CT Cystography in the Evaluation of Major Bladder Trauma

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Computed tomographic (CT) cystography has been advocated in lieu of conventional cystography in the initial work-up of patients with suspected urinary bladder trauma. CT cystography was applied to a classification scheme for bladder injury based on the degree of wall injury and anatomic location and demonstrated characteristic imaging features for each type of injury. In bladder contusion (type 1), findings are normal. In intraperitoneal rupture (type 2), CT cystography demonstrates intraperitoneal contrast material around bowel loops, between mesenteric folds, and in the paracolic gutters. Manifestations of interstitial injury (type 3) include intramural hemorrhage and submucosal extravasation of contrast material without transmural extension. In extraperitoneal rupture (type 4), the path of extravasated contrast material is variable: Extravasation is confined to the perivesical space in simple extraperitoneal ruptures, whereas in complex extraperitoneal ruptures, contrast material extends beyond the perivesical space and may dissect into a variety of fascial planes and spaces. Combined intra- and extraperitoneal rupture (type 5) usually demonstrates extravasation patterns that are typical for both types of injury. Familiarity with these CT cystographic features allows accurate classification of bladder injury and allows prompt, effective treatment with less radiation exposure than and without the added cost of conventional cystography.
Introduction
Urinary bladder injury may result from either blunt or penetrating trauma. Ruptures of the urinary bladder are most frequently seen in multi-trauma patients with blunt injuries (1–3). The propensity for bladder injury is related to the degree of bladder distention at the time of impact. Associated injuries may lead to a mortality rate as high as 44% (1). Delay in the diagnosis and treatment of a ruptured bladder may substantially increase mortality. Therefore, early and accurate diagnosis with imaging techniques is imperative.

Sandler et al (4) initially described five types of bladder injuries with conventional cystography. The type of injury is determined by the degree of wall injury and anatomic location. Type 1 represents simple bladder contusion; type 2, intraperitoneal rupture; type 3, interstitial bladder injury, which can be identified by the presence of contrast material dissecting into and limited to the bladder wall; type 4, extraperitoneal rupture, which is distinguishable from a type 3 injury by the location of extravasated contrast material at cystography; and type 5, combined intraperitoneal and extraperitoneal rupture (Table).

Accurate classification of injury in the clinical setting is critical for proper treatment (3,5,6). Intraperitoneal bladder ruptures (type 2) and combined intraperitoneal and extraperitoneal ruptures (type 5) require laparotomy with surgical repair of the bladder defect and diverting vesicostomy. Contusions (type 1) and interstitial injuries (type 3) are managed conservatively with Foley catheterization. Most extraperitoneal ruptures (type 2) may be treated with catheter drainage if the urine clears of blood, the catheter functions well, and the bladder neck is not injured; otherwise, formal surgical repair is necessary. Prognosis for clinical recovery is excellent if these diagnostic criteria are used (3,5,6).

Conventional cystography has long been considered the standard of reference for evaluating patients with suspected bladder injury. Initial attempts to diagnose bladder trauma with computed tomography (CT) with intravenously administered contrast material showed decreased sensitivity compared with conventional cystography. This was due to inadequate antegrade bladder filling from renal excretion (1,3,7–9). Kane et al (10) improved CT sensitivity by delayed imaging, which allowed further bladder distention; however, this also resulted in increased scan times. These authors also used ionic contrast material, which has a diuretic effect that is not seen with nonionic, intravenously administered contrast material and is now often used in the trauma setting. Although the time delay between initial and repeat imaging was only 15–30 minutes in their study, such a delay may not be feasible in a busy emergency department.

It has been well documented that filling the bladder with a minimum of 250–300 mL of contrast material is necessary to safely rule out a tear (8). Borrowing from the experience of other investigators with conventional cystography, Mee et al (8) suggested that retrograde filling of the bladder with this volume of contrast material prior to routine abdominopelvic CT may improve detection of extravasation (Fig 1). This advance in technique has led to CT cystography with retrograde bladder distention replacing radiography in many trauma centers. CT cystography has demonstrated a diagnostic accuracy approaching 100% in small series (7,8). No large studies have been conducted comparing the efficacy of CT cystography with retrograde bladder filling with that of conventional cystography.

In our practice, CT cystography is routinely considered in any patient with known pelvic frac-
tures as well as in patients with gross hematuria or severe pelvic trauma with no known pelvic fractures. Bladder catheterization is performed only after the trauma surgeon determines urethral continuity based on clinical or retrograde urethrogram findings.

In this article, we describe CT cystographic technique and the characteristic imaging features of each of the five types of bladder injury described earlier.

**CT Cystographic Technique**

Retrograde bladder distention is required prior to CT cystography through the pelvis. This represents the only change in our standard protocol for abdominopelvic CT in the trauma setting, which includes both intravenous bolus injection and oral administration of contrast material. We do not intentionally delay imaging of multi-trauma patients to achieve complete bowel opacification.

After Foley catheter insertion, adequate bladder distention is achieved by instilling at least 350 mL of a diluted mixture of contrast material (50 mL of Hypaque 60 [Nycomed, Princeton, NJ] and 450 mL of normal saline solution) into the bladder under gravity control (7). Contiguous 10-mm axial images are then obtained from the dome of the diaphragm to the perineum, thus including the upper thighs.

In our experience, postdrainage images through the decompressed bladder are not required. Removal of the Foley catheter to identify bladder base lacerations has also proved unnecessary. Even simple deflation of the balloon with possible inadvertent removal of the catheter would be detrimental in the patient with associated urethral injury.

The normal CT cystogram will demonstrate a uniformly hyperattenuating, well-distended urinary bladder with thin walls. The adjacent fat planes will be distinct, with no evidence of extravasated contrast material.
CT Cystographic Findings in Bladder Injury

Type 1: Contusion
Bladder contusion is defined as an incomplete or partial tear of the bladder mucosa (2). Although patients present with hematuria, findings at conventional and CT cystography are normal. Bladder contusion is believed to be the most common bladder injury in multitrauma patients but is not in itself considered to be a major bladder injury. Reliable statistics as to the prevalence of contusion are not available (2,11).

Type 2: Intraperitoneal Rupture
Intraperitoneal bladder rupture occurs in approximately 10%–20% of major bladder injuries (12). This injury is typically the result of a direct blow to the already distended bladder. The sudden increase in intravesicular pressure causes intraperitoneal rupture of the bladder dome. CT cystography demonstrates intraperitoneal contrast material around bowel loops, between mesenteric folds, and in the paracolic gutters (Figs 2–4).

Figure 2. Intraperitoneal rupture in a 53-year-old man who was involved in a motor vehicle accident. (a) CT cystogram demonstrates the classic appearance of an intraperitoneal rupture, with extravasated contrast material between loops of small bowel (arrows) and the anterior pararenal fascia (arrowheads). (b) CT cystogram demonstrates heterogeneous attenuation at the bladder dome rupture site (arrow). (c) On a CT cystogram, an intravesical hematoma (arrow) and a small focus of air introduced during bladder filling are seen as filling defects.
Figure 3. Intraperitoneal rupture in a 41-year-old man who was involved in a motor vehicle accident. The patient underwent peritoneal lavage prior to CT cystography. (a) CT cystogram clearly depicts subtle intraperitoneal contrast material between small bowel loops (arrows) despite the presence of lavage fluid. (b) CT cystogram demonstrates intraperitoneal contrast material diluted by peritoneal lavage fluid in the rectovesical recess (curved arrow). Other intraperitoneal collections of lavage fluid with contrast material–fluid levels are also present (straight arrows).

Figure 4. Intraperitoneal rupture with subcutaneous contrast material extravasation in a 29-year-old man who sustained multiple pelvic fractures in a motor vehicle accident. (a) CT cystogram shows intraperitoneal contrast material outlining the liver (arrows). (b) CT cystogram demonstrates intraperitoneal contrast material outlining small bowel loops (arrowheads). Extravasation through a tear of the transverse and oblique muscles of the abdominal wall (arrow) without perivesicular extravasation is an unusual variant of intraperitoneal rupture.
Type 3: Interstitial Injury
Interstitial bladder injury is rare and is defined as an intramural or partial-thickness laceration with intact serosa (Fig 5) (2). Consequently, CT cystography may demonstrate intramural contrast material without extravasation (Fig 6).

Type 4: Extraperitoneal Rupture
Extraperitoneal rupture is the most common type of bladder injury (80%–90% of cases) (12). It is usually caused by penetrating trauma; in blunt trauma, the presumed mechanism is direct laceration of the bladder by bone fragments from a pelvic fracture. The path of extravasated contrast material is variable. Extravasation is confined to the perivesical space in simple extraperitoneal ruptures (Type 4a) (Fig 7), whereas in complex...
extraperitoneal ruptures, contrast material extends beyond the perivesical space (Type 4b) and may dissect into a variety of fascial planes and spaces (Figs 8–11). A thorough understanding of abdominopelvic anatomy and associated fascial planes will help avoid misdiagnosis of complex extraperitoneal rupture.

Figures 8, 9. (8) Complex extraperitoneal rupture in a 37-year-old woman who was involved in a motor vehicle accident. CT cystogram shows extravasated contrast material in the thigh due to disruption of the inferior fascia of the urogenital diaphragm (perineal membrane). Contrast material is also seen in the adductor muscles of both legs (solid arrows), in the perivesical space, and bordering the lateral portion of the vagina (open arrow). Fractures of the pubis symphysis and left inferior pubic ramus are also noted (arrowheads). (9) Complex extraperitoneal rupture in a 23-year-old man who was involved in a motor vehicle accident. (a) CT cystogram demonstrates extraperitoneal perivesicular extravasation with the typical molar tooth appearance (solid arrows) (cf Fig 7). There is extension into the rectus abdominis muscle as well as the superficial fatty layer (fascia of Camper) and deeper membranous layer (Scarpa fascia) of the subcutaneous fascia (open arrow). (b, c) CT cystograms (c obtained at a lower level than b) show diastasis of the pubis symphysis (arrowheads in b) with disruption of the urogenital diaphragm, which allows contrast material to extend directly into the deeper membranous subcutaneous fascial planes and along the scrotal sub-dartos fascia (arrows).
Combined bladder rupture consists of simultaneous intraperitoneal and extraperitoneal injury. The prevalence of combined bladder rupture is 5%–12% in published series that include both penetrating and blunt trauma (2,12). CT cystography usually demonstrates extravasation patterns that are typical for both types of injury (Fig 12). However, there are reported cases of surgically proved combined ruptures in which only one component of bladder injury was demonstrated at cystography (4).

**Figures 10, 11.** (10) Complex extraperitoneal rupture in a 38-year-old man who was injured in a fall from scaffolding. (a) CT cystogram demonstrates multiple pelvic fractures (arrow), which caused disruption of the superior fascia of the urogenital diaphragm or of the urogenital diaphragm itself and allowed contrast material to extend into the scrotum. (b) On a CT cystogram, contrast material in the scrotum remains contained within the dartos fascia (open arrow) while contrast material has also extended into the left abductor muscles (solid arrow). (11) Complex extraperitoneal rupture in a 76-year-old man who was struck by an automobile while walking. (a) On a CT cystogram, contrast material is seen in the properitoneal space (extraperitoneal subserous tissue) of the right lower quadrant (arrowheads). This should not be confused with intraperitoneal contrast material. (b) CT cystogram shows perivesical contrast material in the extraperitoneal pelvis (arrows). On other images (not shown), this contrast material was contiguous with properitoneal contrast material (cf a).
Figure 12. Combined intraperitoneal and extraperitoneal rupture in a 23-year-old man who was involved in a motor vehicle accident. (a) CT cystogram demonstrates free contrast material delineating loops of small bowel, a finding that is characteristic of an intraperitoneal rupture. (b) CT cystogram shows contrast material insinuating itself into the perivesical and perirectal spaces of the extraperitoneal pelvis (straight arrows). Pubic rami fractures are also noted (curved arrow).

Conclusions

CT cystography may be performed expeditiously and is highly accurate as an adjunct to routine abdominopelvic CT in the trauma setting. This technique obviates a separate study with conventional cystography, which entails additional cost and higher radiation exposure. Bladder injuries have characteristic CT cystographic features that can be used for accurate classification and treatment planning.

References