# Spine

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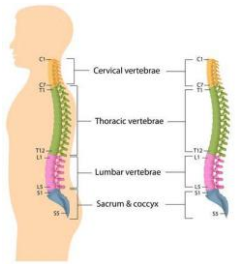
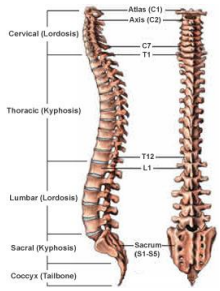
## Spinal Anatomy

- Spinal Column
  - 33 vertebrae, interlocking
  - Upper 24 moveable
    - Cervical, Thoracic, Lumbar
  - Lower 9 fused
    - Sacrum, coccyx immobile



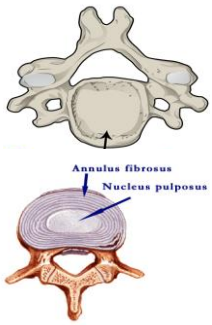

## Spinal Column

- S shaped curve when viewed from the side
  - Cervical and lumbar lordosis
  - Thoracic kyphosis
- Curvatures work like a coiled spring
  - Shock absorption, maintain balance and provide ROM



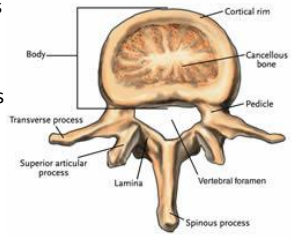
## Vertebral Body

- Anterior portion is solid
  - Cancellous interior bone covered by cortical bone
  - Endplates on either side of the body function to contain the discs and spread weight evenly
- Intervertebral discs
  - Annulus fibrosus-strong sheets of collagen fibers
  - Nucleus pulposus-loose fibers



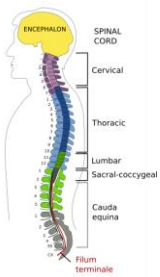

## Vertebral Arch

- Paired lateral pedicles
- Paired transverse processes
- One posterior spinous process
- Bilateral laminae
- Articulating Facets
- Vertebral foramen



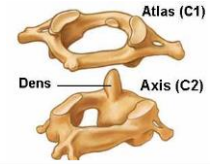

## Spinal Canal

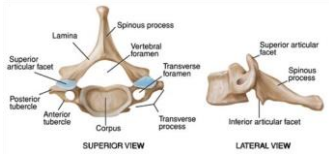
- Central canal protects spinal cord
- The spinal cord extends from the base of the medulla to the conus medullaris
- Below the conus medullaris is the filum terminale, a continuation of the meninges



## Cervical Vertebrae

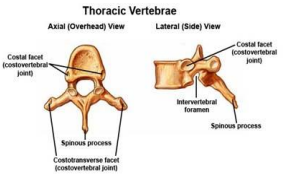
- 7 vertebrae
  - C1 –atlas
  - C2-axis
  - Odontoid process/dens (C2)
- Transverse foramen
  - Vertebral artery
  - Veins
  - Sympathetic nerves



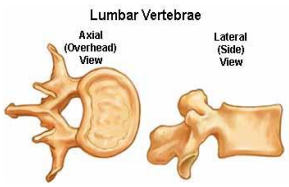

## Thoracic Vertebrae

- 12 Vertebrae
  - Intermediate in size compared to cervical and lumbar
  - Increase in size from T1-T12
  - Facets on either side of the body articulate with the head of the ribs, facets on the transverse processes articulate with the tubercles of the ribs (except T11 and T12)
  - Spinous processes are projected downwards and overlap T5-T8



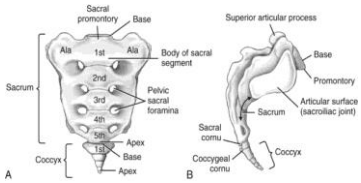

## Lumbar Vertebrae

- 5 vertebrae
  - Largest segments of the vertebral column
  - Support the weight of the body and allow movement



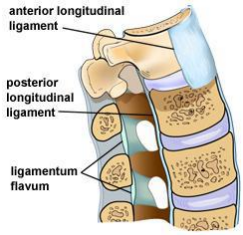
## Sacral and Coccygeal Vertebrae

- Sacrum-5 fused vertebrae
- Coccyx-4 fused vertebrae
  - AKA "tailbone"




## Ligaments

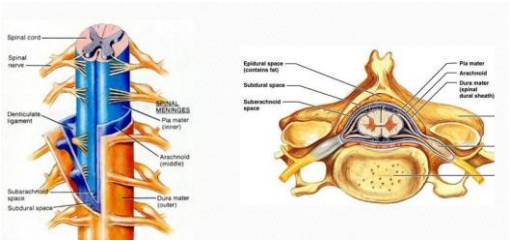
- Anterior longitudinal
  - Anterior to the vertebral bodies
- Posterior longitudinal
  - Posterior to the vertebral bodies
  - Thins as it descends
- Ligamentum flavum
  - Attaches between the lamina of each vertebral body
  - Thinner in the cervical region, thickest in lumbar region




## Meninges

- Dura mater
  - Continuous with the cranial dura down to S2
  - Epidural and subdural spaces
- Arachnoid
  - Continuous with the cranial arachnoid; extends to S2
  - Surrounds nerve roots and root filaments
  - Subarachnoid space and lumbar cistern
- Pia mater
  - Thicker and firmer; contains vasculature
  - Dual layers
  - Filum terminale
  - Dentate ligament

## Meninges



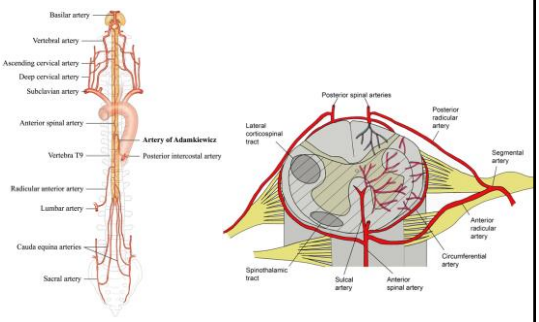

## Arterial Vasculature

- Anterior spinal artery
  - Formed by union of the bilateral vertebral arteries
  - Runs along the ventral surface of the cervical spinal cord, narrows near T4
  - Supplies 2/3 of the cord
- Posterior spinal arteries
  - Paired, much smaller
  - Branch at multiple levels to form the posterolateral plexus
  - Supply the dorsal white columns and the posterior portion of the dorsal gray columns

## Arterial Vasculature

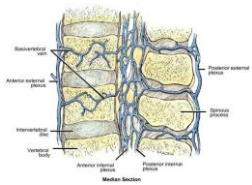
- Radicular arteries
  - Supplied by some of the intercostal arteries from the aorta
  - Branches supply the spinal cord from T1-L1
- Great ventral radicular artery (artery of Adamkiewicz)
  - Largest of the radicular arteries
  - T8-L4
  - Arterial supply for the lower half of the spinal cord
  - Occlusion rare, but can cause severe neurologic deficits (paraplegia, loss of sensation of LE, urinary incontinence)

## Arterial supply

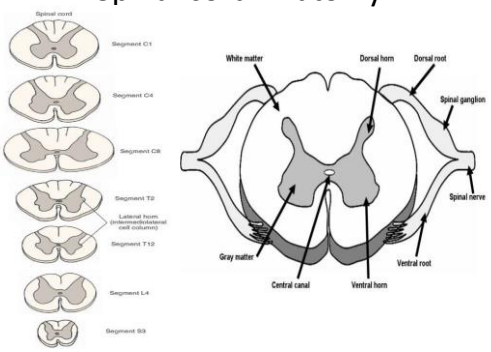



## Venous Vasculature

- Venous drainage via external venous plexus and internal venous plexus
  - Both lie in epidural space
  - Extends the length of the spinal cord
  - Ultimately drains into the vena cava




## Spinal cord Anatomy

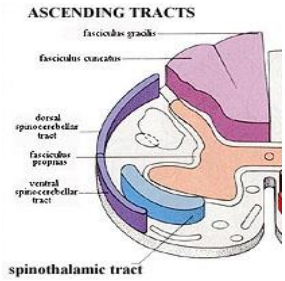


## Spinal Cord

- White matter
  - Made from myelinated and demyelinated nerve fibers
  - Surrounds the gray matter and the central canal
  - Each half divided into columns (large bundles) containing ascending and descending tracts
- Gray matter
  - H-shaped, unmyelinated
  - Divided into horns containing motor and sensory cell bodies
  - Varies in shape depending on level
  - More gray matter located in cervical and lumbar levels

## Ascending tracts

- Provide pathway from the environment to the CNS
- Primarily sensory tracts
- Posterior dorsal columns and anterior columns

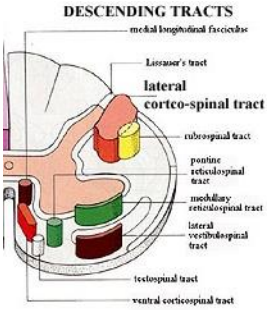



## Ascending Tracts

- Dorsal columns
  - Do not cross
  - Located posteriorly
  - Fasciculus gracilis carries impulses from LE
  - Fasciculus cuneatus carries impulses from the UE
- Functions
  - Pressure, deep pain, vibration and two point discrimination
- Anterior columns
  - Spinothalamic
  - Cross at one or two segments above entry into cord
- Functions
  - Pain, temperature and light touch

## Descending Tracts

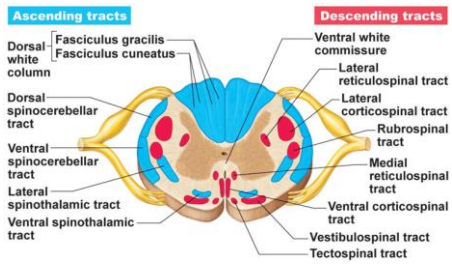
- Conduct motor information from the CNS




## Descending Tracts

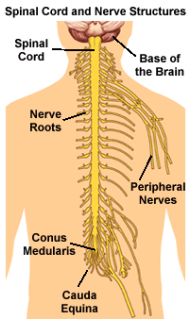
- Corticospinal (pyramidal tract)
  - Crosses in the medulla, receives information from the basal ganglion and cerebellum
  - Voluntary movement, fine motor control and coordination
- Rubrospinal
  - Arises in the red nucleus of the midbrain
  - Motor innervation of muscles
- Tectospinal
  - Arises in the tectum of the posterior midbrain
  - Turns head in response to sudden auditory or visual stimulus
- Vestibulospinal
  - Arises in the vestibular nucleus
  - Provides balance and rapid response to changes in body position, antigravity muscle coordination and excites extensor muscles
- Reticulospinal
  - Arises in the reticular formation of the brainstem
  - Modifies pain sensation

## Ascending and Descending Tracts



## Spinal Nerve Roots

- 31 pairs of nerves arising from the spinal cord
  - 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal
- Conus medullaris
  - Tapered lower end of the spinal cord, beginning at L1
- Cauda Equina
  - Bundle of spinal nerves, L2-S5, coccygeal nerve

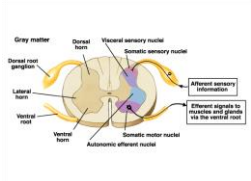



## Spinal Nerve Roots

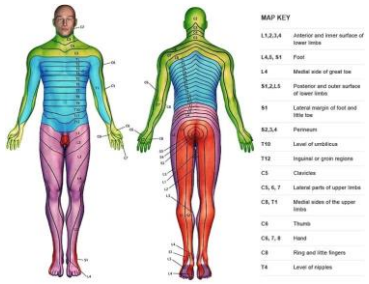
- Somewhat named for corresponding bony level
  - Cervical nerves exit ABOVE the level for which they are named, except for C8 (C8 exits between C7 and T1)
  - Lumbar nerves exit BELOW the level for which they are named


## Spinal Nerve Roots

- Ventral root
  - Anterior, Efferent, Motor
  - Transmits to skeletal muscle
  - Exits via the anterior horn
- Dorsal Root
  - Posterior, Afferent, Sensory
  - Transmits to the CNS
  - Enters via the posterior dorsal horn



## Dermatomes




## Myotomes of the Upper Extremity

| Level | Motor | Reflex | Sensory |
|---|---|---|---|
| C5 | Shoulder abduction | Bicep tendon | Lateral upper arm |
| C6 | Elbow flexion, Wrist extension | Brachioradialis | Radial forearm, thumb, index finger |
| C7 | Elbow extension, Wrist flexion | Triceps tendon | Middle finger (may have some C6 and C8) |
| C8 | Finger flexion (grip) | None | Ulnar forearm, ring and little finger |
| T1 | Finger abduction | None | Upper medial forearm and medial arm |

## Myotomes of the Lower Extremities

| Level | Motor | Reflex | Sensory |
|---|---|---|---|
| L2 | Hip flexor | None | Anterio-medial thigh |
| L3 | Leg/knee extension | None | Mid-thigh around the knee |
| L4 | Dorsiflexion and Inversion of foot | Patellar tendon | Medial foot |
| L5 | Great toe extension | None | Dorsal foot |
| S1 | Foot eversion | Achilles tendon | Lateral foot |
| S 2,3,4 | External bladder sphincter (bladder control) | Bulbocavernous | Perianal area |

## Motor Disturbances

- Lower motor neuron
  - Weakness
  - Flaccid paralysis of the involved muscles
  - Decreased tone
  - Muscle atrophy
  - Muscle fasciculations
  - Reflexes diminished or absent
- Upper motor neuron
  - Weakness
  - Spastic paralysis
  - Increased tone
  - Little to no atrophy (from disuse) or fasciculations
  - Hyperactive or abnormal reflexes (Babinski's), clonus

## Lower vs Upper MND

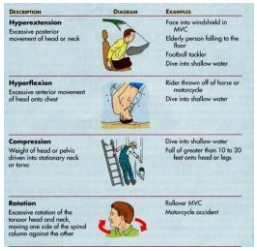
| Symptoms | Lower motor neuron | Upper motor neuron |
|---|---|---|
| Weakness | Yes | Yes |
| Atrophy | Yes | Rare, atrophy of disuse |
| Reflexes | Hypoactive or absent | Hyperactive (spastic) |
| Muscle Tone | Hypotonic (flaccid) | Hypertonic (spastic) |
| Abnormal Movements | Fasciculations | Babinski's response |

## Spinal Cord Injury

- Compression, tearing, laceration or ischemia of the spinal cord
  - Can cause temporary or permanent loss of sensory, motor or autonomic function
  - Can be worsened by edema or hemorrhage of the cord
- Contributing factors
  - Vehicular (including motorcycle, bicycles and ATVs) 42%
  - Falls 21%
    - Most common cause in those >60 years old
  - Acts of violence (GSW) 17%
  - Sports-related 10%

## Mechanisms of Injury

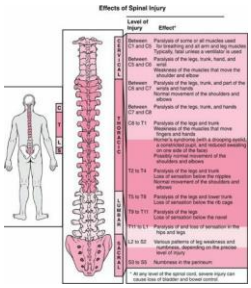
- Hyperflexion
- Rotational
- Hyperextension
- Vertical compression
- Penetrating injury
- Soft tissue injury involving ligaments or muscles
- Vertebral injury




## Vertebral Injury

- Simple fractures
  - Single column, break in the spinous processes, transverse process, pedicle or facets. Neurologic compromise rare.
- Compression fractures
  - Causes flattening or wedging of the vertebral bodies.
- Teardrop fractures
  - Small bone chips , unstable fractures resulting from hyperflexion.
- Atlas Fractures
  - Involve disruption in the anterior and posterior arch of C1.
- Axis fractures (Odontoid/Dens)
  - Occur after extreme flexion, extension or rotation; rarely associated with SCI. Typed 1-3
  - Hangman's fractures involve bilateral pedicles of C2; neurologic compromise is rare
- Fracture dislocations
  - Typically involve the facets, variable degrees of neurologic compromise, unstable
- Subluxation
  - Rotary subluxation by abnormal rotation of C1-C2 complex
  - May also involve facet misalignment without bony fracture, only ligamentous changes; "perched facets"

## Levels of Injury



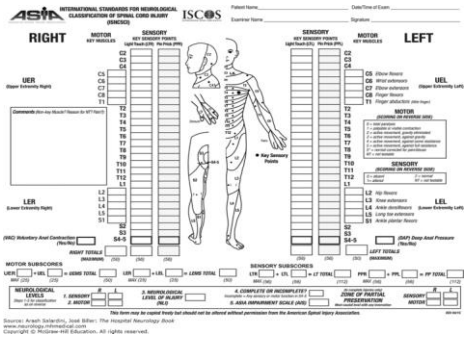
## Classification of SCI

- Complete
  - Result in loss of all voluntary motor and sensory function below the level of injury
- Incomplete
  - Allow some motor or sensory transmission through the level of injury; some motor tracts remain intact and functional through the area of injury
- Sacral sparing
  - Aids in determining complete vs incomplete
  - Refers to motor/sensory function at the most caudal sacral segments on exam.
    - Complete injury no sacral sparing (motor and sensory) at S4-5
    - Incomplete injury some sacral sparing (motor and sensory) at S4-5

## ASIA Impairment Scale

- ASIA A-Complete; no motor or sensory at S4-5
- ASIA B- Sensory incomplete; sensory but no motor at S4-5
- ASIA C-Motor incomplete; motor function preserved below level of injury; less than ½ key muscles graded 3 or higher below the level of injury
- ASIA D-Motor incomplete; motor function preserved below level of injury; at least ½ of key muscles graded 3 or higher below the level of injury
- ASIA E-SCI has occurred, but sensory and motor function are normal

## ISNCSCI



## Pathophysiology of SCI

- Primary injury-mechanisms of injury cause immediate destruction of neurons and supporting glial cells, damage vasculature, and interrupt ascending/descending tracts. This damage often leads to hemorrhage and cell death which then creates an ischemic environment and triggers a cascade of intracellular events (secondary injury).

## Secondary Injury

- Decreased spinal cord perfusion
- Electrolyte shifts
- Excitatory amino acids
- Inflammatory processes
- Resulting damage

## Secondary Injury

- Spinal shock
  - Primary injury to the cord causes a state of areflexia at and below the level of injury
    - Flaccid paralysis
    - Areflexia
    - Absence of sensation
    - Thermoregulatory disturbances
    - Loss of autonomic function
    - Bowel and bladder dysfunction
  - Four phases: areflexia, initial reflex return, early hyperreflexia, spasticity

## Secondary Injury

- Neurogenic shock
  - Manifests as bradycardia, severe hypotension and hypothermia due to autonomic dysfunction
  - Interruption of the normal sympathetic response causes unopposed vagal tone and bradycardia, decreased PVR and cardiac output, but typically normal CVP.
  - Severity of neurogenic shock correlates to the severity of SCI.

## Aftermath of SCI

- Paralysis
- Loss of touch sensation
- Loss of sexual function
- Loss of voluntary bowel and bladder function (neurogenic bowel/bladder)
- Loss of body temperature regulation; decreased hot/cold sensation
- Cardiovascular risks (bradycardia, hypotension, DVTs)
- Respiratory/breathing difficulties (PE, pneumonia, atelectasis, sleep apnea)
- GI system compromise (ileus, gastric erosion/ulcers, fiber and fluid intake, constipation)
- Neuropathic pain
- Psychologic disorders (depression, anxiety, suicidal ideation)
- Pressure ulcers
- Muscle spasm/spasticity/contractures

## Nursing Implications

| Body System | Potential Problem | Nursing Intervention |
|---|---|---|
| Cardiovascular | • Acute hypotension | • Maintain MAP >85 for first 7 days after injury |
| | • Bradycardia | • Monitor HR<br>• Administer medications for symptomatic bradycardia, as ordered |
| | • Poikilothermia | • Maintain normothermia |
| | • DVT | • Minimize risk<br>• Initiate prophylaxis |
| | • Orthostatic hypotension | • Monitor for orthostatic hypotension |
| | • Autonomic dysreflexia | • Monitor for signs/symptoms of AD |

| Body System | Potential Problem | Nursing Intervention |
|---|---|---|
| Respiratory | Respiratory insufficiency, failure or both | • Monitor respirations for signs of fatigue and impending failure<br>• Provide pulmonary toileting<br>• Administer bronchodilators, as ordered |
| GI | • Urinary retention | • Decompress bladder via indwelling catheter, as ordered<br>• Initiate intermittent straight catheterization protocol when appropriate |
| GU | • Ileus | • Monitor for abdominal distention |
| | • Constipation | • Maintain bowel elimination<br>• Fiber and hydration |

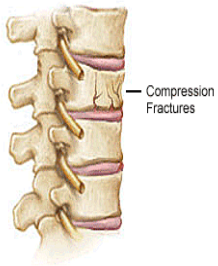
| Body System | Potential Problem | Nursing Intervention |
|---|---|---|
| Musculoskeletal | • Contractures | • Provide frequent ROM exercises<br>• Administer antispasmodics, as ordered |
| Dermatologic | • Skin Breakdown | • Perform meticulous skin care, inspecting under braces, splints, orthotics<br>• Reposition every 2 hours while in bed<br>• Shift weight every 30 minutes when OOB in upright chair |

## Pain

- Acute and chronic pain common in SCI patients
- Musculoskeletal
  - "Dull, aching"; responds to anti-inflammatory or opioid medications
- Visceral
  - Typically located in the abdominal, thoracic or pelvic regions; "cramping, dull, tenderness"
- Neuropathic
  - "Burning, sharp, shooting"; often associated with abnormal sensation; can occur at (within 3 dermatomes) or below (more than 3 dermatomes) the level of injury

## Vertebral Compression Fractures

- Result from bone weakened by osteoporosis, trauma, tumors/hemangiomas




## Vertebral Compression Fractures

## Osteoporosis

- Osteoporosis accounts for the majority of vertebral compression fractures.
  - Men 5% lifetime risk vs Women 15%
  - Bilateral oophorectomy, DM, emphysema, asthma, cirrhosis, CKD, RA, parathyroid tumors, hyperparathyroidism, hyperthyroidism, vit. D deficiency
  - Advanced age
  - Early/premature menopause or 5 years postmenopausal without HRT
- Medications
  - Steroids, AEDs, cytotoxic therapy (methotrexate), cyclosporine, excessive thyroxine, prolonged heparin, lithium
- Other factors
  - Cigarette smoking, excessive EtOH, poor nutrition, low calcium intake, decreased physical activity, small frame/underweight, Caucasian

## Vertebral Compression Fracture

- Metastatic tumors to the vertebrae can weaken the spine and cause compression/collapse
- Vertebral hemangiomas can also weaken the vertebrae, resulting in collapse
- Trauma directly to the vertebral body
- Predisposing factors can increase the risk in conjunction with a traumatic event
- Majority of vertebral compression fractures happen in the thoracic or lumbar spine and can result in progressive kyphotic deformity

## Clinical Presentation

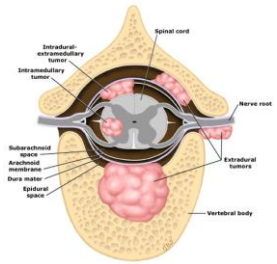
- Sudden onset, debilitating pain
- Myelopathy
  - Neurologic changes secondary to spinal cord compression; lower extremity weakness and paresthesia
- Gait disturbance
- Bowel or bladder dysfunction
- Radiculopathy
  - Neurologic changes secondary to nerve root compression; sharp, stabbing, burning pain in a dermatomal distribution

## Treatment Considerations

- Early mobilization (if stable), analgesics, muscle relaxants, Gabapentin/Lyrica/TCAs for radicular pain, heat/ice, Lidocaine patches, bracing
- Surgical intervention to decompress the spinal cord (kyphoplasty, vertebroplasty if no SC compression)
- Encourage smoking cessation as nicotine can delay bony healing
- Weight bearing activity is encouraged, however, high impact activities or activities that place excessive strain (bending, lifting, twisting) should be avoided

## Spinal Cord Tumors

- Primary: astrocytoma, ependymoma, meningioma
- Neurofibroma
- Metastatic




## Spinal Cord Tumors

- Abnormal tissue within the spinal cord, between the meninges and spinal cord or in the epidural space.
- 1/10 as common as brain tumors
- 60% are benign in adults
- Gliomas and sarcomas more common in children
- Thoracic 50%, Lumbar 25%, Cervical 20%, Cauda equina 5% (correlates with the amount of cord tissue)
- 10-30% of cancer patients will develop a metastasis from breast, lung, prostate and non-Hodgkin lymphoma

## Classification

- Extradural
  - Occur outside the spinal cord in the epidural space
  - Can develop in the vertebral bodies causing spinal cord compression
  - Can develop from the dura
  - Meningioma, metastatic
- Intradural
  - Occur within or under the spinal dura or meninges
  - Extramedullary occur outside the spinal cord, but still within the dura
    - Schwannoma, Neurofibroma, Meningioma
  - Intramedullary occur within the spinal cord
    - Astrocytoma, ependymoma

## Astrocytoma

- Intramedullary, occurring within the cord itself
- Well differentiated, graded similarly to brain astrocytomas (I-IV); grade can increase over time
- Higher incidence in men
- 50% have cystic component
- Unilateral or bilateral paresis, bowel/bladder dysfunction, sensory level
- Treatment
  - Surgical aspiration of cystic component, debulking/resection
  - Radiation
  - Role of chemotherapy not clearly defined

## Ependymoma

- Also intramedullary, accounts for 20% of all cord tumors
- Commonly found in the cauda equina (lumbar, sacral, conus medullaris and filum terminale)
- Rarely malignant; graded I-IV, grade may increase over time (if malignant can spread to other spinal or cranial areas)
- Pain, weakness, bowel/bladder dysfunction, radicular pain
- Treatment
  - Surgical resection if possible, otherwise radiation and possible chemotherapy

## Meningioma

- Can be extradural or Intradural extramedullary
- Tumor is benign
- Over half occur in the thoracic spine
- Women between 40 and 60 years old comprise 80% of incidence
- Can be highly vascular
- Symptoms depend on size and level of lesion
- Treatment
  - Surgical resection, steroids to reduce inflammation and limit neurologic deficit

## Neurofibroma

- Benign tumor of the supportive tissue in peripheral nerves; slow growing, progressing over years; can undergo malignant transformation, however
- Associated with Neurofibromatosis type 1 and 2
- Treatment can be conservative with pain management and, in asymptomatic patients without neurologic deficits, serial physical exams and contrasted MRIs to assess for growth
- Surgical treatment indicated when the tumor causes neurologic compromise or is growing larger; biopsy indicated in cases of rapid growth to rule out malignant conversion

## Metastatic Spinal Tumors

- Approximately 20% of patients with cancer will develop spinal metastases
- In 10% of cancer patients the initial symptom is related to spinal metastasis (typically from breast, lung, prostate, renal cell or GI cancer)
- Can develop spinal cord compression due to vertebral bony metastasis
- Amount of vascularity coincides with development of metastatic disease
- Most patients present with pain or neurologic compromise

## Metastatic Spinal Tumors

- Complete thorough H&P, MRI with contrast
- Surgery indicated for progressive neurologic deficits to restore or prevent neurologic compromise, to relieve pain, to stabilize the spine or to correct a spinal deformity
- Radiation and stereotactic radiosurgery can provide pain relief in many patients
- Survival rates dependent on primary pathology
- Involve patients and their families when discussing palliative care or hospice

## Questions?

- AANN Core Curriculum for Neuroscience Nursing is a great resource.
- Study hard, get a good night's sleep, and eat a nutritious breakfast
- Good luck!!