16th lecture – 11/04/16

- Muscles can be compartmentalized, and one nerve innervates one compartment of the upper limb (in general). Upper limb arteries give off branches that go to bone, muscle, joints, skin, nerves etc. Branches form anastomoses at joints. There are muscular, articular, nutrient, cutaneous and arteriae nervorum arteries. Collateral branches enable flow to occur when the main artery is squeezed shut.
- Coming off the aortic arch is an artery that goes under the clavicle. It is the subclavian artery and is the origin of the blood supply to the upper limb. Into the upper limb, the artery becomes the axillary artery, and passes through arm structures to become the brachial artery. It is the major blood vessel of the arm, is in a flexor compartment on the ventro-medial aspect of the arm, and divides into radial and ulnar arteries. Brachial artery is at the same horizontal location as the heart.
- Ulnar artery is the largest and more important compared to the radial artery. Ulnar is the principal blood supply to forearm and hand, terminates at the superficial palmar arch, and is palpable at the wrist (antero-medially). The radial artery supplies lateral aspect of the forearm, posterior branch passes through the snuff-box, terminates in the palmar arch, and is important for coronary artery grafts.
- Two palmar arterial arches anastomose with each other. Digital arteries are regarded as end arteries, and are vulnerable to vasoconstrictor drugs. They can cause vasospasm and necrosis.
- Volkmann's ischemic contracture- ischaemia leading to contracture of forearm flexor muscles. Fractured scaphoid may cause ischaemia leading to avascular necrosis.
- **Veins**- superficial veins are in the superficial fascia and are highly variable. They begin on back of hand as dorsal venous arch. Main tributaries are cephalic, basilic and median cubital. They communicate on the median cubital vein. It is one of the more consistent veins.
- Deep veins- via perforating veins, and accompany major arteries as venae comitantes. There is also a muscular venous pump. Valves ensure unidirectional flow.
- Upper limb lymphatics- lymphatic channels/plexuses in the hand, follow superficial veins of the upper limb, flow into axillary lymph nodes, drain via lymph trunks to venous system in neck, axillary nodes also drain chest, breast, and neck. Left drains through thoracic duct, and right through right lymphatic.
- The upper limb receives its nerve supply from the brachial plexus. It arises from cervical and thoracic spinal cord segments (C5-T1). There are five major terminal branches. The nerves come via the anterior rami. The anterior/ventral rami supply muscles, skin of the upper limb, and the posterior/dorsal rami side innervate the back muscles.
- There are trunks arranged, then divide into divisions. The superior, middle, and inferior trunks divide to form more complexity. There are anterior and posterior divisions. All in the anterior compartment are by anterior divisions, and so posterior etc. The organisation of the brachial plexus therefore forms segregation. They reorganise and form cords, and then there are terminal branches.
- **Musculocutaneous nerve-** anterior divisions, and will go to flexor compartment- anterior compartment of the arm. It will supply all the muscles in the anterior part of

the arm. It arises from C5, 6, and 7. The skin it innervates is the lateral aspect of the forearm. The flexors of the elbow are supplied by this nerve.

- The **median nerve** also arises from anterior divisions. It goes to the forearm, and arises from C5, 6, 7, 8, and T1. It passes through the arm, over the elbow joint, and into the forearm. It innervates most of the muscle so the anterior forearm. It passes under the carpal tunnel, and also supplies most muscles of the thumb. For skin, palmar 3 and a half digits, and nail beds. IT is susceptible to compression in the carpal tunnel.
- **Ulnar nerve**- also arises from anterior divisions. Passes through the arm and forearm, and innervates the hand muscles. They are the most intrinsic muscles of the hand. They arise from C8, T1. It passes over the carpal tunnel. It innervates almost all muscles in the hand. It passes superficial to flexor retinaculum. It innervates medial 1.5 digits (palmar and dorsal). It is susceptible to injury at medial epicondyle against the handlebar of a bike.
- **Radial nerve**- arises from C5, 6, 7, 8, and T1. Supplies posterior compartments of the arm and forearm. Muscles include the extensor muscles of arm and forearm, triceps, posterior forearm muscles. Skin includes the posterior skin of arm and forearm, and part of the back of the hand. It runs across the shaft of the humerus between medial and lateral heads of triceps. They are susceptible to damage in humeral shaft fracture, compression (Saturday night palsy), and wrist drop.
- **Dermatomes-** upper limb grows out from C5-T1; brachial plexus gives rise to innervation of the arms. The body early in development begins as a single tube, then in the 4th week of life the upper limb buds emerge. There is an axial line roughly in the middle of the arm.
- The axillary, radial etc nerves all arise from nerve roots of the brachial plexus. The peripheral nerves take on the values of the nerve roots. For example, the axillary nerve arises from C5 and C6. The Musculocutaneous nerve arises from C5 and C6. The ulnar nerve is derived from C8 and T1. Dermatomes are related to peripheral neurosomes.
- **Myotomes-** movements are very organised as well. Myotomes are the segmental supply of muscle groups. The more proximal muscles are innervated by upper parts of the brachial plexus, and the more distal muscles are innervated by lower parts of the brachial plexus. Most muscles are supplied from 1-2 adjacent segments, and muscles with the same action at the joint also have the same myotomes.
- **Nerve injuries-** common sites of brachial plexus injury- upper trunk (C5, 6)- forceful lateral flexion of head from shoulder, for example in car accident/during birth. Paraesthesia in C5, 6 dermatomes and paralysis of C5, 6 myotomes. Elbow flexors/forearm supination, 'waiter's tip' position (Erb's palsy). Lower trunk (C8, T1)- sudden traction of the upper limb, body weight is caught and hangs from arm/during birth. Paraesthesia in C8, T1 dermatomes, paralysis of intrinsic hand muscles; claw hand, poor fine motor control (Klumpke's palsy). Also shoulder dislocation/fracture of surgical neck, carpal tunnel syndrome, ulnar nerve palsy, radial nerve palsy.

17th lecture – 12/04/16

- Same general structure of lower limbs is the same, but animals have adapted over time.

- Lower limbs attached to the axial skeleton by the pelvic girdle. There is the thigh, leg, and foot. Joints include the pelvis and hip, knee, ankle, and foot.
- Pelvic girdle is stable, and does not move much at all. Lower limbs tend to be longer than upper limbs for leverage. Upper limbs rotate during development so that thumbs are lateral. They rotate 90 degrees externally. Lower limbs rotate so the big toe is medial. They rotate 90 degrees internally. Lower limbs are 180 degrees from upper limbs. Posterior parts are flexors, and anterior parts are extensors.
- We have an angulated femur. We have paired bones in the leg, and we cannot pronate or supinate the legs. We have an opposable thumb, but a non-opposable big toe.
- **Pelvic girdle-** sacrum and coccyx are part of the axial skeleton. The hip bones then attach to the sacrum posteriorly, and attach to each other anteriorly. We have two joints involved. We have a stable ring of bone so we can stand and walk.
- There are dimorphic differences for the pelvis. The male pelvis is longer and narrower, and female pelvis is shorter and wider. The pelvis is first developed with three distinct bones.
- There is the ilium bone (gluteal muscles), the ischium (hamstring muscles), and the pubis (adductor muscles). The bones come together and form a foramen. It is covered over by a membrane, so is closed. This is the obdurator foramen. The acetabulum is a rounded, semi-lunar structure that is the hip joint. The femur articulates with it. It is round and deep. It provides much greater stability for the hip joint.
- **The femur**- similar to the humerus. There is a head and neck; neck is longer in the femur than the humerus. We have bony protuberances called trochanters. We have a greater trochanter and lesser trochanter (for muscle and ligament attachments). They are larger due to the force of the pull of muscles being greater. We have the long, smooth shaft attaching muscles. It ends in medial and lateral condyles. The patella is a sesamoid bone, and is leverage for knee extensors. It is the kneecap.
- **Bony trabecula-** 2 main systems intersect to resist weight bearing forces, especially on the neck. The powerful muscle pulls. The bone aligns itself so it resists lines of force. The bone will strengthen in places to tolerate force. Trabeculae line up in vertical bundles. There is an arcuate bundle to resist the pull of the muscles attaching to the trochanter. There is a site of relative weakness with sparse trabeculae. Osteoporosis may result.
- **Tibia and fibula-** tibia is larger of the two bones. Similar to radius and ulna. There is an interosseous membrane between these two bones. These two bones don't move relative to each other. This is a difference. The tibia is weight bearing. The tibial plateau is for the knee joint. The shaft (shin) is the anterior surface subcutaneous. There is a tibial tuberosity. The shaft becomes flatter distally until the protrusion of the medial malleolus. It is an attachment for muscle There is a trochlear notch most distally for the ankle joint. The fibula is non-weightbearing, has a shaft for extra muscle attachments, and the lateral malleolus.
- **Ankle and foot-** we have tarsals, metatarsals, and phalanges in the foot. Of the tarsal bones, there is a talus. This is part of the ankle joint. It sits on top of the heel bone, known as the calcaneus. There are five more tarsal bones, and also sesamoid bones. Formation of the bones forms an arch. There are some important ligaments around the foot that provide us with the arch. The arch can be variable.

- The main function of the lower limb is to support our weight. The line of gravity in relation to joints of lower limb- we don't want gravity to run exactly through our joints, or that will cause degenerative changes. The line of gravity passes behind the hip joint (resisted by anterior capsule), slightly in front of the knee (resisted by posterior capsule), and a long way in front of the ankle (resisted by calf muscles, especially soleus.
- **Joints of the pelvic girdle-** there is a complete ring of bone. The weight of our trunk will come down on the sacrum and will be shared around the ring. Our urogenital anatomy is down in the pelvis. We have weight-bearing and transfer, and stability. We have strong ligamental support. The joint between the sacrum and ileum is the sacroiliac joint. There is a synovial plane joint, and strong interosseous ligament. The sacrococcygeal joint has cartilaginous joint. Anteriorly the hip bones meet at the pubic symphysis, and is also a strong cartilaginous joint. The pelvic girdle is the interface between the spine and lower limb. There is a strong complete ring of bone for weight transfer that protects contents. There is a tradeoff between stability and mobility. There is strong ligamentous support.
- **Hip joint** is a ball and socket joint that allows movement in three planes. It is much more inherently stable than the shoulder joint as congruency is much greater. There is a labrum like the shoulder joint that deepens the articular relationship. There is a strong hip joint capsule reinforced by strong ligaments. In front, there is the iliofemoral ligament that spirals and tightens with the hip. This is from the ilium to the femur. It is one of the strongest ligaments in the body.
- We also have a ligament from the pubis to the femur: the pubofemoral ligament. There is one from the ischium as well, the ischiofemoral ligament. The femur locks into the acetabulum. The most stable position is when it spirals and tightens.
- The hip joint is liable to injury. **Fractured neck of the femur-** a fracture near the head can occur. The result of the fracture can lead to avascular necrosis of femoral head. The degree of displacement is critical. The blood supply runs distal to proximal. The fracture on the head run a risk of cutting off the blood supply to the head, causing the necrosis. Age, relative mobility, and displacement must be used to determine whether to treat conservatively or drastically. A total hip replacement is replacing the head and neck of the femur and replacing it with a metal one. **Dislocation of hip-** joint capsule unwinds in flexion, position of greater laxity; sciatic nerve is susceptible to injury in posterior dislocation.
- **Knee joint-** complex joint with a disc, and a complex joint with two synovial joints in the one capsule. The patellofemoral joint is the femur connecting to the patella. The patella is a sesamoid bone. Dislocation can be inhibited by a higher ridge on one side of the femur. There is the tibiofemoral joint with the femur connecting with the tibia.
- The femur ahs rounded condyles, and the tibia has a plateau. They are relatively incongruent. The knee joint is a hinge joint with only movement in the flexion/extension plane. It is not a true hinge joint as there is minimal rotation in the knee joint. It has good ligamentous support, and has a relatively large range of motion. It is most stable at extension.
- Support primarily comes form 3 pairs of structures. There are two menisci in each knee (lateral and medial). The lateral meniscus is more rounded, and the medial is more oval-shaped. They are fibrocartilaginous intra-articular discs. The menisci are

mobile, but are attached to the ridge of bone by horns. They only cover part of the surface of the knee joint. They are wedge shaped as they are larger peripherally, and taper down toward the centre of the knee joint. Menisci increase area of contact of the bones by a third, they shock absorb, and spread synovial fluid.

- **The anterior and posterior cruciate ligaments** are in the inner knee joint and are important for knee joint stability. Anterior arises from the anterior portion of the tibial plateau, and corresponding to posterior. The name is from Latin term meaning 'to cross'. The ligaments cross, and this is how they get their name. They provide stability in the sagittal plane. It stops the tibia moving too far anteriorly. The posterior cruciate resists the tibia going to far posteriorly. Injury occurs when there is too much rotation around the joint. The ligaments will twist around each other; the anterior is not as strong, so a rupture will usually occur in the anterior.
- **Knee joint collateral ligaments-** all hinge joints have collateral ligaments. These extracapsular ligaments are medial and lateral. A flat, broad band is inherent with the joint capsule. It is a thickening of the joint capsule, and its most internal fibres blend in with the joint capsule. Some even attaches to the medial meniscus. The lateral collateral ligament is much thinner, rounder and taut band on the lateral side of the knee, and attaches to the head of the fibula, not the tibia. They resist abduction and adduction occurring at the knee joint. They provide support in the coronal plane.
- **Knee joint bursae-** bursae are normally synovial fluid-filled sacs and occur where bone will rub on something, like on the tip of the elbow, and the knee. It is the prepatellar bursa. Clinical sign of a knee injury is swelling above the knee, which may include blood.
- **Applied anatomy-** multiple structures are injured at the same time, such as two or three structures, due to their anatomical arrangement. E.g. if there is a tear to the medial collateral ligament, it is attached to the medial meniscus, and then the anterior cruciate ligament. The unhappy triad is when three structures fail at once, and a repair of the ACL is required, replacing the tendon with another tendon. Meniscus can tear in multiple ways.
- **Tibifibular joints-** superior and inferior. There is very little movement between these two joints for stability to become bipedal. Superior is a plane synovial joint, allows some gliding movement, and has ligament support. The inferior joint is extremely stable, and important. The syndesmosis is a fibrous joint protected by ligaments. It prevents the tibia and fibula from separating distally. So good stability and low loading means dislocation is rarer than fracture. We need this strong joint for our ankle.
- **Talocrural joint-** ankle joint. It is a malleolar mortis. It means a really tightly fitting joint. This will produce another hinge joint. We get dorsiflexion (extension of ankle joint) and plantarflexion (flexion of ankle joint). We have collateral medial and lateral ligaments. The deltoid ligaments are very strong, and are triangular in shape. You very rarely have an injury on the medial side of the ankle. Usually the lateral strains. There are three ligaments. The overall coverage and protection is substantially less than the medial ligament. Consequently, we are most likely to sprain the lateral side of the ankle.
- **Joints of the foot-** a number of joints. There are intertarsal, metatarsal, and phalange joints. Talus and calcaneus- underneath the talus is the subtalar joint.

18th lecture – 14/04/16

- We can flex, extend, abduct and adduct the lower limbs. There are relative movements in the pelvis. We can internally and externally rotate. Knee gets flexion and extension, and knee and foot is ankle dorsiflexion/ plantar flexion, and the foot can invert and evert. The ankle joint is a hinge joint (only flexion and extension). Inversion and eversion occur at the subtalar joint.
- **Fascia-** layer of fibrous tissue that surrounds individual and groups of muscles that divides muscles into compartments. It reduces friction/allows muscle to glide.
- **Muscles of the pelvic girdle-** bring hips into flexion. Anteriorly, the iliopsoas muscle- the iliacus, psoas major and psoas minor. They have a common insertion point onto the femur. They are a common muscle that crosses the hip joint and causes flexion.
- Posteriorly, there are the gluteal muscles. Gluteus maximus brings power extension. There is also medius and minimus that are slightly more lateral. They are muscles of abduction, but maximus is for extension. The medius and minimus has a primary role of maintaining position of pelvis in locomotion.
- **Muscle compartments of the thigh-** anterior, posterior, medial and lateral. These are four compartments of muscle in the thigh. The lateral compartment is the gluteal muscles and do not extend to the thigh.
- **Anterior compartment-** there are 5 muscles to consider. The Sartorius is not important. The quadriceps muscle is important. There are four. The different one is the most anterior, the rectus femoris (flexes at hip). It is most prone to injury as it crosses the hip and knee joints. The other three muscles are under the rectus- the vastus muscles- medialis, lateralis, and intermedius. They form a common quad tendon that goes to the patella, and the patella ligament connecting to the tibia.
- The patella is subject to dislocation laterally because of the arrangement of the lower limb. The angle of inclination of the femur- Femur first goes outward, but then goes back inward to get the basis of support of the lower limb. This inclination pulls the patella laterally. The most distal portion of vastus medialis has oblique fibres to stop dislocation.
- **Posterior muscle compartment of the thigh-** hamstring muscles- three -2-joint muscles- semimembranosus, semitendinosus, and biceps femoris (long head). There is a short and long head. They provide extension at the hip joint and also flex. They cross two joints, and are more liable for injury as they are stretched to beyond their tolerable length.
- **Medial compartment-** adductor muscles; are the adductor of the hip. They bring the leg back into the midline. Adductor longus is going to be a source of pain in young athletes for example. There is a small hole in the muscle. It is the adductor magnus. The hole is the adductor hiatus. It is important when considering the nerve and vessels of the lower limb.
- **Muscle compartments of the leg-** anterior, lateral and posterior compartment.
- **Anterior compartment-** tibialis anterior, extensor hallucis longus, and extensor digitorum longus. They are dorsiflexors of the ankle, and extensors of the toes. Overuse may lead to shin splints (tenoperiostitis). The hallucis is an independent extensor for the big toe, and the digitorum is for the toe.
- Fascia encloses compartments in the anterior and posterior compartments. Things can move freely and be restrained, but some fascia is tight in the anterior

compartment. You can develop compartment syndrome. If swelling occurs, neurovascular structures are susceptible to compression. Swelling into a compartment increases pressure. Veins that remove the blood from the compartment close down very easily. The blood won't be able to get out. This can cause pain, and the fascia needs to be cut through a fasciotomy to decompress everything.

- **Lateral compartment-** peroneal (fibularis) muscles longus and brevis. They are everters of the foot. They are susceptible to strain and proprioceptive role in ankle sprains. The ankle joint is a hinge joint. These are not particularly strong.
- **Posterior muscle compartment of the leg- superficial muscles** are called gastrocnemius, plantaris, and soleus. G and S come together in the Achilles tendon (calcaneal tendon). These are plantarflexors of the ankle joint. G is a power muscle and we use it in strength activities. Deep to G is S. It is for posture, but is not powerful. It can maintain contraction for a long period of time. Line of gravity lies anteriorly to the ankle joint. Sustained contraction of soleus allows us to stand for long periods of time. There are venous sinuses in the soleus. We have venous pooling. Plantarflexion allows the blood to return to general circulation. Any muscle crossing two joints can be lengthened over two joints. Calf strain is common. You can also get Achilles' tendinitis.
- **Deep muscles of the posterior**- tibialis posterior, flexor hallucis longus, and flexor digitorum longus. It is almost a copy of anterior muscles. They are plantarflexors of the ankle and flex the toes. We have a tarsal tunnel where nerves, vessels, and tunnels pass under. Anterior we have dorsiflexors and dorsiextensors, lateral we have everters, and posterior we have plantarflexors, and flexors of digits.
- **Intrinsic muscles of the foot-** plantar muscles- hallucis muscles, digiti minimi muscles, and central muscles. Long tendons; plantar aponeurosis and ligaments that support arches.
- **Applied anatomy of muscles of the lower limb-** 2 joint muscles are susceptible to strain when acting across both joints simultaneously. These include hamstring muscles, the quadriceps muscles rectus femoris crosses the hip and knee. The gastrocnemius posteriorly crosses the knee and ankle. Muscles may be strained through the muscle belly, musculotendinous junction, or the tendon. Weakest site may be tendon/bone interface, which is an avulsion fracture.