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Anatomy and Radiographic Positioning Terminology
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Radiographers must possess a thorough knowledge of anatomy and medical terminology

General Anatomy

- Definitions of terms
- Body planes
- Body cavities
- Divisions of the abdomen
- Surface landmarks
- Body habitus

Definitions of Terms

- Anatomy
  - the term applied to the science of the structure of the body
- Physiology
  - the study of the function of the body organs
- Osteology
  - the detailed study of the body of knowledge relating to the bones of the body
- Radiographers must have a solid understanding of all body systems and their functions
- Radiographers must also know the surface landmarks used to locate different body parts
- Radiographers must be able to visualize the skeleton within
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Body Planes

• Imaginary planes that subdivide the body in reference to anatomic position
• Planes “slice” the body in all directions at designated levels
• Fundamental planes
  – sagittal: left and right parts
  – coronal: anterior/posterior parts
  – horizontal: superior/inferior parts
  – oblique: any other angle
• Sagittal planes divide the body into right and left segments, passing vertically from front to back
• Midsagittal plane (MSP) is a specific sagittal plane that passes through midline and divides the body into equal right and left halves
• Coronal planes pass through the body vertically from side to side, dividing the body into anterior and posterior parts
• Midcoronal plane (MCP), also called midaxillary plane, is the specific plane that passes through midline and divides the body into equal anterior and posterior halves
• Horizontal planes pass crosswise through the body or body part at right angles to the longitudinal axis
  – positioned at right angle to sagittal and coronal planes
  – divides the body into superior and inferior portions
  – also called transverse, axial, or cross-sectional planes
• Oblique planes pass through a body part at any angle between the previous three planes
Body Planes

- Special planes are localized to specific parts or areas of the body
  - interiliac plane transects the body at the pelvis at the top of the iliac crests (level of L4)
  - occlusal plane formed by the biting surfaces of the upper and lower teeth with the jaw closed

Body Cavities

- Two great cavities
  - thoracic cavity
  - abdominal cavity
- Abdominal cavity has no lower partition, but the lower portion is called the pelvic cavity
- Often referred to as the abdominopelvic cavity
- Thoracic cavity contains:
  - pleural membranes
  - lungs
  - trachea
  - esophagus
  - pericardium
  - heart and great vessels
Body Cavities

- Abdominal cavity contains:
  - peritoneum
  - liver
  - gallbladder
  - pancreas
  - spleen
  - stomach
  - intestines
  - kidneys
  - uterus
  - major blood vessels

- Pelvic portion contains:
  - rectum
  - urinary bladder
  - part of the reproductive system

Divisions of the Abdomen

- Bordered superiorly by diaphragm
- Bordered inferiorly by superior pelvic aperture (pelvic inlet)
- Abdomen divided in two methods:
  - quadrants
  - regions
- Quadrants are useful for describing the location of various abdominal organs
- Four quadrants
  - right upper quadrant (RUQ)
  - right lower quadrant (RLQ)
  - left upper quadrant (LUQ)
  - left lower quadrant (LLQ)
- Abdomen divided into nine regions by four planes, two horizontal, and two vertical
- Not used as often as quadrants
Divisions of the Abdomen

- Superior regions
  - right hypochondrium
  - epigastrium
  - left hypochondrium
- Middle regions
  - right lateral
  - umbilical
  - left lateral
- Inferior regions
  - right inguinal
  - hypogastrium
  - left inguinal

Surface Landmarks

- Most anatomic structures cannot be seen or palpated
- To accurately position, radiographers rely on palpable external landmarks to locate unseen anatomy
- Practice is needed to use surface landmarks accurately
- Glabella and glabellomeatal line (GML)
- Outer canthus and orbitomeatal line (OML)
- Infraorbital margin and infraorbitomeatal line (IOML)
- Acanthion and acanthiomeatal line (AML)
- Mental point and mentomeatal line (MML)
- Cervical area
  - mastoid tip: C1
  - gonion (angle of mandible): C2, C3
  - hyoid bone: C3, C4
  - thyroid cartilage: C5
  - vertebra prominens: C7, T1
Surface Landmarks

- **Thoracic area**
  - 2” above jugular notch: T1
  - jugular notch: T2,3
  - sternal angle: T4,5
  - inferior angles of scapulae: T7
  - xiphoid process: T9,10

- **Lumbar and pelvic area**
  - inferior costal margin: L2,3
  - iliac crests: L4,5
  - anterior/superior iliac spine (ASIS): S1,2
  - pubic symphysis, greater trochanter: coccyx

Body Habitus

- Defined as the common variations in the shape of the human body
- Important in radiography because habitus determines size, shape, and position of organs of the thoracic and abdominal cavities
- Organs affected by body habitus
  - heart
  - lungs
  - diaphragm
  - stomach
  - colon
  - gallbladder
- Four major types of body habitus
  - sthenic
  - hyposthenic
  - asthenic
  - hypersthenic
- Sthenic and hyposthenic are considered average
- Hypersthenic and asthenic are the extremes
Body Habitus

- Sthenic body habitus
  - 50% of population
  - heart: transverse
  - lungs: moderate length
  - diaphragm: moderately high
  - stomach: high, upper left
  - colon: slight dip in transverse colon
  - gallbladder: centered on right side
  - moderately heavy build with long abdomen, thorax is short, broad, and deep, small pelvis

- Hyposthenic body habitus
  - 35% of population, hard to classify
  - heart: vertical and transverse
  - lungs: moderate length
  - diaphragm: high
  - stomach: centered left
  - colon: dip in transverse colon
  - gallbladder: lower right side, towards midline
  - moderate build with medium-length abdomen, thorax and pelvis are moderate

- Asthenic body habitus
  - 10% of population
  - heart: vertical and midline
  - lungs: long, apices above clavicle, broad base
  - diaphragm: low
  - stomach: low and medial
  - colon: low and folds on itself
  - gallbladder: lower right side, towards midline
  - frail build with short abdomen, thorax is long and shallow, wide pelvis

- Hypersthenic body habitus
  - 5% of population
  - heart: near transverse
  - lungs: short, apices near clavicle
  - diaphragm: high
  - stomach: high, transverse, midline
  - colon: around periphery of abdomen
  - gallbladder: high right side, laterally
  - massive build with long abdomen, thorax is short, broad, and deep, narrow pelvis
Osteology

• Skeletal divisions
• General bone features
• Bone development
• Classification of bones

Bone Functions

• Attachment for muscles
• Mechanical basis for movement
• Protection of internal organs
• Support frame for body
• Storage for calcium, phosphorus, and other salts
• Production of red and white blood cells

Skeletal Divisions

• Total of 206 bones in the body
• Divided into two main groups
  — axial skeleton: 80 bones
  — appendicular skeleton: 126 bones
• Axial skeleton supports and protects the head and trunk
  — 80 bones
    • skull
    • neck
    • thorax
    • vertebral column
• Appendicular skeleton provides means for movement
  — 126 bones
    • shoulder girdle
    • upper limbs
    • lower limbs
    • pelvic girdle
General Bone Features

- Compact bone
  - strong, dense outer layer
  - provides protection and gives support
- Spongy bone
  - inner, less dense layer
  - contains a spiculated network called trabeculae
    - trabeculae filled with red and yellow marrow
- Red marrow produces red and white blood cells
- Yellow marrow stores fat cells
- Long bones have medullary cavity
  - central cavity of long bones
  - contains trabeculae filled with yellow marrow
  - red marrow found in ends of long bones
- Periosteum
  - tough, fibrous connective tissue that covers bone, except at articular ends
- Endosteum
  - lines marrow cavity
- Bones are live organs that require a vast blood supply
- These vessels come and go through foramina
- The nutrient foramina is near the center of all long bones and supplies the cancellous bone with blood and nutrients

Bone Development

- Ossification is the term that applies to the development and formation of bones
- Begins in the second month of embryonic life
- Two processes
  - intramembranous: during fetal development
  - endochondral: during fetal development with the presence of cartilage
- Flat bones are formed by intramembranous ossification
  - skull
  - clavicles
  - mandible
  - sternum
- Short, irregular, and long bones are created by endochondral ossification
- Endochondral ossification occurs from two distinct centers of development
  - primary
  - secondary
- Primary ossification begins before birth and forms long central shaft in long bones
  - long shaft of the bone is called diaphysis
- Secondary ossification occurs after birth when separate bones begin to develop at both ends of long bones
  - ends are called epiphyses
Bone Development

- At birth, epiphyses and diaphysis are separate, as growth occurs a plate of cartilage called epiphyseal plate develops
- Fully developed by age 21
- This plate is seen in pediatrics and a common site for fractures

Classification of Bones

- Classified by shape
  - long
  - short
  - flat
  - irregular
  - Sesamoid

- Long bones
  - found only in limbs
  - consist of body and two enlarged articular ends
  - these ends contain a smooth, slippery articular surface covered with cartilage
  - may articulate with other long bones
  - examples: femur, humerus, and phalanges

Classification of Bones

- Short bones
  - consist mainly of cancellous bone with a thin outer layer of compact bone
  - vary in shape and allow minimum flexibility of motion in a short distance
  - example: carpal bones

- Flat bones
  - consist of two plates of compact bones sandwiching cancellous bone
  - middle layer of cancellous bone is called diploë
  - the flat portion provides protection and broad surfaces allow for muscle attachment
  - examples: sternum, cranium, and scapulae

- Irregular bones
  - peculiarly shaped
  - they have compact bone on the exterior and cancellous, red marrow containing bone on interior
  - their odd shape serves as attachments of muscles, tendons, ligaments, and other bones
  - examples: vertebrae, facial bones, and pelvic bones

- Sesamoid bones
  - very small and oval
  - develop inside and beside tendons
  - help decrease friction, act as a pulley system
  - protect the tendon from excessive wear
  - examples: patella (largest), others are inferior to the metatarsophalangeal joint, and the metacarpophalangeal
Arthrology

- Defined as the study of joints, or articulations, between bones
- Classified two ways
  - functional
  - structural

Functional Classification

- Three subdivisions based on mobility of joint
  - synarthroses: immoveable (sutures of the skull)
  - amphiarthroses: slightly moveable (pubic symphysis)
  - diarthroses: freely moveable (shoulder)

Structural Classification

- Three distinct groups based on connective tissues
  - fibrous
  - cartilaginous
  - synovial
- 11 specific types of joints fall within the above broad categories

Fibrous Joints

- Do not have a joint cavity (skull sutures)
- United by various fibrous and connective tissues and ligaments
- Strongest joints in the body
- Three types:
  - syndesmosis
  - suture
  - gomphosis
- Syndesmosis
  - immoveable or very slightly moveable
  - united by fibrous sheets
  - example: inferior tibiofibular joint
- Suture
  - immoveable joint only in the skull
- Gomphosis
  - immoveable joint only in roots of teeth
Cartilaginous Joints

- Do not have a joint cavity
- Virtually immovable
- Two types:
  - symphysis
  - synchondrosis

- Symphysis
  - slightly moveable joint
  - separated by a pad of fibrocartilage
  - designed for strength and shock absorbency
  - example: pubic symphysis

- Synchondrosis
  - immovable joint
  - united by rigid cartilage
  - example: epiphyseal plate

Synovial Joints

- Permit wide range of motion; freely moveable
- Complex joints
- Enclosed by articular capsule
- Many have accessory soft tissues
  - meniscus
  - bursae
- Six types
  - gliding
  - hinge
  - pivot
  - ellipsoid
  - saddle
  - ball and socket
Gliding Joint

- Simplest synovial joint
- Examples: intercarpal and intertarsal joints

Hinge Joint

- Permits flexion and extension only
- Examples: elbow and knee

Pivot Joint

- Allows rotation around a single axis
- Example: atlantoaxial joint (C1-C2 joint)

Ellipsoid Joint

- Allows flexion, extension, abduction, adduction, and circumduction
- Example: radiocarpal (wrist) joint

Saddle Joint

- Allows movement similar to ellipsoid
- Difference is in the shape of the articular surfaces
- Example: carpometacarpal joint between trapezium and first metacarpal

Ball and Socket Joint

- Permits widest range of motion
- Examples: hip and shoulder

Bone Markings and Features

- Processes or projections
  - extend beyond or project out from the main body of a bone (mastoid process)
- Depressions
  - hollow or depressed areas
- Fractures
  - a break in bone
Processes and Projections

• Condyle
  — rounded process at an articular end
• Coracoid or coronoid (coronoid process-ulna)
  — beak-like or crown-like process
• Crest (between greater and lesser trochanter, ant. femur)
  — ridge-like process
• Epicondyle (above condyle of inferior femur)
  — projection above a condyle
• Facet (spine)
  — small, smooth-surfaced articular process
• Hamulus (pterygoid hamulus, sphenoid)
  — hook-shaped process
• Head (femoral/humeral)
  — expanded end of a long bone

Processes and Projections

• Line (opposite of crest on posterior femur)
  — linear elevation; not as prominent as a crest
• Malleolus (ankle)
  — club-shaped process
• Protuberance (occipital protuberance)
  — projecting prominence
• Spine (ASIS)
  — sharp process
• Styloid (ulnar styloid process)
  — long, pointed process
• Trochanter (greater trochanter)
  — either of the two large, rounded, and elevated processes of the proximal femur
• Tubercle (greater tubercle)
  — small, rounded, and elevated process
• Tuberosity (tibial tuberosity)
  — large, rounded, and elevated process
Depressions

- Fissure (superior orbital fissure, sphenoid, and ethmoid)  
  - cleft or deep groove
- Foramen (optic foramen-sphenoid)  
  - hole in a bone for transmission of vessels and nerves
- Fossa (coronoid fossa)  
  - pit, fovea, or hollow space
- Groove (bicipital groove)  
  - shallow linear channel
- Meatus (EAM)  
  - tube-like passageway
- Notch (trochlear notch)  
  - indentation in the border of a bone
- Sinus (paranasal)  
  - recess, groove, cavity, or hollow space
- Sulcus (sulci of the brain)  
  - furrow or trench

Fractures

- Closed: does not break through skin
- Open: projects through skin
- Nondisplaced: retains normal alignment
- Displaced: not in alignment
- Common classifications  
  - compression (vertebrae)
  - compound (open)
  - simple (just a break)
  - greenstick (not complete)
- Many fractures fall into more than one category  
  - transverse (across)
  - spiral (around)
  - comminuted (pieces)
  - impacted (upon itself)
Anatomic Relationship

• Anatomic relationship terms (must be in anatomical position)
  — anterior (ventral)
    • forward or front part of the body or of a part
  — posterior (dorsal)
    • back part of body or part
  — caudad
    • parts away from the head of the body
  — cephalad
    • parts toward the head

Central Ray (CR)

• This is the principal x-ray beam emitting from the x-ray tube
• The CR is nearly always centered to the image receptor (IR)

Anatomic Relationship Terms

• Superior
  — nearer the head or situated above
• Inferior
  — nearer the feet or situated below
• Central
  — mid area or main part of an organ
• Peripheral
  — at or near the surface, edge, or outside of another body part
• Medial
  — toward the median plane of the body or toward the middle of a body part
• Lateral
  — away from the median plane or away from the middle of a part
• Superficial
  — near the skin or surface
• Deep
  — far from the surface
Anatomic Relationship Terms

• Distal  
  — farthest from the point of attachment or origin
• Proximal  
  — nearer to the point of attachment or origin
• External  
  — outside the body or part
• Internal  
  — inside the body or part
• Parietal  
  — the wall or lining of a body cavity
• Visceral  
  — the covering of an organ
• Ipsilateral  
  — parts on the same side of the body
• Contralateral  
  — parts on the opposite side of the body
• Palmar  
  — palm of the hand
• Plantar  
  — sole of the foot
• Dorsum  
  — anterior, or top, of the foot or the back of the hand

Positioning Terminology

• Projection  
  — defined as the path of the CR as it exits the x-ray tube, passing through the patient to the IR  
  — identified by the entrance and exit points of the body in anatomical position
• Position  
  — overall posture of the patient or general body position  
  — also refers to the specific placement of the body or part in relation to the table or IR
• View  
  — used to describe the body part as seen by the IR  
  — exact opposite of projection, the preferred term in the United States
• Method  
  — refers to a specific radiographic projection developed by an individual  
  • Towne (PA axial), Waters (PA)
Essential Projections

- Anterior-posterior (AP)
  - CR enters the anterior surface and exits the posterior
- Posterior-anterior (PA)
  - CR enters the posterior surface and exits the anterior
- Axial
  - longitudinal angle of the CR
- Tangential
  - CR directed along the outer margin of a curved body surface
- Lateral
  - CR enters one side of the body, passing transversely along the coronal plane
- Oblique
  - CR enters from side angle
  - entrance and exit surfaces still specified (e.g., AP oblique)

Positions

- General body positions
  - upright: erect or vertical
  - seated: upright, but sitting on a stool
  - recumbent: lying down in any position
  - supine: lying on the back
  - prone: lying face down
  - Trendelenburg’s position: supine with the head lower than the feet
  - Fowler’s position: supine with the head elevated
  - Sims’ position: recumbent with patient lying on left anterior side with left leg extended and right knee and thigh partially flexed
- Oblique position
  - body is rotated so that the coronal plane is not parallel with the table or IR
  - angle of rotation is specific for anatomy of interest
  - named according to side and surface of body closer to table or IR
- Decubitus position
  - recumbent position with a horizontal CR
  - named according to the body surface on which the patient is lying
- Lordotic position
  - upright position in which the patient is leaning backward
• Abduct or abduction
  — movement of a part away from the central axis of the body
• Adduct or adduction
  — movement of a part toward the central axis of the body
• Extension
  — straightening of a joint
• Flexion
  — bending of a joint
• Hyperextension
  — forced or excessive extension
• Hyperflexion
  — forced overflexion
• Evert/eversion
  — outward turning of the foot at the ankle
• Invert/inversion
  — inward turning of the foot at the ankle

• Pronate/pronation
  — rotation of forearm so that the palm is down
• Supinate/supination
  — rotation of forearm so that the palm is up
• Rotate/rotation
  — turning of the body or part around its axis
  — rotation of a limb is either medial (toward midline) or lateral (away from midline)
• Circumduction
  — circular movement of a limb
• Tilt
  — tipping or slanting a body part slightly
• Deviation
  — a turning away from the regular or standard course
Image Receptors

- Device that receives the energy of the x-ray beam and forms the image of the body part
- Four types:
  - cassette with film
  - image plate (computerized)
  - digital radiography
  - fluoroscopic screen
- Image receptor placement
  - longitudinal (long axis with long axis)
  - horizontal (short axis across long axis)
  - corner to corner

Quality Factors

- Know the anatomy so the exam may be accurately performed
- Density
  - optimal density must be in diagnostic range
  - correct technical factors (mA, sec, mAs)
  - amount of darkness
- Contrast
  - difference in adjacent densities (tissues)
  - shades of grey
  - controlled by kilovolt peak (kVp)
- Recorded detail
  - ability to visualize small structures
  - controlled by:
    - geometry
    - film
    - distance
    - screen
    - focal spot size
    - motion
Quality Factors

• Distortion
  – misrepresentation of the size/shape of a structure
  – may be caused by:
    • alignment
    • CR
    • anatomical part
    • IR
    • angulation
    • Magnification

• Source to image receptor distance (SID)
  – distance from the anode inside the x-ray tube to the IR
  – affects magnification (longer SID less magnification), recorded detail (longer SID better recorded detail), and patient dose
    • no less than 12”
    • 40” on most
    • 72” on some with increased object image distance (OID)

Quality Factors

• Motion
  – must communicate clearly
  – make patient comfortable
  – watch your patient
  – three types of motion
    • voluntary
    • involuntary
    • equipment

• Collimation
  – reduces patient dose
  – reduces scatter radiation
  – produces better recorded detail

• Markers
  – requirement that all radiographs contain R or L marker
  – should never obscure anatomy or patient ID
  – placed on the edge of collimation border
  – placed on lateral side
  – writing R or L on radiograph is not acceptable
Anatomy and Radiographic Positioning Terminology

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