proximal to the sphincter, especially in children,¹⁰ as in 3 of our 10 patients. Clinically it is still important to confirm the anatomy of urethral injuries when planning urethroplasty by preoperative retrograde urethrogram, preoperative retrograde urethrogram with voiding cystourethrogram or magnetic resonance imaging.¹⁴

Mechanism of injury. Our observations seem to support previously published assertions that urethral injury occurs when shear forces on the pubic bone result in posterior as well as upward displacement.¹⁰ What differs in our observation is the finding that the pubic bone and urogenital diaphragm are tightly adherent to the urethra proximal to the striated sphincter but less so distal to the sphincter. This appears to result in a tendency toward urethral fracture at the weaker, more distal point, that is the bulbar urethra.

Simple vs complex injury. We were gratified to confirm the clinical observations of Turner-Warwick concerning simple and complex urethral distraction injuries.³ In this classification simple strictures were short, had minimal associated fibrosis and could be treated with perineal approach anastomotic urethroplasty. They were seen in 6 of the 9 complete urethral injuries (66%) in this series. Complex strictures were long, had significant associated fibrosis and might be complicated by false passages, pubic osteomyelitis, fistulas or coincident bladder neck injury. They were seen in 3 of the 9 patients (33%) in this series. Complex injuries such as those in this series may cause the complex strictures described in 1989 by Turner-Warwick.³ These patients might require more aggressive therapy, such as combined abdominoperineal approach anastomotic urethroplasty, omental wrapping of the repair, pubectomy, fistula repair, bladder neck repair or other adjunct surgical therapy. When approached perineally, these cases may be more technically demanding or experience higher failure rates and complications. However, in general we believe the assertions of others^{14,16,17} that most urethral stricture defects can be safely approached perineally and only the minority require the combined abdominoperineal approach.

We confirmed that some complex urethral distraction injuries were associated with tissue between the torn urethral ends (fig. 3). We hypothesize that this tissue might make early endoscopic realignment difficult or impossible when present. Although this study was not designed to answer this question, we also hypothesize that such tissue might make subsequent urethroplasty more difficult when this tissue heals in place.

CONCLUSIONS

The site of urethral injury after pelvic fracture distraction injury appears to be just distal to the urogenital diaphragm

in most cases (70%). Simple and complex acute injuries appear to exist and they may model subsequent simple and complex urethral stricture, as described by Turner-Warwick.³ The average size of urethral mucosal distraction defects is 3.3 cm for simple injuries and 3.8 cm for complex injuries. Because of retraction of the urethral mucosa, the spongiosal defect is about 1.5 cm shorter than the more retracted mucosa. The mechanism of urethral injury appears to involve shear forces on the pubic bone, resulting in posterior and upward bony displacement, which pulls the urethra apart at its weakest point, that is the bulbar urethra. The pubic bone and urogenital diaphragm are tightly adherent to the proximal urethra but less so to the distal urethra, resulting in a tendency toward urethral fracture at the weaker point distal to the sphincter.

REFERENCES

1. Pokorny, M., Pontes, J. E. and Pierce, J. M., Jr.: Urological injuries associated with pelvic trauma. *J Urol*, **121**: 455, 1979
2. Colapinto, V. and McCallum, R. W.: Injury to the male posterior urethra in fractured pelvis: a new classification. *J Urol*, **118**: 575, 1977
3. Turner-Warwick, R.: Prevention of complications resulting from pelvic fracture urethral injuries—and from their surgical management. *Urol Clin North Am*, **16**: 335, 1989
4. Sandler, C. M., Goldman, S. M. and Kawashima, A.: Lower urinary tract trauma. *World J Urol*, **16**: 69, 1998
5. Andrich, D. E. and Mundy, A. R.: The nature of urethral injury in cases of pelvic fracture urethral trauma. *J Urol*, **165**: 1492, 2001
6. Mundy, A. R.: The role of delayed primary repair in the acute management of pelvic fracture injuries of the urethra. *Br J Urol*, **68**: 273, 1991
7. Jordan, G. H. and Schlossberg, S. M.: Surgery of the penis and urethra. In: *Campbell's Urology*, 8th ed. Edited by P. C. Walsh, A. B. Retik, E. D. Vaughan, Jr. and A. J. Wein. Philadelphia: W. B. Saunders Co., vol. 4, sect. XIII, chapt. 110, pp. 3886–3954, 2002
8. Mundy, A. R.: Reconstruction of posterior urethral distraction defects. *Atlas Urol Clin North Am*, **5**: 139, 1997
9. Pennal, G. F., Tile, M., Waddell, J. P. and Garside, H.: Pelvic disruption: assessment and classification. *Clin Orthop*, **151**: 12, 1980
10. Koraitim, M. M., Marzouk, M. E., Atta, M. A. and Orabi, S. S.: Risk factors and mechanism of urethral injury in pelvic fractures. *Br J Urol*, **77**: 876, 1996
11. Koraitim, M. M.: The lessons of 145 posttraumatic posterior urethral strictures treated in 17 years. *J Urol*, **153**: 63, 1995
12. Dorschner, W., Biesold, M., Schmidt, F. and Stolzenburg, J. U.: The dispute about the external sphincter and the urogenital diaphragm. *J Urol*, **162**: 1942, 1999
13. Mitchell, J. P.: Injuries to the urethra. *Br J Urol*, **40**: 649, 1968
14. Morey, A. F. and McAninch, J. W.: Reconstruction of posterior urethral disruption injuries: outcome analysis in 82 patients. *J Urol*, **157**: 506, 1997
15. McCoy, G. B., Barry, J. M., Lieberman, S. F., Pearse, H. D. and Wicklund, R.: Treatment of obliterated membranous and bulbous urethras by direct vision internal urethrotomy. *J Trauma*, **27**: 883, 1987
16. Webster, G. D. and Ramon, J.: Repair of pelvic fracture posterior urethral defects using an elaborated perineal approach: experience with 74 cases. *J Urol*, **145**: 744, 1991
17. Corriere, J. N., Jr.: 1-Stage delayed bulboprostatic anastomotic repair of posterior urethral rupture: 60 patients with 1-year followup. *J Urol*, **165**: 404, 2001