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MAIN OUTCOMES

Errors in interpretation

- Discuss interpretation and diagnostic errors
- Intuitive thought processes
- Identify types of errors
- Understand radiologic errors

Interpretation Improvement

- Strategies for error reduction
- Cognitive processes
- Checklist approach
- Structured Reporting

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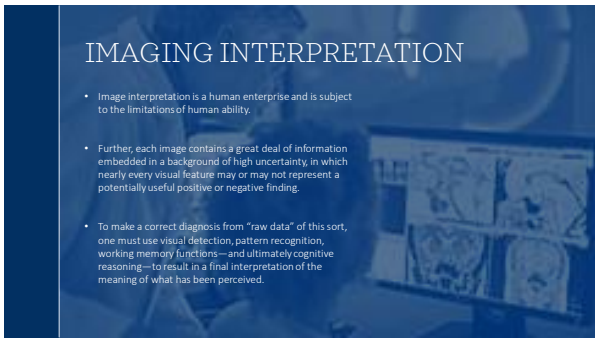

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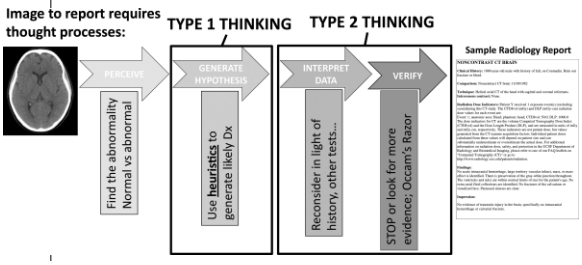
INTERPRETATION– IT'S COMPLEX!



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HUMAN DECISION MAKING

- Heuristics, also known as system 1, type 1, or **fast thinking**, describe the ability of the brain to **think and act intuitively**. Experienced interpreters may reach a diagnosis without much conscious deliberation using a variety of heuristic techniques; however, heuristics may fail due to inherent errors called biases.
- In comparison with type 1 thinking, type 2 thinking, or system 2, is an **analytical, slow, deliberate**, and effortful approach to decision making. Type 2 thinking takes over when situations become difficult, and it **is more likely** than type 1 thinking **to help determine the correct diagnosis.**

Type 1 Thinking Features	Type 2 Thinking Features
Fast	Slow
Intuitive	Analytical
Unconscious	Deliberate
Driven by heuristics	Rational
Prone to cognitive biases	Most likely to facilitate the correct diagnosis

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COMPLEX DECISION MAKING

A clinician must acknowledge his or her susceptibility to cognitive biases, which can result from type 1 thinking, when developing a thought process that incorporates both types of thinking to make diagnoses and generate reports.

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DIAGNOSTIC ERRORS

- Missed radiologic diagnoses from ***interpretation errors*** **account for 30%** of all malpractice suits in the United States [4]
- Garland (research from the 1960's), discovered that even skilled and experienced radiologists failed to note important findings on 30% of chest radiographs that were positive for disease and also had a false-positive rate of approximately 2% for negative cases. [1]
- Recent studies have confirmed his findings and furthered these findings by helping bring to light the **prevalence and nature of radiologic errors**.

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INTERPRETATION AND ERROR

- Cognitive or interpretive errors occur when an abnormality is identified on an image but its importance is incorrectly understood, resulting in an incorrect final diagnosis.
- This type of error may be secondary to a lack of knowledge, a cognitive bias on the part of the interpreter, or misleading clinical information distorting the apparent pretest probability of disease.
- It could also simply be a result of inadvertently propagating an error made in a previous radiology report (sometimes termed an alliterative error or satisfaction of report).
- There are two broad categories of error
  - Perceptual Error – 60-80% of all interpretation errors
  - Cognitive Error

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PERCEPTUAL ERROR

- Occur during the initial detection phase of image interpretation.
- Deemed to have occurred when an **abnormality is retrospectively determined to have been present on a diagnostic image** but was not seen at the time of primary interpretation.
- The finding would need to be deemed sufficiently conspicuous and detectable in retrospect by the interpreting radiologist or in the consensus of his or her peers.

Example of a perceptual error.

Anteroposterior radiograph of the chest of a 4-year-old boy. The presence of a swallowed coin within the esophagus was missed twice by a skilled pediatric radiologist. The clinical history provided did not mention the possibility of a swallowed coin.

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COGNITIVE ERROR

- Cognitive or interpretive errors occur when an **abnormality is identified on an image but its importance is incorrectly understood**, resulting in an incorrect final diagnosis.
- This type of error may **be secondary to a lack of knowledge**, **a cognitive bias** on the part of the radiologist interpreting the study, **or misleading clinical information** distorting the apparent pretest probability of disease.

Example of a cognitive error.

Anteroposterior supine radiograph of the pelvis and hips in a 76-year-old man. The interpreting radiologist correctly identified an abnormal bone around the painful left hip arthroplasty stem and made an incorrect diagnosis of small-particle disease. At reinterpretation, the proximal left femur was noted to be expansile, with cortical and trabecular thickening, and it featured a blade-of-grass advancing edge (arrowhead). These findings were most consistent with a diagnosis of Paget disease. This error might have been due to insufficient knowledge.

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TOP REASONS ERRORS OCCUR

Cause of Error	Explanation	Occurrence (%)
Underreading (missed findings)	A finding is present on the image but is missed.	42%
Satisfaction of search	A finding is missed because of failure to continue to search for additional abnormalities after the first abnormality was found.	22%
Faulty Reasoning	A findings is appreciated and interpreted as abnormal but is attributed to the wrong cause (true-positive finding misclassified)	9%
Location	A finding is missed because of the location of a lesion outside the area of interest on an image	7%

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UNDERSTANDING ERRORS

Because perceptual error is the most common type of error, it follows that to substantially reduce the overall prevalence of radiologic error, the underlying psychophysical processes involved in perception must be better understood.

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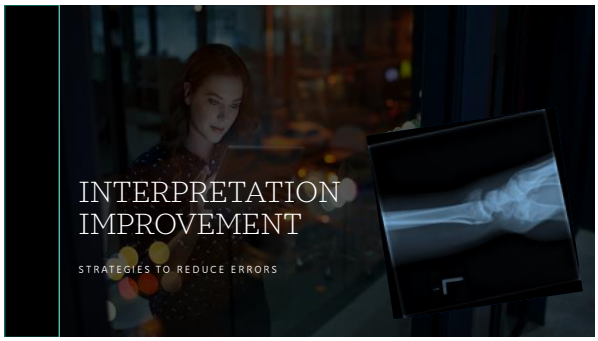

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REDUCING PERCEPTUAL ERRORS

- To find an abnormality via visual search, **one must move his or her eyes around the image to concentrate the central visual field on each of many areas of interest.**
- The visual search pattern can be **guided by habit, practice, or—ideally—clinical knowledge of the anatomic locations, disease patterns, and types of abnormalities** being searched for, and all of these appear to be critical factors.
- Visual search may also be augmented by detection of an area of interest in the peripheral vision in many cases, and there is evidence that peripheral vision makes a considerable contribution to a radiologist's search, with an interplay observed between foveal and peripheral vision noted as the observer scans an image.

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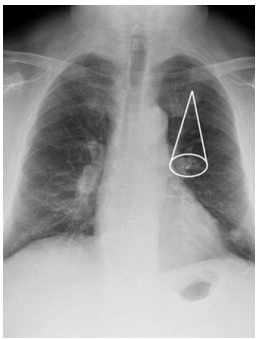
SUPER VISION?

- **Fine details are best seen with the fovea**, but spatial resolution drops off quickly toward the periphery.
- Radiograph shows the useful visual field (~5° in diameter) that can be processed with high-resolution foveal vision as the observer moves his or her eyes around an image to gather information.[4]
- Recognizing our limitations in field of vision highlights the need to thoroughly search key areas and review the image in its entirety.



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SCANNING PATTERNS

Establishing a systematic way of visually searching a radiograph the same way every time you approach that region.

This establishes patterns of recognition and connects the fast thinking system, making this (eventually) an intuitive process.

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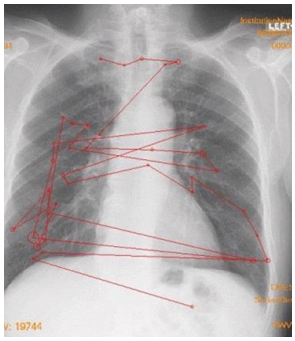

LASER VISION

- Chest radiograph shows the pattern typically used by a radiologist in searching for pulmonary nodules.
- Each circle represents a fixation point where the eye lands with foveal vision. The size of the circle reflects dwell time (ie, how long the observer's eye remains at that location), with larger circles reflecting longer dwell time. [4]
- The lines between fixation points represent jumps between locations.
- Eye tracking studies have shown more experienced readers tend to find lesions faster and to require less time actually fixating on a lesion before deciding whether a finding really is a lesion.
- In short, with experience, interpreters become more efficient and effective decision makers.

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STRUCTURED REPORTING – ABC'S

MSK Exams

- Highlights **boney anatomy**
- **BCAS** formatting
- Discuss your bone findings first followed by joint (cartilage), alignment and soft tissue
- Don't forget the pertinent negatives related to each region

Soft Tissue Exams

- Highlights **soft tissue anatomy** (chest and abdomen views)
- **SBCA** formatting
- Soft tissue findings are discussed first, followed by bone, joint (cartilage), and alignment
- Pertinent negatives for each exam

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PERTINENT NEGATIVES

A pertinent or relevant negative is the absence of a finding which would help in narrowing the differential diagnosis or would be important in management of the patient.

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CHECKLISTS

The rationale is that a checklist that is well designed and not too lengthy can reduce errors of omission by reminding the reader to take a second look at certain aspects, areas, and features of the images.

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Radiology Interpretation

Normal Anatomy

- Landmarks and Osseous Anatomy
- Joints
- Soft Tissue

Interpretation

- Systematic Approach
- Importance of Normal Anatomy

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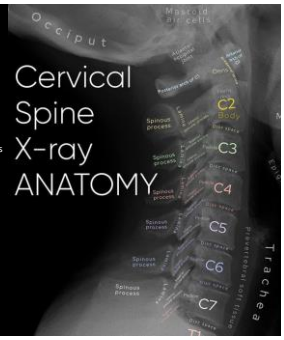
Lateral Cervical Interpretation

- ✓ **Outline the vertebral bodies** checking height is maintained and there is no endplate disruption suggesting fracture or erosion.
- ✓ **Look at the disc spaces** - have these lost height? Intervertebral discs (should increase in size slightly from C2 to C6 but be roughly symmetrical)
- ✓ **Assess the Remaining Joints -** no sclerotic areas or marginal osteophytes at the uncinates or the zygapophyseal joints.
- ✓ **ADI -** < 3 mm (up to 4 mm in kids)
- ✓ **Assess alignment**. Check that all of the lumbar spine vertebrae line up with each other and one isn't displaced forwards (spondylolisthesis).
- ✓ **Dentition** check for resorption around the teeth
- ✓ **Sella Turcica** borders should be well defined (15 mm x 12 mm)
- ✓ **No calcifications or foreign bodies**

Be systematic in your approach to assessing the anatomy.



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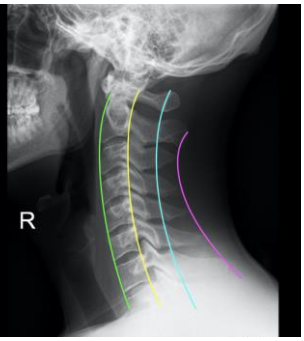
Pertinent Negatives

- ✓ **Prevertebral Soft Tissues - Retropharyngeal and retrotracheal space**
  - ✓ Retropharyngeal (1-7 mm at C2)
  - ✓ Retrotracheal (9-22 mm at C6)
- ✓ **Sinuses** aeration of the sinuses should be roughly symmetrical and lucent
- ✓ **If hardware is present – check for resorption of bone as a sign of loosening or for displacement**



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AP Interpretation

This needs to be reviewed in conjunction with lateral and APOM views.

- ✓ **Pedicles** - Check to see there are two pedicles present at each vertebral level as a missing pedicle could represent an aggressive lesion such as a bone metastasis.
- ✓ **Outline the vertebra** - outline each vertebral body and check for any erosion of the endplates or loss of vertebral height. Then correlate this with the lateral view..
- ✓ **Vertebral body count** (C3-C7)
- ✓ **Posterior Joints** - no sclerotic areas or marginal osteophytes
- ✓ **No calcifications or foreign bodies**

As always be systematic! Most mistakes are made because of a lack of a thorough review rather than a lack of knowledge.

Pertinent Negatives

- ✓ **Tracheal deviation** – should align over the spinous processes to the level of T2, will then deviate because of the thoracic aorta
- ✓ **Lung apices** are clear

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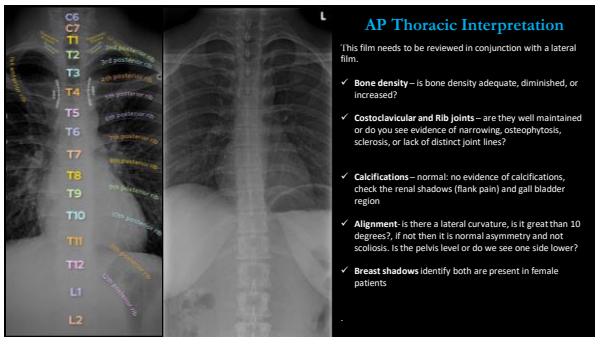

AP Thoracic Interpretation

This film needs to be reviewed in conjunction with a lateral film.

- ✓ **Bone density** – is bone density adequate, diminished, or increased?
- ✓ **Costoclavicular and Rib joints** – are they well maintained or do you see evidence of narrowing, osteophytosis, sclerosis, or lack of distinct joint lines?
- ✓ **Calcifications** – normal: no evidence of calcifications, check the renal shadows (flank pain) and gall bladder region
- ✓ **Alignment**- is there a lateral curvature, is it great than 10 degrees?, if not then it is normal asymmetry and not scoliosis. Is the pelvis level or do we see one side lower?
- ✓ **Breast shadows** identify both are present in female patients

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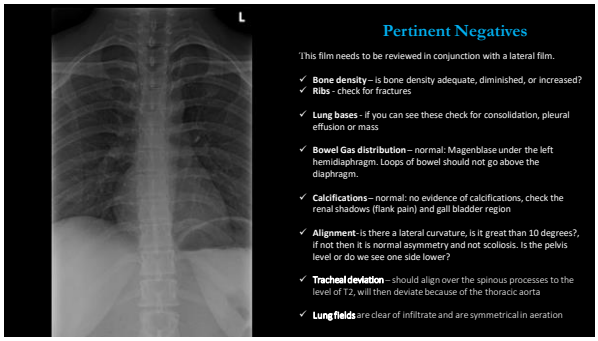

Pertinent Negatives

This film needs to be reviewed in conjunction with a lateral film.

- ✓ **Bone density** – is bone density adequate, diminished, or increased?
- ✓ **Ribs** - check for fractures
- ✓ **Lung bases** - if you can see these check for consolidation, pleural effusion or mass
- ✓ **Bowel Gas distribution** – normal: Magenblase under the left hemidiaphragm. Loops of bowel should not go above the diaphragm.
- ✓ **Calcifications** – normal: no evidence of calcifications, check the renal shadows (flank pain) and gall bladder region
- ✓ **Alignment**- is there a lateral curvature, is it great than 10 degrees?, if not then it is normal asymmetry and not scoliosis. Is the pelvis level or do we see one side lower?
- ✓ **Tracheal deviation** – should align over the spinous processes to the level of T2, will then deviate because of the thoracic aorta
- ✓ **Lung fields** are clear of infiltrate and are symmetrical in aeration

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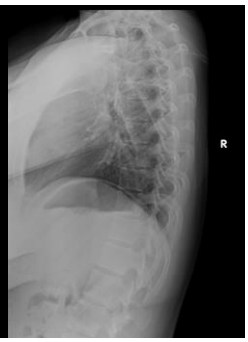
Pertinent Negatives

- ✓ **Look at the disc spaces** - have these lost height or are they well maintained? Typical appearance to the thoracic discs are slightly reduced in anterior height and the thinnest of all the spine regions.
- ✓ **Assess alignment**.
- ✓ **Calcifications**- If you found calcifications on the AP, triangulate on the lateral. Renal lithiasis will overlie the vertebral column as the kidneys are retroperitoneal. GI and gallbladder calcifications will fall anteriorly. Abdominal aortic calcification will follow anterior to the vertebral column in a linear pathway.

Be systematic in your approach to assessing the anatomy.



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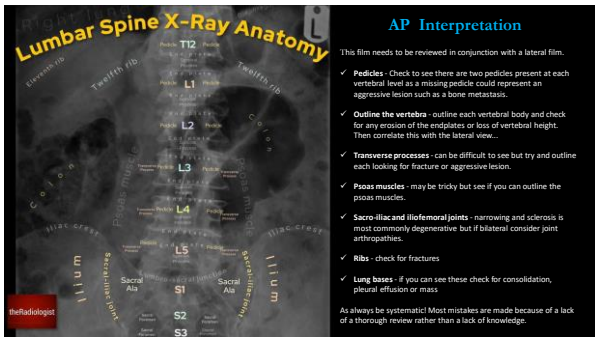
Lumbar Spine X-Ray Anatomy
AP Interpretation
This film needs to be reviewed in conjunction with a lateral film.
Pedicles - Check to see there are two pedicles present at each vertebral level as a missing pedicle could represent an aggressive lesion such as a bone metastasis.
Outline the vertebra - outline each vertebral body and check for any erosion of the endplates or loss of vertebral height. Then correlate this with the lateral view...
Transverse processes - can be difficult to see but try and outline each looking for fracture or aggressive lesion.
Psoas muscles - may be tricky but see if you can outline the psoas muscles.
Sacro-iliac and iliofemoral joints - narrowing and sclerosis is most commonly degenerative but if bilateral consider joint arthropathies.
Ribs - check for fractures
Lung bases - if you can see these check for consolidation, pleural effusion or mass
As always be systematic! Most mistakes are made because of a lack of a thorough review rather than a lack of knowledge.
theRadiologist

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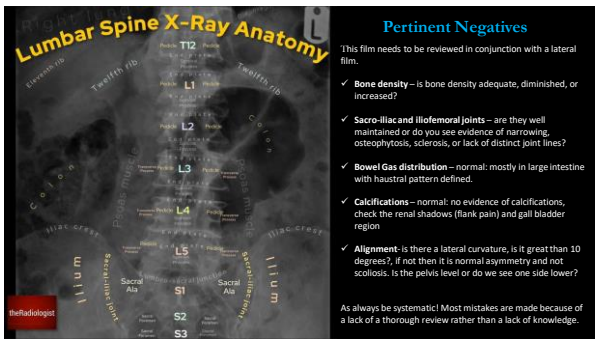
Lumbar Spine X-Ray Anatomy
Pertinent Negatives
This film needs to be reviewed in conjunction with a lateral film.
Bone density – is bone density adequate, diminished, or increased?
Sacro-iliac and iliofemoral joints – are they well maintained or do you see evidence of narrowing, osteophytosis, sclerosis, or lack of distinct joint lines?
Bowel Gas distribution – normal: mostly in large intestine with haustral pattern defined.
Calcifications – normal: no evidence of calcifications, check the renal shadows (flank pain) and gall bladder region
Alignment- is there a lateral curvature, is it great than 10 degrees?, if not then it is normal asymmetry and not scoliosis. Is the pelvis level or do we see one side lower?
As always be systematic! Most mistakes are made because of a lack of a thorough review rather than a lack of knowledge.
theRadiologist

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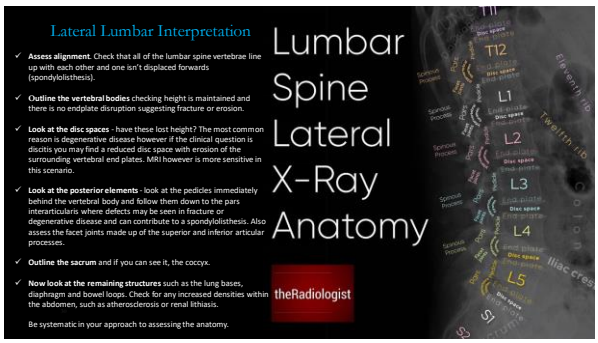
Lateral Lumbar Interpretation
Assess alignment. Check that all of the lumbar spine vertebrae line up with each other and one isn't displaced forwards (spondylolisthesis).
Outline the vertebral bodies checking height is maintained and there is no endplate disruption suggesting fracture or erosion.
Look at the disc spaces - have these lost height? The most common reason is degenerative disease however if the clinical question is discitis you may find a reduced disc space with erosion of the surrounding vertebral end plates. MRI however is more sensitive in this scenario.
Look at the posterior elements - look at the pedicles immediately behind the vertebral body and follow them down to the pars interarticularis where defects may be seen in fracture or degenerative disease and can contribute to a spondylolisthesis. Also assess the facet joints made up of the superior and inferior articular processes.
Outline the sacrum and if you can see it, the coccyx.
Now look at the remaining structures such as the lung bases, diaphragm and bowel loops. Check for any increased densities within the abdomen, such as atherosclerosis or renal lithiasis.
Be systematic in your approach to assessing the anatomy.
Lumbar Spine Lateral X-Ray Anatomy
theRadiologist

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Pertinent Negatives

- ✓ **Look at the disc spaces** - have these lost height or are they well maintained? Do you see disc narrowing, endplate osteophytosis, or sclerosis associated with degeneration? If disc herniation is suspected an MRI is the definitive dx.
- ✓ **Assess alignment**. Check that all of the lumbar spine vertebrae line up with each other and one isn't displaced forwards (spondylolisthesis). Normal is slighlty retro to segment below. Is there a loss of the lordosis or is well maintained? Do you see pelvic anterior or posterior tilt?
- ✓ **Calcifications**- If you found calcifications on the AP, triangulate on the lateral. Renal lithiasis will overlie the vertebral column as the kidneys are retroperitoneal. GI and gallbladder calcifications will fall anteriorly. Abdominal aortic calcification will follow anterior to the vertebral column in a linear pathway.

Be systematic in your approach to assessing the anatomy.

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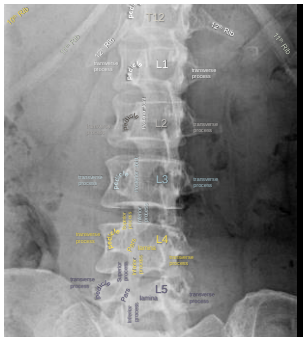

Lumbar Oblique Interpretation

- ✓ Check lumbar spine – visualize from T12/L1 - L5/S1
- ✓ Trace the scottie dog sign, showing the articular processes and facet joints
- ✓ Trace the lumbar vertebral bodies, with both trabecular and cortical bone outlined
- ✓ Pedicles should be complete and easily identified
- ✓ Always compare the pars interarticularis region on the AP and lateral views

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2. **Identifying Error Types in Visual Diagnostic Skill Assessment**. Ravesloot CJ, van der Gijp A, van der Schaaf MF, Huige JCBM, Ten Cate O, Vincken KL, Mol CP, van Schaik JPJ. Identifying error types in visual diagnostic skill assessment. Diagnosis (Berl). 2017 Jun 27;4(2):93-99. doi: 10.1515/dx-2016-0033. PMID: 29536921.
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