Preface

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Team Slim Academy

P.S. This summary has been written based on the author's own interpretation. It remains a summary and should be seen as a supplement to the required study materials — not a replacement

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Ageing, frailty, and polypharmacy

Chapter 1 - Anatomy of the vertebral column

This will be covered in a separate anatomy booklet.

Chapter 2 - Anatomy of the upper limb

This will be covered in a separate anatomy booklet.

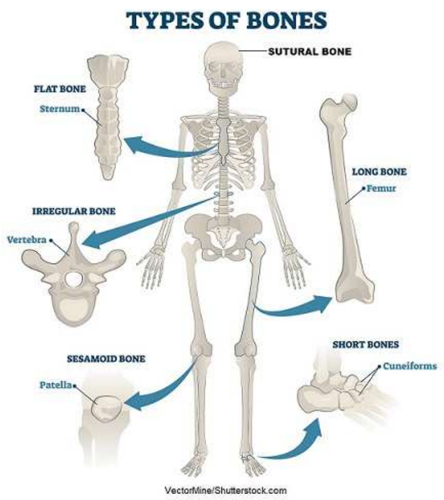
Chapter 3 - Structure, growth, and biochemistry of a long bone

Introduction

This chapter discusses the function, classification, microscopic structure, and growth of bones.

Function of Bone
Bone is a tissue that provides structural support, protection for vital organs, facilitates movement, mineral homeostasis (especially of calcium and phosphate), storage of triglycerides in marrow, and blood cell production through hematopoiesis.

Classification of Bones
Bones are classified according to shape and structure. Long bones, such as the femur, tibia, fibula, radius, and humerus, include a shaft and two ends and function as levers for movement. Short bones, including carpals and tarsals, provide stability with limited motion. Flat bones, like the skull, sternum, ribs, and scapulae, are thin and flattened, serving protective and attachment roles. Irregular bones, such as vertebrae, facial bones, and parts of the pelvis, have complex shapes for specific functions. Sesamoid bones, like the patella, are small, round bones embedded within tendons to reduce friction. Sutural bones are small bones located between cranial sutures.



Types of bones. *Source: registerednursern.com*

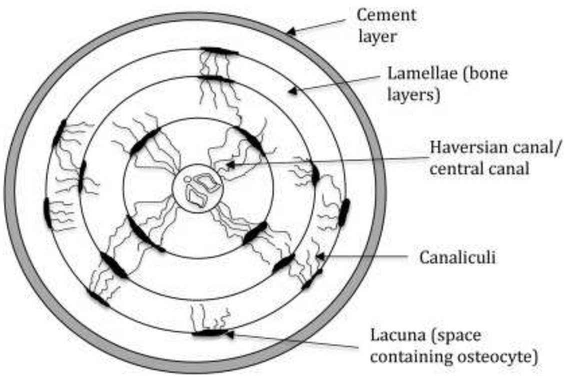
Structure of a Long Bone
A long bone consists of the diaphysis (shaft), metaphysis, and epiphysis. The epiphyses are the distal and proximal ends, containing spongy bone with red marrow, and are covered by articular cartilage to reduce friction and absorb shock. The metaphysis connects the diaphysis and epiphysis and contains the epiphyseal plate, which allows longitudinal growth before becoming the epiphyseal line after maturation. The diaphysis is composed of compact bone surrounding the medullary cavity, which contains yellow marrow for fat storage. Compact bone provides rigidity and strength through Haversian systems that contain blood vessels and nerves. Spongy bone, composed of trabeculae, supports marrow and distributes forces efficiently. The periosteum is a tough connective tissue sheath covering the bone (except at joints) with an outer fibrous layer and an inner cellular layer containing osteoprogenitor cells. The endosteum lines the medullary cavity and contains osteoclasts involved in bone resorption.

Bone Matrix Composition and Cellular Components

The bone matrix is composed of organic and inorganic components. The inorganic portion, mainly hydroxyapatite (calcium phosphate crystals), provides hardness and rigidity, while type I collagen (accounting for 90% of bone collagen) is for flexibility and tensile strength. Bone cells are derived from mesenchymal and hematopoietic stem cells. Osteoprogenitor cells, found in the periosteum and endosteum, differentiate into osteoblasts, chondrocytes, fibroblasts, or adipocytes. Osteoblasts synthesize osteoid (unmineralized bone matrix) and are responsible for bone formation. Once osteoblasts are trapped in the matrix, they become osteocytes, mature cells residing in lacunae, which maintain bone tissue and regulate calcium homeostasis via canaliculi connections. Osteoclasts, derived from monocyte-macrophage lineages, are large multinucleated cells responsible for bone resorption and remodeling, playing a role in calcium balance.

Haversian System and Bone Organization

Compact bone is organized into structural units called osteons or Haversian systems. Each osteon consists of concentric lamellae (layers of bone matrix) surrounding a central canal containing blood vessels and nerves. Lacunae, which house osteocytes, are connected by canaliculi that facilitate nutrient and waste exchange. Spongy bone, found mainly in epiphyses and lining the medullary cavity, contains trabeculae that provide structural support and house bone marrow.



Haversian Systems. *Source:* [sciencedirect.com]

Cartilage and Its Role in Bone Development

Cartilage is an avascular connective tissue that cushions joints and provides a framework for bone formation. Chondrocytes, the main cartilage cells, are embedded in lacunae within the extracellular matrix. There are three main types: hyaline cartilage (found in the nose, trachea, and ends of long bones), elastic cartilage (in the ear and epiglottis), and fibrocartilage (in intervertebral discs and pubic symphysis). Cartilage acts as a precursor in endochondral ossification and contributes to smooth joint articulation as articular cartilage.

Stages of Bone Remodelling

Osteoblasts secrete osteoid, an unmineralized organic matrix composed of collagen and proteins, which is the precursor of bone mineralization. Osteoid facilitates the deposition of calcium and phosphate, leading to osteogenesis and the calcification of bone from the osteoid precursor. Osteoclasts, derived from monocyte progenitor cells, are multinucleated cells responsible for bone resorption. In a process called osteolysis, osteoclasts secrete acids and lysosomal enzymes to dissolve mineralized bone and degrade the organic matrix. Bone resorption and formation are tightly coupled, ensuring the replacement of bone with equivalent strength and maintaining mineral homeostasis. When bones experience increased mechanical load, osteoblast activity increases, leading to bone thickening (Wolff's law). Conversely, lack of mechanical stress enhances osteoclast activity, resulting in bone resorption and reduced density.

Intramembranous Ossification
Intramembranous ossification is the direct transformation of mesenchymal tissue into bone without a cartilage intermediary, forming flat bones such as the skull and sternum. The process involves mesenchymal cells differentiating into osteoprogenitor cells and then osteoblasts, which secrete osteoid. The osteoid becomes mineralized, trapping osteoblasts as osteocytes. The calcified matrix forms trabeculae, giving rise to spongy bone, while surrounding mesenchyme develops into the periosteum. Subsequent remodeling converts portions of the spongy bone into compact bone.

Endochondral Ossification
Endochondral ossification is the process by which long bones develop from a preexisting cartilage model. Mesenchymal cells differentiate into chondroblasts that secrete a cartilage matrix, forming a hyaline cartilage model surrounded by the perichondrium. In response to bone morphogenetic proteins (BMPs) and growth factors, perichondrial cells differentiate into osteoblasts, forming a bone collar around the mid-diaphysis. Chondrocytes in the center hypertrophy, secrete alkaline phosphatase to calcify the matrix, and die, creating a central cavity. Blood vessels invade the space, bringing osteoprogenitor cells that form the primary ossification center. Osteoblasts deposit bone matrix on calcified cartilage remnants, forming spongy bone, while osteoclasts remodel it into a medullary cavity containing yellow marrow. Secondary ossification centers develop in the epiphyses, and articular cartilage remains on joint surfaces. The epiphyseal plate between the diaphysis and epiphysis allows longitudinal bone growth until it ossifies into the epiphyseal line after puberty.

Regulatory Molecules in Ossification
Key regulators of ossification include bone morphogenetic proteins (BMPs), which induce mesenchymal differentiation into chondrocytes and osteoblasts; Indian hedgehog (IHH), which regulates chondrocyte proliferation and differentiation; and alkaline phosphatase, which promotes matrix calcification. These signaling molecules coordinate chondrocyte maturation, matrix mineralization, and vascular invasion.

Slim Summary!
• Bone Functions: Support, protection, movement, mineral storage, fat storage, and blood cell production. • Bone Types: Long, short, flat, irregular, sesamoid, and sutural bones. • Hydroxyapatite + collagen; osteoblasts build, osteocytes maintain, osteoclasts resorb; cartilage cushions joints and guides bone formation. • Bone remodelling continuously replaces old bone with new tissue via coordinated osteoblast and osteoclast activity, maintaining strength, mineral balance, and adapting to mechanical stress. • Ossification and growth occur through intramembranous (flat bones) and endochondral (long bones) processes, regulated by BMPs, IHH, and the epiphyseal plate zones. • GH and IGF-1 stimulate longitudinal bone growth, protein synthesis, and tissue repair via JAK-STAT and PI3K-AKT/MAPK pathways, with thyroid hormones enhancing growth plate activity.

Chapter 4 - Calcium homeostasis

Introduction

This chapter discusses calcium homeostasis and its regulation by hormonal and molecular mechanisms that keep ionized calcium within a normal physiological range. The parathyroid hormone (PTH), vitamin D, and calcitonin act together through feedback loops involving bone, kidney, and the intestine to maintain this balance.

Calcium Homeostasis

Calcium in the human body is predominantly stored in bone as hydroxyapatite crystals ($Ca_{10}(PO_4)_6(OH)_2$) that form the mineral matrix. In plasma the normal total calcium concentration is roughly 2.2–2.6 mmol/L, of this, about 35–40% is bound to albumin, ~5% is complexed with small anions (phosphate, bicarbonate, citrate, sulfate), and the remainder of 1.1–1.3 mmol/L is made up of ionized (free) Ca^{2+}, which is the biologically active form. Ionized calcium is the best physiological representation of calcium levels, because changes in pH and albumin do not alter the levels of ionized or free Ca^{2+}.

CaSR and PTH Secretion

Plasma ionized calcium is sensed by the calcium-sensing receptor (CaSR), a G-protein–coupled receptor located on the chief cells of the parathyroid glands. Ionized Ca^{2+} and PTH (parathyroid hormone) have an inverse relationship: when ionized Ca^{2+} rises, CaSR activation suppresses PTH secretion and when ionized Ca^{2+} falls, reduced CaSR activation leads to increased synthesis and pulsatile release of parathyroid hormone (PTH). Therefore, PTH secretion is an immediate endocrine response to hypocalcemia.

Actions of PTH on Bone

PTH increases serum calcium primarily via actions on bone. It binds to PTH1R receptors on osteoblasts, which activates G-protein and cAMP/PKA signaling pathways.This stimulates expression of RANKL, a protein responsible for the formation of osteoclasts as well as reduces osteoprotegerin (OPG) production by osteoblasts. RANKL binds RANK on immature osteoclasts and promotes their differentiation into mature osteoclasts and as they break down bone they release calcium and phosphate into the circulation. A continuous elevation of PTH promotes net bone resorption and bone loss, whereas intermittent/pulsatile PTH can stimulate bone formation.

Actions of PTH on The Kidney

In the kidney, PTH has two key effects that restore ionized calcium. First, in the proximal tubule PTH reduces phosphate reabsorption by degrading the Na^+-phosphate cotransporters (NaPi-IIa/IIc), causing phosphate to exit in the urine. This lowers filtered phosphate and helps increase free Ca^{2+} by shifting $Ca–PO_4$ equilibrium. Second, PTH increases calcium reabsorption in the distal convoluted tubule via upregulation of epithelial Ca^{2+} channels such as TRPV5 and intracellular calbindin that move Ca^{2+} to the basolateral transporters, NCX1 and PMCA, thereby reducing urinary calcium loss. PTH also stimulates the conversion of 25-hydroxyvitamin D to active 1,25-dihydroxyvitamin D (calcitriol) through the expression of renal 1α-hydroxylase (CYP27B1) in proximal tubular cells.

Vitamin D Synthesis, Activation and Actions

Vitamin D (cholecalciferol, vitamin D_3) is produced in skin from 7-dehydrocholesterol under UVB light, then converted in the liver to 25-hydroxyvitamin D (calcidiol) by 25-hydroxylases. The kidney's 1α-hydroxylase converts 25-OH D (calcidiol) to 1,25-$(OH)_2$D (calcitriol), this is the active hormone whose activity is increased by PTH and by low serum phosphate. Activity of calcitriol is suppressed by fibroblast growth factor-23 and high calcitriol levels. Calcitriol acts via the vitamin D receptor, a nuclear transcription factor, which increases intestinal absorption of calcium and phosphate by upregulating expression of epithelial Ca^{2+} channels (TRPV6/TRPV5), calbindins (intracellular Ca-binding proteins), and basolateral transporters. In bone, calcitriol increases mineral mobilization partly by promoting RANKL expression (synergizing with PTH) and by supporting osteoclastogenesis indirectly. Overall, calcitriol raises extracellular calcium by increasing gut absorption, promoting bone resorption, and enhancing renal calcium reabsorption.

Calcitonin and Short-term Calcium Lowering

Calcitonin is a 32–amino-acid peptide secreted by parafollicular C cells of the thyroid in response to hypercalcemia. It acts on the calcitonin receptor on osteoclasts to inhibit osteoclastic bone resorption, causing fall in ionized, free calcium. In humans calcitonin's physiological role is minor and redundant, it is most relevant as a pharmacologic agent to rapidly reduce serum calcium in short-term situations.

Integrated feedback Loops

A fall in ionized calcium will lead to decreased CaSR stimulation which signals for an increase in PTH secretion. Within the kidneys, renal Ca^{2+} will be conserved in response to PTH secretion. PTH also induces 1α-hydroxylase activity which facilitates increased conversion of calcidiol to calcitriol → increased intestinal calcium absorption and a restoration of ionized Ca^{2+}. Rising ionized calcium feeds back to suppress PTH, reduce 1α-hydroxylase activity, and increase calcitonin release to limit further increases.

Molecular Transporters and Proteins

Key membrane proteins include TRPV5/TRPV6 which are apical Ca^{2+} entry channels in renal DCT and intestinal enterocytes, calbindin which is an intracellular Ca^{2+} transporter, NCX1 (Na^+/Ca^{2+} exchanger) and PMCA (plasma membrane Ca^{2+}-ATPase). In bone, RANK/RANKL/OPG control osteoclast differentiation and activity. The CaSR regulates PTH secretion and also modulates renal handling of Ca^{2+} and Mg^{2+}.

Pharmacologic and Pathophysiologic Modifiers of Calcium Balance

Drugs and disease commonly alter calcium homeostasis. Loop diuretics (e.g., furosemide) inhibit the Na^+/K^+/$2Cl^-$ cotransporter in the thick ascending limb and increase urinary calcium excretion (hypercalciuria). By contrast, thiazide diuretics enhance distal calcium reabsorption and reduce urinary calcium excretion. Primary hyperparathyroidism (often a parathyroid adenoma) causes chronic PTH excess leading to hypercalcemia, hypophosphatemia, bone loss, and hypercalciuria with risk of kidney stones. Secondary hyperparathyroidism arises from chronic hypocalcemia where PTH is elevated as a compensatory response. Severe hypocalcemia (e.g., vitamin D deficiency, hypoparathyroidism, or renal failure) results in neuromuscular irritability and requires restoration of ionized calcium.

Clinical Measurements and Interpretation

Because albumin binding affects total calcium, clinicians either correct total calcium for albumin concentration using standard formulas or measure ionized calcium directly when accurate assessment is needed (e.g., acid–base disturbance, severe illness, or hypoalbuminemia). Interpretation of calcium labs should always consider serum albumin, phosphate, PTH, and vitamin D status for a full picture of the regulatory axis.

Slim Summary!

- PTH is the primary regulator of low calcium, increasing serum Ca^{2+} through bone resorption, enhanced renal calcium reabsorption, reduced phosphate reabsorption, and activation of vitamin D.
- Vitamin D (calcitriol) raises calcium by increasing intestinal absorption, supporting osteoclast activity, and aiding renal calcium handling.
- Calcitonin provides minor, short-term lowering of calcium by inhibiting osteoclasts, though it plays a small physiological role in humans.
- Feedback loops involving CaSR, PTH, vitamin D, and calcitonin tightly regulate ionized calcium, while diseases (e.g., hyperparathyroidism) and drugs (thiazides, loop diuretics) significantly modify calcium balance.

Chapter 5 - Bone remodelling and repairing fractures

Introduction

This chapter discusses the phases of bone remodelling when bone undergoes mechanical stress or microdamage. Bone fracture repair is also discussed

Phases of Bone Remodeling

1. Activation Phase

Bone remodeling begins when areas of bone sustain mechanical stress or microdamage. Osteocytes embedded in the bone matrix detect this strain and signal to surface osteoblasts, which in turn increase expression of RANKL. RANKL binds to RANK receptors on osteoclast precursors in the bone marrow, stimulating their recruitment to the site and promoting their differentiation into mature, multinucleated osteoclasts. This prepares the damaged bone surface to undergo resorption.

2. Resorption Phase

Mature osteoclasts attach tightly to the bone surface and create a sealed microenvironment known as the resorption lacuna. Within this compartment, osteoclasts secrete hydrochloric acid (H^+ via proton pumps) to dissolve hydroxyapatite crystals which forms a hard, mineral part of bone which must be resorbed to facilitate recovery. Osteoclasts also secrete cathepsin K, a proteolytic enzyme that degrades collagen and other organic components of the matrix. Calcium and phosphate released from the dissolved bone enter the bloodstream. The resorption phase lasts several weeks and produces a concave cavity on the bone surface.

3. Reversal Phase

Following resorption, osteoclasts undergo apoptosis or move away, and reversal cells (macrophage-like mononuclear cells) migrate into the cavity. These cells clean the area by removing residual debris and prepare the bone surface for new bone formation. They also release signaling molecules that recruit osteoblast precursors to the site, transitioning the process from catabolic to anabolic activity.

4. Formation Phase

Osteoblasts derived from mesenchymal stem cells migrate into the resorption cavity and begin synthesizing osteoid, an unmineralized matrix rich in type I collagen and bone-specific proteins. As osteoid accumulates, it gradually undergoes mineralization, incorporating calcium and phosphate to form new hydroxyapatite crystals. Some osteoblasts become embedded within the matrix and differentiate into osteocytes, while others remain on the surface as lining cells. This phase restores bone density and structural integrity.

Bone Fracture Repair

1. Hematoma Formation

Immediately after a fracture, blood vessels in the periosteum, endosteum, and surrounding tissues rupture, creating a hematoma at the fracture site. The hematoma fills the gap between bone fragments, providing an initial scaffold for migrating cells. It is rich in platelets and inflammatory mediators, including PDGF (platelet-derived growth factor) and TGF-β, which recruit mesenchymal stem cells and initiate the healing cascade.

2. Inflammatory Phase

Within the hematoma, neutrophils and macrophages infiltrate to remove necrotic bone and tissue debris. These cells release pro-inflammatory cytokines such as IL-1, IL-6, and TNF-α, which enhance cellular recruitment and angiogenesis and stimulate the proliferation of fibroblasts and chondrocytes. This phase prepares the environment for the formation of new tissue.

3. Soft Callus Formation

Fibroblasts begin producing collagen fibers, while chondrocytes lay down cartilage around the fracture site. Together, these components form a soft (fibrocartilaginous) callus, which stabilizes the fracture by bridging the bone ends. The soft callus is not fully rigid but provides enough support to limit movement at the fracture site.

4. Hard Callus Formation

Osteoblasts gradually replace the cartilage within the soft callus with woven bone, forming a hard bony callus. Woven bone is rapidly produced and mechanically stronger than the soft callus, although it is less organized than mature lamellar bone. This stage significantly restores mechanical strength to the fractured bone.

5. Remodeling Phase

Over months to years, the woven bone of the hard callus is remodeled into lamellar bone, restoring the bone's original architecture and mechanical properties. Osteoclasts resorb excess or misaligned bone, while osteoblasts deposit new lamellar bone along lines of mechanical stress. Eventually, the bone returns as closely as possible to its pre-injury shape and strength.

Slim Summary!
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Chapter 6 - Effect of ageing on physical function and bone

Introduction

This chapter discusses the structural and functional changes with age, making older adults more susceptible to fractures and skeletal weakness. Both the dense cortical layer and the spongy trabecular bone are affected, compromising the bone's ability to withstand mechanical stress. Age-related hormonal changes, along with imbalances in bone remodeling, further contribute to the decline in bone strength and physical function.

Thinning of the Cortical Layer

With advancing age, the cortical bone which is the dense, outer shell that provides most of the bone's structural strength gradually becomes thinner. This thinning is especially pronounced in long bones such as the femur, tibia, and fibula. Because cortical bone is responsible for resisting bending and torsional forces, its loss significantly weakens the skeleton. As a result, older adults have a higher risk of fractures, even from relatively minor falls or mechanical stress.

Changes in Trabecular (Spongy) Bone

The trabecular bone located within the interior also undergoes major age-related changes. This spongy, lattice-like structure becomes more porous and less dense over time. Regions rich in trabecular bone such as the vertebrae, hips, and wrists are especially vulnerable. Thinning and loss of the trabeculae reduce the bone's internal support system, increasing the likelihood of vertebral compression fractures, hip fractures, and distal radius fractures.

Increased Bone Porosity From Remodeling Imbalance

Aging disrupts the balance between bone resorption and bone formation. Osteoclast activity (bone breakdown) tends to increase, while osteoblast activity (bone building) decreases. This imbalance leads to a net loss of bone mass and greater bone porosity. As the architecture of bone becomes more fragile, the skeleton is less able to withstand mechanical loads, making fractures more common.

Hormonal Effects on Bone Structure and Physical Function

Hormonal changes play a major role in age-related bone loss. Estrogen, which normally inhibits RANKL (a molecule that stimulates osteoclast formation), declines significantly with age, especially after menopause. This drop in estrogen allows RANKL levels to rise, increasing osteoclast activity and accelerating bone resorption. Similarly, testosterone contributes to bone strength by promoting bone formation and supporting muscle protein synthesis. As testosterone levels decrease with age, the protective effects on both bone and muscle diminish. This not only weakens the skeleton but also reduces physical function and increases the risk of falls, further compounding fracture risk.

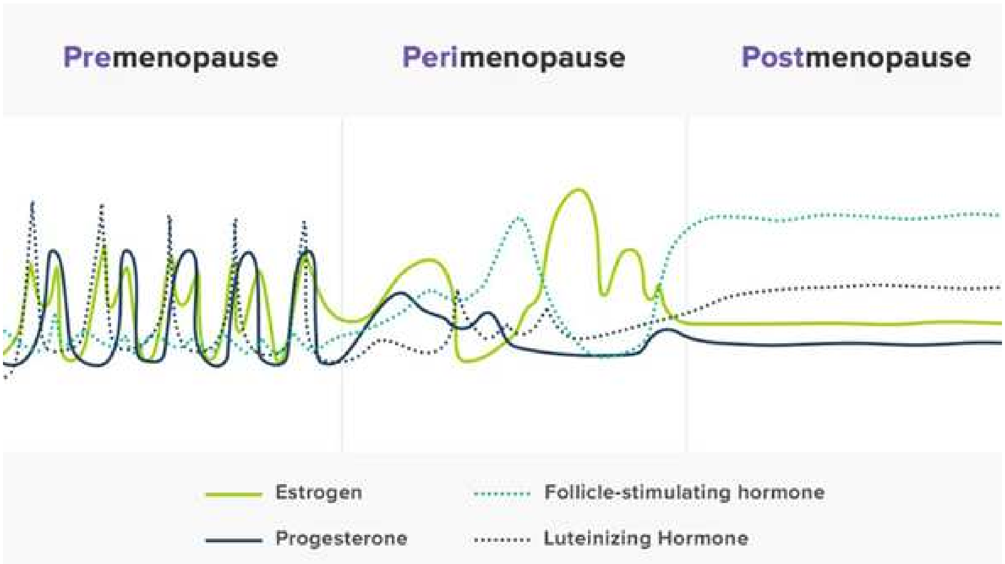
Slim Summary!

- Aging leads to thinning of the cortical bone and increased porosity of trabecular bone, reducing the skeleton's overall strength and increasing fracture risk.
- Bone remodeling becomes imbalanced, with greater osteoclast activity and reduced osteoblast function, causing progressive bone loss.
- Hormonal declines, especially reduced estrogen and testosterone, further accelerate bone resorption, weaken muscle and bone, and heighten the likelihood of falls and fractures.

Chapter 7 - Menopause

Introduction
This chapter describes the hormonal changes associated with menopause, and the consequent changes in oestrogen-dependent tissues. **Menopause** is defined clinically as the **last menstrual period**, and a retrospective diagnosis can be given one year after the last menstrual period. The average age of menopause in the UK is **51**, with the typical age range being 45-55 years old. By the age of 54, 80% of females have stopped having periods. Before menopause is a period of **perimenopause**, which is the time from the first changes to periods to the diagnosis of menopause, and the average age for this to start is 47.

Hormonal changes and effects
During perimenopause, the production of oestrogen and progesterone falls as the ovarian follicles are depleted. This removes the negative feedback effect on the pituitary gland, and there is an increase in the release of FSH and LH. The levels of oestrogen fluctuate irregularly, and it is the **oestrogen dips** that tend to cause the menopausal symptoms. The unstable hormone levels mean that the uterus is no longer reliably stimulated to shed its lining and periods become irregular and often heavier. Eventually, the ovarian and menstrual cycle ceases, and periods are no longer experienced. As well as the effect on periods, several other symptoms are experienced, such as fatigue, acne, weight gain, mood changes, gastrointestinal issues, headaches, and hot flashes. These symptoms vary between individuals, and some may have more severe symptoms than others. The vulva, vagina, urethra, and bladder are also dependent on oestrogen, and with oestrogen decline the epithelium of these tissues thins, which can cause urinary incontinence and the increased risk of urinary tract infections.



Hormone fluctuations before, during, and after menopause. *Source: flordis.com.au*

The decrease in oestrogen during menopause also increases the risk of osteoporosis and this will be covered in more detail in the next chapter.

Diagnosing menopause
If a patient presents with menopausal symptoms and is over the age of 45, then no laboratory tests are needed, and perimenopause can be diagnosed based on vasomotor symptoms and irregular periods. Menopause is officially diagnosed when there has been no period for over 12 months, and no hormonal contraception is being used. Those under the age of 45 with menopausal symptoms including menstrual changes should have their FSH levels tested. This FSH test is ideally performed on day 2-5 of the menstrual cycle and repeated 4-6 weeks later to confirm the result. Any hormonal contraception should also be stopped for at least 6 weeks before testing. Serum FSH level of above 30 IU/L indicates a degree of ovarian insufficiency. Other tests should be done to rule out other diagnoses such as breast, ovarian and cervical cancers. If premature menopause or premature ovarian insufficiency is diagnosed, then DEXA scans should be performed to examine bone mass density and assess the risk of osteoporosis.

Slim Summary!

- Menopause is defined as the last menstrual period, and before this a period of perimenopause is experienced, with symptoms such as irregular, heavy periods, hot flashes, mood changes, incontinence, and fatigue;
- Menopause can also increase the risk of osteoporosis, and if premature menopause or ovarian insufficiency is diagnosed, then DEXA scans should be performed to monitor BMD.

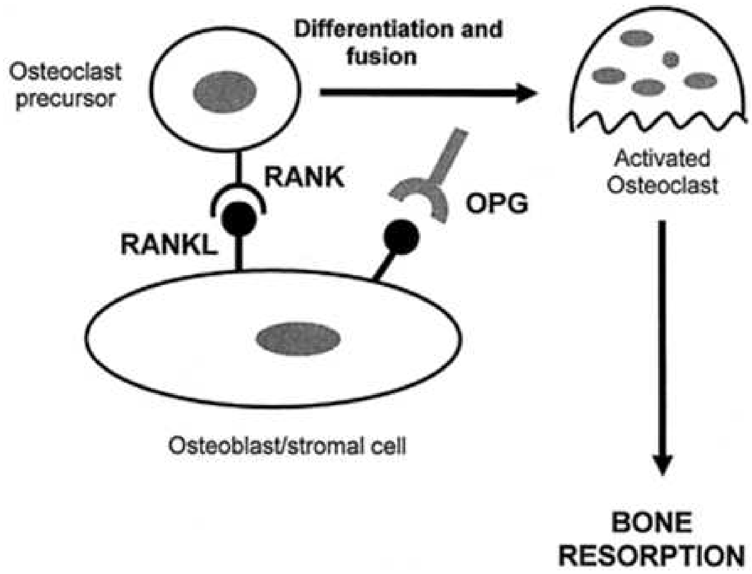
Chapter 8 - Risk factors and management of osteoporosis

Introduction
This chapter defines the risk factors for osteoporosis and explains the benefits of physical activity in the prevention and management of this condition. Osteoporosis is the loss of bone substance and bone mass density (BMD) such that fractures of non-traumatic origin are sustained.

Risk factors for osteoporosis
Osteoporosis is clinically diagnosed when bone mass density is 2.5 standard deviations or more below the normal healthy density. If BMD is between 1-2.5 standard deviations below normal, then this is defined as **osteopenia**, and having osteopenia can be indicative of developing osteoporosis in the future. Bone markers can be tested for to detect changes in osteoblast and osteoclast activity and detect abnormalities. Proteins used in bone mineralisation, such as BALP and osteocalcin, are tested for to monitor osteoblast activity, whilst type 1 collagen breakdown products including NTX and CTX are tested for to monitor osteoclast activity.

As the body ages, bone remodelling is also slowed, as osteoblasts can no longer keep up with osteoclast activity and deficits in BMD become much more common. The decrease in oestrogen during **menopause** also increases the risk of osteoporosis. This is because oestrogen has a role in maintaining bone mass density. Oestrogen increases alkaline phosphatase expression, collagen type 1 synthesis, and growth factor synthesis, which regulates osteoblast proliferation. It also stimulates VDR expression, which is a marker of osteoblast maturation.

Oestrogen affects osteoclast activity too via osteoblasts with the **RANKL** ligand. Osteoclast cells have RANK receptors which bind to the RANKL ligand on osteoblasts in order to become activated. Oestrogen upregulates the expression of a protein called **OPG**. This OPG acts as a decoy for RANK and will bind to RANKL. This means that the RANKL ligand is blocked from binding to RANK, and less osteoclasts will be able to be activated. When oestrogen becomes depleted in menopause, less OPG is expressed and there is increased activation of osteoclasts via RANKL to RANK binding, which causes the breakdown of bone cells. This can lead to decreased bone mass density, and the development of osteoporosis. However, not all individuals who go through menopause will develop osteoporosis.



RANK and OPG receptors. *Source: Medscape*

Although oestrogen decline will mainly affect females, males can also be affected as oestrogen affects BMD in both men and women. Males who have a mutation which causes unresponsive oestrogen receptors or ineffective aromatase enzymes will experience BMD deficits and this increases the risk of osteoporosis. Males with osteoporosis actually have a higher rate of morbidity and mortality than females with osteoporosis, even though females are more likely to have the condition.

Other risk factors include heavy smoking and drinking, hypogonadism, and **steroid therapy**. Corticosteroid therapy is used for several conditions including asthma, rheumatoid arthritis, and inflammatory diseases. As long as steroid use is not heavy and prolonged, it does not usually greatly increase the risk of osteoporosis. However, if used heavily over a long period of time, it can affect the levels of calcium ions and parathyroid hormone in the body, which can cause BMD deficits.

Prevention and management of osteoporosis
Regular physical activity is important in the management of osteoporosis and can also prevent the development of it for high-risk individuals. Weight-bearing and resistance exercises in particular can stimulate increased BMD and reduce the risk of fractures. It also improves co-ordination and prevents the risk of falls, which is important to consider especially in older patients, as falls are common and easily cause fractures and other injuries. Patients may be given tailored exercise programmes to target bone strength.

Other treatment and management may include calcium and vitamin D supplements. HRT potentially may be given if oestrogen levels are known to be depleted. However, a healthy lifestyle and regular exercise are just as important in management of osteoporosis and health in general and don't come with as many unwanted side effects.

Slim Summary!
• Osteoporosis is clinically diagnosed when bone mass density is 2.5 standard deviations or more below the normal healthy density; • Menopause causes a decline in oestrogen, which increases the risk of osteoporosis due to oestrogen's involvement in osteoblast and osteoclast activation; • Other risk factors include heavy smoking and drinking, hypogonadism, and steroid therapy; • Regular physical activity is important in preventing and managing the condition, along with supplements and possibly medication.

Chapter 9 - Hormone replacement therapy

Introduction
This chapter explains the principles of hormone replacement therapy (HRT) and the associated risks.

HRT is used in the treatment of **menopause** to reduce menopausal symptoms. It mainly involves taking oestrogen but may also include other hormones such as progesterone and even testosterone. These hormones may be administered as oral tablets, gels, patches, or implants. Patients who have had a hysterectomy are typically prescribed oestrogen only, whilst combined HRT is typically given to patients who still have a uterus to prevent the development of endometrial cancer.

However, several risks are associated with HRT. One of these is the development of **breast cancer** from increased exposure to oestrogen, which can increase the proliferation of some breast cancer cells. HRT also increases the risk of blood clots in the form of **venous thromboembolisms**, including deep vein thrombosis and pulmonary embolism. These can be fatal conditions, so it is important to consider, especially if patients are overweight or have family history of blood clots. There may also be links to HRT increasing the risk of strokes and dementia. Therefore, it is important to monitor patients carefully when taking HRT and it should not be used excessively.

Other treatment options for menopause are available, which tend to be more specific to particular symptoms. These include SSRIs and SNRIs for hot sweats and mood, vaginal moisturisers and lubricants, and vaginal oestrogen. Vaginal oestrogen is not considered systemic HRT as it is low dose oestrogen in the form of a cream or vaginal ring, so endometrial protection with progesterone is not necessary. Some patients may choose to use herbal treatments or just change lifestyle factors, but there is mixed evidence for these.

Slim Summary!

- HRT is used to treat menopausal symptoms and involves administering oestrogen, either alone or with other hormones;
- It can increase the risk of breast cancer due to the increased exposure to oestrogen, and can also increase the risk of thromboembolisms and strokes.

Chapter 10 - Frailty

Introduction
This chapter describes frailty and its associated risks for patients.

Frailty is a syndrome defined as a state of increased vulnerability to poor resolution of homeostasis after a stressor event, which increases the risk of adverse outcomes. Scaling a person's frailty involves assessing their mental and physical resilience, and their ability to recover from an illness or injury. Its prevalence and severity often increase with age. Below is a clinical frailty scale with descriptions of different severities of frailty.

Clinical Frailty Scale. *Source: physio-pedia.com*

Frailty usually causes worse outcomes for patients, such as more falls, increased rates of hospitalisation, increased rates of care home admission, and increased rates of mortality. Falls in particular are a common cause for hospitalisation and they may occur for various reasons. These include sedative drugs, conditions such as osteoporosis and kyphosis, and simple trip hazards such as poor footwear or rugs. When a frail person is injured and hospitalised, there is also an increased risk of developing infections as the immune system is weakened.

It is important that appropriate treatment is given, and this doesn't just include medications, but also assessments of mental health and social circumstances. A comprehensive geriatric assessment should be carried out for frail patients, and if there are concerns about their health then it may be necessary to suggest a care home admission or provision of carers. Patient preference should also be considered but in some cases, such as where a patient lacks capacity to make certain decisions, doctors may have to act against their preferences in the patient's best interest.

Slim Summary!
• Frailty is a syndrome defined as a state of increased vulnerability to poor resolution of homeostasis after a stressor event; • It usually means worse outcomes for patients, for example after falls or infections and increased hospitalisations.

Chapter 11 - Components of the skin

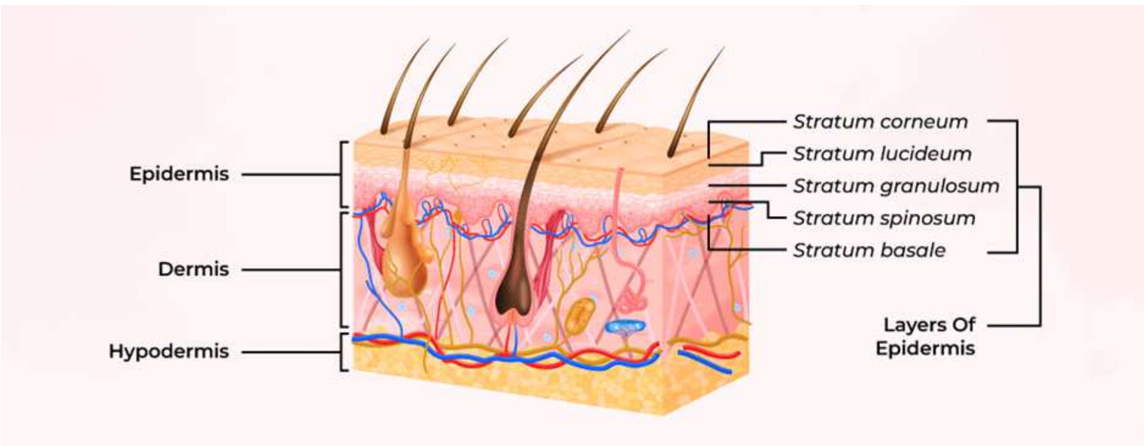
Introduction
This chapter describes the major components of the skin, including the dermis, epidermis, and epidermal appendages.

The **epidermis** is made up of multiple layers. The bottom layer is the **stratum basale**, a single layer of cells where mitosis occurs. There are also melanocytes in the stratum basale, which produce melanin that protects against UV radiation. The **stratum spinosum** is a prickle cell layer, which includes 8-10 layers of cells characterised by spines or cytoplasmic processes that connect neighbouring cells. This layer provides strength and flexibility. The **stratum granulosum** consists of 3-5 layers of cells containing granules that are precursors to keratin. The **stratum lucidum** is a thin, transparent layer of cells which is only in thick areas of skin, such as the palms of hands and the soles of the feet. It consists of keratinocytes that have accumulated keratin. Finally, the top layer of keratinised stratified squamous epithelium is termed the **stratum corneum**.

The **dermis** consists of dense irregular connective tissue that resists stretching and distension. It contains: bundles of collagen fibres, elastic fibres, little ground substance and fibroblasts, blood vessels and nerves throughout. The dermis is subdivided into the papillary layer (outer portion), and the reticular layer.

The **subcutaneous layer**, also known as the **hypodermis** or **superficial fascia** is areolar connective tissue that binds the skin tightly to organs. It contains varying amounts of adipose tissue, some collagen fibres, and has an extensive vascular supply.

Epithelial appendages include the hair follicles and hairs, which extend from the subcutaneous layer. The base is expanded at the hair bulb which encloses the hair papilla. These hairs are involved in regulating temperature. The sebaceous glands are found in the dermis and they produce sebum which is released by holocrine secretion. Sebum is a lipid that maintains hair and has some weak anti-bacterial and anti-fungal properties.



Layers of the skin. *Source: geeksforgeeks.org*

Slim Summary!
• The skin is made up of three main layers. The surface layer is known as the epidermis, the middle layer is known as the dermis, and the third and deepest layer is known as the hypodermis; • The epidermis is divided into many sublayers, starting from the base the layers are: basalis, spinosum, granulosum, lucidum, corneum; • The hypodermis is found beneath the dermis and is made up of adipose tissue, collagen fibres, and large blood vessels.

Chapter 12 - Wound healing

Introduction

This chapter discusses wound healing as a process that restores tissue integrity after injury. It occurs through three major stages: the inflammatory stage, the proliferation stage, and the maturation stage.

Inflammatory Stage

The inflammatory stage begins immediately after the wound is created. The first part of this phase is hemostasis, where blood vessels rapidly constrict to reduce blood loss. Platelets then aggregate and interact with fibrin to form a stable clot. This clot not only prevents further bleeding but also creates a temporary scaffold that supports the migration of essential cells into the wound area.

Following hemostasis, inflammation begins. Blood vessels dilate in response to chemical mediators, allowing lymphocytes, nutrients, enzymes, and growth factors to reach the wound site. These substances promote cell migration and tissue repair. The classic signs of inflammation are erythema, edema, and pain which appear during this time. In addition, exudate is produced as fluid leaks from the blood vessels, helping maintain the moist environment that supports cellular movement and wound healing.

Two key cell types dominate this phase. Neutrophils arrive first and perform phagocytosis to remove bacteria and debris. Afterward, macrophages take over, continuing phagocytosis and releasing cytokines that regulate inflammation and stimulate the next stage of healing. This phase sets the foundation for tissue reconstruction.

Proliferation Stage

The proliferation stage focuses on rebuilding the wound through the formation of granulation tissue, angiogenesis, and epithelialization. During the granulation phase, the wound becomes filled with new granulation tissue, which restores structural integrity. Fibroblasts produce type III collagen, which provides early tensile strength, while also generating a rich extracellular matrix that acts as a scaffold for cell attachment and organization.

Angiogenesis occurs simultaneously as endothelial cells proliferate under the influence of growth factors such as VEGF. These cells form new capillary loops, supplying oxygen and nutrients to support tissue formation. Healthy granulation tissue appears pink to red, slightly uneven in texture, and does not bleed easily. In contrast, dark or dusky granulation tissue suggests poor perfusion or early ischemia.

As granulation tissue fills the wound, epithelialization begins. Epithelial cells migrate from the wound edges, spreading over the new tissue while proliferating and differentiating into mature skin cells. This creates a new surface layer that restores the barrier function of the skin and marks the beginning of wound closure.

Maturation Stage

The maturation stage which is also known as the remodeling phase is the final phase of wound healing. It begins once the wound is fully closed and may last from several weeks to many months. The primary goal of this stage is collagen remodeling. The initially deposited type III collagen, which is weaker, is gradually replaced by type I collagen, which is stronger and more organized. The collagen fibers become highly cross-linked, greatly increasing the wound's tensile strength.

During this phase, overall cellular activity decreases. Excess fibroblasts and parts of the extracellular matrix are removed through programmed cell death, and many newly formed blood vessels regress as the metabolic demands of the tissue decline. Although the wound becomes significantly stronger, healed tissue typically reaches only about 80% of its original tensile strength.

Slim Summary!

- Inflammatory Stage: Begins immediately after injury with hemostasis (clot formation) followed by inflammation, where neutrophils and macrophages remove debris, fight infection, and release cytokines to prepare the wound for repair.
- Proliferation Stage: Focuses on rebuilding tissue through granulation tissue formation, angiogenesis, and epithelialization, restoring structural integrity and creating a new skin barrier.
- Maturation (Remodeling) Stage: Final phase where type III collagen is replaced with stronger type I collagen, excess cells and vessels regress, and the wound gradually strengthens, reaching about 80% of the original tensile strength.

Chapter 13 - Control of infection

Introduction
This chapter defines the control of infection in a clinical environment and specifically explains the risks of MRSA infection and its management.

Signs of infection
The main signs of infection include redness, swelling, heat, pain, and loss of function. This can take the form of many presentations, including inflammation, suppuration, necrosis, lymphadenopathy, fever, fatigue, headache, nausea, gastrointestinal disturbance, rash, weight loss, and night sweats. It is important to notice the warning signs of infection in a clinical setting so that it can be treated promptly and the risk of spread can be reduced.

Treatment of infection
Symptomatic and topical treatment may be given for less severe infections, and in some cases, surgery may be required to remove infected abscesses or biofilms. Antimicrobials, which include antibiotics, are often prescribed accordingly. Treatment with broad-spectrum antibiotics may be initiated before the targeted microorganisms are identified, and this is known as **empiric** therapy, which is used so that treatment can be given to quickly deteriorating patients, even if a culture report has not yet been obtained. Once the specific microorganisms are known, **targeted** therapy should be given. When prescribing antibiotics, it is important that the correct drug and dose are prescribed and that the duration of the course of the drug is clearly explained to the patient. It is important that the patient takes the correct dose for the full length of time required in order to destroy all the bacteria and prevent the development of resistant strains. Side effects and allergies should also be considered when prescribing antibiotics. When interacting with patients with infections, the correct hygiene precautions should be taken, including wearing PPE and cleaning hands and equipment thoroughly.

Preventing infection
As mentioned before, it is important that hygiene measures are followed to prevent the spread of infections. Patients may also be isolated if they are at high risk of contracting infections and having severe effects from it; for example, if a patient's immune system is extremely suppressed due to a disease or treatment. In some cases, antimicrobials may be prescribed as pre-emptive therapy or prophylaxis if a patient is at high risk of developing a severe infection.

MRSA infection
MRSA is **methicillin-resistant Staphylococcus aureus**. S. aureus is a gram-positive bacteria which rapidly forms biofilms and is common in medical device infections. It is also found in superficial lesions, pneumonia, endocarditis, food poisoning, and toxic shock syndrome. It is therefore very commonly seen in hospitals and the management of it is important. Staphylococcal penicillin would usually be used, but in the case of MRSA, the strain is resistant, and penicillin would not be effective. The strain is most commonly resistant to beta-lactam antibiotics, such as penicillin and amoxicillin. Other antibiotics classes, such as glycopeptides would have to be used. For example, vancomycin is commonly used for MRSA. It may also be necessary to use several antibiotics rather than just one, as there is the risk that the bacteria may be resistant to multiple types. As more resistant strains of bacteria emerge, antibiotic custodianship becomes increasingly important to prevent the morbidity and mortality rates of infections.

Slim Summary!

- The main signs of infection include redness, swelling, heat, pain, and loss of function, and it is important to recognise and treat infection quickly;
- Antibiotics are commonly used to treat bacterial infections and can be used for both empiric and targeted therapy, but they should always be used according to the principles of antibiotic custodianship;
- MRSA is a common resistant strain of S. aureus, and cannot be treated with methicillin or penicillin, so alternative options include glycopeptides like vancomycin.

Chapter 14 - Sepsis

Introduction
This chapter explains the principles of sepsis and how it is prevented and treated. Sepsis is a medical emergency and is defined as life-threatening organ dysfunction caused by a dysregulated host response to infection. Different microbes can be involved, and some symptoms may be unpredictable depending on each patient's immune response. It has a much higher mortality rate than other diseases, and the recovery after can be very difficult for patients.

Signs of sepsis
The main symptoms of sepsis include a high respiratory rate, tachycardia, low blood pressure, and signs of organ dysfunction. Some signs of organ dysfunction include confusion, anuria, oedema, and gastrointestinal disturbance. Meningitis is also a life-threatening medical emergency which can lead to sepsis and presents with a rash which does not fade when pressed. Tests for levels of bilirubin, platelets, and creatinine may be performed to confirm organ dysfunction.

Treatment and prevention of sepsis
To treat sepsis, there are three things to give to patients, and three things to take from patients. These form the "**sepsis six**". **Oxygen, antibiotics, and fluids** should be administered to patients, and **blood, lactate, and urine** should be taken and tested. Patients should be monitored closely, and organ support should also be given for any organ dysfunction. In severe cases, it may be necessary to amputate necrotic tissue, where the tissue has turned black and gangrenous due to reduced blood flow. The long-term recovery from sepsis may involve rehabilitation and therapy and is often difficult for patients, so it is important that the relevant support is given to them. In order to prevent sepsis, relevant hygiene measures should be taken in clinical environments where infection can easily spread. There are also vaccinations available which prevent the development of severe infections.

Slim Summary!

- Sepsis is defined as life-threatening organ dysfunction caused by a dysregulated host response to infection;
- The "sepsis six" includes oxygen, antibiotics, and fluids which should be administered to patients, and blood, lactate, and urine which should be taken and tested from patients.

Chapter 15 - Steroid treatment

Introduction

This chapter will discuss the indications, contraindications, and effects of steroid hormone treatment. Major classes include androgens, estrogens, progesterone, and corticosteroids, each with distinct physiological roles. However, steroid treatment commonly refers to the use of corticosteroids which is explored below.

Use of Corticosteroids

Corticosteroids are steroid hormones produced by the adrenal cortex. They are essential for regulating metabolism, immune function, stress responses, and electrolyte balance. Clinically, synthetic corticosteroids are widely used for inflammation and autoimmune conditions because of their strong immunosuppressive properties. Corticosteroids are prescribed to suppress the immune system, especially in autoimmune diseases such as lupus or rheumatoid arthritis. It also reduces inflammation, particularly in conditions like asthma, severe allergies, and inflammatory skin diseases.

Types of Corticosteroids

Glucocorticoids (prednisone, dexamethasone, and hydrocortisone) regulate glucose metabolism, reduce immune activity, and play a major role in the body's stress response. They are commonly used to treat autoimmune and inflammatory disorders. Mineralocorticoids (eg. aldosterone, fludrocortisone) maintain blood pressure and electrolyte balance by regulating sodium and water reabsorption in the kidneys.

Prescribing Principles for Corticosteroids

When corticosteroids are required, healthcare providers aim to use them as safely and effectively as possible. The primary goal is to prescribe the lowest effective dose to achieve the desired therapeutic outcome while minimizing adverse effects. Treatment duration should also be limited whenever possible to reduce the risk of long-term complications. For patients who need prolonged corticosteroid therapy, supportive measures are often recommended. These may include bone protection strategies such as vitamin D, calcium supplementation, or bisphosphonates, regular blood glucose monitoring due to the risk of steroid-induced hyperglycemia; and gastrointestinal protection when appropriate, especially if additional medications like NSAIDs are being used.

Adverse Effects of Corticosteroids

Short-term corticosteroid use, typically less than three weeks, is generally well tolerated and associated with minimal side effects. However, long-term use significantly increases the risk of complications, particularly those affecting bone health, metabolism, and body composition.

Steroid-Induced Osteoporosis

Prolonged exposure to corticosteroids is a major cause of secondary osteoporosis. Several mechanisms contribute to this condition: corticosteroids reduce calcium absorption in the gastrointestinal tract, which can trigger an increase in parathyroid hormone (PTH) that draws calcium from bones. They also enhance osteoclast activity, accelerating bone breakdown. Together, these effects lower bone density and increase the likelihood of fractures.

Cushing's Syndrome

Chronic high levels of glucocorticoids, either from long-term medication use or disease can lead to Cushing's syndrome. This condition is marked by characteristic physical changes such as a round "moon" face, a fatty "buffalo hump," central obesity, thinning skin, easy bruising, and purple striae. These arise from the widespread metabolic and structural effects of excess glucocorticoids on the body.

Mechanism of Action of Glucocorticoids

Genomic Actions

Glucocorticoids exert many of their effects through genomic pathways. After entering the cell, they bind to glucocorticoid receptors (GRs) in the cytoplasm. The resulting hormone–receptor complex moves into the nucleus, where it influences gene transcription. This can include upregulating anti-inflammatory cytokines like IL-10 and TGF-β, while downregulating pro-inflammatory cytokines such as IL-1 and TNF-α. Because these actions require changes in gene expression and protein synthesis, genomic effects typically take hours to days to develop.

Non-Genomic Actions

Glucocorticoids also produce rapid effects through non-genomic pathways. Instead of going into the nucleus, glucocorticoids interact with receptors on the cell membrane or directly with cell signaling systems inside the cell (like MAPK pathways). These fast actions can produce immediate effects, like reducing inflammation quickly, even before the slower genomic effects kick in.

Slim Summary!
• Corticosteroids regulate metabolism, immunity, and inflammation. Glucocorticoids treat autoimmune/inflammatory conditions, while mineralocorticoids control electrolytes. • Long-term use can cause osteoporosis, fractures, metabolic issues, and Cushing's syndrome. • They act via genomic pathways (gene regulation) and non-genomic pathways (rapid cellular effects).

Chapter 16 - Impact of ageing on the body's handling of drugs

Introduction

This chapter discusses pharmacology in older adults is influenced by age-related changes in both pharmacokinetics and pharmacodynamics. Aging alters these processes, often leading to increased drug sensitivity, accumulation, and risk of adverse effects.

Pharmacokinetics

Pharmacokinetics describes how the body absorbs, distributes, metabolizes, and excretes drugs.

Absorption

Age-related changes in the gastrointestinal (GI) tract can affect drug absorption, though the clinical impact is often modest. Older adults typically have reduced secretion of digestive enzymes and gastric acid, decreased surface area for absorption, slower gastric emptying, and reduced intestinal motility. These changes may delay the time to peak drug concentration and, in some cases, reduce the extent of absorption, particularly for drugs requiring an acidic environment.

Distribution

Changes in body composition with age significantly affect drug distribution. Total body water decreases, resulting in a smaller volume of distribution for water-soluble drugs. This can lead to higher plasma concentrations and increased risk of toxicity, such as with aminoglycosides. Conversely, body fat increases with age, enlarging the volume of distribution for lipid-soluble drugs. These drugs may accumulate in fat tissue, prolonging their half-life and delaying clearance. Plasma proteins, particularly albumin, often decline in older adults, leading to higher levels of free (active) drug for protein-bound medications, which increases the potential for drug toxicity.

Metabolism

Hepatic metabolism is also altered with age. Liver size and blood flow decline, reducing the metabolism of many drugs. Phase I reactions, including oxidation, reduction, and hydrolysis, decrease, particularly those mediated by cytochrome P450 enzymes, resulting in prolonged drug half-lives. In contrast, Phase II reactions such as glucuronidation, sulfation, and acetylation remain largely unchanged. Reduced first-pass metabolism can also increase the bioavailability of orally administered drugs. These changes make careful dose adjustment and monitoring essential for medications metabolized primarily by the liver.

Excretion

Renal excretion declines with age, primarily due to reduced glomerular filtration rate (GFR), which decreases by approximately 1% per year after age 40. Tubular function also becomes less efficient, impairing secretion and reabsorption of drugs. These changes, compounded by comorbidities such as diabetes, heart failure, or chronic kidney disease, can result in accumulation of renally excreted drugs and a higher risk of toxicity. Monitoring renal function and adjusting doses accordingly is critical in older adults.

Pharmacodynamics

Pharmacodynamics describes how drugs affect the body, including their mechanisms of action. Older adults often exhibit increased sensitivity to drugs due to reduced physiological reserves and altered receptor responses. For example, opioids, NSAIDs, and aminoglycosides carry a higher risk of neurotoxicity, nephrotoxicity, and gastrointestinal toxicity in the elderly. Baroreceptor function is blunted, making older adults prone to orthostatic hypotension, a sudden drop in blood pressure when standing, which can increase the risk of falls. Drugs with anticholinergic activity block the action of acetylcholine, which naturally declines with age and is critical for memory, learning, and cognition. These drugs can exacerbate vulnerability to cognitive decline, dementia, and Alzheimer's disease. Common anticholinergic side effects include blurred vision, dry mouth, constipation, skin flushing, and tachycardia.

Slim Summary!
• Pharmacodynamics: Aging affects absorption, distribution, metabolism, and excretion, increasing the risk of drug accumulation and toxicity. • Pharmacodynamics Changes: Older adults have increased sensitivity to drugs due to reduced physiological reserves and altered receptor responses, making them more vulnerable to adverse effects.

Chapter 17 - Multiple morbidity and polypharmacy

Introduction

This chapter discusses multiple morbidity and polypharmacy which increase the risk of adverse effects and drug interactions

Multiple morbidity (or multimorbidity) refers to the presence of two or more chronic health conditions in the same individual, and it becomes increasingly common with age. This creates significant challenges because each condition may require separate treatments, tests and monitoring, which can conflict with one another. A medication that benefits one illness can worsen another, and patients with multiple conditions have reduced physiological reserves, making them more vulnerable to adverse drug effects. Multimorbidity also increases the likelihood of fragmented care, as patients often see several specialists who may prescribe medications independently, raising the risk of duplication or unsafe combinations.

Polypharmacy, is defined as the use of five or more medications, often arises as a direct consequence of multimorbidity. As the number of medications increases, the risk of adverse drug reactions grows exponentially. Older adults are especially susceptible due to age-related changes in drug absorption, distribution, metabolism and excretion. Polypharmacy also raises the likelihood of drug–drug interactions, drug–disease interactions and complications such as falls, cognitive impairment and hospital admissions. Many medications used by older adults, including sedatives, antidepressants, opioids, antihypertensives and hypoglycaemic agents can significantly increase fall risk. Drugs with anticholinergic properties can worsen memory, confusion and delirium, while complex medication regimens can make adherence difficult for patients, leading to missed doses or unintentional overdosing.

Recognising these issues involves understanding the clinical consequences of both multimorbidity and polypharmacy. Effective management requires regular medication reviews, deprescribing where appropriate, simplifying treatment regimens and avoiding high-risk medications in older adults whenever possible. Improved communication between healthcare professionals and greater use of non-pharmacological approaches also reduce unnecessary prescribing. Overall, recognising the issues of multiple morbidity and polypharmacy means appreciating how these factors interact to increase patient vulnerability and adapting clinical care to minimise harm while maximizing therapeutic benefit.

- Multimorbidity involves having two or more chronic conditions, which can lead to conflicting treatments and increased vulnerability to drug-related harm.
- Polypharmacy, defined as taking five or more medications, further raises the risk of adverse drug reactions, falls, cognitive impairment, and hospitalisation.
- Effective management requires regular medication reviews, deprescribing when appropriate, simplification of regimens, and careful monitoring to minimize harm.

Chapter 18 - Societal influences on perceptions of age

Introduction
This chapter describes the societal influences on perceptions of age.

There are several influences in society which can affect perceptions of ageing and the elderly population. The media often portrays elderly people with low competencies and vulnerability, making it seem like they are very dependent on others and have less active lifestyles. This can form stereotypical perceptions in society and people may behave in derogatory ways towards the elderly population. It also encourages people to feel pity for the elderly, rather than viewing them as active and important members of society. The elderly commonly experience boredom and social isolation due to people not including them in active daily activities, and their mental health may decline as a result. There are also some cultural differences in perceptions of the elderly, as some cultures highlight great respect for the elderly in their traditions.

Slim Summary!
• The media has a big influence on society's perception of the elderly, and can lead to stigma and mistreatment; • The elderly may experience social isolation and depression when they are not included in active daily life.

Chapter 19 - Biopsychosocial model and successful ageing

Introduction

This chapter discusses the biopsychosocial model and how it provides a framework for understanding how biological, psychological, and social factors interact to support health, well-being, and functional independence in older adults.

The concept of successful aging can be understood effectively through the biopsychosocial model. Biologically, successful aging involves maintaining physical health, minimising disease and disability, and preserving functional independence for as long as possible. This includes avoiding frailty through good nutrition, physical activity, chronic disease management and preventive healthcare. Psychological aspects include cognitive resilience, the ability to adapt to life changes, emotional stability and maintaining a sense of purpose. Older adults who use positive coping strategies, stay mentally stimulated and maintain autonomy are more likely to experience a sense of well-being even in the presence of chronic illness.

Regarding the social aspect of the model, successful aging is strongly supported by meaningful social connections, supportive relationships, community belonging and opportunities to remain socially engaged. Loneliness and isolation negatively affect health outcomes, while strong social networks improve mood, cognition and even physical health. Factors such as socioeconomic status, access to healthcare and safe living environments also shape an individual's aging experience. Overall, the biopsychosocial model highlights that successful aging is multidimensional, emphasising wellness, adaptability and social support rather than simply the absence of illness.

Slim Summary!
• When biological, psychological and social elements interact positively, an individual is more likely to age successfully, not necessarily defined as aging without disease, but as aging with high quality of life, preserved dignity and the ability to participate in life according to one's values.

Chapter 20 - Breaching confidentiality

Introduction

This chapter discusses circumstances where it may be necessary to breach a patient's confidentiality. If a healthcare professional is unsure about breaking confidentiality, then they should consult a senior colleague before doing so. When breaking confidentiality, robust notes should also be kept to document and justify the reasoning for breaking confidentiality.

Breaching confidentiality

As discussed previously, if there is potential harm caused to others by not breaking confidentiality, then it may be necessary to break it. An example of this is when a patient has a sexually transmissible disease (STD) such as HIV and they are sexually active. Whilst the HIV is transmissible, sexual partners of the patient would need to be informed of the risk to them as potential harm could be caused. The patient should be informed of this requirement and encouraged to tell their partner themselves about their condition. However, if the patient refuses the doctor would still have a duty to inform the partner as there is potential risk and harm. If the patient has taken the relevant medications and their HIV becomes undetectable (and therefore untransmissible), then it would not be necessary to breach confidentiality as the virus can no longer be transmitted by the patient to their partner.

In cases of communicable diseases, it may be in the public interest to breach confidentiality, because there is a high risk of harm to the general public. Therefore, healthcare professionals and courts may have a duty to release patient information in order to protect the general public. The amount of information needed to be shared should be assessed, and ideally patients should be encouraged to consent to the release of their information. Confidentiality should still be respected as much as possible, so only the necessary information about their health should be released. It may also be in the public interest to breach confidentiality in cases of work accidents and food poisoning to prevent potential harm being caused to others.

Patients may also lack capacity to consent to a breach of confidentiality, for example if they are unconscious or have a condition affecting their cognition. If this happens in an emergency situation, it may be necessary to breach confidentiality and inform next of kin about the situation. This is so that any relevant information about their health can be obtained and imperative decisions about treatment can be made.

Slim Summary!
• It is necessary to breach confidentiality where there is potential harm caused to the general public by disease transmission, such as with STDs and communicable diseases; • Patients may also lack capacity to consent to breaching confidentiality in emergency situations, so it may be necessary to inform next of kin.

Chapter 21 - Risk of breast cancer

Introduction
This chapter outlines the risk factors and epidemiology of breast cancer in the UK.

Breast cancer is much more common in women and is the most common cancer diagnosed in women, but it is still possible for men to get breast cancer. The risk of breast cancer increases with age, and it is more common in white women. Family history and genetic predispositions, which were mentioned in previous chapters, are also high-risk factors. Early menarche and HRT also increases the risk of breast cancer as there is increased exposure to oestrogen, and in contrast child-bearing decreases risk. Other lifestyle factors such as high alcohol consumption, heavy smoking, and obesity also increase risk. Approximately 56,900 new cases of breast cancer are diagnosed every year in the UK and there has been a slight increase in incidence rates in the last decade.

Slim Summary!
• Risk factors of breast cancer include female gender, early menarche, HRT, poor diet, old age, and heavy smoking or drinking.

Afterword

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