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PICTORIAL REVIEW

Musculoskeletal pitfalls and pseudotumours in the pelvis: a pictorial review for body imagers

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ABSTRACT

Many musculoskeletal abnormalities in the pelvis are first seen by body imagers while reviewing pelvic cross-sectional studies, and some of these abnormalities may mimic malignancy or another aggressive process. This article describes nine musculoskeletal pseudotumours and interpretative pitfalls that may be seen on CT, MRI and ultrasound imaging of the pelvis. Awareness of these pitfalls and pseudotumours may help avoid misdiagnosis and prevent inappropriate intervention or management.

Musculoskeletal abnormalities in the pelvis are often first seen by body imagers. Some of these abnormalities may mimic malignancy or aggressive processes, leading to inappropriate referral and/or intervention. Awareness of these pitfalls may help body imagers avoid misinterpretation and facilitate better patient care. This pictorial essay describes the radiological findings in nine potentially confusing pelvic musculoskeletal processes that body imagers may encounter.

PELVIC INSUFFICIENCY FRACTURE

Insufficiency fractures are often seen in a pelvis weakened by osteoporosis or pelvic radiation, typically occurring in the sacral ala, pubic rami or acetabula. Many patients have two or more concomitant fractures, frequently bilateral and symmetric.^{1,2} On CT, insufficiency fractures typically manifest as medullary sclerosis owing to trabecular compression and bone turnover, with or without visible cortical disruption (Figure 1b). In the sacrum, this sclerosis is usually linear and parallels the sacroiliac joint. Sclerosis may be mistaken for an osteoblastic metastasis or other sclerotic bone tumour, but an insufficiency fracture generally lacks the circumscribed, mass-like appearance of a tumour. MRI is more sensitive than CT for diagnosing an insufficiency fracture³ and characteristically shows an ill-defined region of bone marrow oedema and corresponding enhancement, sometimes with a hypointense fracture line (Figure 1a). Soft-tissue oedema may be seen around pubic and acetabular fractures and less frequently around sacral

fractures.¹ The bone marrow changes on MRI can sometimes appear lobular and geographic, mimicking an aggressive tumour; in indeterminate cases, CT correlation for a cortical fracture and the characteristic band-like sclerosis may be helpful.⁴ In the case of bilateral sacral ala insufficiency fractures, the two fractures may communicate via a transverse fracture component, producing a pathognomonic H-shaped appearance termed the “Honda sign”, which can be visible on CT, MRI or bone scintigraphy. Insufficiency fractures should show no cortical destruction, the presence of which suggests malignancy.⁵

BONE HARVEST SITE

Cancellous bone is commonly harvested from the iliac crest in patients undergoing spinal surgery or autologous bone marrow transplantation. The harvest site can be mistaken for a tumour on CT and MRI. In the early post-operative period, the harvest site may be somewhat ill-defined as the bone undergoes healing, but with time, the site will become peripherally corticated and well circumscribed (Figure 2a). The site usually fills with fibrovascular tissue, but occasionally, a surgeon may choose to backfill the harvest site in order to minimize future complications; this can result in a well-defined sclerotic focus in the bone, which can be misinterpreted as osteoblastic malignancy⁶ (Figure 2b). However, the area of sclerosis should remain well defined, and an overlying scar is sometimes visible. At no point should a suspected bone graft harvest site show frank or progressive osseous destruction, aggressive periosteal reaction

Figure 1. Bilateral sacral insufficiency fractures in a 65-year-old female with metastatic breast cancer, status post chemotherapy. Initial MRI was performed for back pain. (a) Axial short tau inversion recovery image shows geographic, somewhat band-like region of hyperintensity in the left sacral ala and to a lesser extent right sacral ala (arrows), with subtle linear hypointensity in the anterior left sacral ala compatible with fracture. (b) Follow-up axial CT image at 10 months reveals linear sclerosis and anterior cortical offset (arrows) bilaterally.

or a solid soft-tissue component, findings that are more suggestive of malignancy (Figure 2c).

PERINEURAL (TARLOV) CYST

Perineural cysts are cerebrospinal fluid (CSF)-filled cysts that arise within the arachnoid covering at the junction of the dorsal root ganglion and the nerve root. They are usually asymptomatic, incidental findings, located in the S1–S4 region. These cysts are most commonly confined to the sacral canal and/or neural foramina but may lie in the presacral soft tissues. In such cases, they can be misdiagnosed as gynaecological masses, hydrosalpinges or adnexal cysts.⁷ Perineural cysts are usually well-defined, smoothly rounded or lobular and avascular. On pelvic ultrasound, a Tarlov cyst may be differentiated from a gynaecological mass if it is located in front of the sacrum, separate from the ovary and

immobile on respiration (Figure 3a).⁷ On CT or MRI, the cyst is usually of CSF attenuation or signal intensity but may be slightly heterogeneous owing to internal proteinaceous debris⁸ (Figure 3b). The traversing nerve root is sometimes visible. Larger cysts may cause smooth cortical remodelling of the adjacent bone. Cysts should demonstrate no internal enhancement on post-contrast imaging; nodular enhancement suggests a neoplasm rather than a Tarlov cyst.

ILIOPSOAS BURSA

The iliopsoas bursa is normally a collapsed synovial sac located between the iliopsoas tendon and the anterior aspect of the hip joint and measures approximately 3–7 cm.⁹ Processes such as biomechanical change, iliopsoas tendinitis and autoimmune disease may result in an enlarged and painful bursa, which may be misdiagnosed as a cystic mass or even a femoral artery aneurysm or pseudoaneurysm.^{9,10} Imaging usually shows a fluid-filled mass adjacent or deep to the iliopsoas tendon or muscle (Figure 4a,b). On ultrasound, the bursa is usually homogeneously hypoechoic and thin walled (<2 mm), and on CT and MRI, displays as homogeneous fluid attenuation and intensity; however, it may show some mild heterogeneity owing to internal debris and septations.¹¹ On post-contrast imaging, the bursa will show thin, peripheral synovial enhancement, but if actively inflamed, the wall may be somewhat thickened;¹¹ however, no internal nodular enhancement should be seen, a finding that is more suggestive of neoplasm. Communication with the underlying hip joint can be seen in approximately 50% of cases on ultrasound or CT but is more easily demonstrated on MRI¹¹ (Figure 4a). Rarely, gas bubbles may be seen within the bursa, even without underlying infection, possibly owing to vacuum phenomenon and “gas-pumping” transmission from the joint space (Figure 5);^{12,13} such a finding must be interpreted in the context of the patient’s clinical condition rather than reflexively diagnosed as an abscess.¹⁴

MUSCLE TRANSPOSITION

Surgical muscle transposition may be utilized to provide soft-tissue coverage during reconstructive procedures for malignancies, tissue debridement, vascular graft repair or lymphadenectomy. In the pelvis, muscle flaps are commonly harvested from the sartorius or rectus abdominus muscle, and the transposed tissue may be mistaken for a tumour on subsequent imaging. On CT, the transposed muscle should appear isoattenuating to muscle, or hypoattenuating owing to fatty atrophy of the transposed muscle tissue, and lie anterior to the femoral vessels (Figure 6).¹⁵ On MRI, the signal intensity of the flap evolves with time. Non-contrast T_1 weighted imaging shows variable muscle- and fat-intensity signals depending upon the degree of fatty atrophy. T_2 weighted and post-contrast T_1 weighted sequences show variable T_2 hyperintensity and enhancement relative to normal muscle, which can be exacerbated by superimposed changes from radiation therapy.¹⁶ Visualization of parallel fibres within the flap helps characterize the tissue as musculature. Regardless of the imaging modality used, the critical radiologic step to prevent misdiagnosis is comparison of the right and left musculature; the unilateral absence of muscle tissue on the affected side should ensure accurate diagnosis.

Figure 2. Axial CT images of bone graft donor sites in two patients and a malignancy mimicking a donor site in a third patient. (a) A typical left iliac bone graft donor site appears as a well-circumscribed, homogeneous lucency in the posterior left iliac bone with cortical disruption posteriorly (arrow). (b) Surgical backfill of a right iliac bone graft donor site shows a well-defined focus of sclerosis in the expected location of a donor site (arrow), without adjacent osseous destruction. (c) An irregular lytic lesion in the left posterior iliac bone (arrows) in a patient with prostate carcinoma shows irregular margins and a soft-tissue component, compatible with a lytic metastasis; irregular sclerosis in the right iliac bone and sacrum (arrowheads) is compatible with sclerotic metastatic disease.

Figure 3. Incidental perineural (Tarlov) cyst found on ultrasound and MRI of a 44-year-old patient with intrauterine device pain. (a) Longitudinal ultrasound image of the pelvis shows a lobulated, hypoechoic mass (arrows) in the cul-de-sac, posterior to the uterus (UT) and cervix (CVX). (b) Coronal T_2 weighted image shows the mass (arrow) to be of homogeneous fluid-intensity and tracking along one of the sacral nerve roots, compatible with a perineural cyst.

HETEROTOPIC OSSIFICATION/ MYOSITIS OSSIFICANS

Heterotopic ossification is a non-neoplastic mass of proliferating spindle cells that eventually mature into bone and cartilage. When occurring within the muscle, this process is commonly referred to as “myositis ossificans”. Frequent causes around the pelvic region include trauma and paralysis, but it can also result from spontaneous haematoma related to anticoagulation.

Heterotopic ossification often shows a heterogeneous and often disconcerting MRI appearance in its early stages that can be misdiagnosed as neoplasm or infection; such an appearance includes T_2 hyperintensity and enhancement with surrounding oedema and mass effect on MRI. Over the next 6–8 weeks, a characteristic hypointense, calcified rim may form, subsequently evolving into a peripheral osseous cortex with central medullary fat (Figures 7 and 8).^{17,18} As the mass matures, its T_2 hyperintensity will decrease, although enhancement may persist.¹⁹ Additionally, in cases of paralysis, the process is often bilateral and localized around the hips.²⁰ The ossified rim may be subtle on MRI but is well demonstrated on CT and often on radiographs (Figures 7c and 8a). Of note, the ossification in heterotopic ossification is the densest peripherally, whereas tumours are more heavily ossified or calcified in their central portions.

Biopsy of suspected heterotopic ossification should be avoided, as the central portion of the lesion typically shows atypical mitoses and pleomorphism that may be misdiagnosed as osteosarcoma.²¹ One key to diagnosis of heterotopic ossification is the knowledge of any of the predisposing patient factors such as trauma, paralysis, surgery or anticoagulation. Correlation with radiographs or CT may help demonstrate the characteristic peripheral ossification pattern. If heterotopic ossification is suspected, follow-up imaging in 1–2 months can be performed to assess for change, particularly if the lesion occurs at the site of prior trauma or at a common site of avulsion injuries.

Extraskelatal osteosarcoma is the most common radiation-associated soft-tissue sarcoma²² and, owing to its ossification,

Figure 4. Iliopsoas bursal fluid in two different patients. (a) Axial contrast-enhanced CT image of the pelvis shows a non-enhancing, fluid-attenuation mass (arrow) interposed between the right common femoral neurovascular bundle and iliopsoas muscle. (b) Coronal fat-suppressed T_2 weighted MR image of the right hip in another patient demonstrates an elongated, fluid-intensity mass tracking along the course of the iliopsoas muscle (arrow) and communication with the hip joint. The mild heterogeneity along the walls of the bursa likely represents synovitis.

(a)

(b)

can be mistaken for heterotopic ossification on imaging. Close interval follow-up imaging of a mass developing in a previously irradiated region is needed to avoid this pitfall.

Recombinant human bone morphogenetic protein-2 is a more recently described cause of heterotopic ossification. The use of this autologous bone graft substitute has been linked to complications including exuberant heterotopic bone formation that can extend a significant distance from the implantation site, including retroperitoneal structures such as the psoas and iliacus muscles and the iliac crest^{23,24} (Figure 9).

Figure 5. Gas-containing sterile iliopsoas bursal fluid in an asymptomatic 59-year-old female with metastatic uveal melanoma. Axial CT image of the right hemipelvis shows gas-containing fluid (arrow) deep to the iliopsoas muscle, extending anterior to the hip joint on more caudal images. Findings were considered suspicious for bursitis and infection. Subsequent CT-guided biopsy showed no evidence of infection or tumour. The gas most likely originates from vacuum phenomenon within the hip joint, with which the bursa communicates.

AVULSION INJURIES

Myotendinous avulsion injuries can mimic soft-tissue or osseous neoplasms. They occur most commonly in skeletally immature patients owing to forceful muscular contraction at the relatively weak apophyseal growth plate but may also occur in adults owing to repetitive stress. Common sites include the ischial tuberosity, anterior superior and anterior inferior iliac spines, pubic body and the greater trochanter.²⁵ The presence of tendon

Figure 6. Axial CT images of sartorial muscle transposition. A soft-tissue mass extends along the anteromedial aspect of the left common femoral vessels (arrow). Adjacent surgical clips support the diagnosis of surgical flap. Note the normal sartorius muscle on the right (arrowhead).

Figure 7. Heterotopic ossification (myositis ossificans) in a 44-year-old female after resection of atypical lipomatous tumour 4 months earlier. (a–b) Axial T_1 weighted (a) and post-contrast fat-suppressed T_1 weighted (b) images of the left thigh show an area of irregular T_1 hypointensity and enhancement in the resection bed (arrows). Mild enhancement is noted in the bone marrow. The corresponding T_2 hyperintensity was visible on other sequences. (c) Subsequent axial CT image performed 1 week later, prior to a planned biopsy, shows the lesion (arrow) contains ossification that is densest peripherally, compatible with heterotopic ossification.

laxity can be a helpful sign of an avulsion. An avulsion may be misdiagnosed as malignancy or infection when a soft-tissue avulsion is present without an osseous fragment. Acutely, it will demonstrate surrounding soft-tissue oedema and haemorrhage. MRI will often show feathery oedema and enhancement tracking into the affected myotendinous unit and bone marrow oedema and enhancement subjacent to the donor site. Subacutely, heterotopic ossification, haematoma, T_2 hyperintense and enhancing scar tissue and periosteal reaction may be seen; these findings should decrease over time. Chronically, one may see deformity and/or enlargement of the osseous donor site related to osseous healing.²⁵

Keys to correct diagnosis include the location of the abnormality and the clinical history. If the lesion lies next to a tendon origin or insertion and trauma has occurred, the possibility of a benign avulsion injury should be considered before pursuing further work up. In the absence of an osseous avulsion fragment, the presence of tendon laxity is a helpful secondary sign. However, the presence of an avulsion fracture without substantial trauma (particularly in an adult) should raise concern for underlying neoplasm;²⁵ in such cases, close inspection of the subjacent bone for signs of trabecular or cortical destruction and review of the clinical record for a history of malignancy are recommended.

CALCIFIC TENDINITIS

Calcific tendinitis may affect tendons in numerous regions of the body, most commonly those of the shoulder or hip. Occasionally, such tendinitis may produce an inflammatory enthesitis that results in cortical erosions and subjacent bone marrow oedema pattern,^{26,27} which, on imaging, may be mistaken for metastatic disease, a primary bone tumour or infection.

Tendon calcifications may not be apparent on radiographs owing to overlapping structures. On CT, the correct interpretation requires both detection of calcification in the tendon overlying the cortical erosion as well as awareness that the calcification could be the cause of the erosion (Figure 10). The erosion may be poorly defined and irregular in shape or may have a thin sclerotic margin. The diagnosis can be more challenging on MRI, given that small calcifications are often unapparent; a bone marrow oedema pattern is seen near the erosion in about one-third of cases with osseous involvement²⁶ and may be extensive. Awareness that calcific tendinitis can cause subjacent osseous changes is key to considering this diagnosis, which can be confirmed with CT.

RED MARROW CONVERSION

Adult bone marrow may undergo a process of conversion from mature fatty marrow to cellular haematopoietic marrow. This may occur in response to anaemia, cytotoxic therapy, irradiation, haemorrhage or bone marrow stimulants used with oncological treatments (e.g. granulocyte-colony stimulating factor, erythropoietin or interleukin-3).²⁸

On MRI, these marrow changes may be misinterpreted as metastatic disease or multiple myeloma. In assessing marrow signal, muscle signal intensity serves as a reference point on all sequences. Red marrow is most commonly isointense to muscle on T_1 and T_2 weighted sequences (Figure 11a,b).²⁹ On post-contrast T_1 weighted sequences, it is usually isointense to muscle but can show variability among healthy individuals.³⁰ It generally demonstrates a “feathery” morphology that is poorly defined and interdigitated with fatty marrow and is usually bilateral and symmetric in distribution.³¹ By contrast, metastases

Figure 8. Heterotopic ossification (myositis ossificans) in a different patient. (a) Axial CT image shows a peripherally calcified mass (M) (arrows) lateral to the left acetabulum (A), suggestive of heterotopic ossification. (b) Axial fat-suppressed proton density image reveals oedema (arrows) around the mass. Note that the adjacent acetabulum is normal in appearance.

(a)

(b)

and multiple myeloma are usually asymmetric, well defined, T_1 hypointense and, unless sclerotic, more prominently T_2 hyperintense and enhancing than the muscle. The pattern of

Figure 9. Heterotopic ossification related to recombinant human bone morphogenic protein-2 in a patient who previously underwent spinal fusion surgery. Non-contrast axial CT image reveals an ossified mass tracking from the lumbar spine along the anterior aspect of the left psoas muscle (arrow).

involvement is useful in diagnosing red marrow conversion; it typically occurs in the axial skeleton first, followed by metaphyses, then diaphyses and finally epiphyses and apophyses. Thus, on adult pelvic MRI, red marrow is usually apparent in the pelvic bones and lower lumbar spine, with lesser involvement of the proximal femora; unless the conversion is severe, the femoral heads and the greater and lesser trochanters usually maintain normal fatty marrow signal.²⁹ In equivocal cases, in- and out-of-phase MRI may help differentiate red marrow from malignancy, as red marrow will demonstrate a drop in signal in out-of-phase imaging owing to the presence of microscopic fat, whereas neoplasm will not.^{31,32} Adult red marrow may revert to normal fatty marrow once the underlying cause for conversion is removed (Figure 11c).

CONCLUSION

Many benign musculoskeletal abnormalities in the pelvis may mimic malignancy or other aggressive processes, leading to erroneous diagnosis and inappropriate intervention. Awareness of these pitfalls may help avoid misdiagnosis and prevent inappropriate interventions or management.

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Figure 10. Calcific tendinitis in a 76-year-old male with prostate and lung cancers and a sclerotic lesion in the right greater trochanter on CT. (a) The axial CT image shows a round sclerotic lesion (arrow) in the medullary cavity of the right femoral greater trochanter. CT-guided biopsy was performed owing to suspicion of bone metastasis; during the procedure, the lesion was found to be quite soft, unlike a typical sclerotic bone lesion. Pathological examination revealed dystrophic calcification but no tumour. A review of a CT image obtained 15 months earlier at a slightly different level (b) shows that the sclerotic lesion in (a) actually represented calcific tendinitis (arrow) that had eroded into the bone in the interval, simulating a blastic bone metastasis.

(a)

(b)

Figure 11. Red marrow conversion in a 58-year-old male with pleomorphic sarcoma who underwent pre-operative chemotherapy and radiation therapy. Coronal (a) T_1 weighted image demonstrates patchy hypointense marrow signal abnormalities isointense to the muscle. Coronal short tau inversion recovery (b) image shows corresponding signal abnormalities, slightly hyperintense relative to the muscle. The signal abnormalities in the femur are confined to the diaphyses and metaphyses, sparing the epiphyses and apophyses, characteristic of red marrow conversion. (c) Coronal T_1 weighted sequence obtained 5 months later reveals reversal of the red marrow conversion, with a return of normal fatty marrow.