Cervical Spondylosis

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Neurosurgery Half Day
Cervical Spondylosis

- Introduction
- Anatomy
- Pathophysiology
- Clinical Presentation

- Differential Diagnosis
- Diagnosis
- Natural History
- Management
Cervical Spondylosis

- Chronic degenerative changes in the spine, including joints, intervertebral discs, ligaments & connective tissue of cervical vertebrae
- Natural consequence of aging
- Clinical syndromes:
  - Axial Neck Pain (controversial etiology)
  - Radiculopathy (root compression)
  - Myelopathy (cord compression)
  - Combinations
Cervical Spondylosis

- Neck Pain
- Radiculopathy
- Myelopathy
Cervical Spondylosis

- Begin symptomatic at age 40-50
- Men > Women
- C5-6 > C6-7

Risk factors:
- Frequent lifting
- Smoking
- Diving
- Genetic predisposition
CSM

- The most common cause of spinal cord dysfunction in older persons
- Overall prevalence is unknown
- 23.6% of 585 patients with non-traumatic quadriparesis or paraparesis admitted to a UK neuroscience center (Moore 1997)
The most common cause of acquired spastic paraparesis in adults

Clinical presentation varies depending on severity of stenosis & portion of cord involved

From subtle findings for years to acute quadriparesis over hours

Requires high degree of suspicion for diagnosis
Anatomy

- Disc & 4 articulations:
  - 2 facet joints
  - 2 uncovertebral joins (of Luschka)

- Cervical canal diameter: average 17mm
- Spinal cord diameter: average 10mm
- If canal reduced to < 13mm → spinal stenosis
Pathophysiology
Neck Pain Pathophysiology

1. Muscular:
   - Postural, poor ergonomics, stress ± chronic muscle fatigue
   - May be postural adaptation of primary source of pain in shoulder, craniovertebral junction or TMJ
   - Via unencapsulated free nerve endings
2. **Discogenic:**

- Sinuvertebral nerve (recurrent meningeal)
  Bogduk 1988
  - Formed by branches from ventral nerve root & sympathetic plexus
  - Supplies posterior annulus, PLL, periosteum of vertebral body & pedicle
  - Reliable pattern of neck pain with 12 yr experience of discography (Grubb 2000)
Grubb 2000

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Neck Pain Pathophysiology

3. Facet-joint-induced:
   - Dwyer 1990: provocative injections of facet joints at multiple levels different pain patterns
   - Aprill 1990: facet joint blocks relieved the pain

Bogduk 1993:
   - 56 patients with post-traumatic neck pain underwent both discography and facet joint blocks
   - 41% both pathology responsible, 23% only facet joints, 20% only disc, 17% neither
Cascade of spondylotic changes

- Age-related changes in chemical composition of NP & AF → progressive loss of viscoelasticity
- Loss of disc height & bulge posteriorly into the canal
- Vertebral bodies drift toward one another
- Infolding of ligamentum flavum & facet joint capsule → decrease canal & foraminal dimension
- Osteophytes form around disc & at uncovertebral & facet joints
Pathophysiology of Radiculopathy

- Mechanical compression:
  - Herniated disc, osteophytes, thickened soft tissue, foraminal stenosis

- Chronic edema: Cooper 1993
  - Compression → increase permeability of intrinsic blood vessels of nerve root
  - Chronic edema & fibrosis → alter the response to threshold & increase sensitivity

- Dorsal root ganglion:
  - Chemical mediators & florid local response
Radiculopathy
Pathophysiology of Myelopathy

Mechanical:
- Compression: disc, osteophytes, OPLL
- Congenital Stenosis: AP diameter of canal < 13mm

Dynamic:
- Dynamic cord compression: hyperextension narrows the spinal canal by shingling the laminae & buckling the ligamentum flavum
- Dynamic changes of cord morphology (Breig 1966): cord stretches with flexion, shortens & thickens with extension

Vascular
Causes of spinal cord compression in CSM

- Stenosis
- Compensatory Subluxation
- Cervical Kyphosis
- OPLL
5 Categories of CSM
Crandall & Batzdorf 1966

1. Transverse Lesion Syndrome:
   - Corticospinal, spinothalamic & posterior cord tracts involved with equal severity
   - Longest duration of symptoms, ? end stage

2. Motor System Syndrome:
   - Corticospinal tracts & anterior horn cells affected
   - Spasticity
5 Categories of CSM
Crandall & Batzdorf 1966

3. Central Cord Syndrome:
   - Motor & sensory deficits affecting upper extremity > lower

4. Brown-Séquard Syndrome:
   - Ipsilateral motor deficits with contralateral sensory deficits
   - The least advanced form of the disease

5. Brachialgia Cord Syndrome:
   - Radicular pain in the upper extremity with motor ± sensory long tract signs
CSM Syndromes
Ferguson & Caplan 1985

1. **Medial Syndrome**: long tract symptoms
2. **Lateral Syndrome**: radicular symptoms
3. **Combined**: medical & lateral, most common
4. **Vascular Syndrome**: rapidly progressive, vascular insufficiency of the cord
Clinical Presentation
Signs & Symptoms of CS

- **Neck Pain:**
  - Insidious neck pain, exacerbated by excess motion
  - Occipital headache
  - No neurologic signs or symptoms

- **Radiculopathy:**
  - One or multiple roots
  - Neck, shoulder ± arm pain, paresthesias & numbness
  - Physical Examination: Motor, Sensory & Reflexes (LMNLs)
  - Overlap of findings b/c intraneural intersegmental connections of sensory nerve roots
## Findings in Nerve Root Compression

<table>
<thead>
<tr>
<th>Level</th>
<th>Root</th>
<th>Muscles Affected</th>
<th>Sensory Loss</th>
<th>Reflex</th>
</tr>
</thead>
<tbody>
<tr>
<td>C3-4</td>
<td>C4</td>
<td>Scapular</td>
<td>Lateral neck, Shoulder</td>
<td>None</td>
</tr>
<tr>
<td>C4-5</td>
<td>C5</td>
<td>Deltoid, Biceps (variable)</td>
<td>Lateral arm</td>
<td>Biceps (variable)</td>
</tr>
<tr>
<td>C5-6</td>
<td>C6</td>
<td>Biceps, ECRL &amp; ECRB, Triceps (supination)</td>
<td>Lateral forearm, thumb &amp; index</td>
<td>Biceps Brachioradialis</td>
</tr>
<tr>
<td>C6-7</td>
<td>C7</td>
<td>Triceps, Wrist flexors (FCR)</td>
<td>Middle finger</td>
<td>Triceps</td>
</tr>
<tr>
<td>C7-8</td>
<td>C8</td>
<td>Interossei, Finger flexors (variable)</td>
<td>Ulnar hand</td>
<td>None</td>
</tr>
<tr>
<td>C8-T1</td>
<td>T1</td>
<td>Interossei</td>
<td>Ulnar forearm</td>
<td>None</td>
</tr>
</tbody>
</table>

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Differential Diagnosis of Radiculopathy

- Peripheral Entrapment Syndrome (may coexist)
- Rotator cuff/shoulder pathology
- Brachial plexitis
- Herpes Zoster
- Thoracic outlet syndrome
- Tumor
- Cardiac ischemia
Symptoms: variable level & extent of involvement
- Weakness (upper > lower extremity)
- ↓ manual dexterity
- Ataxic broad-based gait, difficulty walking
- Sensory changes
- Spasticity
- Urinary retention
Nurick Classification of Disability from CSM 1972

Grade I: No difficulty in walking
Grade II: Mild gait involvement not interfering with employment
Grade III: Gait abnormality preventing employment
Grade IV: Able to walk only with assistance
Grade V: Chair bound or bedridden
Clinical Presentation of Myelopathy

**Signs:**
- Extent of cord ± root involvement
- Upper motor neuron lesion signs below level of cord pathology: Hyperreflexia, Hoffmann’s sign, inverted radial reflex, clonus, Babinski’s sign, spasticity
- Lower Motor Neuron Lesion Signs (coexisting radiculopathy) at level of root pathology
- Lhermitte’s phenomenon (radiating lightning-like sensation down the back with neck flexion)
“Myelopathy Hand”
Ono 1987

- **Finger-escape Sign:**
  - When asked to fully extend the digits with the palm facing down, the ulnar digits drift into abduction & flexion

- **Grip-and-release Sign:**
  - Weakness & spasticity of the hand result in a decreased ability to rapidly open & close the fist
Spondylotic degeneration can give rise to concurrent stenosis of the lumbar and cervical portions of the spinal canal in tandem

Triad:
- intermittent neurogenic claudication
- progressive gait disturbance
- findings of mixed myelopathy and polyradiculopathy in both the upper and lower extremities
Differential Diagnosis of CSM

- Peripheral Neuropathy
- Motor Neuron Disease
- Amyotrophic Lateral Sclerosis
- Multiple Sclerosis
- CVA
- Syringomyelia
- Tumors: intrinsic spinal cord or extrinsic metastatic
Diagnosis
Diagnosis of CS

- Signs & Symptoms
- Radiography:
  - Plain X-ray:
  - CT
  - MRI
  - CT Myelogram
  - Discography
- Electrodiagnostic Studies: EMG, NCV, SSEPs
Plain X-ray

- AP, Lateral, Oblique (Flex-Ex if suspect instability)
- Abnormalities of alignment (spondylolisthesis), spontaneous fusion, osteophyte formation, overall bone quality
- Do not visualize the neural elements directly or indirectly
- Direct measures of canal size from plain radiography not reliable
- **Pavlov’s Ratio** = AP diameter of spinal canal / AP diameter of vertebral body
  - Normal >1
  - < 0.8 → absolute stenosis
If diameter < 13mm →
Cervical spinal stenosis

X-ray measurement represents 20-30% magnification

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Spondylosis Index = DSSD - SSSD

DSSD: Developmental Segmental Sagittal Diameter
SSSD: Spondylotic Segmental Sagittal Diameter
MRI

Advantages:
- No radiation
- Non-invasiveness
- Ability to directly visualize in multiple planes, including sagittal
- Excellent resolution of disk and neural elements
- Ability to visualize intrinsic changes in the cord and disk
- Ability to detect prevertebral edema suggestive of acute trauma
MRI

- Disadvantages:
  - Expense
  - Limited visualization of neural foramen
  - Inability to distinguish between soft and hard disk pathology or OPLL
  - High incidence of major abnormalities in asymptomatic patients
MRI

- AP compression ratio (Ono 1977)
  - AP diameter of cord / transverse diameter x 100
  - If < 0.4 → worse neurologic function
Myelography

- Demonstrates neural compressive pathology indirectly through dural sac contour
- Invasive and not very specific:
  - Central compression may represent an osteophyte or a soft disk herniation
  - Sleeve cut-off may represent foraminal narrowing or a lateral disc
- 70-90% accurate.
CT-Myelography

- Combination CT and myelography yields more information than either alone
- Direct visualization of neural compression
- Better visualization of lateral pathology
- Differentiation of soft from hard disk and OPLL
Natural History
Natural History

- DePalma 1972:
  - Patients with axial symptoms from cervical spondylosis after 3 mo of non-operative care:
    - 21% complete relief, 49% partial relief, 22% no relief

- Rothman & Rashbaum 1978: similar group
  - 23% of patients remained partially or totally disabled by end of 5 yr
  - No difference between operative & non-operative treatment for axial neck pain
Natural History of CSM

- Current literature does not allow prediction of course

Clark & Robinson 1956:
- Once myelopathy is recognized, complete remission never occurs
- Spontaneous regression of neurologic deficits is unusual
- 75% had progressive myelopathy: 2/3 ongoing deterioration, 1/3 stabilized
**Natural History of CSM**

- **Symon & Lavender 1967**: >60% steady progressive deterioration, 18% improved.

- **Kumar 1999**: 18% of patients with CSM will improve spontaneously, 40% will stabilize & 40% will deteriorate if no treatment is given.
Management
Neck Pain Management

Non-operative:
- NSAIDs
- Soft collar
- Physiotherapy: traction, heat & ultrasound
- Activity modification: avoid extension & heavy lifting
- Epidural steroid injection: controversial

Operative: not recommended
- Whitecloud & Seago 1987: 70% good-to-excellent results from anterior interbody fusion for patients with concordant neck pain on discography
- Conor & Darden 1993: 84% of patients positive discography; 13% complications including quadriplegia; 46% good-to-excellent
Decision Making

1. Which neurologic structure is compromised?
2. What is the source of compression?
3. What is the direction of compression?
4. How many levels are involved?
5. What is the cervical alignment?
6. Are there coexisting segmental instability?
7. Prior cervical spine or head & neck surgery or radiation?
8. Any medical comorbidities?
Cervical Radiculopathy Management

- **Non-operative:**
  - Same as for axial neck pain

- **Indications for surgery:**
  - Failure of a 3-month trial of non-operative treatment to relieve persistent or recurrent radicular arm pain with or without neurologic deficit
  - Progressive neurologic deficit
Surgical Options for Radiculopathy

- **Anterior Decompression:**
  - Anterior cervical discectomy (ACD) ± interbody fusion (ACDF)
  - Anterior corpectomy with fusion (ACF)

- **Posterior Decompression:**
  - Posterior laminoforaminotomy
  - Laminectomy ± fusion
  - Laminoplasty

- **Combined**
Surgical Options for Cervical Radiculopathy

- **ACDF:**
  - Radiculopathy with significant degenerative neck pain
  - Bilateral radiculopathy
  - Presence of localized kyphosis
  - Anterior plating recommended for 3 levels, or 2 levels with high risk of nonunion

- **ACF:**
  - Alternative to 2 levels ACDF
  - Posterolateral soft disc herniation at 2 levels
  - Spondylotic radiculopathy at 2 levels
  - Migrated (sequestered) disc fragment behind vertebral body
Surgical Options for Cervical Radiculopathy

- **Posterior laminotomy/foraminotomy:**
  - Unilateral radiculopathy w/o significant neck pain
  - Absence of localized kyphosis
  - C7-T1 level in short neck patients

- **Laminectomy:**
  - Multiple-level radiculopathy
  - Bilateral radiculopathy at multiple levels
  - Maintenance of cervical lordosis
  - Absence of significant neck pain
  - Ankylosed or stiff neck
Surgical Options for Cervical Radiculopathy

- Laminoplasty:
  - Unilateral, multilevel radiculopathy
  - Congenital cervical stenosis
  - Maintenance of cervical lordosis
  - Absence of significant neck pain
ACDF

- Robinson:
  - Tricortical iliac crest wedge graft
    - Donor site morbidity
  - Freeze-dried tricortical iliac crest allograft
    - Zdeblick & Ducker 1991: allograft has more non-union & more collapse, but similar clinical result

- Simmons:
  - Rectangular iliac crest contoured to match the beveled surface of vertebral bodies

- Others:
  - Cloward and Bailey & Badgley: no direct nerve root decompression, seldom used
ACD

- Chestnut 1992: The presence of fusion following discectomy has not been uniformly correlated with a favorable clinical outcome, nor has nonunion consistently resulted in a clinical failure.
- Pseudoarthrosis may be associated with a good clinical result led to the concept of ACD.

**Advantage:**
- Lack of donor site morbidity

**Disadvantages:**
- Postoperative neck pain > ACDF
- Post-discectomy collapse & angular kyphosis → recurrent nerve root compression (so bilateral foraminotomy is a must)
- Avoid in patients with evidence of spondylosis who requires distraction

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ACF

- Necessary if a sequestered fragment has migrated behind the vertebral body
- Preferred over two-level ACDF, because less surfaces that must fuse
- Consider anterior cervical plate ± rigid external orthosis to maintain stability postoperatively
Laminoforaminotomy

- Remove no more than 50% of the facet to prevent iatrogenic instability
Laminectomy

- An option for multilevel spondylotic radiculopathy with anterior bony ankylosis when cervical lordosis has been preserved.
- Risk of subsequent subluxation & kyphotic deformity → consider primary fusion
Laminoplasty
Combined Anterior & Posterior

- Patients with advanced osteopenia (three or more level & slow fusion)
- Impaired healing potential (RA, renal failure, transplant)
- Excessive use of tobacco or nicotine products
- Anticipated inability to comply with postoperative restrictions (e.g., psychopathology, movement disorder)
Management of Cervical Myelopathy

++ controversy, natural history is not well known

Close Observation & Follow Up:
- e.g., a patient with mild, non-progressive, long-standing myelopathy that does not cause significant disability

Indications for surgery:
- Progressive myelopathy
- Moderate or severe myelopathy that is stable & short duration (< 1 yr)
- Mild myelopathy that affects routine activities of daily living

Goal of surgery: to prevent neurological worsening independent of age or severity

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Anterior vs. Posterior

Factors:

- Site of compression
- Presence or absence of spinal stability
- Sagittal alignment of the cervical spine
- Extent of the disease process
Scenarios

- Anterior compression of spinal cord limited to intervertebral disc space w/o intervening stenosis of canal at the vertebral body level → ACDF
- If multiple levels involved → ACF
- Compressive pathology at disc level & posterior to vertebral body → ACF
- If kyphosis presents → ACF
- If kyphosis accompanied by significant subluxation → combined anterior & posterior
- Spondylosic spurring & spinal stenosis over several segments → posterior approach
- If compression ratio < 0.5 (sagittal diameter/transverse diameter of spinal cord) → posterior
Surgical Options for Cervical Myelopathy

ACDF:
- Myelopathy with one- (or more) level disease due to disc herniation
- Anterior plating recommended for multilevel cases

ACF:
- Myelopathy due to disc or osteophyte posterior to the vertebral body at multiple levels
- Loss of cervical lordosis
- Presence of significant neck pain
Surgical Options for Cervical Myelopathy

- **Laminectomy:**
  - Cord compression at 3 or more levels
  - Maintenance of cervical lordosis
  - Ankylosed, stiff spine
  - Absence of significant neck pain
  - Concomitant fusion recommended if there is vertebral subluxation or instability, or significant neck pain
Surgical Options for Cervical Myelopathy

- Laminoplasty:
  - Continuous OPLL at multiple levels
  - Congenital cervical stenosis
  - Maintenance of cervical lordosis
  - Absence of significant neck pain
Spinal Instrumentation

- The role in radiculopathy & myelopathy is less clear than in traumatic conditions.
- In spondylosis, nonunion rate & graft dislodgement increase with the number of levels operated on.

**Goals of instrumentation:**
- Provide immediate stability.
- Increase fusion rate (not documented in spondylosis).
- **Prevent loss of fixation of the bone graft**.
- Improve postoperative rehabilitation.
- Avoid requirements for an external orthosis.
Buttress or kick plate

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Advantages

**Anterior**
- Direct decompression
- Stabilization with fusion
- Correction of deformity
- Axial lengthening of spinal column
- Good axial pain relief

**Posterior**
- Less loss of motion
- Not as technically demanding
- Less bracing needed
- Avoids graft complications
Disadvantages

**Anterior**
- Technically demanding
- Graft complications
- Need postop bracing
- Loss of motion
- Adjacent segment disease

**Posterior**
- Indirect decompression
- Preoperative kyphosis limitations
- Inconsistent axial pain results
- Late instability
Complications

- **Approach-related:**
  - Anterior: recurrent laryngeal nerve stretching, dysphagia, upper airway compromise
  - Posterior: axial neck pain, late instability

- **Decompression-related:**
  - Injury of spinal cord or nerve root, vertebral artery

- **Graft-related:**
  - Graft donor site morbidity: pain, hematoma, fracture, nerve injury
  - Graft: dislodgement, fracture, severe settling

- **Long-term**
  - Anterior: pseudoarthrosis, adjacent-segment disease
  - Posterior: postlaminectomy kyphosis, swan-neck deformity, instability
Complications of Anterior Approach

- **Vocal Cord Paralysis:**
  - Right vs. Left: Beutler 2001 – no difference
  - Apfelbaum 2000: retractor displaces the larynx against the shaft of the ET, allowing impingement on the vulnerable intralaryngeal segment of the RLN
    - Recommend: monitoring ET cuff pressure and release of pressure after retractor replacement or repositioning was used, which allowed the ET to recenter within the larynx

- **Injury to internal branch of Superior Laryngeal Nerve:**
  - Retraction or accidental ligation
Bottom Line
CS is disease of controversy

Anterior vs. Posterior vs. Combined

Discectomy vs. Corpectomy vs. Foraminotomy

Foraminotomy vs. Laminectomy vs. Laminoplasty

Allograft vs. Autograft vs. Cage vs. Artificial Disc

Instrument or not?

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