Scoliosis
Introduction

• Why should you know about scoliosis?

• What should you know about scoliosis?
Why should you know about scoliosis?

• Patients with scoliosis may present themselves directly to the radiology department
  – Primary healthcare physician
  – Referred from the pediatric, neurology or neurosurgery services
• Many of these physicians look toward the radiologist as the expert, after the orthopedist, therefore radiologists should know:
  – The basics of scoliosis
  – How to perform the radiologic examination
  – Read these films correctly
  – Make a coherent and helpful interpretation
  – Radiation exposure effects– measures- imaging interval
What should you know about scoliosis?

• Why do imaging?
  – What imaging modality
  – How should it be done
  – How often should it be done
    • What could happen is imaging is done too often

• What should be measured
  – How should it be measured

• What are the red flags?
Standing PA and lateral views of the entire spine demonstrate a severe main thoracic right curve and minimal lumbar curve.

No associated bony anomalies are noted.

The Cobb angle measured from the superior endplate of T7 to the inferior endplate of L2 measures 32 degrees. The apex of the curve is at T10. The thoracolumbar kyphosis measured from the superior endplate of T10 to the inferior endplate of L2 is 31 degrees.

Lateral bending films show persistence of the curve with bending to the right and increased curvature with bending to the left, indicating a structural thoracic curve.

The iliac apophyses are incomplete and not fused with the ilium, Risser 3, indicating skeletal immaturity.

Follow-up imaging is advised within 12 months.
Overview

- Introduction
- Etiology
- Classification
- Natural history
- Imaging
- Treatment
- Conclusion
Introduction

• Scoliosis is described as a deviation from the midline in a frontal plane
  – A small deviation (< 10 degrees) is sometimes called spinal asymmetry
  – “True” scoliosis has a deviation of ≥10 degrees
• Accompanied by a rotation that is maximally at the apex of the curve

• Thoracic region: typical chest wall prominence known as the “Adams sign”
Etiology

• Congenital scoliosis
  – Embryologic or intrauterine maldevelopment of vertebral elements
    • Segmentation
    • Formation
  – Commonly associated with cardiac or urologic abnormalities

• Neuromuscular disorders
  – Cerebral palsy
  – Muscular dystrophy
  – Some generalized diseases and syndromes (i.e. Marfan syndrome, neurofibromatosis, rheumatoid disease or bone dysplasia)
Etiology

- Traumatic scoliosis
  - Bony lesion
    - Fractures
    - Dislocations
- Idiopathic scoliosis
  - Most frequent type (80%)
Idiopathic scoliosis

- Genetic factors
  - Multigene dominant inheritance
  - Variable phenotypic expression
  - Family members of affected individuals patients have an increased incidence of scoliosis
    - 73-92% concordance in monozygotic twins
    - Affected siblings: x7
Idiopathic scoliosis

- Tissue deficiencies in bone, muscle, ligament and/or disc
- Vertebral growth anomalies
  - When anterior spinal growth outpaces posterior growth in the adolescent, hypokyphosis is produced with subsequent buckling of the vertebral column
- Central nervous system disorders
  - Equilibrium and vestibular dysfunction
  - Melatonin deficiency
  - Syringomyelia
  - Spinal tumors
Prevalence

• 0.5-3.0 % in the childhood and adolescent population
  – 0.5 % is reported in the infantile group
  – 10 % in the juvenile group
  – ±90 % in the adolescent group

• 0.04-0.29 % for larger curves (> 30 degrees)
Clinical features

• Patients with mild idiopathic scoliosis (< 25 degrees) usually have no or only very little discomfort
  – Patients presenting with severe pain, neurologic symptoms or rapidly progressing scoliosis require thorough further examination

• Cardiopulmonary complications are almost exclusively seen in early onset scoliosis (< 5 years old)
Classification

- Etiology
- Curve location
- Age at onset
- Curve type
• Curve location is defined by its center, known as the apex, which is the most lateral disc or vertebra of the curve.
• Usually the apical vertebra is also the most horizontal
• Classification:
  – Cervical (apex between C2 and C6)
  – Cervicothoracic (C7-T1)
  – Thoracic (T2-T11)
  – Thoracolumbar (T12-L1)
  – Lumbar (L2-L4)
  – Lumbosacral (L5 and below)
Classification: age at onset

- Age at onset or rather diagnosis
  - Infantile (0 to 3 years)
    - Male:female ratio is 3:2
    - Left thoracic curve in 90% of cases
  - Juvenile (4 to 10 years)
    - Male:female ratio is 1:2 to 1:4, boys being more affected between 3 and 6 years (1:1), girls between 6 and 10 years (1:8)
    - Right and left curves equal in the younger group (< 6 years at presentation) and right curves predominate in the older group (80%)
  - Adolescent (11 to 17 years)
    - For minor curves the male:female ratio is equal
    - For larger curves the ratio is as high as 1:8
  - Adult (> 18 years)
Classification: curve type

- **Cobb angle**
  - Spinal asymmetry (< 10 degrees)
  - Mild scoliosis (10-25 degrees)
  - Severe scoliosis (≥ 25 degrees)

- **Primary – secondary**
  - Primary curves are the first to develop
  - Secondary curves develop afterwards as a means to balance the head and trunk over the pelvis

- **Structural – nonstructural**
  - Structural curves can not be corrected with side-bending or traction
  - Nonstructural curves can be secondary curves or functional curves (postural, secondary to short leg, muscle spasm, …)
Natural history

• Congenital scoliosis
  – Progression in 75% of cases
  – Poorest prognosis
    • Thoracic curves
    • Depends on type

<table>
<thead>
<tr>
<th>Condition</th>
<th>Progression Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block &amp; wedge vertebrae</td>
<td>&lt; 1 degree/year</td>
</tr>
<tr>
<td>Hemivertebrae</td>
<td>1 to 2.5 degrees/year</td>
</tr>
<tr>
<td>Double hemivertebrae</td>
<td>2 to 5 degrees/year</td>
</tr>
<tr>
<td>Unilateral unsegmented bars with contralateral hemivertebrae</td>
<td>Up to 10 degrees/year</td>
</tr>
</tbody>
</table>
Natural history

- Infantile idiopathic scoliosis
  - Vast majority is self-limited
  - Progression very likely if the rib-vertebral angle difference is $\leq 20$ degrees

*Figure 15-13.* The rib-vertebra angle difference (RVAD) of Mehta, calculated by subtracting the convex value from the concave value at the apical vertebra of a thoracic curve. (From Koop, S.E.: Infantile and juvenile idiopathic scoliosis. Orthop. Clin. North Am. 19:332, 1988.)
Natural history

• Juvenile idiopathic scoliosis
  – 70 % progressive
  – Curves of > 30 degrees are almost always progressive
    • 1 to 10 degrees/year
  – Cardiac and pulmonary compromise
  – Thoracic curves require surgery in > 95%

• Adolescent idiopathic scoliosis
  – Only 5% have a progression > 30 degrees

• Adult idiopathic scoliosis
  – < 30 degrees usually no progression
  – 50…75 degrees continuing rate of 1 degree/year
  – Increased mortality rate in untreated patient almost only > 90 degrees
Risk factors for progression

- Remaining skeletal growth
  - Age
  - Risser sign
    - Risser <1: progression in 60…70%
    - Risser 3: progression ≤ 10%

- Curve position
  - Primary thoracic curve > primary lumbar curve
  - Larger curve: more progression
Imaging in scoliosis

- Imaging technique
- Imaging interval
- Measurements
- Special imaging techniques
Imaging technique

• Screening
  – Upright PA radiograph of the entire spine
  – Head and pelvis should be on the same film
  – Standing, except for
    • Young patients
    • Severe neuromuscular disorders
  – Lateral film is not required

• Minimize radiation of sensitive organs
  (breast, thyroid, ovaries, bone marrow, lens,...)
  – 70 percent higher risk of breast cancer than
    women in the general population
  – PA technique reduces radiation to the breast 3 to
    7 folds
  – Breast shielding
Imaging interval

- **Idiopathic curve**
  - Before skeletal maturity
    - $< 30$ degrees: 12 months, depending on the age and growth of the patient
    - $> 30$ degrees: depending on therapy
  - After skeletal maturity
    - $< 30$ degrees no follow-up unless symptoms
    - $> 30$ degrees every 3 years
Imaging: measurement

- **Cobb angle**
  - For each curve that is present
  - Comparing different radiographs usually same endvertebrae
  - Wide inter- and intra-observer variation (5 degrees)

- **Vertebral rotation**
  - Maximal at the apex
  - Inaccurate
  - Mohr

- **Skeletal maturity**
  - Risser sign
Imaging technique

- When surgical treatment is considered
  - Lateral bending radiographs
  - Lateral films
  - Traction films
Specialized imaging

• Magnetic resonance imaging is required in
  – Infantile and juvenile idiopathic scoliosis
  – Congenital bony anomalies
  – Scoliosis associated with specific neurological or cutaneous abnormalities
  – Pre-operative assessment
  – The role of MR in extremely severe scoliosis remains unclear
  – MR-screening for all patients with scoliosis is not indicated

• Computed tomography (CT)
  – Visualization of complex deformities
    • Deformity of the spine is 3D
    • Regional deformity is almost always 2D, but in a different plane.
  – Computer assisted surgery (CAS)
• Only in patients with substantial remaining spinal growth (Risser 3 or less)
  – 25-45 degrees
  – Annual growth of > 5 degrees
• 23 hours per day
  – Usually for several years
  – Until the curve is stabilized
  – Until skeletal maturity is reached (Risser 5 or no spinal growth for 18 months)
• Final result is the maintenance of the curve degree
• < 5 degrees in 75% of patients, compared to 35% in a comparable non-treated group
Surgery

• Indication
  – > 45 degrees
  – AND remaining spinal growth

• Method
  – Corrective instrumentation (rods)
  – AND arthrodesis (strength)
Results of surgery

- Generally achieves good to excellent improvement of the Cobb angle
- Conflicting reports on the long-term functional results such as low back pain
Conclusion

• Why do imaging?
  – What imaging modality?
  – How should it be done?
  – How often should it be done?
    • What could happen if imaging is done too often
• What should be measured?
  – How should it be measured?
• What are the red flags?
References