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Lower urinary tract trauma

Abstract This article reviews and illustrates bladder and urethral injuries, including their mechanisms of injury, imaging diagnosis, systems for classification, and the accuracy/pitfalls of the diagnostic methods. The bulk of this review will focus on lower urinary tract injuries caused by high speed, wide impact blunt trauma which is the most common mechanism of lower urinary tract injury encountered in civilian practice.

Although the basic mechanisms of lower urinary tract injuries have been known for more than 20 years, advances in management have reemphasized the importance of prompt radiologic diagnosis. The bulk of this review focuses on lower urinary tract injury caused by high-speed wide-impact blunt trauma, the most common mechanism of lower urinary tract injury encountered in civilian practice.

Bladder injuries

Injury of the bladder may occur as a result of blunt, penetrating, or inatrogenic trauma. The susceptibility of the bladder to injury varies with its degree of filling; a collapsed or nearly empty bladder is much less vulnerable to injury than is a distended organ.

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Radiologic examination

Either static or computer-assisted tomographic (CT) cystography may be performed. The procedure we use for static cystography, which may be performed with or without fluoroscopy, is as follows [12]. After an initial scout radiograph, approximately 100 ml of 20–30% contrast material is instilled into the bladder via a Foley catheter to check for gross bladder extravasation. In males a retrograde urethrogram must be performed prior to placement of the catheter if there is clinical suspicion of urethral injury. If no extravasation is present, this bladder is filled completely, which often requires an additional 200–250 ml of contrast, and a 14×17-inch radiograph of the entire abdomen is exposed. In this fashion the pattern of extravasation, if present, may be clearly visualized. A postdrainage radiograph following as complete an emptying of the bladder as possible to demonstrate contrast material extravasation behind a distended bladder is then made; studies have shown that the diagnosis of bladder injury may be recognized only on this radiograph in approximately 10% of cases [14].

CT cystography [6, 8] may be used in place of a conventional cystogram but must be performed using retrograde filling of the bladder with a minimum of 350 cc diluted (3–5%) contrast material. Axial 10-mm contiguous sections through the pelvis are obtained. The utility of postdrainage CT has not been established, but it is presumably not necessary as contrast material extravasation behind the bladder will be visualized on the axial sections. If CT of the abdomen for evaluation of intra-abdominal injury is contemplated, however, the bladder should be drained of as much residual contrast as possible prior to the abdominal examination.

The accuracy of cystography for the diagnosis of bladder injury varies between 85% and 100% in the reported series [1]. All authors stress, however, that careful attention to proper technique in the performance of cystography is necessary to achieve a high degree of accuracy. Falsely negative cystograms have been most

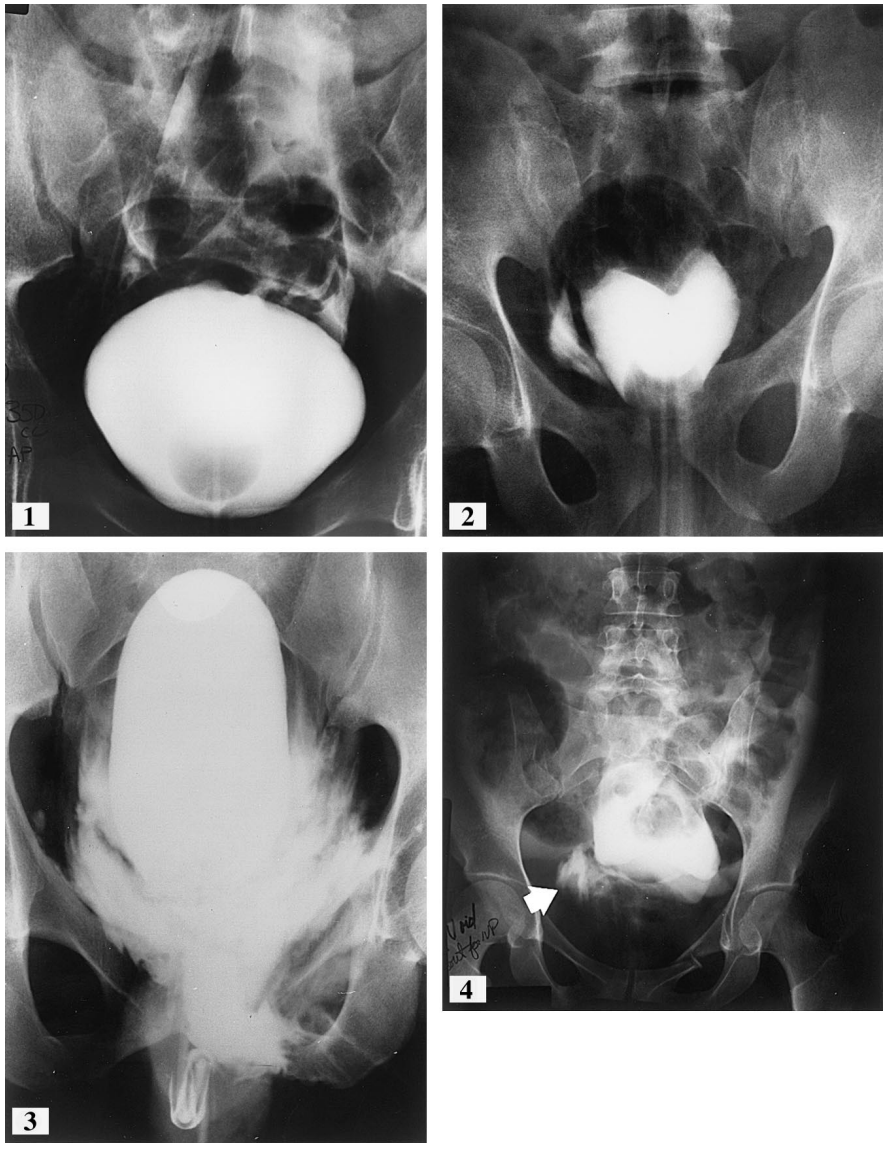


Fig. 1 Intraperitoneal bladder rupture: an AP view from a conventional static cystogram demonstrates extravasation from the dome of the bladder in a patient who suffered a blow to the lower abdomen

Fig. 2 Simple extraperitoneal bladder rupture: a flame-shaped area of contrast material extravasation is present that is confined to the pelvic extraperitoneal space. A fracture of the right pubis is also visible

Fig. 3 Complex extraperitoneal rupture: a conventional cystogram shows extensive contrast material extravasation that extends into the perineum. A pelvic fracture with diastasis of the symphysis pubis was present (not shown)

Fig. 4 Combined intraperitoneal and extraperitoneal bladder rupture: both the extraperitoneal (*arrow*) and intraperitoneal components are shown on the AP view from a static cystogram

commonly reported in patients suffering injury from small-caliber bullet wounds. In such cases it is assumed that the bladder rent temporarily seals with either mesentery or blood clot; this results in the falsely negative examination. It is important to remember that a seemingly normal appearance of the bladder on the cystographic phase of an excretory urogram does not exclude bladder injury; only a properly performed cystogram should be used to exclude bladder injury reliably. The accuracy of CT cystography is reported to be similar to that of conventional static cystography.

Bladder injury in blunt pelvic trauma

Major bladder injury occurs in approximately 10% of patients suffering from pelvic fracture. Such injuries are classified radiologically as follows:

1. Type I – bladder contusion
2. Type II – intraperitoneal rupture (Fig. 1)
3. Type III – interstitial bladder injury
4. Type IV – extraperitoneal rupture
   a. Simple (Fig. 2)
   b. Complex (Fig. 3)
5. Type V – combined bladder injury (Fig. 4)

Bladder contusion (type I) represents an incomplete tear of the bladder mucosa following blunt injury. The results of cystography are normal. The diagnosis of bladder contusion is usually established by exclusion in patients with hematuria following blunt pelvic trauma for which no other cause is found. Although bladder contusion is generally regarded as the most common form of bladder injury following blunt trauma, it is not considered to be a major injury. *Intraperitoneal rupture* (type II) occurs when there is a sudden rise in intravesicle pressure as a result of a blow to the lower abdomen in

a patient with a distended bladder. The increased intravesicle pressure results in rupture of the weakest portion of the bladder, the dome, where the bladder is in contact with the peritoneal surface. Intraperitoneal rupture accounts for approximately one-third of major bladder injuries. Approximately 25% of such injuries occur in patients *without* pelvic fracture. On cystography, contrast material extravasation into the paracolic gutters and outlining loops of small bowel will be visible. *Interstitial bladder injury* (type III) represents an incomplete perforation of the bladder wall without frank rupture and is extremely uncommon. On cystography a mural defect in the bladder wall representing an intramural hematoma will be found, but there is no contrast material extravasation. The classically described mechanism for *extraperitoneal bladder rupture* (type IV) is laceration of the bladder by a bone spicule in association with an anterior pelvic arch fracture. Such an injury results in contrast material extravasation from the bladder adjacent to the site of the bony spicule. Recent data, however, have shown that cystograms in such patients often demonstrate that the site of extravasation is often far removed from the site of fracture [2, 4]. This suggests that extraperitoneal rupture may occur by other mechanisms as well. Extraperitoneal rupture represents approximately 60% of major bladder injuries. With *simple extraperitoneal rupture*, contrast extravasation is limited to the pelvic extraperitoneal space. With *complex extraperitoneal rupture*, contrast material extravasation may extend into the anterior abdominal wall, the penis, the scrotum, or the perineum. The presence of complex extraperitoneal injury implies that the fascial boundaries of the pelvis have been disrupted by the injury; however, such extravasation should not be mistaken as evidence of a coexisting urethral injury. Such a coexisting injury can be diagnosed only on a preceding retrograde urethrogram. *Combined bladder injury* (type V) results when both intraperitoneal and extraperitoneal bladder injury are present. This injury is present in 5% of patients with bladder rupture.

External penetrating bladder injury

Penetrating injury of the bladder occurs as a result of bullet or knife wounds of the pelvis or perineum or as the result of impalement of the bladder by a variety of objects. Penetrating injuries are classified as intraperitoneal rupture, extraperitoneal rupture, or combined bladder injury.

Acute urethral injuries

The widespread acceptance of urethrography as the primary diagnostic procedure in male patients suspected of having urethral injury has improved our understanding of the extent and mechanism of such injuries. In the past the diagnosis was often based solely on the clinical triad of (1) blood at the urethral meatus, (2) the patient's inability to void, and (3) a palpable urinary bladder. In other cases the inability to pass the catheter into the bladder was considered diagnostic of a posterior urethral injury. It is now well established, however, that diagnostic catheterization is to be condemned, as such a procedure may convert a partial urethral injury into a complete one, increases the risk of hemorrhage in the prostatic bed, and may infect the previously sterile hematoma. Injury of the female urethra from blunt trauma is extremely rare; such injuries are generally found in association with a major pelvic ring disruption with a concomitant vaginal laceration, usually in girls.

Technique of urethrography

Although many different methods of urethrography have been described, we prefer to use the Foley catheter

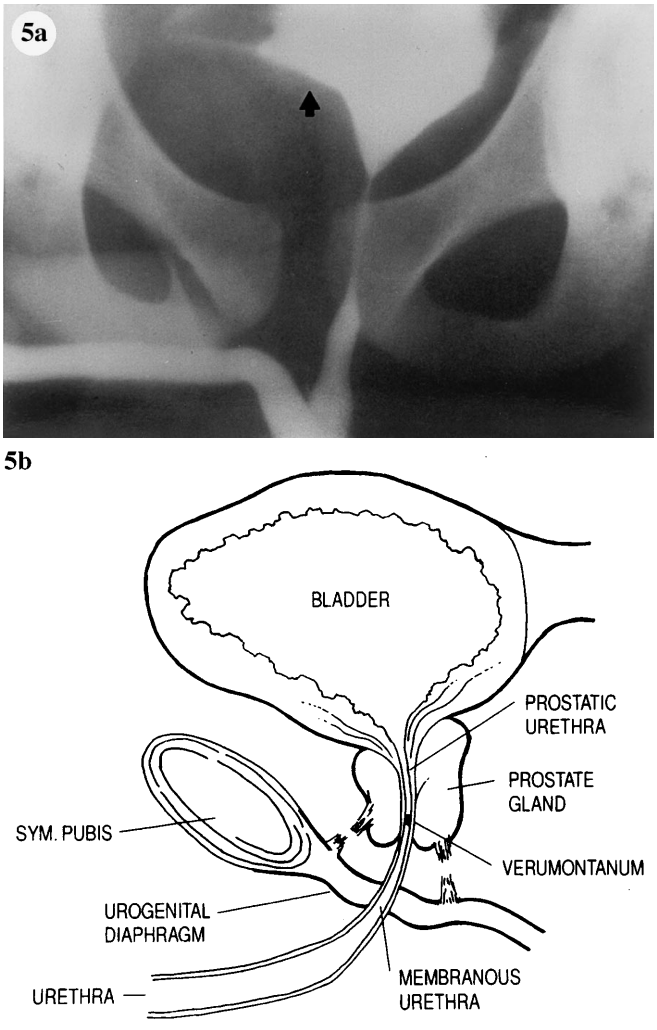
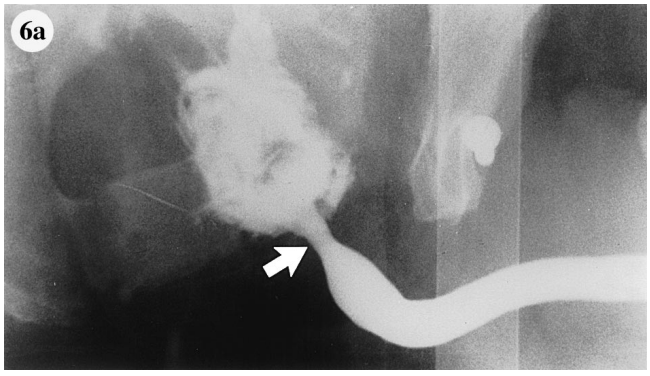


Fig. 5a,b Type I urethral injury. **a** Retrograde urethrogram. **b** Diagrammatic illustration. There is a hematoma indenting the base of the bladder (*arrow*). (Reproduced with permission from Goldman et al. [5])



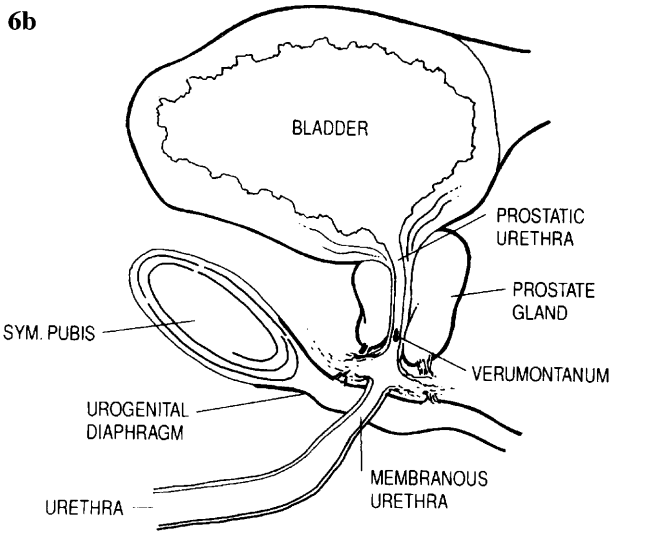
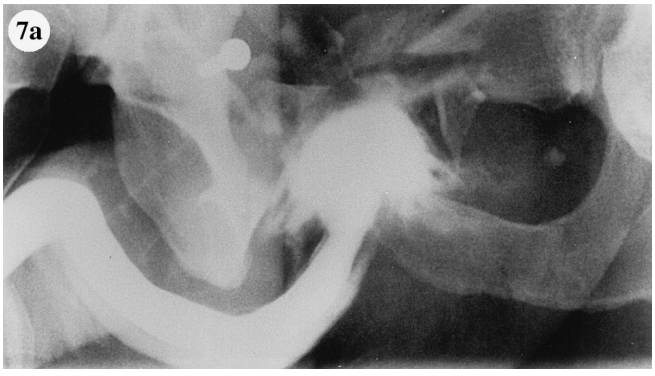


Fig. 6a,b Type II urethral injury. **a** Retrograde urethrogram. **b** Diagrammatic illustration. (Reproduced with permission from Goldman et al. [5])



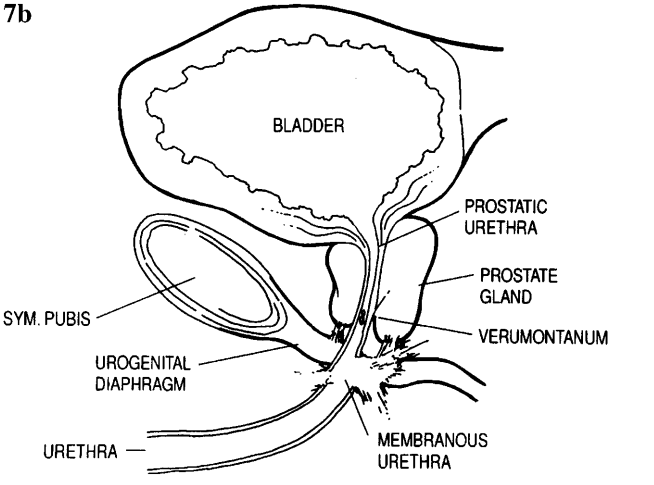


Fig. 7a,b Type III urethral injury **a** Retrograde urethrogram. **b** Diagrammatic illustration. (Reproduced with permission from Goldman et al. [5])

technique for the evaluation of trauma patients [12]. A Foley catheter is inserted such that its balloon can be partially inflated in the fossa navicularis of the penile urethra. No lubricant is used and the exposure is made during the active injection of 20–30 cc of full-strength (60%) ionic contrast material. In this fashion the deep bulbar and prostatic urethras will be filled; if the exposure is not made during the active injection of contrast, no such filling will be present. Fluoroscopic guidance is desirable but not necessary.

Mechanism of injury

Urethral injuries from external violence generally occur by two different mechanisms:

1. Urethral injury occurs in approximately 5% of male patients with pelvic fracture [10]. The prostate is sheared from its connection to the urogenital diaphragm as the puboprostatic ligaments are ruptured. The urethral injury is attributable to a violent force that disrupts the soft tissues rather than to a laceration of the urethra by a bony spicule. A hematoma collects in the retropubic and perivesicle spaces. Urine, however, does not escape from the bladder unless it is also injured or the bladder-neck sphincter mechanism has been disrupted by prior surgery (i.e., prostatectomy).

2. Straddle injuries occur as a result of a blow to the perineum. This commonly occurs when the male patient falls astride a hard object such as the crossbar of a bicycle. The bulbous urethra and corpus spongiosum are compressed between the hard object and the inferior aspect of the symphysis pubis. A pelvic fracture is generally not present but may be seen as a concomitant injury in patients with wide-impact trauma.

Classification

A new unified system of classification of urethral injuries has recently been proposed [5]. This system unifies the previously used separate classifications of anterior and posterior urethral injuries, rectifies anatomic inconsistencies, and addresses combined injuries of the urethra and bladder that heretofore were not included in any of the commonly used classification systems. The new system, proposed by Goldman and associates from the University of Texas-Houston, modifies and extends the previously used McCallum and Colapinto classification [3] which addressed only posterior urethral injuries:

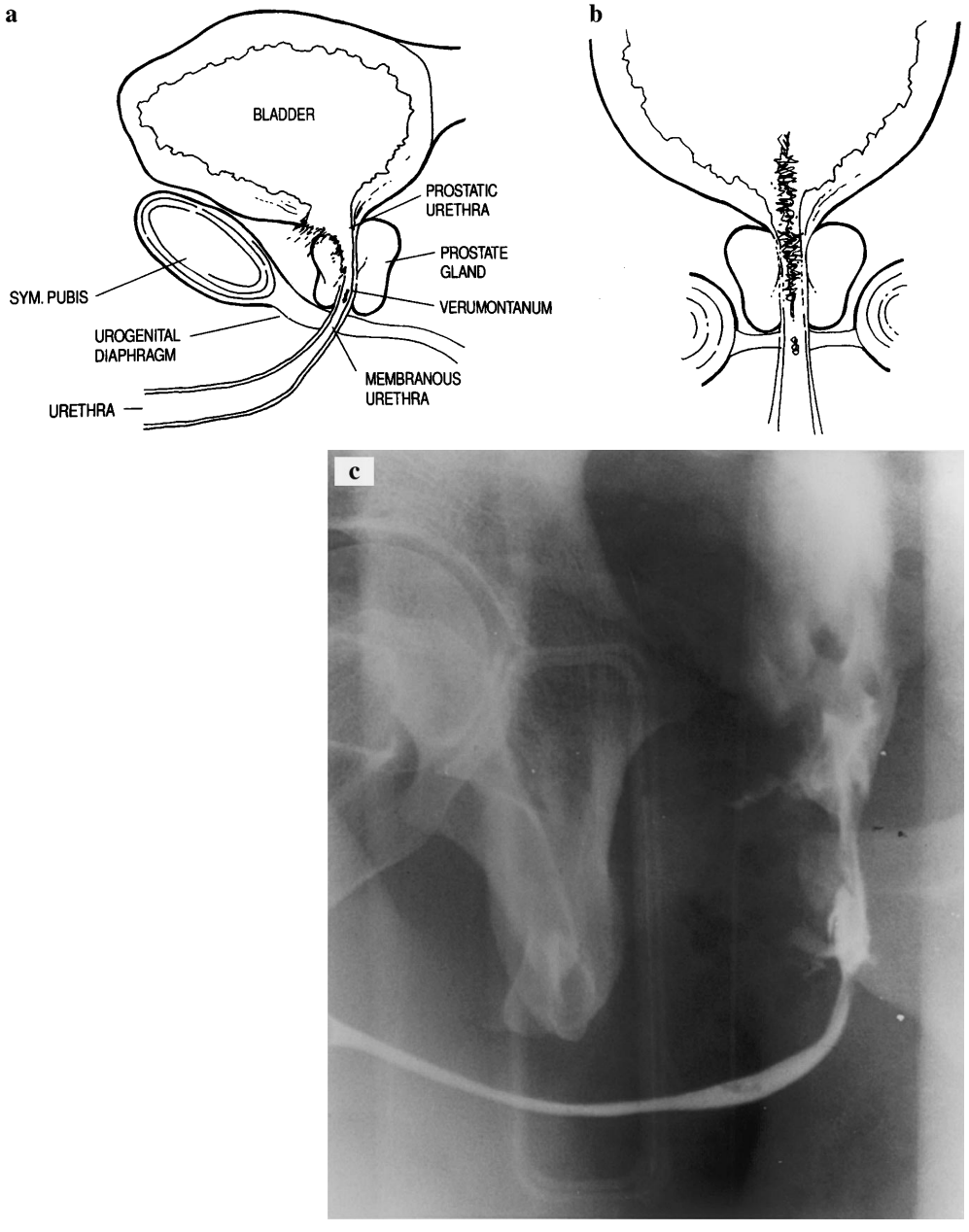


Fig. 8a–c Type IV urethral injury. Diagrammatic illustration in **a** lateral **b** AP projections. **c** Retrograde urethrogram. (**a,b** reproduced with permission from Goldman et al. [5])

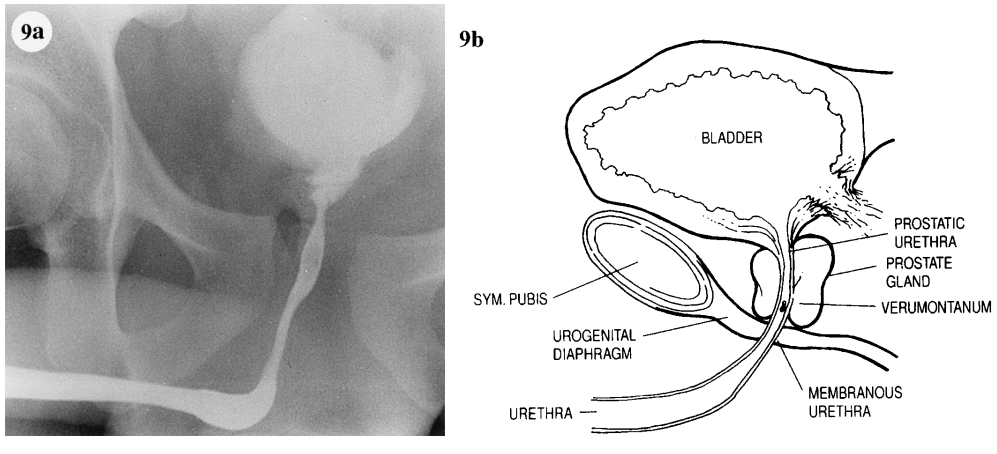


Fig. 9a,b Type IVa urethral injury. **a** Retrograde urethrogram. **b** Diagrammatic illustration. (Reproduced with permission from Goldman et al. [5])

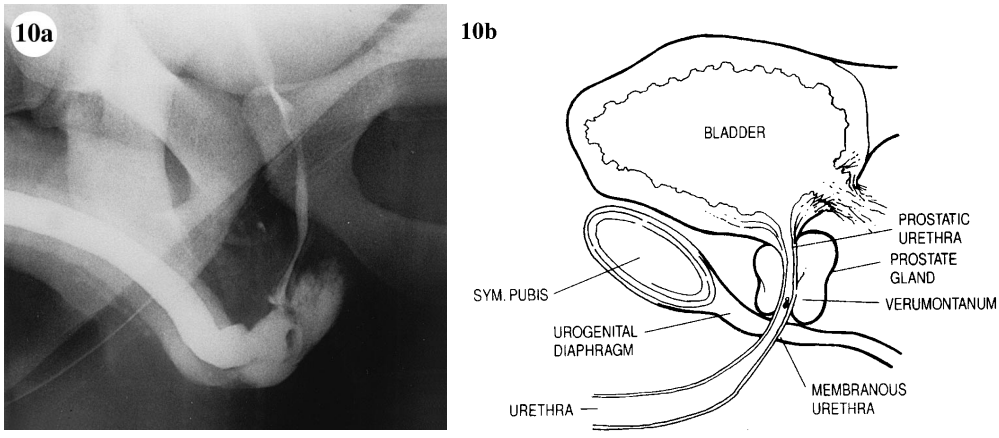


Fig. 10a,b Type V urethral injury **a** Retrograde urethrogram. **b** Diagrammatic illustration. (Reproduced with permission from Goldman et al. [5])

1. Type I – posterior urethra intact but stretched (Colapinto and McCallum type I, Fig. 5)
2. Type II – pure posterior injury with tear of membranous urethra above the urogenital diaphragm – partial or complete (Colapinto and McCallum type II, Fig. 6)
3. Type III – combined anterior/posterior urethral injury with disruption of the urogenital diaphragm – partial or complete (colapinto and McCallum type III; Fig. 7)
4. Type IV – bladder neck injury with extension into the urethra (Fig. 8)
5. Type IVA – injury of the base of the bladder with periurethral extravasation simulating a true type IV urethral injury (Fig. 9)
6. Type V – pure anterior urethral injury – partial or complete (Fig. 10)

Type I injuries occur when the puboprostatic ligaments are ruptured but the continuity of the urethra is maintained. A hematoma collects in the prostatic fossa, resulting in dislocation of the bladder base out of the pelvis and stretching of the posterior urethra. True type I injuries are uncommon; mere extrinsic compression of the posterior urethra by a periurethral hematoma without dislocation of the bladder should not be considered a true type I injury. *Type II* injuries demonstrates contrast extravasation into the pelvic extraperitoneal space *above* the urogenital diaphragm. The urogenital diaphragm is intact, which prevents contrast material extravasation from extending into the perineum. Before the widespread use of urethrography demonstrated otherwise, this was thought to be the most common injury of the posterior urethra, but it has since been shown to occur in only 15% of urethral injuries that result from pelvic fracture. Urethrography has demonstrated that *type III* injuries are the most common form of urethral injury. The membranous urethra is torn as in type II injuries; however, there is extension of the injury into the proximal bulbous urethra, disruption of the urogenital diaphragm itself, or both. Thus, the injury is not a true "posterior" urethral injury but is more accurately classified as a combined anterior/posterior injury. It results in contrast material extravasation on urethrography *below* the urogenital diaphragm (UGD) into the perineum. Since the degree of disruption of the UGD varies, depending on the severity of the injury, the amount of contrast extravasation into the perineum also varies [13]. As long as some extravasation extends into the perineum (which indicates that at least some disruption of the UGD is present), the injury should be classified as type III. *Type IV* injuries are newly described injuries of the bladder neck that extend into the proximal urethra. True type IV injuries need careful clinical assessment because of the potential for injury of the internal urethral sphincter as there is a laceration that extends through the bladder neck. *Type IVA* injuries are actually extraperitoneal bladder ruptures, which can generally be managed by external catheter drainage without surgery but are radiographically indistinguishable from true type IV injuries as both demonstrate periurethral contrast material extravasation on urethrography. Perry and Husmann [11] found that *Type IV* injuries in woman occurred in 4.6% of patients with pelvic fracture after high-speed motor vehicle accidents. We have seen such injuries in males as well. *Type V* injuries occur as a result of straddle injury. If Buck's fascia remains intact, the extravasation is limited to the space between Buck's fascia and the tunica albuginea of the corpus spongiosum. If Buck's fascia is ruptured, contrast extravasation on urethrography will be present within the confines of Colle's fascia.

Both type II and type III injuries may be either partial (a portion of the continuity of the urethra remains intact such that contrast is seen flowing into the urinary bladder during urethrography) or complete (no contrast flows into the bladder). The relative frequency of partial injuries as compared with complete disruptions varies widely in the reported series-McAnich [7] reported that 19% of his patients had partial disruptions, whereas Mitchell [9] found that 90% of his patients had partial injuries. The reasons for this wide variation in the reported incidence of partial injuries is not known. The prognosis for patients suffering both type II and type III

injuries is similar. When complete, both injuries will result in a complete urethral stricture. In most centers, such strictures are repaired on a delayed basis, usually 6 months after the initial injury. By this time the pelvic hematoma has resolved, the pelvic fracture has stabilized, and the bladder has redescended into the pelvis. In general, type II injuries result in a shorter stricture that is somewhat easier to repair than those associated with type III injuries, which tend to be at least several centimeters long. Partial ruptures are reported to have lower long-term morbidity than do complete ruptures; thus, the importance of accurate radiologic diagnosis is emphasized.

Type V injuries may also result in either partial or complete rupture of the bulbous urethra. Partial anterior urethral injuries are more common than complete disruptions. The typical straddle injury will result in a focal stricture in the proximal third of the bulbous urethra on follow-up examination.

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ANNOUNCEMENT

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