Anatomy and Pathophysiology of the Lumbar Spine

Design Features and Foundational Knowledge

Mechanical Principles

- Provides axial rigidity to the abdominal portion of the trunk
- Separates the thorax from the pelvis
- Enables certain movements between the thorax and the pelvis
- Affords an origin for parts of the abdominal muscles

Rigidity

- Axial rigidity is a cardinal feature
- Allows the human to walk upright
- Rigidity is essential, but mobility is also required
- A single bone would not allow for mobility – similarly neither does spinal fusion

Separation

- The height of the vertebral bodies and the inter vertebral discs provide separation of the thorax and the pelvis
- Without this separation the thorax and pelvis would clash with simple movements

Compression

- Body weight and gravity provide compressive forces on the lumbar spine
- Lumbar vertebrae are designed to withstand axial compression loading
- Trabeculae design adds to strength

Mobility

- Joints provide movement
- Principle joints are between vertebral bodies
- Secondary joints are facet (xygopophyseal) joints
- Cartilaginous joints either side of the vertebral bodies

Intervertebral Disc

- Acts as a shock absorber between each vertebral body
- Cartilaginous outer coat provides strength and rigidity
- Each disc is approximately 10mm in height
- Discs 'shrink' during the day and are replenished at night
- Disc height does not change with age

Ligaments of the Lumbar Spine

- Ligamentum flavum – connects the lower end of the internal surface of one lamina to the upper end of the external surface of the lamina below
- Extensible ligament which stretches when the lumbar spine flexes
- Contains elastin fibers to recoil when extension is regained

Ligaments of the Lumbar Spine

- Intertransverse ligament – connects the transverse processes but are too thin to truly acts as ligaments
- More like a membrane than a ligament

Ligaments of the Lumbar Spine

- Interspinous Ligaments – dorsal portion is ligamentous in nature, the ventral portion constitutes tendinous fibers from the erector spinae.
- Supraspinous Ligament – not a ligament. This is really a collection of tendinous fibers from various muscles. It is lacking below L3

Ligaments of the Lumbar Spine

- Posterior Longitudinal Ligament – covers the floor of the vertebral canal
- Contains short fibers that span consecutive vertebrae
- Contains longer fibers that can span multiple vertebrae

Ligaments of the Lumbar Spine

- Anterior Longitudinal Ligament – covers anterior aspects of the vertebral bodies and discs
- Many fibers are not ligamentous but constitute the prolonged tendons of the crura of the diaphragm

Ligaments of the Lumbar Spine

- Iliolumbar Ligament – strongest ligament attached to the lumbar spine
- Arises from the tip of the and borders of the transverse process of the 5th lumbar vertebrae and passes backwards and laterally to the ilium
- They anchor the 5th lumbar vertebra on the pelvic girdle – prevent it from sliding forward

Facet (Zygopophyseal) Joints

- Designed to block axial rotation and forward sliding of the lumbar vertebrae
- Prevent the discs from excessive torsion
- Joint faces are set in such a way that they prevent excessive motion through bony interfacing

The Sacrum

- Block of bone that supports the lumbar vertebral column
- Transmits forces between the vertebral column and the lower limbs
- Consists of 5 segments that are fused together

Sacroiliac Joint

- The great debate
- Does it move or does it not?
- You will meet those who believe it does and then you will meet me
- Let me taint your opinion on the sacroiliac joint

Sacroiliac Joint

- Mobility of the SI joint - ≤2°
- No muscles act to produce active movement on the SI joint
- SI joint is designed to allow a little flex in the pelvis during ambulation
- Strong ligaments surround it
- Undulations on the articular surfaces interlock the sacrum and the ilium

Ligaments of the SI joint

- Interosseus Sacroiliac ligament – short, thick ligament arising from the sacrum and inserts into opposing area on the ilium
- Tension in this ligament keeps the sacrum and ilium compressed together
- Long and short posterior SI ligaments connect the ilium to the posterior surface of the sacrum

Ligaments of the SI joint

- Anteriorly the capsule is thickened to form the anterior SI ligament
- Prevents the anterior edges of the sacrum and ilium from separating
- Sacrospinous and sacrotuberous ligaments anchor the sacrum to the spine of the ischium and the ischial tuberosity
- They prevent forward nutation of the sacrum

Muscles of the Lumbar Spine

- There are three distinct muscle groups
- Intertransverse muscles
- Anterior muscles
- Posterior muscles

Intertransverse Muscles

- Several distinct small muscles attached to the transverse processes
- Intertransversarii mediales – tiny slips passing from an accessory process to a mamillary process below
- Intertransversarii laterales dorsales – pas from an accessory process to the transverse process below
- Involved in proprioception - lots of muscle spindles present

Anterolateral Muscles

- Psoas Major – covers the lateral aspects of the lumbar vertebral bodies and proximal quarter of the anterior aspects of the transverse processes
- Fibers arise from transverse processes, IV discs, margins of vertebra adjacent to discs
- Attach at the lesser trochanter on the femur

Anterolateral Muscles

- Acts to flex the hip, with the lumbar spine providing the base of support
- No real movement at the lumbar spine occurs with psoas activity – due to the proximity of the fibers to the axis of movement
- May exert very large compressive forces on the IV discs – during hip flexion or sit-ups

Quadratus Lumborum

- Covers the anterior surfaces of the transverse processes
- Most fibers pass from the ilium and iliolumbar ligament to the 12th rib
- Joined by fibers from the transverse processes to the 12th rib

Quadratus Lumborum

- Primary action appears to be to brace the 12th rib in order to provide a steady base from which the lower fibers of the diaphragm can act
- Additional fibers pass from the ilium to L1 – L4 transverse processes although these fibers are irregular differing from patient to patient
- These fibers may have an action on the lumbar spine – lateral flexion or control of bending in the opposite direction

Posterior Back Muscles

- Interspinales – thin rectangular sheets of fibers that connect apposing spinous processes
- Too small to exert any true action on the lumbar spine
- Believed to contribute to proprioception

Other Posterior Back Muscles

- Three columns of muscle (med – lat)
  - Multifidus
  - Longissimus thoracis
  - Iliocostalis lumborum
- Two layers of muscle

Multifidus

- Fibers are centered on each of the lumbar spinous processes
- Fibers radiate inferiorly to assume a variety of attachments inferiorly
- Arrangement is such as to pull downwards on each spinous process
- Action is thus extension or control of flexion

Multifidus

- Fibers are arranged in laminated bands with fibers from L1 covering those from L2 laterally and posteriorly – and so on
- This allows multifidus to act on each spinous process individually and separately
- Mulitidus is NOT a ROTATOR of the lumbar spine
- Predominant action is to pull down on the spinous processes

Longissimus Thoracic Pars

- Slender muscle that lies immediately lateral to multifidus
- Fibers arise from tip of L1-4 accessory processes and converge to a common tendon – lumbar interosseus muscular aponeurosis

Longissimus Thoracic Pars

- Inserts into the ilium just above and medial to the posterior superior iliac spine
- Action is to pull downwards and slightly backwards on the transverse processes – thereby extending the lumbar spine (or controlling flexion)
- Acting unilaterally these muscles act to control side flexion of the lumbar spine

Iliocostalis Lumborum Pars Lumborum

- Fibers arise from the tips of the L1-4 transverse processes
- Pass inferiorly as flat sheets in a laminated fashion
- Insert into the crest of the ilium distal to the PSIS
- Act to pull downwards and backwards on transverse processes – like LTpL

Longissimus Thoracis Pars Thoracis

- Series of muscle bellies that arise from thoracic transverse processes of T1-12
- Each muscle belly is approx 1-2cm wide and 9-12cm long
- Pass to the lumbar region where they are aggregated side-by-side to form the erector spinae aponeurosis

Longissimus Thoracis Pars Thoracis

- Attach to lumbar and sacral spinous processes and the posterior segment of the iliac crest
- Tendons from the highest thoracic levels insert into the L1 – and so on down the spine
- Fibers are arranged to extend the thorax in relation to the pelvis to control trunk flexion

Iliocostalis Lumborum Pars Thoracis

- Series of small overlapping muscle bellies located in the thoracic region
- Arise from the angles of the lower 8 ribs with a long caudal tendon extending to the lumbar region
- Tendons form lateral part of the erector spinae aponeurosis
- Extend the thorax on the pelvis or control forward or lateral flexion of the trunk

Erector Spinae Aponeurosis

- A broad, flat tendon that covers the lumbar region
- Fibers consist exclusively of the caudal tendons of the muscle bellies of:
  - Longissimus thoracis pars thoracis
  - Iliocostalis lumborum pars thoracis
- These tendons cover underlying muscles and do not attach to them

Thoracolumbar Fascia

- Muscles of the lumbar spine are enveloped in three layers of fascia
- The Anterior layer covers the quadratus lumborum
- The Middle layer (aponeurosis) arising from fibers of transversus abdominus
- The Posterior layer is more appropriately an aponeurosis of latissimus dorsi

Spinal Nerves

- Short nerves lying in the intervertebral foramina
- Each is a mixed nerve – sensory and motor
- Connected to the spinal cord by a dorsal and ventral root
- Lie obliquely in the foramen running downwards and laterally out of the foramen

Ventral Rami

- Supply structures in the ventral compartment of the lumbar region and the lower limb
- After leaving the foramen, they enter the substance of the psoas major and communicate with each other to form the lumbar plexus
- Deep branches of the plexus innervate the psoas and quadratus lumborum

Nerves of the Lumbar Plexus

- Iliohypogastric and Ilioinguinal nerves
- Lateral cutaneous nerve of the thigh
- Genitofemoral nerve
- Femoral nerve
- Obturator nerve
- Lumbosacral trunk – provides fibers of the L4 and 5 spinal nerves to the sacral plexus

Dorsal Rami

- Tiny branches that leave the spinal nerves at the IV foramen and enter the posterior compartment of the lumbar region
- Divide into:
  - Lateral
  - Intermediate
  - medial branches
- Lateral branches innervate iliocostalis lumborum

Dorsal Rami

- Lateral branches from L1, 2, 3 also supply cutaneous branches to innervate skin over the upper and lateral regions of the buttock
- Intermediate branches supply the longissimus lumborum pars lumborum
- Medial branches send articular branches to the facet joints and end in the multifidus and interspinalis muscles – segmental distribution

Innervation of the Disc

- Each disc is supplied by multiple sources
- Anteriorly and laterally supplied by branches of the sympathetic trunks
- Posteriorly the annulus receives branches from a plexus which covers the floor of the vertebral canal – derived from the sinuvertebral nerves

Nutrition of the Disc

- IV discs have a very poor blood supply
- Limited to tiny vessels that arise from the external arteries supplying vertebral bodies
- Poor external blood supply = poor nutrition
- 50% comes through vertebral end plates by osmosis
- Nutrition is improved by movement

Any Questions?