Imaging assessment of urogenital emergencies

Poster No.: C-0887
Congress: ECR 2014
Type: Educational Exhibit
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Keywords: Trauma, Obstruction / Occlusion, Acute, Imaging sequences, Cystography / Uretrography, Contrast agent-intravenous, Ultrasound, MR, CT, Urinary Tract / Bladder, Genital / Reproductive system female, Emergency
DOI: 10.1594/ecr2014/C-0887

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Learning objectives

Diagnostic Imaging play an important role in the assessment of urogenital emergencies and is crucial for a rapid and effective management. We propose to:

1) Illustrate the causes of urogenital emergencies

2) Illustrate, for any emergency, different imaging approaches and imaging features
Background

The most important causes of urogenital emergencies are abdominal trauma and acute gynecologic diseases. For any emergency, an accurate imaging work-up is crucial for addressing an accurate diagnosis and reducing comorbidities.

1) ABDOMINAL TRAUMA

Urogenital tract in abdominal trauma has been reported to be involved in 8-10% of all cases. Wide-impact blunt abdominal trauma is responsible for most of closed injuries of the genitourinary organs, with motor vehicle crashes being the most common cause in the Western hemisphere. The incidence of penetrating trauma is also increasing, which is seen particularly in inner city trauma centers, and is becoming a major cause of renal injury. Closed abdominal trauma represent the cause of almost 80% of these injuries.

Adrenal trauma: Trauma to the adrenal glands is unusual because of their relatively well-protected position deep in the retroperitoneum. The gold standard is CT and typical features are:

- expansile, hyperattenuating, round or oval hematoma (Fig.1a).
- irregularity or obliteration of the gland by hemorrhage
- periadrenal fat stranding
- enlargement of the gland due to edema or contusion.
- active adrenal hemorrhage may be seen

Sonography is used to evaluate children who have sustained trauma. The adrenal gland may be enlarged and may show hypoechoic areas of hemorrhage. (Fig.1b)

Renal trauma: Contrast enhanced MDCT is the imaging technique of choice in renal trauma and the role of IV urography (IVU) is currently relegated to situations in which CT may not be available. The severity of renal injuries is graded from 1 to 5 according to a classification system developed by the Organ Injury Scaling Committee of the American Association for the Surgery of Trauma (AAST) and is called the organ injury scale (OIS):

- Grade 1 injuries: renal contusion without a parenchymal laceration and a nonexpanding subcapsular hematoma.
- Grade 2 injuries: superficial cortical lacerations < 1 cm deep (and thus do not involve the collecting system) and a nonexpanding perinephric hematoma (Fig.2)
- **Grade 3 injuries**: deeper lacerations, > 1 cm deep, that do not extend into the collecting system, and nonexpanding perinephric hematoma.

- **Grade 4 injuries**: lacerations that extend into the collecting system and injury to the main and segmental renal vessels *(Fig.3)*

- **Grade 5 injuries**: show shattering of the kidney and dispersion of the avulsed portions, avulsion, laceration or thrombosis of the main renal vessels, hilar injury, and ureteropelvic junction (UPJ) avulsion.

**Ureteral trauma**: Ureteral injuries caused by external trauma are atypical but when they occur are generally related to penetrating trauma, primarily gunshot wounds. Blunt trauma usually affects the UPJ and is related to rapid deceleration injury. One-shot preoperative or intraoperative IVU may show contrast extravasation, but it is often not performed because of poor diagnostic performance and indeed the delay in performing the examination in an unstable patient. Once the patient is able to undergo this exam, complete IVU or contrast-enhanced CT with imaging in the delayed phase may show contrast extravasation from the ureter *(Fig.4)* or partial or complete ureteral obstruction. Furthermore, CT may show urinary ascites or urinoma. In patients with blunt trauma and suspected UPJ injury, CT with excretory phase imaging is a reliable tool for evaluation.

**Urinary bladder trauma**: The most frequent causes of bladder trauma are motor vehicle crashes, falls, crush injuries, and blows to the lower abdomen. CT is now considered to be the diagnostic procedure of choice in the evaluation of abdominal and pelvic injury after blunt trauma. The conventional CT protocol for abdominal trauma may or may not show the presence of bladder trauma because visualization of bladder rupture on CT requires the bladder to be filled with fluid and under pressure. Therefore, if CT examination fails to show bladder rupture and bladder rupture is suspected, especially when water-dense fluid is seen in the peritoneal cavity, CT cystography is indicated. A classification system approved by a consensus panel of the Societe Internationale D'Urologie classifies bladder injury into four types:

- **Type 1**: bladder contusion
- **Type 2**: intraperitoneal rupture *(Fig.5)*
- **Type 3**: extraperitoneal rupture *(Fig.6)*
- **Type 4**: combined injury

**Urethral trauma**: Blunt urethral trauma traditionally has been classified anatomically as either anterior or posterior. Posterior urethral injury usually is caused by a crushing force to the pelvis and is associated with pelvic fractures. The frequency of anterior urethral injuries is one third that of posterior urethral injuries. Retrograde urethrography is the
diagnostic procedure of choice to evaluate patients with suspected urethral injury. CT, MRI and ultrasonography (US) are useful for evaluating periurethral structures. Urethral injuries are classified into five types (Goldman Classification):

- **Type I**: posterior urethra stretched but intact
- **Type II**: urethra disrupted at the membranoprostatic junction above the urogenital diaphragm
- **Type III**: membranous urethra disrupted, with extension to the proximal bulbous urethra or disruption of the urogenital diaphragm (most common type) (Fig.7)
- **Type IV**: bladder neck injury with extension into the urethra (Fig.8)
- **Type IVa**: injury of the base of the bladder and periurethral extravasation simulating a true type IV urethral injury
- **Type V**: partial or complete pure anterior urethral injury

**Testicular trauma**: The testes can be injured with sporting activities, which account for more than half of all cases of testicular injury. Motor vehicle collisions are also an important cause, particularly two-wheeled motorized vehicles, when the testes are crushed between the bony pelvis and the fuel tank. High-frequency US with a linear-array transducer is the first option to take into consideration for the evaluation of testicular trauma. Heterogeneous echotexture in the testis, testicular contour abnormality due to extrusion of the testes through a tunical defect, and disruption of the tunica albuginea (Fig.9) are indicative of testicular rupture. Testicular fractures (Fig.10) are surgically managed with débridement of extruded seminiferous tubules and closure of the tunical defect. Testicular hematomas may also cause the echotexture to be heterogeneous (Fig.11). The appearance of hematomas varies with their age, but they show no internal vascularity. Other findings that may accompany testicular trauma are a scrotal hematocele, scrotal wall hematoma, and traumatic epididymitis. MRI is helpful in patients with equivocal findings.

2) **ACUTE GYNECOLOGIC DISEASES**

An acute gynecologic condition is characterized by sudden onset of lower abdominal pain, fever, genital bleeding, intraperitoneal bleeding, or symptoms of shock. It is important to differentiate diseases such as ovarian torsion, rupture of an ectopic pregnancy, and uterine arteriovenous malformations, which require an immediate surgical or interventional approach, from conditions such as pelvic peritonitis and ovarian hemorrhage, which can be treated with conservative therapy. Physical examination has a limited role in diagnosis of acute gynecologic conditions. US is a useful imaging modality.
for evaluation of patients suspected to have acute gynecologic diseases. However, US findings are not always conclusive and MRI is a valuable complement to US.

**Ovarian torsion:** Ovarian torsion is a well-known complication of ovarian tumors and cysts. Sonography is the diagnostic modality of choice. Typical sonographic features of torsion are:

- enlarged ovaries (>4 cm)
- ovarian cyst or mass
- free fluid
- tenderness
- an abnormal ovarian position (affected ovary in the pouch of Douglas, anterior to the uterus, or on the contralateral side)
- presence of a pedicle
- whirlpool sign
- abnormal Doppler flow (absence of venous or arterial flow)
- presence of follicular rings (Fig.12)

Hemorrhagic necrosis due to torsion can be established by MR imaging evaluation with a combination of fat-suppressed T1-weighted images and contrast-enhanced fat suppressed T1-weighted images. High signal intensity of a tumor on fat-suppressed T1-weighted images suggests hemorrhage or vascular congestion (Fig.13). MR imaging features indicative of ovarian torsion are:

- lack of enhancement of the solid component
- a thickened cyst wall or a mural nodule

**Ectopic pregnancy:** Ectopic pregnancy usually cause lower abdominal pain and hemoperitoneum. Currently, diagnosis in unruptured ectopic pregnancy is achieved using a combination of transvaginal ultrasonography and measurement of serum #hCG concentrations. 95% of ectopic pregnancies occur within the fallopian tube; other sites are the ovary, cervix, and peritoneal cavity. Effectively, in the absence of an intrauterine gestation sac, an ectopic pregnancy can be diagnosed by the presence of an adnexal mass, often visible within the Fallopian tube (Fig.14). Massive hemorrhage from a ruptured tubal or ovarian pregnancy leads to symptoms of shock.

MR imaging findings in ectopic pregnancy include:
- hemosalpinx
- bloody ascites
- heterogeneous adnexal mass composed of a hematoma
- gestational sac

The hemosalpinx and bloody ascites are slightly hyperintense if compared to urine on fat-suppressed T1-weighted images. The heterogeneous mass has mixed signal intensity on fat-suppressed T1-and T2-weighted images (Fig. 15). The bleeding point can be revealed with contrast-enhanced dynamic subtraction MR imaging. Extravasation of contrast material can be seen as a hyperintense spot in the hematoma.

**Uterine arteriovenous Malformations:** Uterine arteriovenous malformations (AVMs) are broadly classified as congenital or acquired. Congenital AVMs are rare and result from abnormal embryologic development of primitive vascular structures whereas acquired or traumatic AVMs are being increasingly diagnosed. Acquired uterine AVMs are usually traumatic, resulting from prior dilation and curettage, therapeutic abortion, uterine surgery, or direct uterine trauma. The most common symptom of AVMs is genital bleeding. Initial evaluation of AVMs is made with ultrasonography, at which they appear either as masses with multiple hypo/anechoic tubular like structures of varying sizes or as focal endometrial and myometrial thickenings. US-Doppler adds the possibility of recognizing vessels within malformations. Spectral analysis permits evaluating the flow within vessels, recognizing high flow and low resistive index within arteries and veins (Fig. 16).

Confirmation of the diagnosis traditionally comes from angiography. Tortuous and tubular signal voids in the myometrium, in the parametrium, and protrusions into the endometrial cavity are seen on both T1-and T2-weighted images (Fig. 17). A vascular lake with sluggish flow is demonstrated as a hyperintense structure mimicking a tumor or placental polyp on T2-weighted images. Contrast-enhanced dynamic subtraction imaging reveals that the lesion enhances as intensely as vessels. Dynamic subtraction MR angiography clearly demonstrates vascular anatomy, abnormal vessels, and hemodynamics and enables noninvasive confirmation of a diagnosis of uterine arteriovenous malformations.

**Hemorrhagic Ovarian Cyst:** is an abdominal mass formed by the bleeding into a follicular ovarian cyst or corpus luteum cyst. It is detected as pelvic mass by ultrasonography, but is often misdiagnosed with other organic masses because of its variable clinical and sonographic findings and in some cases may lead to laparotomy. Main sonographic features observed are the presence of fibrin strands or a retracting clot, with the absence of suspected septations and wall irregularity as secondary helpful findings (Fig. 18).
MR imaging shows hemorrhagic cysts as hyperintense on both T1- and T2-weighted images or hyperintense on T1-weighted images and hypointense on T2-weighted images (Fig. 19).

**Pelvic Inflammatory Disease**: is described as a spread of inflammation from the endometrial cavity and fallopian tubes into the pelvis. It is an umbrella term, which encompasses endometritis, salpingitis and tubo-ovarian abscesses. Patients often have lower abdominal pain, fever, leukocytosis, an elevated blood level of C-reactive protein and adnexal tenderness. Endometritis and myometritis can be treated conservatively with antibiotic therapy. However, tubo-ovarian abscess and pyosalpinx often need to be treated surgically. Transabdominal Ultrasound can demonstrate uterine enlargement and thickening of the endometrium and can also show the loss of tissue plains and an ill-defined uterus. Hydrosalpinx or pyosalpinx is a common complication of salpingitis. Ultrasound can identify dilated fallopian tubes containing heterogenous fluid with echogenic debris; features typical of pyosalpinx. The fallopian tubes may be folded and demonstrate areas of tube tapering, and intraluminal small linear echogenic foci may be visualised (Fig. 20). As pyosalpinx develops into tubo-ovarian abscesses, echogenic debris can be seen in the fallopian tubes and ovaries, representing inflammatory exudates, blood and pus. On MR Imaging, inflammation in the parametrium may be seen as ill-defined hyperintense areas on T2-weighted fat-suppressed images, in addition to enhancement on gadolinium-enhanced T1-weighted images. A pyosalpinx can be visualised as a dilated, fluid-filled, tortuous C or S-shaped structure. Thickwalled fluid-filled abscesses and pyosalpinx may have heterogeneous signal intensity on both T1 and T2 weighting due to mixtures of pus, haemorrhage and debris. The thick-walled mass typically demonstrates marked enhancement following iv gadolinium administration (Fig. 21).
Fig. 1: In a 52-year-old man after motorcycle collision unenhanced CT scan reveals high-density right adrenal mass (arrow) suspected to be hematoma (A). 12-year-old boy after motor vehicle collision who has right adrenal hemorrhage: sagittal sonogram shows right adrenal gland to be enlarged and predominantly hypoechoic, consistent with acute hemorrhage (B).


Fig. 2: 32-year-old woman with grade II left renal injury after fall from second-story balcony. Small (< 1 cm) cortical laceration (arrow) is present with large perirenal hematoma.
Fig. 3: 43-year-old man with grade IV left renal injury after being struck by car while walking. Wedge-shaped perfusion defect (arrow) is present in interpolar region of left kidney with surrounding hematoma.
Fig. 4: A 29-year-old man involved in a highway motor vehicle collision. CT reveals contrast retention in the perirenal retroperitoneum bilaterally (arrows) caused by bilateral complete ureteral disruption.


Fig. 5: 34-year-old woman with intraperitoneal bladder rupture after motor vehicle collision. A-C, CT cystography images (A, axial; B, coronal; C, sagittal) show site of
bladder rupture at dome (arrows) with contrast extravasation into peritoneal space (arrowheads). Note enlarged uterus with fibroids (F).

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**Fig. 6:** 19-year-old man with extraperitoneal bladder rupture after motor vehicle collision. A-C, CT cystography images (A, axial; B, coronal; C, sagittal) show site of bladder rupture at right lateral wall (arrows) with contrast extravasation into extraperitoneal space (arrowheads).

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Fig. 7: Posterior urethral rupture extending through the urogenital diaphragm to involve the bulbous urethra following blunt trauma (type III urethral injury). Retrograde urethrogram reveals contrast material extravasation at the membranous urethra (arrow). The contrast material extends below the urogenital diaphragm and surrounds the proximal bulbous urethra.

**Fig. 8:** Bladder neck urethral injury (type IV) in a 23-year-old woman. (A) Cystogram shows extraperitoneal contrast material extravasation (arrow) that extends from the bladder neck to the left underneath the balloon of a Foley catheter. (B) Cystogram obtained 2 minutes later shows progressive extraperitoneal contrast material extravasation.

Fig. 9: Testicular rupture. Longitudinal color Doppler US image of the left testis in a patient with scrotal trauma depicts tunica albuginea disruption (arrowhead) with a loss of vascularity in the ruptured portion of the testis (*).

Fig. 10: Testicular fracture. Longitudinal color Doppler US image in a patient with scrotal trauma depicts a hypoechoic avascular band (arrows) that crosses the testicular parenchyma.

**Fig. 11:** Intratesticular hematoma. Transverse color Doppler US image in a patient with scrotal trauma demonstrates an avascular hypoechoic area (arrow) within the testis. The hematoma was managed conservatively.

**Fig. 12:** Follicular rings (arrow) visible on transabdominal scans. The torsed ovary is impacted in the pouch of Douglas with the uterus lying anterior.

Fig. 13: Twisted left ovarian cystic teratoma with hemorrhagic necrosis in a 10-year-old girl. (A, B) Axial T1-weighted (A) and fat-suppressed T1-weighted (B) MR images show a cystic tumor (solid arrows) with a markedly thickened wall, which is slightly hyperintense. A small fat component (open arrow) within the tumor is hyperintense on the T1-weighted image (A) and hypointense on the fat-suppressed T1-weighted image (B).

Fig. 14: Transvaginal gray-scale US image of left adnexa reveals a 25mm hyperechoic mass with a central hypoechoic shadow, suggestive of a tubal pregnancy. ES: ectopic sac; CL: corpus luteum.


Fig. 15: Ovarian pregnancy in a 22-year-old woman with pelvic pain. (A, B) Axial fat-suppressed T1-weighted (A) and T2-weighted (B) MR images show a heterogeneous,
hyperintense mass (long arrows) on the right side of the uterus (*). The margin of the mass has irregular low signal intensity (short arrows) on the T2-weighted image (B).


**Fig. 16:** Spectral analysis of the right uterine artery showing high-velocity flow with low resistance index and pulsatility index. References:

**Fig. 17:** AVMs in a 28-year-old woman with massive genital bleeding 2 months after dilation and curettage. (A) Sagittal fat-suppressed T2-weighted MR image shows tangled signal voids protruding into the endometrial cavity (arrows). (B) Sagittal contrast-enhanced dynamic subtraction MR image (arterial phase) shows that the signal voids (arrows) enhance as intensely as the abdominal aorta (*), a finding indicative of a vascular lesion.

**Fig. 18:** Sonogram showing fibrin strands (long arrow) in a portion of a mass, which proved to be a hemorrhagic cyst (resolved 4 weeks later). Note the apparent thick septation (short arrow) in the mass caused by a clot, which resolved.

**Fig. 19:** Hemorrhagic ovarian cyst with hemoperitoneum in a 20-year-old woman with pelvic pain. Axial fat-suppressed T2-weighted (A) and fat-suppressed T1-weighted (B) MR images show a complex left adnexal mass (solid arrows). The mass is mostly hypointense with a small hyperintense portion on the T2-weighted image (A); it is hyperintense and isointense on the T1-weighted image (B). There is a fluid collection (open arrow), which is hyperintense on the T2 weighted image (A) and slightly hyperintense relative to urine (±) on the T1-weighted image (B), an appearance suggestive of bloody ascites. Note the layering low signal intensity (arrowhead) on the T2-weighted image (A); this finding is considered to represent fibrin debris or clots. Large * = right ovary, small * = uterus.


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**Fig. 20:** PID with pyosalpinx on Ultrasound. This patient presented to the emergency department with lower abdominal pain, pyrexia and vomiting. A-B Transvaginal ultrasound of both adenexa. There are bilateral adenexal cysts that contain low-level echogenic material and have a tubular configuration (white arrows). The appearance is in keeping with bilateral pyosalpinges, a complication of PID.

**Fig. 21:** PID with pyosalpinx on MRI. This patient presented to the emergency department with pyrexia, lower abdominal pain and diarrhea. (A) Sagittal T2 image of the pelvis demonstrates multiple fluid-filled cystic structures within the right adnexa (red arrows). The complex cyst is thick walled and there is adjacent fat stranding. (B) Axial T2 image demonstrates bilateral tubo-ovarian abcesses. (C) Axial T1 fat-saturated image following gadolinium administration demonstrates low signal intensity within the pus-filled cavities and marked enhancement of the inflammatory walls.

Findings and procedure details

We used contrast-enhanced Computer Tomography for most series of emergencies. Furthermore, we used Cystography, Urethrography, Ultrasonography, Angiography and MR imaging.
Conclusion

Imaging is crucial in the evaluation of the urogenital emergencies. Contrast-enhanced CT is usually the first-line imaging technique used to evaluate upper and lower urinary tract. Cystography and Urethrography remain useful techniques in the initial evaluation and follow-up of trauma to the urinary bladder and urethra. Ultrasonography is a useful imaging modality for evaluation of acute gynecologic diseases, but is not always conclusive; effectively MRI represents appropriate complement to US.