ORIGINAL RESEARCH PAPER
Volume - 12 | Issue - 06 | June - 2023 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

CT IN PELVIC TRAUMA: PICTORIAL REVIEW

Radiology

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ABSTRACT

Pelvic trauma is associated with high rates of morbidity and mortality due to hemodynamic instability. In most cases, pelvic trauma is seen with high energy so it is often associated with additional other organ injuries. Immediate detection of injured structures via appropriate diagnostic modalities is crucial. CT scan is the mainstay of emergency department diagnostic imaging due to its widespread availability, speed of acquisition, and versatility. Because of the complexity of pelvic & acetabular fractures, exact pathological anatomy is difficult to demonstrate by radiographs. In many cases, details of fractures are not appreciated. Moreover, the uncooperative patient or the difficulty of maintaining special positions can be overcome by using computed tomography. Spiral computed tomography gives information about the extent of the fractures and is complementary to radiography for ascertaining the spatial arrangement of fracture fragments. The use of intravenous contrast media helps in the simultaneous evaluation of soft tissues and vascular structures. The purpose of this article is to review the role of CT in pelvic trauma i.e. patterns of pelvic fractures and associated soft tissue injuries.

KEYWORDS

Pelvic trauma, Pelvic Injuries, Pelvic fractures, CT pelvis.

INTRODUCTION:

Advances in CT scan and improved access have increased the role of CECT in hemodynamically unstable patients in setting of pelvic trauma [1]-[2].

CT has many advantages over plain radiography and FAST.

Because of the complexity of pelvic & acetabular fractures, exact pathological anatomy is difficult to demonstrate by radiographs. In many cases, details of fractures are not appreciated. Moreover, the uncooperative patient or the difficulty of maintaining special positions can be overcome by using computed tomography.

Spiral computed tomography gives information about the extent of the fractures and is complementary to radiography for ascertaining the spatial arrangement of fracture fragments. Combined with multi-planar reconstruction two-dimensional (MPR 2D) reformatted images or three-dimensional images, spiral CT is an excellent tool for understanding complex pelvic fracture patterns. Subtle fractures, especially those oriented in the axial plane, are much better seen on multiplanar reconstruction images or 3D volume-rendered images. Complex injuries and complicated spatial information can be better demonstrated with 3D volume-rendered technique.

The use of intravenous contrast media helps in the simultaneous evaluation of soft tissues and vascular structures. Volume rendering eliminates most of the streak artifacts and produces high-quality images. CT is more sensitive than plain x rays for detecting acetabular, sacral, and SI joint fractures. [3]-[4]-[5].

Injuries to the genitourinary system, rectum, muscles, and vessels are not uncommon with pelvic fractures. CT scan can identify all these injuries to the great extent.

Anatomical Consideration In Pelvic Trauma (fig.1 &2)

Understanding the anatomic features of the pelvis and the biomechanical basis of different types of lesions is necessary for the appropriate treatment of such fractures. The pelvis is composed of 3 bones, namely the sacrum and 2 innominate bones. It is a ring-like structure (figure no.1).

The pelvic ring has two arches, anterior and posterior arch. The anterior arch is formed by the 2 pubic bones & pubic symphysis, while the posterior arch is formed by the 2 iliac bones and sacrum. The pelvis is a ring-like structure, hence fractures of the anterior arch are often had a concomitant injury to the posterior arch [6].

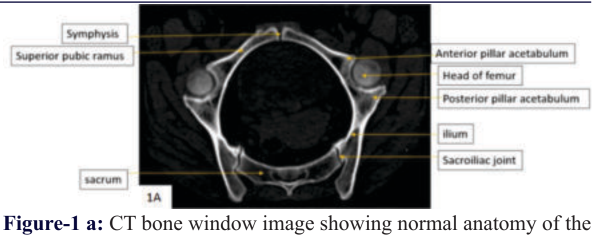

Figure-1 a: CT bone window image showing normal anatomy of the pelvic ring.

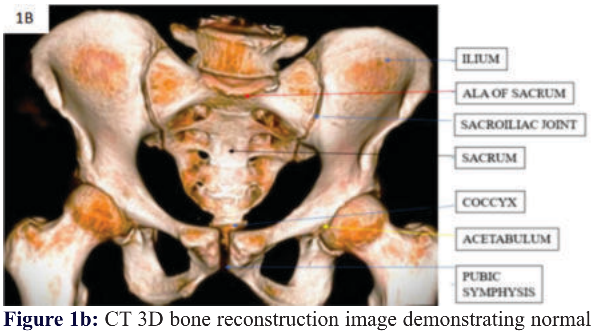

Figure 1b: CT 3D bone reconstruction image demonstrating normal anatomy of the pelvic bone.

Pelvic Fracture Classification

Young and Burgess classification is most widely used classification of pelvic ring fracture.

It is based on the direction of forces causing fractures, associated instability of the pelvis. Young and Burgess classification and grading [7-8-9-10-11].

Grade	Lateral compression	Anteroposterior compression	Vertical shear
I	Horizontal pubic rami fractures, compression fracture of ipsilateral anterior sacrum	Vertical pubic rami fractures Symphysis pubis widening	
II	Posterior fracture of the ipsilateral iliac bone and/or sacroiliac joint widening	Symphysis pubis widening >2.5 cm Anterior widening of a sacroiliac joint due to anterior ligament injury	Vertical displacement involving both anterior and posterior arches, vertical pubic rami fractures, and disruption of the sacroiliac joint. **Malgaigne fracture or bucket handle fracture**
III	**Windswept pelvis**, fracture, or sacroiliac joint injury to contralateral hemipelvis	Widening of a posterior sacroiliac joint due to posterior ligament injury; "**open book**"	

Anteroposterior Compression Injury

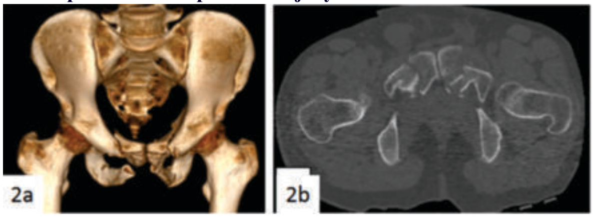

Fig. 2 (a) 3D reconstruction demonstrating comminuted displaced fractures of bilateral superior pubic rami and undisplaced type II sacral fracture on the right side.

Fig. 2 (b). *NECT bone window axial image* showing communited displaced fracture of the pubic bone.

Open book type of pelvic injury with hip dislocation

Fig. 3A. 3D CT reconstruction showing diastasis of the symphysis pubis, dislocation of right hip joint, communited displaced fracture of right acetabulum, fracture of bilateral superior pubic rami and right inferior pubic rami. Also noted is a Type II sacral fracture involving the S1-S3 neural foramina.

Fig. 3B. CT bone window (in coronal oblique MPR) confirms the right hip dislocation with communited fracture of the right acetabulum.

Fig. 3C CT bone window axial image Linear minimally displaced fracture of the inferior part of the right ala of the sacrum.

Vertical Shear Pattern Of Injury

Fig. 4A. 3D CT reconstruction shows a communited displaced fracture of the right acetabulum and iliac bone with protrusio acetabuli. Displaced fracture of left inferior ramus and sacrum on the left side is also seen.

Fig. 4B. NCCT bone reconstruction axial image shows linear displaced fracture of the left half of sacrum (Denis type II) and right iliac blade.

Fig. 4C. NCCT bone window image shows communited displaced fracture of right acetabulum.

Fractures Of Sacrum (figure 4-D)

The undiagnosed and untreated sacral fractures frequently result in neurologic symptoms and neuro deficits to the lower limbs and urinary, rectal, and sexual dysfunctions [39].

Denis Classification of sacrum fracture: In their original description, Denis et al. described three zones of injury [40].

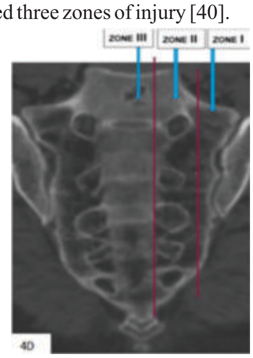

Figure [4D]: CT bone window oblique coronal image demonstrating of types of sacral fracture according to Denis classification.

Soft Tissue Injuries Associated With Pelvic Fractures

1. Injury To Urinary Bladder

Bladder rupture, a relatively rare condition, is most commonly due to abdominal or pelvic trauma [12].

Bladder rupture may occur in the peritoneal space but are more commonly extraperitoneal [13,14]. Blunt traumatic injury of the bladder frequently occurs with deceleration injuries such as occurs in motor vehicle collisions; 83% to 97% of patients with bladder rupture have associated pelvic fractures [15-16]. Conversely, only approximately 10% of patients with pelvic fractures sustain bladder injuries [17,18]. Traumatic bladder ruptures may be either extraperitoneal or intraperitoneal. Extraperitoneal bladder perforation is more common than extraperitoneal bladder perforation.[19]. The mechanism of extraperitoneal bladder rupture was thought to be direct perforation of the urinary bladder by fractured fragments. But, traumatic deformation of the bony pelvis may cause a burst or shearing mechanism that leads to rupture of the bladder (anterolateral aspect).

Depending upon the location of the injury and its relationship with the peritoneal reflection, urinary bladder rupture is divided as:

1. Intraperitoneal bladder rupture occurs when the injury is above the peritoneal reflection (on the bladder dome).
2. Extraperitoneal bladder rupture occurs when the injury is below the peritoneal reflection and not on the dome. Intraperitoneal bladder rupture occurs due to direct blow or steering wheel injury. When to suspect urinary bladder rupture in pelvic trauma? When a patient has gross hematuria, microhematuria, inability to urinate, and blood at the urethral meatus.

Definitive evaluation of bladder rupture involves retrograde cystography, where the bladder is filled with contrast through a Foley catheter, followed by CT. This approach identifies extraperitoneal bladder rupture with a sensitivity of 92.8% and intraperitoneal rupture with a sensitivity of 100%[20].

Bladder rupture can be categorized into five types depending on the location and extent of the rupture [21]:

1) Bladder contusion It involves an incomplete tear of the mucosa.
2) Subserosal bladder rupture or interstitial tear It is a rare entity, caused by a tear on the serosal surface.
3) Intraperitoneal bladder rupture Typically occurs due to a direct blow to the distended/full bladder.
4) Extraperitoneal bladder rupture It is the most common type of bladder injury.
5) Combined bladder rupture Simultaneous intraperitoneal and extraperitoneal injury.

EXTRAPERITONEAL V/s	INTRAPERITONEAL BLADDER RUPTURE
More common.	Less common as compared to extraperitoneal.
Pathophysiology: ➢ Direct perforation of the urinary bladder by fractured fragment. ➢ Burst or shearing mechanism caused by Traumatic deformation of the bony pelvis. ➢ The site of injury is below the peritoneal reflection and not on the dome. ➢ Usually at bladder base anterolaterally	➢ Injury to the already distended bladder. ➢ Direct blow or steering wheel injury. ➢ Injury is above the peritoneal reflection (on the bladder dome).
CT cystography findings: ➢ Extraluminal contrast into perivesical space (simple) ➢ Molar Tooth Sign: Contrast flows out of the ruptured bladder, occupying the preperitoneal cavum Retzii and surrounds the bladder in the shape of a molar tooth[54]. ➢ Extension of extraluminal contrast to the thigh, scrotum, or perineum (complex).	➢ The contrast in paracolic gutters and between loops of small bowel
Treatment: Usually conservative	Requires surgical repair.

Pelvic fracture with "Extraperitoneal" urinary bladder perforation.

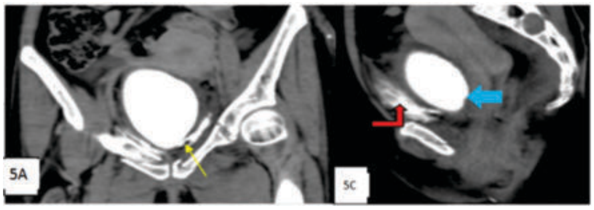

Fig 5: CT Cystography coronal (fig 5A) and sagittal (fig.5B) showing a defect in the left inferolateral wall of the bladder (yellow arrow) with extravasation of contrast into anterior (red arrow) and lateral perivesical space, **suggesting extraperitoneal bladder rupture.** Sky blue arrows mark the urinary bladder.

Intraperitoneal" urinary bladder perforation with no evidence of obvious pelvic fracture.

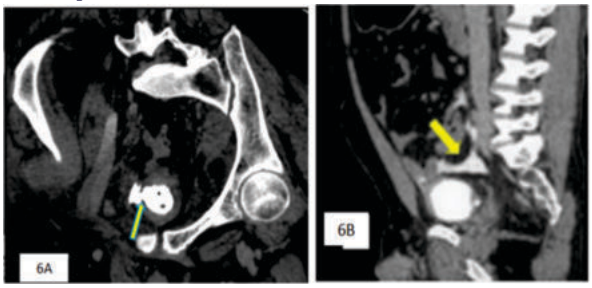

Fig. 6A: Curved MPR CT image in delayed phase showing rent in the right lateral aspect of urinary bladder wall (shown by yelloew arrow) suggestive of bladder rupture.

Fig. 6B. CT cystography sagittal image shows extravasated contrast in the peritoneal cavity, mainly in a rectovesical pouch (yellow arrow) suggesting intraperitoneal urinary bladder perforation.

"Combined (Intraperitoneal + Extraperitoneal) Urinary Bladder Rupture"

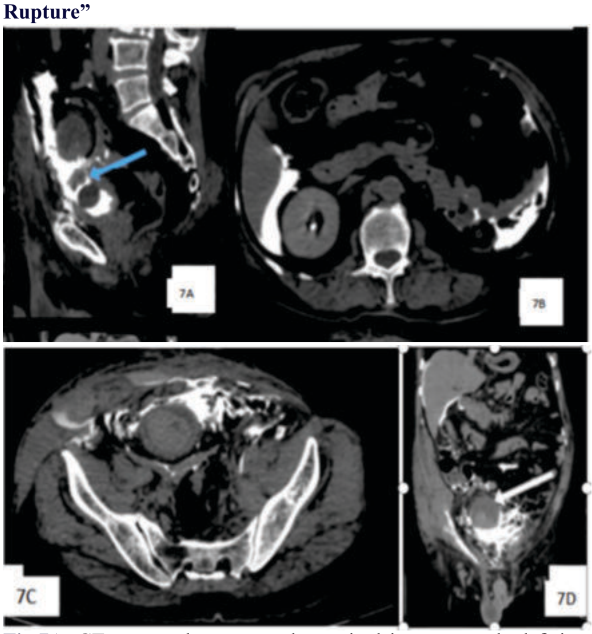

Fig.7A. CT retrograde cystography sagittal image reveals deficient dome of the urinary bladder with intraperitoneal extravasation of contrast into the peritoneal cavity.

Fig. 7B. CT retrograde cystography shows intraperitoneal extravasation of contrast into the peritoneal cavity around the small bowel loops, paracolic gutter, and sub-hepatic region.

Fig. 7C. & Fig. 7D. CT retrograde cystography images showing sentinel clot (White arrow) intraperitoneal extravasation of contrast into the peritoneal cavity around the small bowel loops and in sub-hepatic regions. Extraperitoneal extravasation of contrast seen along the perivesical region, symphysis pubis, anterior abdominal wall in the right lumbar region, and the right inguinal region.

Urethral Injuries

Urethral injury is a common complication of pelvic trauma; it occurs in as many as 24% of adults with pelvic fractures [22].

Imaging plays a pivotal role in the diagnosis of urethral injuries, with retrograde urethrography (RUG) being the standard of reference [23]. Urethral injuries are traditionally diagnosed with retrograde urethrography [24].

CT Signs of Urethral Injuries

- Extravasation of urinary tract contrast material at or below the urogenital diaphragm.
- Elevation of the prostatic apex above the urogenital diaphragm (separation of prostatic tissue from the urogenital diaphragm by a minimum of two sections (2 cm with 10-mm-thick sections).
- Distortion or loss of urogenital diaphragm (UGD) fat plane
- Hematoma of ischiocavernosus
- Distortion or obscuration of prostatic contour
- Distortion or obscuration of bulbocavernosus
- Hematoma of obturator internus

Pelvic fracture with "Urethral injury"

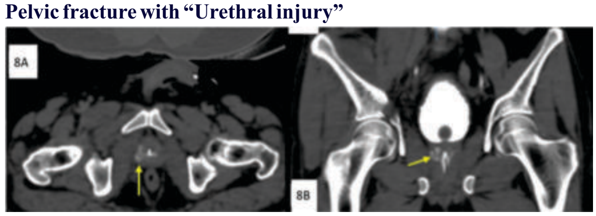

Fig. 8A. NCCT bone window axial image Retrograde administered contrast is extravasated around the prostatic part of the urethra suggesting probable prostatic urethra injury.

Fig. 8B. reveal normally distended urinary bladder with retrograde filled contrast. No obvious leak/rent is seen from the bladder. Retrograde administered contrast is extravasated around the prostatic part of the urethra suggesting probable prostatic urethra injury.

Vascular Injury

CT angiography (CTA) is the preferred modality for diagnosing pelvic arterial injury, having supplanted digital subtraction angiography [25]. The advance of MDCT has allowed the integration of CTA as part of routine trauma imaging with only a single contrast medium bolus [26]. Images should include an arterial phase, a venous phase, and possibly a late phase in certain cases [27,28].

Arterial injuries include active bleeding (blush of contrast can be seen), pseudoaneurysm, thrombosis, stenosis, dissection, and AV fistulas. CT can detect all these pathologies.

Active arterial bleeding is the most common vascular injury. On arterial phase, it shows similar attenuation as that of the aorta. It gets enlarges over time in venous and delayed phases.

An active venous bleed shows extravasation of contrast in the venous phase within the hematoma. This contrast blush is not visible in the arterial phase.

Being a hyperdense structure bone fragments simulate contrast medium extravasation and may mimic vascular injury. However, the bone fragments can be differentiated from an active bleed with the help of multiphasic acquisition and bone window settings. A bone fragment remains stable in size, shape, and attenuation, unlike an arterial or venous active bleed [26].

Early opacification of the vein in the arterial phase is seen in an arterio-venous shunt.

Irregularities in arterial diameter may indicate spasm or traumatic injury (dissection with a non-circulating false lumen)[29]. CT angiography is often able to identify the intimal flap as a curvilinear non-enhancing intimo-medial flap.

Non-opacification of the artery or vein indicates thrombosis.

Pelvic fracture with "vascular injury"- Active blush (probably from a left iliolumbar artery).

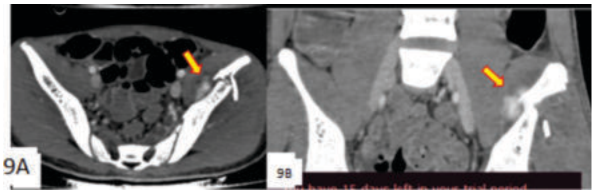

Fig. 9A and 9B. Arterial phase axial (Fig E) and coronal (Fig F) images showing active contrast blush, probably from a left iliolumbar artery (yellow arrow).

Dissection & thrombosis of a right external iliac artery

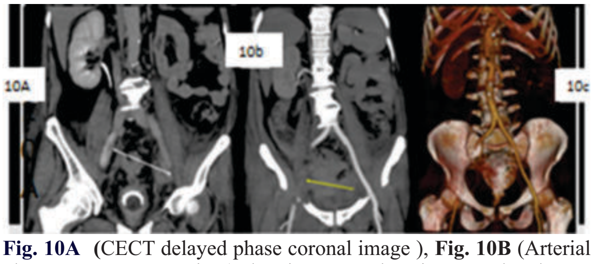

Fig. 10A (CECT delayed phase coronal image), **Fig. 10B** (Arterial phase MIP reconstruction) showing non-enhancing complete lumen filling defect (yellow arrow) in the mid-right external iliac artery extending up to proximal common femoral artery for the approx length of 10cm. On delayed phase focal segment of 4 cm of EIA is hyperdense with suspicious flap (double head white arrow).

Fig. 10C: 3D reconstruction in arterial phase showing cut-off in the right external iliac artery.

Scrotal Trauma

- Scrotal trauma is relatively uncommon and accounts for less than 1% of all cases of trauma annually [30].
- A blunt force to the scrotum may cause testicular contusion, hematoma, or fracture/rupture.
- Ultrasonography is the most frequent modality used to evaluate the injured scrotum. Ultrasound has a high sensitivity for diagnosing testicular injury [31-32].
- Testicular or scrotal hematoma may be encountered in CT scan done in the pelvic trauma patient.

Pelvic fracture (APC injury according to Young and Burgess) with "scrotal hematoma".

Fig. 11A . NECT bone window axial) image showing communited displaced fracture of the pubic bone.

Fig. 11B CECT soft tissue window axial (fig.E) and coronal (Fig.F) images showing high density (Avg. HU +40) fluid free in the scrotum, suggestive of **haemoscrotum**

Morel-lavallée Lesion

Morel-Lavallée lesions occur due to high energy trauma. It is a closed degloving injury that affects the area deep to the subcutaneous plane. The mechanism proposed behind these lesions is, disruption of capillary leading to formation usually which contains hemolymph and necrotic fat [33].

Timely identification with proper management of these lesions is very important because they may be missed or diagnosed lately in polytraumatized patients due to distracting injuries in the polytraumatized patient [97].

One of the complications of it is the high chances of perioperative infections. Because such closed soft tissue injury promotes bacterial growth and colonization. Hence early diagnosis and proper management are essential.

Role of Imaging: All 3 imaging modalities (Ultrasonography, Computed Tomography (CT & Magnetic Resonance Imaging) can be used for diagnosis and characterization Morel-Lavallee lesions. MRI is the preferred modality for evaluation of Morel-Lavallée lesions[33]. However, CT is readily available and has the capability of fast image acquisition. Hence CT is the initial modality of choice, particularly in recent trauma patients[34].

CT scan, reveals fluid-fluid level in the lesion due to sedimentation of blood products. The HU of the lesion is usually less than that of the simple hematomas because of the mixing of lymphatic fluid. The average density ranges from 15-40 Hounsfield units.

Morel-Lavallee lesions in the acute phase are usually ill-defined and show surrounding fat stranding. Subacute and chronic lesions are well defined. The disadvantage of CT is radiation exposure and it is not good for soft tissue characterization. Differential diagnoses for chronic lesions include seromas, bursitis, lymphoceles, and neoplasms.

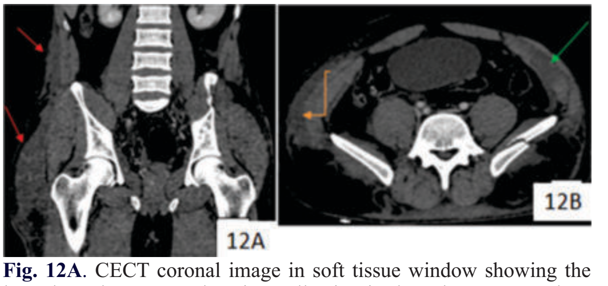

Fig. 12A. CECT coronal image in soft tissue window showing the large hypodense nonenhancing collection in the subcutaneous plane over the right half of the anterior abdominal wall with a similar collection over the anterolateral aspect of the right thigh --- **representing Morel Lavallee lesions** (red arrows).

Fig. 12B. CECT axial image in soft tissue window showing bulky left internal oblique muscle showing large hypodense non-enhancing areas within **- representing muscle edema(green arrow)** nonenhancing collection in the subcutaneous plane over the right half of the anterior abdominal wall (morel Lavallee lesion- orange arrow).

Retroperitoneal & pelvic hematoma (Vertical shear pattern of injury)

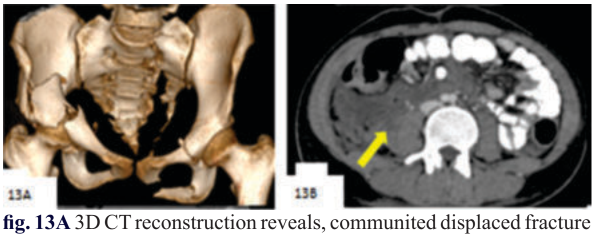

fig. 13A 3D CT reconstruction reveals, communited displaced fracture of the right acetabulum and iliac bone with protrusio acetabuli. Displaced fracture of left inferior ramus and sacrum on the left side is also seen.confirms the fractures which are seen on a radiograph (i.e acetabular, iliac, and left inferior ramus) with a much better demonstration of linear displaced fracture of the left half of sacrum along the left S1 to S4 sacral neural foramina.

Fig 13B CECT axial image shows bulky right Psoas muscle with mild high-density free fluid and fat stranding in suggestive of retroperitoneal hematoma.

Muscle hematoma

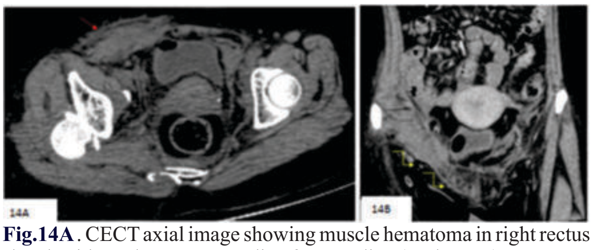

Fig.14A . CECT axial image showing muscle hematoma in right rectus sheath with moderate surrounding fat stranding (Red arrow).

Fig. 14B. CECT coronal image Bulky right external, internal oblique muscles and inguinal canal contents with intermuscular emphysema (yellow arrows).

REFERENCES:

1] Wijffels DJ, Verbeek DO, Ponsen KJ, Goslings JC, van Delden OM. Imaging and Endovascular Treatment of Bleeding Pelvic Fractures. Cardiovascular and interventional radiology. 2019 Jan 1;42(1):10-8.
[2] Jin PH, Goslings JC, Ponsen KJ, van Kuijk C, Hoogerwerf N, Luitse JS. Assessment of a new trauma workflow concept implementing a sliding CT scanner in the trauma room: the effect on workup times. Journal of Trauma and Acute Care Surgery. 2008 May 1;64(5):1320-6.
[3] Potok PS, Hopper KD, Umlauf MJ. Fractures of the acetabulum: imaging, classification, and understanding. Radiographics. 1995 Jan;15(1):7-23.
[4] Scott JW, Magid D, Fishman EK, Riley JL, Brooker JA, Johnson CA. Three-dimensional imaging of acetabular trauma. Journal of orthopaedic trauma. 1987;1(3):227-32.
[5] Guy RL, Butler-Manuel PA, Holder P, Brueton RN. The role of 3D CT in the assessment of acetabular fractures. The British journal of radiology. 1992 May;65(773):384-9
[6] Bucholz RW. The pathological anatomy of Malgaigne fracture-dislocations of the pelvis. The Journal of Bone and Joint Surgery. American Volume. 1981 Mar;63(3):400-404. PMID: 7204439).
[7] Lasanianos NG, Kanakaris NK, Giannoudis PV, editors. Trauma and orthopaedic classifications: a comprehensive overview.
[8] Alton TB, Gee AO. Classifications in brief: young and burgess classification of pelvic ring injuries. Clinical Orthopaedics and Related Research®. 2014 Aug;472(8):2338-42.
[9] Young JW, Burgess AR, Brumback RJ, Poka A. Pelvic fractures: the value of plain radiography in early assessment and management. Radiology. 1986 Aug;160(2):445-51.
[10] Broadwell SR, Ray CE. Transcatheter embolization in pelvic trauma. seminars in interventional radiology 2004 Mar (Vol. 21, No. 01, pp. 23-35). Copyright© 2004 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA.
[11] Dähnert W. Radiology review manual. Lippincott Williams & Wilkins; 2011.
[12] Simon LV, Sajjad H, Lopez RA, Burns B. Bladder rupture.
[13] Elkbuli A, Ehrhardt JD, Hai S, McKenney M, Boneva D. Management of blunt intraperitoneal bladder rupture: Case report and literature review. International journal of surgery case reports. 2019 Jan 1;55:160-3.
[14] Siccardi MA, Bordoni B. Anatomy, Abdomen and Pelvis, Perineal Body.
[15] Carroll PR, McAninch JW. Major bladder trauma: mechanisms of injury and a unified method of diagnosis and repair. The Journal of urology. 1984 Aug 1;132(2):254-7.
[16] Cass AS. The multiply injured patients with bladder trauma. The Journal of trauma. 1984 Aug 1;24(8):731-4.
[17] Hochberg E, Stone NN. Bladder rupture associated with pelvic fracture due to blunt trauma. Urology. 1993 Jun 1;41(6):531-3.
[18] Morey AF, Iverson AJ, Swan A, Harmon WJ, Spore SS, Bhayani S, Brandes SB. Bladder rupture after blunt trauma: guidelines for diagnostic imaging. Journal of Trauma and Acute Care Surgery. 2001 Oct 1;51(4):683-6.
[19] Gomez RG, Ceballos L, Coburn M, Corriere Jr JN, Dixon CM, Lobel B, McAninch J. Consensus statement on bladder injuries. BJU international. 2004 Jul;94(1):27-32.
[20] Chan DP, Abujudeh HH, Cushing Jr GL, Novelline RA. CT cystography with multiplanar reformation for suspected bladder rupture: experience in 234 cases. American Journal of Roentgenology. 2006 Nov;187(5):1296-302.
[21] Radswiki, T., Baba, Y. Urinary bladder rupture. Reference article, Radiopaedia.org. (accessed on 29 Nov 2021).
[22] Koraitim MM. Pelvic fracture urethral injuries: evaluation of various methods of management. The Journal of urology. 1996 Oct 1;156(4):1288-91.
[23] Sandler CM, Harris Jr JH, Corriere Jr JN, Toombs BD. Posterior urethral injuries after pelvic fracture. American Journal of Roentgenology. 1981 Dec 1;137(6):1233-7.
[24] Ali M, Safriel Y, Sclafani SJ, Schulze R. CT signs of urethral injury. Radiographics. 2003 Jul;23(4):951-63.
[25] Anderson SW, Soto JA, Lucey BC, Burke PA, Hirsch EF, Rhea JT. Blunt trauma: feasibility and clinical utility of pelvic CT angiography performed with 64–detector row CT. Radiology. 2008 Feb;246(2):410-9.
[26] Kertesz JL, Anderson SW, Murakami AM, Pieroni S, Rhea JT, Soto JA. Detection of vascular injuries in patients with blunt pelvic trauma by using 64-channel multidetector CT. Radiographics. 2009 Jan;29(1):151-64.
[27] Esposito AA, Zilocchi M, Fasani P, Giannitto C, Maccagnoni S, Maniglio M, Campoleoni M, Brambilla R, Casiraghi E, Biondetti PR. The value of precontrast thoraco-abdominopelvic CT in polytrauma patients. European journal of radiology. 2015 Jun 1;84(6):1212-8.
[28] Uyeda J, Anderson SW, Kertesz J, Soto JA. Pelvic CT angiography: application to blunt trauma using 64MDCT. Emergency radiology. 2010 Mar;17(2):131-7.
[29] Harris JH. Pelvis, acetabulum, and hips. The radiology of emergency medicine. 4th ed. Philadelphia, Pa: Lippincott Williams & Wilkins. 2000:725-814.
[30] Deurdulian C, Mittelstaedt CA, Chong WK, Fielding JR. The US of acute scrotal trauma: optimal technique, imaging findings, and management. Radiographics. 2007 Mar;27(2):357-69.
[31] Bhatt S, Dogra VS. Role of US in testicular and scrotal trauma. Radiographics. 2008 Oct;28(6):1617-29.
[32] Guichard G, El Ammari J, Del Coro C, Cellarier D, Loock PY, Chabannes E, Bernardini S, Bittard H, Kleinclauss F. Accuracy of ultrasonography in the diagnosis of testicular rupture after blunt scrotal trauma. Urology. 2008 Jan 1;71(1):52-6.
[33] Nair AV, Nazar PK, Sekhar R, Ramachandran PV, Moorthy S. Morel-Lavallée lesion: a closed degloving injury that requires real attention. The Indian journal of radiology & imaging. 2014 Jul;24(3):288.
[34] McKenzie GA, Niederhauser BD, Collins MS, Howe BM. CT characteristics of Morel-Lavallée lesions: an under-recognized but significant finding in acute trauma imaging. Skeletal radiology. 2016 Aug;45(8):1053-60.