The Pelvic X-ray: A Relatively Forgotten But Important Diagnostic Tool

Poster No.: P-0151
Congress: ESSR 2013
Type: Scientific Exhibit
Authors: I. Pressney, E. Sellon, J. L. Bush; Brighton/UK
Keywords: Musculoskeletal bone, Anatomy, Musculoskeletal joint, Plain radiographic studies, Education, Education and training, Trauma
DOI: 10.1594/essr2013/P-0151

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method ist strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.essr.org
Purpose

Orthopaedic evaluation of hip pain in the young adult population is evolving rapidly in part secondary to increasing awareness of structural hip disorders. Early diagnosis to allow for refined surgical techniques for hip disorders, such as femoroacetabular impingement, requires increased ability to identify patients along a spectrum of diseases. However, obtaining an accurate diagnosis remains challenging especially in the setting of mild structural abnormalities. Many different radiographic measurements have been described as indicators of structural disease and some of these will be outlined in the poster.

The pelvic x-ray also forms an integral part in trauma imaging in the Emergency room and as part of ATLS assessment. With the increasing reliance on Computer Tomography the ability to assess plain radiographs is less important. Indeed, a retrospective study suggests that in haemodynamically stable patients with a clinically stable pelvis, its sensitivity is only 67% and it may safely be omitted in favour of a pelvic CT examination if such is available and being planned in adjunct assessment (1).

Plain radiographic assessment therefore serves as a foundation for accurate diagnosis, disease classification, and surgical decision-making both in the acute and out-patient setting.

Methods and Materials

Radiograph Technique

The anteroposterior pelvic radiograph should be made with the patient supine on the x-ray table with both lower extremities orientated in 15° of internal rotation in order to maximise the length of the femoral neck. The x-ray tube to film distance should be 120cm, with the tube orientated perpendicular to the table. The crosshairs of the beam should be centred on the point midway between the superior border of the pubic symphysis and a line drawn connecting the anterior superior iliac spines.

Results

Radiograph Evaluation
Adequacy:

Include the anatomy from the top of both iliac crests superiorly through the ischial tuberosities including both lesser trochanters of the femurs, whilst laterally both anterior portions of the iliac wings should be included.

Projection:

1. Internal rotation of the femurs should be avoided particularly in trauma imaging.
2. Obturator foremen symmetrical.
3. Pelvic tilt - the vertical distance between the upper border of the pubic symphysis and the middle of the sacroccygeal joint turned out to be the most accurate tilt indicator (2). The vertical distance should be between 1-3cm.

Exposure:

The radiographic exposure technique should demonstrate good bone detail. Soft tissue shadows should include the urinary bladder, pelvic portion of the iliopsoas muscle, rectum, and bowel gas.
Fig. 1: Multisplanar reconstruction of CT pelvis to show bony detail obtained in an anteroposterior pelvis. Annotation corresponds with text in results section. 1=IPL line; 2=IIL line; 3=’tear drop’; 5=one of sacral ala (right); 6=shenton’s line; 7=dome of femoral head; 8=pubic symphysis and right sacroiliac joint; \([E/(A+E)]\)=femoral head extrusion index- A=acetabulum, E=extrusion; LCE=lateral centre angle; AI=acetabular index.

References: Clinical Radiology, Brighton and Sussex University Hospital - Brighton/UK

Radiographic Evaluation

In the trauma setting, whilst not only following the contours of the bony anatomy assessing for fractures, there are many lines representing osseous structures that one should evaluate when looking at an AP radiograph of the pelvis to help identify, orientate and classify acute abnormalities which can give information as to the mechanism of injury (3). These are highlighted below:

1. The iliopectineal (IPL) line to evaluate the anterior column.

2. The ilioschial (IIL) line to evaluate the posterior column.
On an AP radiograph, the anterior and posterior columns of the pelvis are represented by the IPL and IIL lines, respectively. Checking that these lines are uninterrupted should ensure that there is not an occult fracture of the pelvis.

See Fig. 2 on page 9

3. The 'tear drop' to evaluate the anteroinferior portion of the acetabular fossa.

The teardrop is a radiographic than an anatomical structure representing the summation of shadows of the medial acetabular wall. Side-to-side comparison of the teardrop width to the femoral head centre which may denote the presence of a hip effusion. The other concept of teardrop width is a true increase in mediolateral size of the teardrop itself. An increase in width of the teardrop implies that, during the period of growth prior to skeletal maturation, the femoral head was displaced laterally and not completely contained within the acetabulum. This displacement could develop either due to a hip dysplasia with its usual lateral displacement or due to a chronic hip effusion, causing unopposed growth of the medial acetabulum with consequent overgrowth.

4. The anterior wall (AW) and posterior wall (PW) of the acetabulum.

Checking that these lines are uninterrupted should ensure that there is not an occult fracture of the acetabulum. Transient (reduced) hip dislocations with accompanying wall fractures may be detected as an interruption in one of these acetabular wall lines (usually posterior).

See Fig. 3 on page 10 and Fig. 4 on page 10

5. Sacral ala.

The sacral ala and its neural foramina can be difficult to evaluate due to overlying bowel gas and contents but subtle injuries here can be satisfying to identify on the AP radiograph.

See Fig. 5 on page 11

6. Shenton's line to evaluate femoral neck and superior pubic ramus.
Shenton's line is an imaginary line drawn along the arc of the inferior border of the superior pubic ramus (superior border of the obturator foramen) and along the inferomedial border of the neck of femur. This line should be continuous and smooth. Interruption of Shenton's line could indicate fractured neck of femur or superior pubic ramus or developmental dysplasia of the hip.

See Fig. 6 on page 12

7. Dome of femoral head.

Head sphericity on gross visual inspection may be sufficient to make this determination, a Mose template (concentric circles) can also be used as a reference. Head sphericity should be assessed on both the anteroposterior and lateral radiographs.

Loss of the outline of the femoral head could suggest femoral head impaction fracture or possibly fragmentation and collapse in established avascular necrosis. Earlier diagnosis and treatment to try and negate the established changes should also be assessed. The earliest radiographic finding of avascular necrosis is relative sclerosis related to resorption of surrounding vascularised bone.

See Fig. 7 on page 13 and Fig. 8 on page 14

8. Pubic symphysis and sacroiliac joints.

The sacroiliac joints are seen at an angle on the AP radiograph, resulting in display of both anterior and posterior joint spaces. Assessing the integrity of these joints and the spatial relationship of the bones of the pelvic ring is of importance in regard of classifications based on force vectors and hence the corrective forces needed for external stabilisation.

See Fig. 9 on page 15


Ensure that you also distinctly see the posterior iliac wing, which is located posterior to the sacral ala, and sacrum. Absence of these structures may indicate a destructive process, which could easily be overlooked.

See Fig. 10 on page 16 and Fig. 11 on page 17
In the out patient setting careful assessment of the features outlined below should be evaluated that may give a clue as to the cause of adult hip pain. Acute injuries highlighted above should, as always, be quickly ruled out as the cause in the first instance.

A. Acetabular Depth

The relationship of the floor of the fossa acetabuli and the femoral head should be evaluated relative to the ilioischial line. Hips are classified as coxa profunda if the floor of the fossa acetabuli touches or is medial to the ilioischial line, and as protrusio acetabuli if the medial aspect of the femoral head is medial to the ilioischial line (4). The generally accepted measurements for medial projection are 3 mm in men and 6 mm in women to qualify for protrusio (5).

See Fig. 12 on page 18 and Table 1 on page 18

B. Acetabular Version

Acetabula can be labeled as retroverted or anteverted on the basis of the presence or absence of a crossover or figure-of-eight sign. An acetabulum is considered to be anteverted if the line of the anterior aspect of the wall does not cross the line of the posterior aspect of the wall. False assessment of version can be made on a rotated or tilted radiograph (see radiographic evaluation above). Prominent extension of the ischial spine into the pelvis is an additional finding that is associated with acetabular retroversion. It should be noted that true acetabular retroversion is associated with a deficient posterior wall while anterior overcoverage refers to the hip with a crossover sign but no posterior wall deficiency.

See Fig. 13 on page 19

C. Acetabular Inclination

Acetabula having a Tönnis angle of 0° to 10° are considered normal, whereas those having an angle of over 10 degrees or less than 0 degrees are considered to have increased and decreased inclination. Acetabula with increased Tönnis angles are subject to structural instability, whereas those with decreased Tönnis angles are at risk for pincer type femoroacetabular impingement. Other quantitative indicators of structural instability include the anterior and lateral centre-edge (LCE) angles (see Figure 1), both useful measures of acetabular coverage of the femoral head. The LCE, or centre-edge angle
of Wiberg, can be used to assess the superolateral coverage of the femoral head by the acetabulum (6).

See Fig. 14 on page 19

D. Femoral Head/Neck Junction

Femoral head/neck offset is more accurately assessed on lateral and axial radiographs and magnetic resonance imaging by measuring the alpha angle and the head-neck offset ratio. But typical pistol-grip deformity as the femoral cause (Cam) type femoroacetabular impingement can be accurately reported on AP radiographs- representing the decreased femoral head/neck offset. Fibrocystic change in the epiphyseal vicinity may develop secondary to the impingement process and is seen as a small area of cystic radiolucency surrounded by a thinner sclerotic margin (7).

See Fig. 15 on page 20

Images for this section:
**Fig. 1:** Multiplanar reconstruction of CT pelvis to show bony detail obtained in an anteroposterior pelvis. Annotation corresponds with text in results section. 1=IPL line; 2=IIL line; 3='tear drop'; 5=one of sacral ala (right); 6=shenton's line; 7=dome of femoral head; 8=pubic symphysis and right sacroiliac joint; \( \frac{E}{(A+E)} \)=femoral head extrusion index- \( A= \) acetabulum, \( E= \) extrusion; \( LCE= \) lateral centre angle; \( AI= \) acetabular index.
**Fig. 2:** Disruption of IPL and IIL consistent with bicolumnar injury with central dislocation at the left acetabulum.

**Fig. 3:** Sequentially rotated multiplanar reformats of right hip to highlight anterior and posterior walls of the acetabulum.
Fig. 4: Right acetabular posterior wall fracture as a result of transient hip dislocation.
**Fig. 5:** Subtle disruption of the left sacral ala line consistent with sacral fracture. Note right acetabular anterior column and pubic symphysis injuries also.
Fig. 6: Disruption of Shenton's line in subcapital neck of femur fracture.
Fig. 7: Grade 3 avascular necrosis of right femoral head- subchondral sclerosis, fragmentation and collapse of femoral head.
Fig. 8: Subtle patchy textural change in right femoral head without collapse. Sequential MRI studies revealed transient osteoporosis of femoral head.
Fig. 9: Bilateral sacroiliac joint diastasis with vertical right superior and inferior pubic rami fractures- vertical shear 'open book' injury.
Fig. 10: Lucent lesion in right acetabular roof is relatively inconspicuous.
**Fig. 11:** Corresponding coronal STIR sequence. Acetabular plasmacytoma with surrounding bone marrow oedema is more conspicuous.

**Fig. 12:** Right AP hip projections of normal, coxa profunda and protrusion acetabuli highlighting different acetabular depths. IIL=ilioischial line; AF=acetabular fossa; FH=femoral head; E=extrusion.
### Table 1

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Coxa Profunda</th>
<th>Protrusio Acetabuli</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femoral head extrusion index [E/(A+E)]</td>
<td>25%</td>
<td>&lt;25%</td>
<td>Zero or negative</td>
</tr>
<tr>
<td>Lateral Centre Angle</td>
<td>25-39 degrees</td>
<td>&gt;40</td>
<td>&gt;40</td>
</tr>
<tr>
<td>Acetabular Index</td>
<td>+ve</td>
<td>Neutral</td>
<td>-ve</td>
</tr>
</tbody>
</table>

**Fig. 13:** Bilateral crossover sign- a sign of acetabular retroversion.
Fig. 14: Pincer impingement. Posterior wall sign positive as posterior wall lies medial to centre of femoral head (arrow). Excessive acetabular coverage (red dots). Tönnis angle = zero, measured by the angle between a line connecting left and right acetabular tear drops and a line connecting inferior and lateral aspects of acetabular sourcil.
**Fig. 15:** Bilateral 'pistol grip' deformities of femoral head/neck junction—a sign of Cam type femoroacetabular impingement. Minor fibrocystic change at the femoral head/neck junction demonstrated.
Conclusion

AP pelvis radiographic assessment therefore serves as a foundation for accurate diagnosis, disease classification, and surgical decision-making both in the acute and outpatient setting.

Overall, radiographic femoroacetabular impingement findings are quite common in a population of healthy young adults, especially in males. These features should be interpreted carefully and related closely to the clinical findings.

References


Personal Information