Overview of Spinal Anatomy, Examination, Common Disorders, & Treatments

Robert Metzger, DNP, APRN, FNP-BC

Objectives
1. Identify the basic anatomy of the spine and spinal cord
2. Determine appropriate physical exam and diagnostic tests for common spine diagnoses.
3. Understand the presentation of common spine diagnoses.
4. Develop appropriate treatment plans for patients with common spine diagnoses.

This presenter has no conflicts of interest to report
Spinal Column
- Consists of the Cervical, Thoracic, and Lumbar regions
- Specific curves to the spinal column:
  - Lordosis: Cervical and Lumbar
  - Kyphosis: Thoracic and Sacral
- Vertebrae are the same throughout, except for C1 & C2, therefore same nomenclature is applicable to all areas of the spine.

Vertebral Structures
- Vertebral Body
- Pedicle
- Transverse Process
- Superior Articular Process
- Spinous Process (Bifid from C2-C6)
- Lamina
- Inferior Articular Process

Vertebral Joints
- Facet Joints (formed by the superior & inferior articular processes)
- Uncovertebral Joints (Cervical Spine)
- Uncinate Process (Cervical Spine)
**CERVICAL SPINE**

- Cervical Spine (7 vertebrae)
  - C1 (Atlas)
    - Supports the weight of the skull
    - Ring shaped vertebrae
  - C2 (Axis)
    - Provides a pivot point for the Atlas
    - Projection into the C1 body, called the Odontoid (Dens)

- C3 – C7: Similar in structure
  - Foramen
    - Vertebral: triangular shaped
    - Intervertebral: Exiting nerve root occupies about 75% of space
  - Uncovertebral Joints
  - Spinal Processes
    - C2-6: Bifid processes
    - C7: Vertebra prominens

**THORACIC SPINE**

- Vertebrae
  - heart shaped
  - AP > ML dimensions
  - Laminae lie in a "roof tile" position
- Spino processes
  - long and project downward (decrease extension in midback)
- Foramen:
  - Vertebral: round with little space for spinal cord
  - Intervertebral: exiting nerve occupies only 25% of the space
**LUMBAR SPINE**
- Vertebræ
  - Kidney shaped bodies
  - ML > AP dimensions
  - Smaller Transverse Process
  - Spinal Processes are large, square, and horizontal
- Foramen
  - Vertebral: wider and triangular
  - Intervertebral: 33% occupied by nerve

**SACRUM**
- 5 Vertebral Bodies
  - Fused to form a single bone
  - Occasionally can have an intervertebral disc, primarily at S1/S2
- Wedge formation between the 2 Iliac bones to form Sacroiliac Joints
- Coccyx: Tailbone

**INTERVERTEBRAL DISCS**
- Discs are located between the endplates of the vertebral bodies
- Most important and unique articulating system in the spine, allowing for multiplanar motion
- Make up ¼ of the total length of the spine column, run from C2/3 to L5/S1
- Largest avascular structure in the human body
- Cartiliginous joint of the motion segment
- Shock absorbers of the spine which are so strong that w/ compression, the vertebral bodies will fail before the discs
Intervertebral Discs

- 2 Components
  - **Annulus Fibrosus**
    - Outer part of the disc
    - Collagen fibers w/ water and proteoglycans
    - Layered in concentric layers called Lamellae which are thicker and more numerous in the anterior portion of disc
  - **Nucleus Pulposus**
    - Interior substance of the disc (gelatinous)
    - Increased water and proteoglycan content (85% Water content)

Ligaments (brief overview)

- Anterior Longitudinal Ligament
- Posterior Longitudinal Ligament
- Ligamentum Flavum (noncontinuous, yellow color)
- Interspinous Ligament (connects the SPs)
- Supraspinous Ligament (connects the tips of the SPs)
- Intertransverse Ligament (connects the TPs)

Spinal Cord / Nerves

- Spinal cord
  - Begins at Foramen Magnum and continues w/ terminus at Conus Medullaris near L1
  - Cauda Equina
  - Collection of nerves which run from terminus to end of Filum Terminale
  - Nerve Roots
    - Canal is broader in cervical/lumbar regions due to large number of nerve roots
    - Branch off the spinal cord higher than actual exit through the intervertebral foramen
      - 1st root exits between C2/C1; 8th cervical root between C7/T1
      - 1st thoracic and so on exit below the vertebral body
DERMATOMES

- Areas of skin innervated by sensory fibers from a single spinal nerve

Diagnostics

X-rays
- Provides basic evaluation of bone and disc spacing allowing visualization of degeneration, fractures, and instability of the spine

Magnetic Resonance Imaging (MRI SCANS – non-radiation)
- Magnet causes Hydrogen atoms in the tissue to line up, then radio waves bounce off the H\(^+\) atoms to provide a picture
- Adept at evaluation of soft tissue pathology (i.e. nerves, spinal cord, and discs)
- Can be performed unless pt has pacemaker/defibrillator implant, aneurysm clips, other motor run implants, spinal cord stimulators, or a bullet close to the spine
- Order w/ contrast if prior surgery has been done to r/o scar tissue involvement or tumor

Computed Tomography (CT SCANS – high radiation)
- Thin beams of x-rays pass through the pt. to a detector which transmits images to a computer
- Particularly good for detecting bony tissue pathology
- May consider CT if patient had prior hardware and there’s concern for artifact on MRI or lucency of the hardware

Special Diagnostics: CT Myelogram

- Needle is introduced into the subarachnoid space and contrast is injected
- Patient is then tilted on the table so the dye will go to the specific region we are testing
- AP/Lat views of spine are taken
  - Contrast appears white w/ neural structures dark
  - Compression or displacement of neural elements may be visualized
- Painful procedure
Diagnostics for cervical evaluation:

- **X-RAYS**
  - AP / Lateral
  - Flexion / Extension – Evaluation for instability or movement of spine
  - Odontoid Views – Evaluation of the C1 & C2 bodies (especially fractures)
- **MRI SCANS**
  - Evaluation for radiculopathy / disc protrusions / stenosis
  - Typically, pt should have neurological involvement
- **CT SCANS**
  - Performed if pt is unable to undergo MRI imaging or if major concern is bone
- **Myelogram**
  - Performed if pt is unable to undergo MRI imaging and concern for possible stenosis

Diagnostics for lumbar evaluation:

- **XRAYS**
  - AP / Lateral
  - Flexion / Extension – Evaluation of instability or movement of spine
  - Oblique Views – Evaluation of spondylolysis (Pars defect) – “Scotty Dog”
- **MRI SCANS**
  - Evaluation for radiculopathy / disc protrusions / stenosis
  - Typically, pt should have neurological involvement
- **CT SCANS**
  - Performed if pt is unable to undergo MRI imaging or if major concern is bone
- **Myelogram**
  - Performed if pt is unable to undergo MRI imaging and concern for possible stenosis

**REMEMBER** the Basic Principles of Musculoskeletal Examination

- **Comprehensive History**
  - Chief Complaint (CC)
  - HPI OLCART
    - Important to note the Mechanism of Injury for pt’s who experienced trauma
  - PMH
  - PSH
  - PFSH
  - ROS
  - Physical exam – use one finger to point to the maximum area of pain

- **Comprehensive Physical Exam**
  - Inspection
  - Palpation
  - Range of Motion
  - Muscle grading
  - Sensation
  - Unusual Findings - atrophy
### Cervical Neurological Examination Keypoints

<table>
<thead>
<tr>
<th>C5</th>
<th>M</th>
<th>Shoulder Abduction (Deltoide), Elbow Flexion (Biceps)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S</td>
<td>Biceps Reflex</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>Lateral portion of Deltoid and Upper Arm to Elbow</td>
</tr>
<tr>
<td>C6</td>
<td>M</td>
<td>Wrist Extension</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>Brachioradialis Reflex</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>Lateral Forearm (below elbow) including Thumb, Index Finger, and ½ of Middle Finger</td>
</tr>
<tr>
<td>C7</td>
<td>M</td>
<td>Elbow Extension (Triceps), Wrist Flexion, Finger Extension</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>Triceps Reflex</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>Medial Forearm (up to elbow), Ring Finger, and Pinky Finger</td>
</tr>
</tbody>
</table>

### Thoracic Neurological Examination Keypoints

<table>
<thead>
<tr>
<th>T1</th>
<th>M</th>
<th>Finger Abduction and Adduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
<td>NONE</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>Medial Forearm and Medial Upper Arm</td>
</tr>
<tr>
<td>T2 – T12</td>
<td>M</td>
<td>Rectus Abdominus (Beevor’s Sign)</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>NONE</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>T4 – Nipples</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T7 – Xiphoid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T10 – Umbilicus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T12 – Groin</td>
</tr>
</tbody>
</table>

### Lumbar Neurological Examination Keypoints

<table>
<thead>
<tr>
<th>T12 – L3</th>
<th>M</th>
<th>Hip Flexion (knee-Raising - iliopsoas) – L2, Quadriceps (Knee Extension) – L3, Hip Abduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
<td>Patellar Tendon-reflex</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>Medial Leg (Tibial Crest – Medially), Medial Foot, and Medial Great Toe</td>
</tr>
<tr>
<td>L4</td>
<td>M</td>
<td>Fast Inversion (Tibialis Anterior), Ankle Dorsiflexion</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>Flexor Dorsalis pedis</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>Lateral Leg (Tibial Crest – Laterally), Dorsum of Foot</td>
</tr>
<tr>
<td>L5</td>
<td>M</td>
<td>Hip Abduction (Gastrocnemius), Great Toe Extension (EHL), 2nd-5th Toe Extension (EDL)</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>Tibialis Posterior</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>Lateral Foot, Portion of Plantar Surface</td>
</tr>
<tr>
<td>S1</td>
<td>M</td>
<td>Fast Extension, Calf ROMs (Gastrocnemius), Hip Extension (Glutes Maximus), Ankle Tendon Reflexes</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>Superficial Peroneal Nerve</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>Lateral Foot, Portion of Plantar Surface</td>
</tr>
<tr>
<td>S2 – S4</td>
<td>M</td>
<td>Intrinsic Muscles of Foot, Bladder motor supply, Knee Flexion – S2</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>Superficial Peroneal Nerve</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>Concentric Ring – S2 – Outermost Ring, S3 – Middle Ring, &amp; S4/S5 – Innermost Ring</td>
</tr>
</tbody>
</table>
Long Tract Signs (Pathologic Reflexes)  
[suggestive of upper motor neuron lesions]

- DTR’s
  - Standard 2+ and equal bilaterally
  - Positive if < 2+ unilaterally or bilaterally
- Hoffman’s Sign
  - Picking of the 3rd DIP
  - Positive if the 1st & 2nd DIP’s flex
- Ankle Clonus
  - Quick dorsiflexion of the relaxed ankle joint
  - Positive with repetitive (4+) twitches/gripping of the foot
- Babinski’s
  - Stroking of lateral aspect of sole of foot from heel to toes
  - Positive with extension of great toe and fanning of four small toes

Special Tests (CERVICAL):

- Lhermitte’s –
  - Look up – Look down (Touch your chin to your chest): Causes electrical shocks down the spine, and occasionally into the legs, if positive
  - Suggestive of Cervical HNP
  - Some practitioners suggest applying compression simultaneously to increase the sensitivity of the test

- Spurling’s ( foraminal compression)
  - Pt bends or side flexes the head to the unaffected side first, followed by the affected side. Each time the examiner presses straight down on the head.
  - Positive with repetitive (4+) twitching/pulsing of the foot

- Gait Testing –
  - Normal Gait Pattern (no evidence of foot drop)
  - Heel Walking: If difficult, can indicate L4/5 involvement
  - Tip Toe Walking: If difficult, can indicate S1 involvement

- Straight Leg Raise (AKA Laseque’s test)
  - Perform if history includes nerve root symptoms
  - Pt lays supine or sits upright while provider passively raises each leg individually with knee extended until the patient complains of pain down the back of the leg. Once pain is elicited, drop the leg slowly until they feel no pain, then dorsiflex the foot.
  - Positive if pain is elicited within the leg between 35-70 degrees of elevation.
  - Dorsiflexion should increase this pain (if not, likely hamstring tightness).

- FABER (AKA Patrick’s Manuever & LaFebere test)
  - Flex the knee and place ankle above contralateral knee. Apply downward force onto the flexed knee to stress the lower back, SI joint, & hip.
  - Positive – pt will elicit pain that should point to the source of pathology

Special Tests (LUMBAR):

- Gait Testing –
  - Normal Gait Pattern (no evidence of foot drop)
  - Heel Walking – If difficult, can indicate L4/5 involvement
  - Tip Toe Walking – If difficult, can indicate S1 involvement

- Straight Leg Raise (AKA Laseque’s test) –
  - Perform if history includes nerve root symptoms
  - Pt lays supine or sit upright while provider passively raises each leg individually with knee extended until the patient complains of pain down the back of the leg. Once pain is elicited, drop the leg slowly until they feel no pain, then dorsiflex the foot.
  - Positive if pain is elicited within the leg between 35-70 degrees of elevation. Dorsiflexion should increase this pain (if not, likely hamstring tightness).

- FABER (AKA Patrick’s Manuever & LaFebere test)
  - Flex the knee and place ankle above contralateral knee. Apply downward force onto the flexed knee to stress the lower back, SI joint, & hip.
  - Positive – pt will elicit pain that should point to the source of pathology
Special Tests (LUMBAR) – cont.:

- Femoral Nerve Stretch
  - Opposite of SLR and tests L3 (femoral nerve)
  - Conducted in standing or prone position with back straight, examiner grasps the limb flexing the knee while slightly hyperextending the hip
  - Positive – produces L2-4 radicular symptoms to the anterior knee

Special Reminders
- German Oktoberfest Dance – Remember the dermatomes of the lower extremity
- Umbilicus – Level of L3/4
- Line across iliac crests – Level of L4/5

Typical Diagnoses of the Cervical Spine:
1. Cervical Disc Degeneration (spondylosis)
2. Cervical Disc Protrusions
3. Cervical Radiculopathy
4. Cervical Stenosis
5. Cervical Myelopathy
6. Cervical Fractures
7. Combination of Above

Typical Diagnoses of the Lumbar Spine:
1. Lumbar Disc Degeneration (spondylosis)
2. Lumbar Disc Protrusions
3. Lumbar Radiculopathy
4. Lumbar Stenosis
5. Spondylolysis & Spondylolisthesis
6. Lumbar Fractures
7. Combination of Above
8. Cauda Equina Syndrome
Degenerative Disc Disease (DDD)

- Loss of normal tissue structure and function due to the aging process.
- Usually is a gradual process, however acute trauma will accelerate the process.
- Changes within the intervertebral disc:
  - Water and proteoglycan decrease in the nucleus first, then the annulus.
  - Fibers of the annulus become distorted, tears may occur in the lamellae decreasing the strength of the disc.
- Most common levels are C5/6 and L4/5.
- By age of 50, 95% of people will have evidence of DDD.

Effects the entire motion segment:

- Facet joints override and wear at the hyaline cartilage.
- Disc shrinks and the disc space narrows.
- Loads are transferred from disc to the endplates.
- Osteophytes may develop and encroach on neurological structures.
DISC HERNIATION

- Most frequent surgically treated pathologies of the spine
- Commonly occurs at C4/5, C5/6, C6/7 & L4/5, L5/S1 (regions w/ great ROM and axial loading)
- Internal disruption to the disc is permanent due to the disc being avascular
- Four degrees of herniation
  1. Fissure / Bulging
  2. Protrusion
  3. Extrusion
  4. Fragmented / Segmented

Symptoms

- Asymptomatic
- Neck pain / Low back pain
- Radiculopathy into upper extremities / lower extremities
- Cauda Equina Syndrome
  - Foot Drop
  - Bladder and/or Bowel Incontinence
Spinal Stenosis

- Stenosis is “narrowing of a tube”
- Spinal stenosis refers to narrowing of the spinal canal and/or lateral foramen
- Developmental or Acquired (most common)
- Degenerative stenosis
  - Found in older population
  - L3/4, L4/5 are most involved lumbar segments
  - C5/6, C6/7 are most involved cervical segments
  - Occasionally associated with spondylolisthesis
- Occurs most often in lower cervical / lower lumbar spine.
Symptoms

- Associated with LBP, occasionally will have buttock, leg pain (BLE)
- Neurogenic claudication
  - Most important sx
  - Worse w/ standing/walking upright
  - Alleviated with bending forward (flexing)
  - Differentiate between vascular claudication

Spinal Stenosis

- CERVICAL STENOSIS
  - Presents more commonly with history of neck trauma
  - Most patients present with radiculopathy of C5, C6, or C7 nerve roots
  - Important to watch for CERVICAL MYELOPATHY
    - Symptoms of myelopathy are altered gait, diminished fine motor coordination, sensory changes, muscle weakness or atrophy, and in late cases, bladder and/or bowel incontinence
Cervical Stenosis w/myelomalacia

Confusing Terminology:
- Spondylosis – degenerative changes in vertebrae at the disc and facet joints
- Spondylolysis – defect in the vertebrae in area of pars interarticularis

Descriptive Terminology:
- Anteriolithesis – anterior / forward
- Retrolithesis – posterior/ backward
- Lateral – sideways movement
Examples of Spondylolysis

- Slippage of one vertebrae in relation to the adjacent vertebrae
- Incidence is approximately 3-4% of all populations
- Strong hereditary factor
- Noticed more in gymnasts, football linemen, and weightlifters
- Most slips are related to a deficit in the pars interarticularis
- Disc degeneration is associated with almost all forms of spondylolisthesis
- Symptoms
  - Most common complaint is LBP
  - Radiation into the buttocks and occasionally posterior thighs

Spondylolisthesis
SPINAL FRACTURES

- Most common fractures seen in an outpatient setting:
  - Compression / Burst
    - Associated with falls from greater than 6 feet or any fall in a patient with osteoporosis
  - Transverse Process / Spinous Process
  - Odontoid (Dens) & Facet fractures are more common in emergent settings
- Trauma to spine implies injury to any or all anatomical structures: bony elements, soft tissues, and neurological structures

SPINAL FRACTURES

- Instability - loss of normal relationship between anatomic structures with alteration in natural function
- Dislocation – misalignment of normal structure of the anatomic components
- Fracture / dislocations may occur in any region of the spine and are associated with high degree of neurologic injury.
Scoliosis

- Defined as a lateral curvature of the spine
- Adult scoliosis: Idiopathic / Degenerative
  - Idiopathic
    - Continued progression from adolescent
  - Degenerative
    - Onset of scoliosis in previous straight spine
    - Result of asymmetric deterioration of spinal components, caused by spondylosis

Treatment & Education

- Patient Education
- Nonpharmacological
  - Exercise
    - Physical Therapy
    - Aqua Therapy
    - IHEP (Walking, Stretching, Swimming, & Cycling)
  - Massage
  - Heat / Ice
  - Weight Loss **
  - Chiropractic Care
  - Acupuncture
  - TENS

- Pharmacological
  - Acetaminophen
  - NSAIDs
  - Steroids
  - Muscle Relaxants
  - Antineuropathics
  - Antidepressants
  - Pain Medication (non-narcotic & narcotic)
Treatment & Education

- Pain Injections
  - Epidural Steroids
  - Facet Injections
  - Rhizotomy
  - Nerve Blocks
  - IDET

- Bracing
  - Cervical
    - Halo
  - CTO (Cervical-Thoracic)
  - Collars (Hard & Soft)
  - Lumbar
    - Binder (Corslet)
    - Jewett
    - TLSO (Thoracic/Lumbar/Sacral)

Treatment & Education

- Coping Behaviors
  - Adaptive Coping Behaviors
    - Distraction
    - Endurance
  - Behavior Modification
  - Health Seeking Behaviors
    - Smoking Cessation
    - Exercise

References:


