Computed tomography (CT) is the accepted frontline imaging modality for blunt abdominopelvic trauma. However, urethral injuries are traditionally diagnosed with retrograde urethrography. The CT appearances of urethral injuries and the signs associated with posterior urethral injuries are not well described in the literature. CT scans of patients with pelvic fractures and urethrographically proved posterior urethral injuries were evaluated. CT scans of patients with similar pelvic fractures who did not have urethral injuries were also evaluated.

The CT findings of elevation of the prostatic apex, extravasation of urinary tract contrast material above the urogenital diaphragm (UGD), and extravasation of urinary tract contrast material below the UGD were specific for type I, II, and III urethral injuries, respectively. If extraperitoneal bladder rupture is present along with periurethral extravasation of contrast material, the possibility of type IV and IVA urethral injuries should be considered. In addition, the CT findings of distortion or obscuration of the UGD fat plane, hematoma of the ischiocavernosus muscle, distortion or obscuration of the prostatic contour, distortion or obscuration of the bulbocavernosus muscle, and hematoma of the obturator internus muscle were more common in patients with pelvic fractures and associated urethral injuries than in patients with uncomplicated pelvic fractures.
Introduction
Posterior urethral injury or bladder rupture is seen in 20% of major pelvic ring disruptions (1). The prevalence of urethral injuries in males with pelvic fractures is 10% (2). Urethral injuries are rare in the absence of pelvic fractures. If not diagnosed and managed in a timely fashion, urethral injuries are associated with increased morbidity (3,4). Urethral injuries have traditionally been classified into three types by using the system of Colapinto and McCallum (5). The current classification put forth by Goldman et al (6) is an expansion of the Colapinto classification and includes bladder injuries that involve or simulate posterior urethral injury, as well as anterior urethral injury.

The classification system of Goldman et al (6) is as follows:

Type I injury: The posterior urethra is stretched and elongated but intact. The prostate and bladder apex are displaced superiorly due to disruption of the puboprostatic ligaments and resulting hematoma.

Type II injury: Disruption of the urethra occurs above the urogenital diaphragm (UGD) in the prostatic segment. The membranous urethra is intact.

Type III injury: The membranous urethra is disrupted with extension of injury to the proximal bulbous urethra and/or disruption of the UGD.

Type IV injury: Bladder neck injury with extension into the proximal urethra.

Type IVA injury: Injury of the base of the bladder with periurethral extravasation simulating a true type IV urethral injury.

Type V injury: Partial or complete pure anterior urethral injury.

Clinical signs of urethral injury such as blood at the urethral meatus, a high-riding prostate at digital rectal examination, and inability to void are not completely sensitive or specific for the diagnosis of urethral injury (7). Imaging plays a pivotal role in diagnosis of urethral injuries, with retrograde urethrogram (RUG) being the standard of reference (8,9). It is essential to be familiar with the computed tomographic (CT) findings that can be helpful in predicting the presence of a possible urethral injury, especially in view of the widespread use of CT as the frontline imaging modality for an acutely traumatized patient (10–12).

In this article, we describe the various types of pelvic hematomas, fat plane abnormalities, and urinary tract contrast material extravasations that are more commonly seen in patients who have urethral injury associated with pelvic fractures than in patients who have isolated pelvic fractures. Specific topics discussed are (a) CT signs specific for types of posterior urethral injuries and (b) indicators of urethral injury that are not type specific. We also briefly discuss the relevant normal pelvic anatomy.

Our focus of discussion is the more common types of urethral injuries, that is, types I, II, and III. Type IV injury is rare (2) and is not always distinguishable from bladder base injury (type IVA). Both of them show contrast material surrounding the proximal urethra in addition to the other RUG and cystographic signs of extraperitoneal bladder injury. Type IV and IVA injuries were not seen in our patient population. Type V injury is an anterior urethral injury and is also not discussed herein.

Materials and Methods
A retrospective review of the departmental records (1990–2001) of male patients diagnosed with pelvic fractures, with and without associated urethral injuries, who presented to our institution (a level 1 trauma center) was performed. The patient population was divided into three groups. The first group (n = 17) included patients who had urethral injury associated with pelvic fractures. These patients were selected from a total of 75 cases of urethral injuries on the basis of the availability of their complete records, including CT scans, RUG images, and urethroscopic or surgical confirmation of their injuries. The age
range was 18–65 years (mean age, 33.8 years). The second group (n = 1100530) was composed of patients who had pelvic fractures (of similar complexity as those in the first group [Table 1]) but no associated urethral injury. The age range was 20–64 years (mean age = 36.2 years). The third group (n = 50) included patients who had neither pelvic fracture nor urethral injuries. The age range was 18–65 years (mean age = 35.4 years).

All patients received 750–1,000 mL of oral contrast material, a 3% solution of diatrizoate meglumine and diatrizoate sodium (Gastroview; Mallinckrodt, St Louis, Mo), 30–60 minutes prior to CT.

Two different scanning techniques were used depending on whether the patient presented for study before or after January 1997. Those who presented before January 1997 included two patients from group 1, three patients from group 2, and seven patients from group 3. CT was performed with a conventional scanner (Somatom DRH; Siemens Medical Systems, Erlangen, Germany). A double-bolus injection technique was used for administration of intravenous contrast material, iohexol with an iodine concentration of 300 mg/mL (Omnipaque 300; Nycomed Amer-sham, Princeton, NJ). One hundred milliliters of intravenous contrast material was injected into a peripheral vein at a rate of 1.8 mL/sec. A scanning delay of 45 seconds from the start of injection was used. Ten-millimeter-collimation axial sections were obtained from the dome of the diaphragm to the iliac crests. A second bolus of 80 mL of intravenous contrast material was then given at a rate of 1 mL/sec. Scanning was continued, without any interruption, from the iliac crests to 2–3 cm below the pubic symphysis.

All of the remaining patients from the three groups underwent CT performed with a helical scanner (CT/i; GE Medical Systems, Milwaukee, Wis). The images were acquired with 10-mm collimation and a pitch of 1.5. The scanned area extended from the dome of the diaphragm to 2–3 cm below the symphysis pubis; 140 mL of intravenous contrast material (iohexol [Omnipaque 300]) was administered at a rate of 2 mL/sec. The scanning delay was 90 seconds.

There was no significant visual difference in the quality of the CT scans or the enhancement of the soft tissues between the two techniques.

Additional images were obtained in two patients with interval delays of 12–14 minutes after intravenous contrast material administration. These images were obtained at the request of orthopedic surgeons for evaluation of acetabular fractures. Helical acquisition with 3-mm collimation and a pitch of 1 was used.

### Table 1: Comparison of Pelvic Fracture Sites Evaluated for Urethral Injuries

<table>
<thead>
<tr>
<th>Fracture Sites*</th>
<th>Patients with Associated Urethral Injuries (n = 17)</th>
<th>Patients without Associated Urethral Injuries (n = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple sites including IPR</td>
<td>14 (82)</td>
<td>19 (63)</td>
</tr>
<tr>
<td>Multiple sites including SPR</td>
<td>8 (47)</td>
<td>12 (40)</td>
</tr>
<tr>
<td>Multiple sites including pubic body</td>
<td>5 (29)</td>
<td>2 (7)</td>
</tr>
<tr>
<td>Multiple sites including ilium or SIJ widening</td>
<td>2 (12)</td>
<td>2 (7)</td>
</tr>
<tr>
<td>Isolated IPR fractures</td>
<td>1 (6)</td>
<td>6 (20)</td>
</tr>
<tr>
<td>Isolated SPR fractures</td>
<td>1 (6)</td>
<td>2 (7)</td>
</tr>
</tbody>
</table>

Note.—Numbers in parentheses are percentages.  
*IPR = ischiopubic ramus, SIJ = sacroiliac joint, SPR = superior pubic ramus.
Essential Anatomy
The male urethra consists of four parts. The posterior urethra is composed of the prostatic and membranous segments. The bulbous and penile portions make up the anterior urethra. Our discussion focuses on posterior urethral injuries and the related anatomy.

Figure 1 shows a coronal section and Figure 2 shows a superficial dissection of the relevant anatomy of the pelvis and perineum discussed herein.

Prostate and Fat Planes
The prostate gland extends from the apex of the bladder to the UGD. It surrounds the prostatic urethra, which is normally not visible on axial CT sections. The normal prostatic contour is well defined at CT. Between the anterior aspect of the prostate and the pubic symphysis and pubic bodies is the fat-filled preprostatic space (Fig 3). The medial and lateral puboprostatic ligaments extend from the posterior aspect of the pubic bodies and the inner aspects of the pubic rami, respectively, to the anterosuperior aspect of the prostate. These are usually not visible at CT.
The UGD forms the external urethral sphincter. At axial CT, the UGD is seen in contiguity with the prostatic apex (Fig 4). The UGD surrounds the membranous urethra and is mainly formed by the deep perineal muscles, including the transverse perinei profundi and the sphincter urethrae. The transverse perinei profundi originate from the medial aspects of the ischial rami to insert into the perineal body, and the sphincter urethrae originates from the inner surface of each pubic ramus to encircle the membranous urethra.

The UGD fat plane forms an inverted V, with the lateral wall formed by the ischiocavernosus muscle.
muscle (Fig 5) and the medial wall formed by the levator ani–UGD complex. Superiorly, this triangular fat space is contiguous with the ischiorectal fossa, where the obturator internus muscle forms the lateral boundary (Fig 4a).

**Bulbocavernosus Muscle**
At axial CT, the bulbocavernosus muscle is seen as a small U-shaped muscle that surrounds the bulb of the penis (Fig 5). It originates from the median raphe and the perineal body to cover the inferolateral aspect of the bulb of the penis and the corpus spongiosum. Posterior fibers insert into the lower surface of the inferior fascia of the UGD. Middle fibers insert into the lateral aspect of the corpus spongiosum. Anterior fibers sweep around the corpora cavernosa and merge with the deep fascia of the penis on the dorsal aspect.

**Bulb of Penis**
The bulb of the penis is a bulblike enlargement of the proximal portion of the corpus spongiosum (Fig 5).

**Ischiocavernosus Muscle**
At axial CT, the ischiocavernosus muscle is seen together with the penile crura at the medial aspect of the ischiopubic ramus. It originates from the medial aspect of the ischial tuberosity. It covers
the crus of the penis and inserts on the ischiopubic ramus (Fig 6). Distally, it merges with the corpus cavernosum.

**Obturator Internus Muscle**

At axial CT, the obturator internus muscle is seen as an elliptical area of soft-tissue attenuation covering the medial aspect of the obturator foramen and the acetabulum (Fig 7). The muscle arises from the inner surface of the obturator membrane and the surrounding bony portion of the obturator foramen. It can be followed to its insertion on the medial surface of the greater trochanter of the femur, above the trochanteric fossa.

**CT Signs Specific for Types of Posterior Urethral Injuries**

**Type I Injury**

In type I injury, the posterior urethra is stretched and elongated but intact. Four patients (24%) met the criteria for type I injury. At CT, this can be identified as elevation of the prostatic apex above the UGD.

We used the criterion of separation of prostatic tissue from the UGD by a minimum of two sections (2 cm with 10-mm-thick sections). This excludes the possibility of volume-averaging artifact. Associated findings include distortion of the prostatic contour and obscuration of the preprostatic fat space by a hematoma (Fig 8). This constellation of findings could be explained by disruption of the puboprostatic ligaments, which run in the preprostatic fat space.
Type II Injury

Type II injury was seen in four patients (24%). In this type of injury, disruption of the urethra occurs above the UGD in the prostatic segment. CT criteria specific for type II injury included extravasation of urinary tract contrast material that was confined above the UGD (Fig 9). This contrast material originated either from prior RUG or when delayed scanning was performed in patients who did not have a Foley catheter and voided on the table during the examination. This criterion could not be applied to those cases where the contrast material was seen both above and below the UGD. In this scenario, the contrast material may have originated either above or below the UGD and tracked down or up along the fascial planes, thus making CT distinction between type II and type III injury impossible.

Type III Injury

In type III injury, the membranous urethra is disrupted with extension of injury into the proximal bulbous urethra and/or disruption of the UGD. Type III injury was present in seven patients (41%). This is seen at CT as extravasation of urinary tract contrast material at or below the UGD (Fig 10). The contrast material may track along the fascial planes to above the UGD in the prostatic segment, in which case it could represent either type II or type III injury; therefore, CT does not allow distinction between these two injury types.

Combined type I and type III injuries were seen in two patients (12%). In this type of injury, there is a combination of tear of the puboprostatic ligaments with elevation of the prostatic apex and tear in the urethra below the UGD.

Indicators of Urethral Injury That Are Not Type Specific

Distortion or Obscuration of the UGD Fat Plane

We used blunting of the apex of the UGD fat plane or partial or complete obscuration of this fat plane as evidence of urethral injury. These findings were seen in 15 patients (88%) when urethral injury was present (Fig 11a). They were seen in only one patient (3%) with comparable pelvic fractures and no urethral injury (Fig 11b).

Hematoma of the Ischiocavernosus Muscle

The ischiocavernosus muscles normally form thin stripes covering the penile crura and the ischiopubic rami. Inclusion criteria for hematoma included asymmetry in the size of the ischiocavernosus muscles or circumscribed blood attenuation in the muscle substance. This was seen in 15
Figure 10. Type III injury. (a) CT scan obtained through the perineal region shows extravasated contrast material (arrows) in the urinary tract below the UGD. (b) RUG image shows extravasated contrast material (arrows) in the urinary tract at the level of the UGD. A streak of contrast material (arrowheads) reaches the bladder, a finding compatible with a partial tear of the urethra. Injury to the membranous urethra, whether alone or in combination with injury above the UGD, constitutes a type III injury.

Figure 11. Distortion or obscuration of the UGD fat plane. (a) CT scan of a patient with a type II urethral injury shows partial absence of the left UGD fat plane (arrow) with a normal right fat plane. (b) CT scan of another patient shows a fracture of the right ischiopubic ramus (arrow) with preservation of the contour and surrounding fat planes of the UGD (arrowheads).
patients (88%) with urethral injury (Fig 12a, 12b) as opposed to only five patients (17%) with similar pelvic fractures and no urethral injury (Fig 12c).

**Distortion or Obscuration of the Prostatic Contour**

In the absence of elevation of the prostatic apex above the UGD, the following additional findings were associated with urethral injury in 10 patients (59%): infiltration of the preprostatic fat by hematoma, partial or complete loss of the prostatic outline, or obvious areas of blood attenuation in the prostatic substance (Fig 13a). These findings were seen in only two patients (7%) with pelvic fractures but without urethral injury (Fig 13b).

**Distortion or Obscuration of the Bulbocavernosus Muscle**

The bulbocavernosus muscle (ventral muscle of the penis) is a small muscle associated intimately with the corpus spongiosum. It surrounds the bulb of the penis. We considered the bulbocavernosus muscle abnormal when there was partial or complete loss of its outline or obvious asymmetry in the contour or size of this normally symmetrical midline structure. Eight patients (47%) who had pelvic fractures with associated urethral injury showed this finding (Fig 14a, 14b); only three patients (10%) with pelvic fractures and no urethral injury showed this CT sign (Fig 14c).

**Hematoma of the Obturator Internus Muscle**

Hematoma of the obturator internus muscle can occur when there is injury of the obturator artery or vein. We defined hematoma of the obturator internus muscle as asymmetry in size or focal blood attenuation in the substance of the muscle. These findings were seen in nine patients (53%) with pelvic fracture and urethral injury (Fig 15a, 15b). Only four patients (13%) with similar pelvic fractures but without urethral injury showed hematoma of the obturator internus muscle (Fig 15c).
Figure 13. Distortion or obscuration of the prostatic contour. (a) CT scan of a patient with a type I urethral injury shows absence of the normal prostatic outline. A periprostatic hematoma obliterates the fat planes. p = prostatic parenchyma. (b) CT scan of another patient shows a fracture of the superior pubic ramus (arrow) with a preserved prostatic contour and preserved preprostatic fat planes. RUG images were normal.

Figure 14. Distortion or obscuration of the bulbocavernous muscle. (a) CT scan of a patient with a type III urethral injury shows a distorted contour of the bulbocavernous muscle (arrowheads) with an obscured fat plane. Note the air in the urethra, which resulted from an unsuccessful attempt at catheterization. (b) CT scan of a patient with a type I urethral injury shows a slightly obscured bulbocavernosus muscle, which cannot be clearly identified around the bulb of the penis (b). Arrowheads = expected location of the bulbocavernous muscle. (c) CT scan of another patient shows a fracture of the left ischiopubic ramus with preserved fat planes (arrowheads) and no hematoma of the ischiocavernosus (arrow) or bulbocavernosus muscle. The patient had no urethral injury.
Table 2 compares the prevalences of the five non-type-specific findings in cases of pelvic fractures with and without associated urethral injury.

Conclusions
In cases of pelvic fractures, certain CT findings were seen with higher frequency in patients with associated urethral injury than in patients without urethral injury. Distortion or obscuration of the UGD fat plane and hematoma of the ischiocavernosus muscle had a much higher prevalence in patients with urethral injury than in those without.

Other findings that were seen with a relatively higher frequency in patients with pelvic fractures and associated urethral injury versus patients with isolated pelvic fractures included distortion or obscuration of the prostatic contour, distortion or obscuration of the bulbocavernous muscle, and hematoma of the obturator internus muscle.

None of these findings were present on the CT scans of the 50 patients (from group 3) who did not have pelvic fracture or urethral injury.

CT findings that are specific for each type of urethral injury were not seen in any of the patients with comparable pelvic fractures without a concomitant urethral injury. These findings were seen only in patients with a particular type of urethral injury. In type I injury, there was elevation of the prostatic apex, which could occur only if the puboprostatic ligaments were disrupted and as a consequence the prostatic segment of the urethra was stretched (ie, type I urethral injury). Similarly, extravasation of urinary tract contrast material either above (type II urethral injury) or below (type III injury) the UGD could occur only if there was a tear in the respective segment of the urethra. Therefore, we conclude that these findings are specific for each type of urethral injury.

Inarguably, RUG is the standard of reference for diagnosis of urethral injury. The trauma protocol for treatment of patients with pelvic fractures dictates performance of RUG before placement of a Foley catheter (13). In most cases, this protocol is followed before the patient is brought to the CT suite. However, there are instances, such as a very busy emergency department with multiple trauma patients arriving simultaneously and issues of availability of the CT scanner or portable radiography equipment, when CT may be performed prior to RUG and placement of a Foley catheter. With a clear understanding of
normal and pathologic CT anatomy, we can better define the different types of pelvic hematomas, fat plane distortions, and contrast material extravasations and their relative importance. In the rare cases where periurethral extravasation of urinary tract contrast material is seen, we can raise the possibility of type II, III, or IV urethral injury in our reports. Similarly, when elevation of the prostatic apex is seen along with other CT signs of urethral injury, the high likelihood of type I injury must be brought to the clinician’s notice. However, these CT findings do not avoid the need for RUG, which must be performed in all such cases to confirm the diagnosis. If non–type-specific findings of urethral injury (Table 2) are present, we must describe the relevant hematomas and fat plane distortions and stress the need for RUG to rule out a urethral injury.

### Table 2

<table>
<thead>
<tr>
<th>CT Signs</th>
<th>Patients with Associated Urethral Injuries (n = 17)</th>
<th>Patients without Associated Urethral Injuries (n = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distortion or obscuration of UGD fat plane</td>
<td>15 (88)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Hematoma of ischiocavernosus</td>
<td>15 (88)</td>
<td>5 (17)</td>
</tr>
<tr>
<td>Distortion or obscuration of prostatic contour</td>
<td>10 (59)</td>
<td>2 (7)</td>
</tr>
<tr>
<td>Distortion or obscuration of bulbocavernosus</td>
<td>8 (47)</td>
<td>3 (10)</td>
</tr>
<tr>
<td>Hematoma of obturator internus</td>
<td>9 (53)</td>
<td>4 (13)</td>
</tr>
</tbody>
</table>

Note.—Numbers in parentheses are percentages.

### References