EUROPEAN SOCIETY OF RADIOLOGY

eBook for Undergraduate Education in Radiology

CHAPTER: Computed Tomography

Preface

Undergraduate teaching of radiology in Europe is provided according to national schemes and may vary considerably from one academic institution to another. Sometimes, the field of radiology is considered as a "cross-cutting discipline" or taught within the context of other clinical disciplines, e.g., internal medicine or surgery.

This e-book has been created in order to serve medical students and academic teachers throughout Europe to understand and teach radiology as a whole coherent discipline, respectively. Its contents are based on the *Undergraduate Level of the ESR European Training Curriculum for Radiology* and summarize the so-called ***core elements*** that may be considered as the basics that every medical student should be familiar with. Although specific radiologic diagnostic skills for image interpretation cannot be acquired by all students and rather belong to the learning objectives of the *Postgraduate Levels of the ESR Training Curricula*, the present e-book also contains some ***further insights*** related to modern imaging in the form of examples of key pathologies, as seen by the different imaging modalities. These are intended to give the interested undergraduate student an understanding of modern radiology, reflecting its multidisciplinary character as an organ-based specialty.

We would like to extend our special thanks to the authors and members of the ESR Education Committee who have contributed to this eBook, to Carlo Catalano, Andrea Laghi and András Palkó who initiated this project, and to the ESR Office, in particular Bettina Leimberger and Danijel Lepir, for all their support in realising this project.

We hope that this ebook may fulfil its purpose as a useful tool for undergraduate academic radiology teaching.

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Chapter Outline

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Chapter Outline

eBook for Undergraduate Education in Radiology

Based on the ESR Curriculum for Undergraduate Radiological Education

Chapter: **Computed Tomography**

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The CT Scanner

- CT scanners include the following main components:
  - An X ray tube
  - A gantry with detectors which are sensitive to X rays. The X ray detectors are located directly opposite the X ray source.
  - A computer

- Images are generated using the same principle as in conventional radiography (see chapter on conventional radiography), however, the X ray source rotates around the gantry (unlike conventional X ray radiography, which uses a fixed X ray tube)

- During a CT examination, the patient lies on a bed that moves through the gantry while the X ray tube rotates around the patient (see Fig. 1).

- Depending on the indication, oral or intravenous or contrast media can be administered (see chapter on contrast media)

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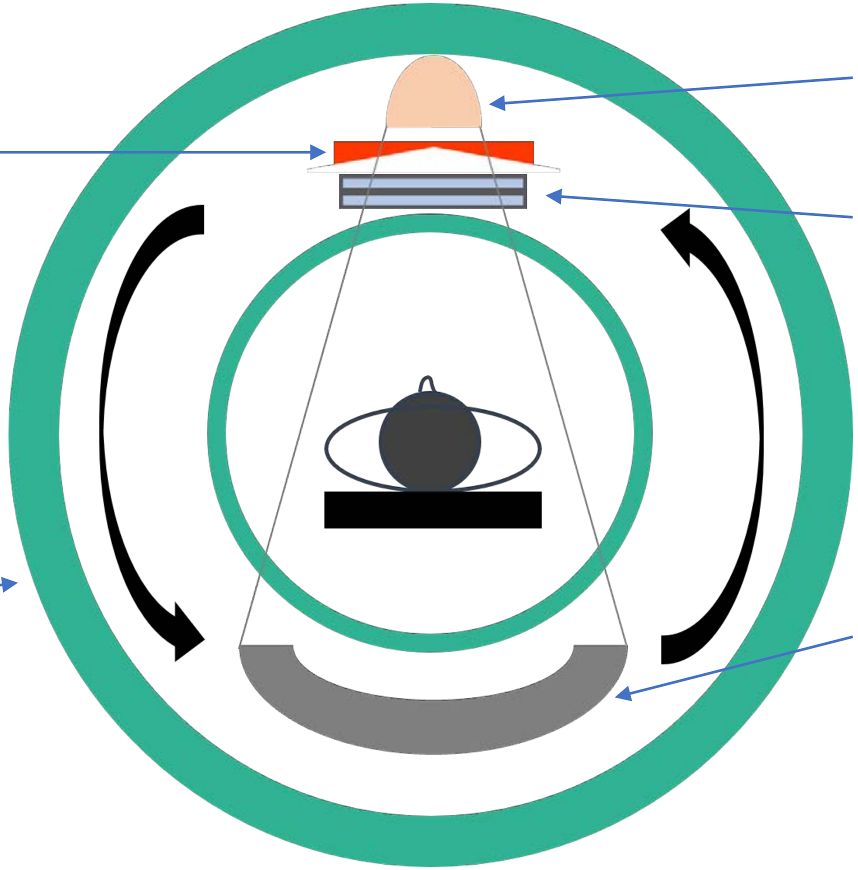
The CT Scanner

Filter
Removes low energy x-rays (unnecessary photons), which optimizes beam spectrum and enables scanning with a lower dose.

Gantry
Enabling rotation of the scaner components.



X-ray tube
Source of x-rays.

Collimator
Restricts scatter radiation and minimizes patient dose.

Detector array
- A scintillator converts x-rays into photons.
- A photodiode converts photons into an electric signal.

Figure 1. Components of the CT scanner
Image adapted with permission from (https://www.radiologycafe.com/frcr-physics-notes/ct-imaging/ct-equipment, last accessed 31.01.2023)

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CT Scanner Generations

3rd generation scanner

- Mostly used CT scanner nowadays.
- The x-ray tube and the detector rotate around the patient.
- The detector row covers the full width of the fan beam.

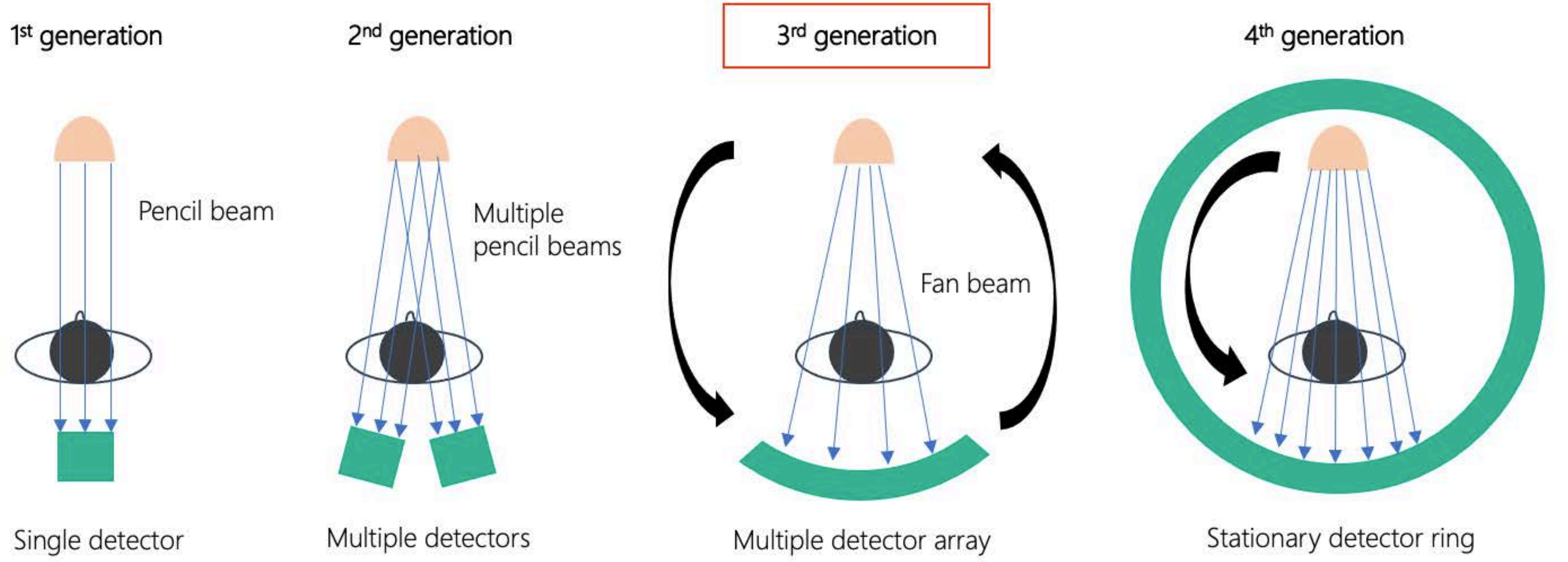

Figure 2. Differences between the various CT scanner generations
Image adapted with permission from (https://www.radiologycafe.com/frcr-physics-notes/ct-imaging/ct-equipment, last accessed 31.01.2023

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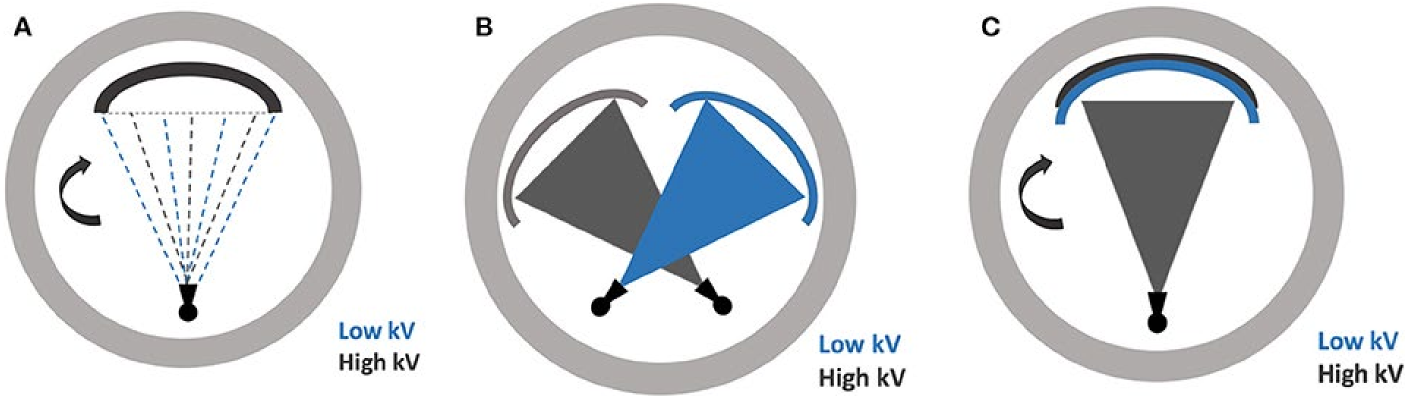
Dual Energy CT (DECT)

Dual Energy CT (DECT)

- **Principle**: Acquiring images at two different energy spectra
- **Benefit**: Enabling separation of materials with different atomic numbers but similar attenuation
- **Construction**: 3 different types of DECT scanners (A-C).



Rapid Energy Switching
X-ray tube rapidly switches between low and high energy beam.

Dual-Source Technique
Two orthogonally placed tube-detector systems operating independently.

Multilayer Detector
'Sandwich' detector (inner and outer layer) differentiating between higher and lower energy levels.

Figure 3. Schematic representation of the Dual-Energy technique

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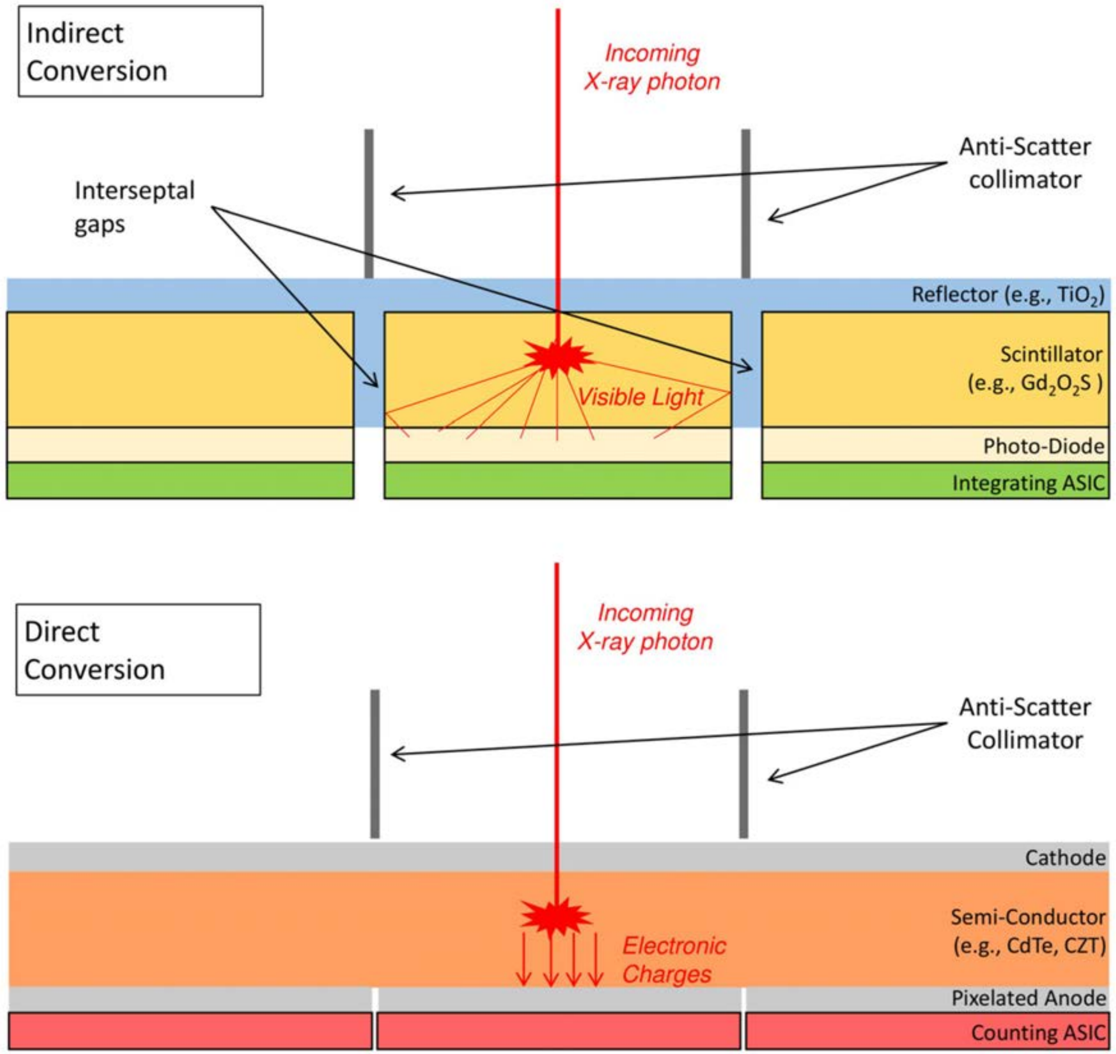
Photon Counting CT



- **Principle**: No indirect conversion via scintillator like conventional energy integrating detectors (upper image), but direct conversion of x-rays into charged particles (bottom image).
- **Photon counting**: Incoming photons are counted individually and divided into different photon bins based on their energy level.

Advantages:

- High contrast to noise ratio
- High spatial resolution
- Potential to reduce radiation dose and metallic artifacts
- Acquisition of multi-energy images from a single x-ray energy source.

Figure 4. Photon-Counting detector technology.

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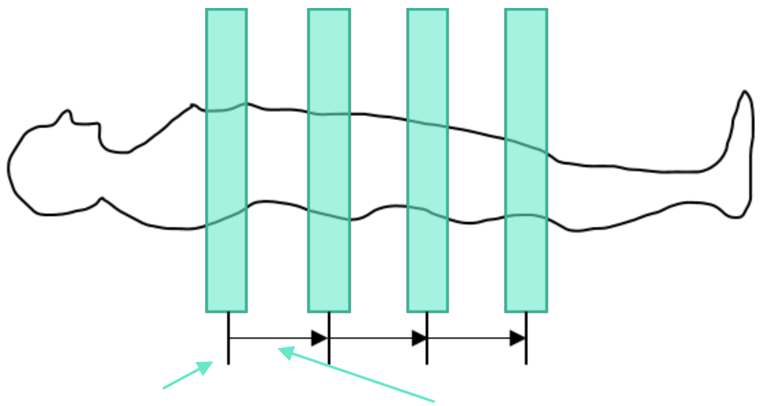
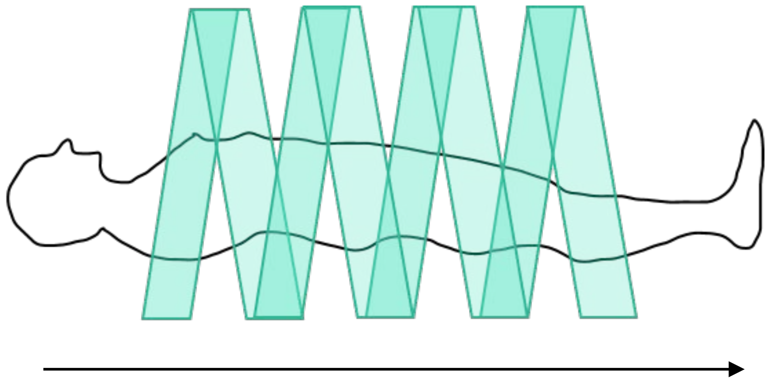
CT Image Acquisition – Axial vs. Helical Scanning

Axial Scanning



1. Stop and scan
2. table moves

Helical Scanning



Continuous scanning during table movement

Axial scanning
1. Acquisition of a single slice.
2. Table moves to the next position.
3. Acquisition of another single slice.

Helical ("spiral") scanning
Continuous scanning with simultaneous table movement.

<u>Advantages:</u>
- Avoiding of respiratory misregistration (whole scan during one breath).
- Scanning of multiple phases with one contrast administration.
- Overlapping sections allow for a better CT image reconstruction.

Figure 5. Differences between axial vs. helical scanning
Image adapted with permission from (https://www.radiologycafe.com/frcr-physics-notes/ct-imaging/acquiring-an-image-part-1/), last accessed 31.01.2023

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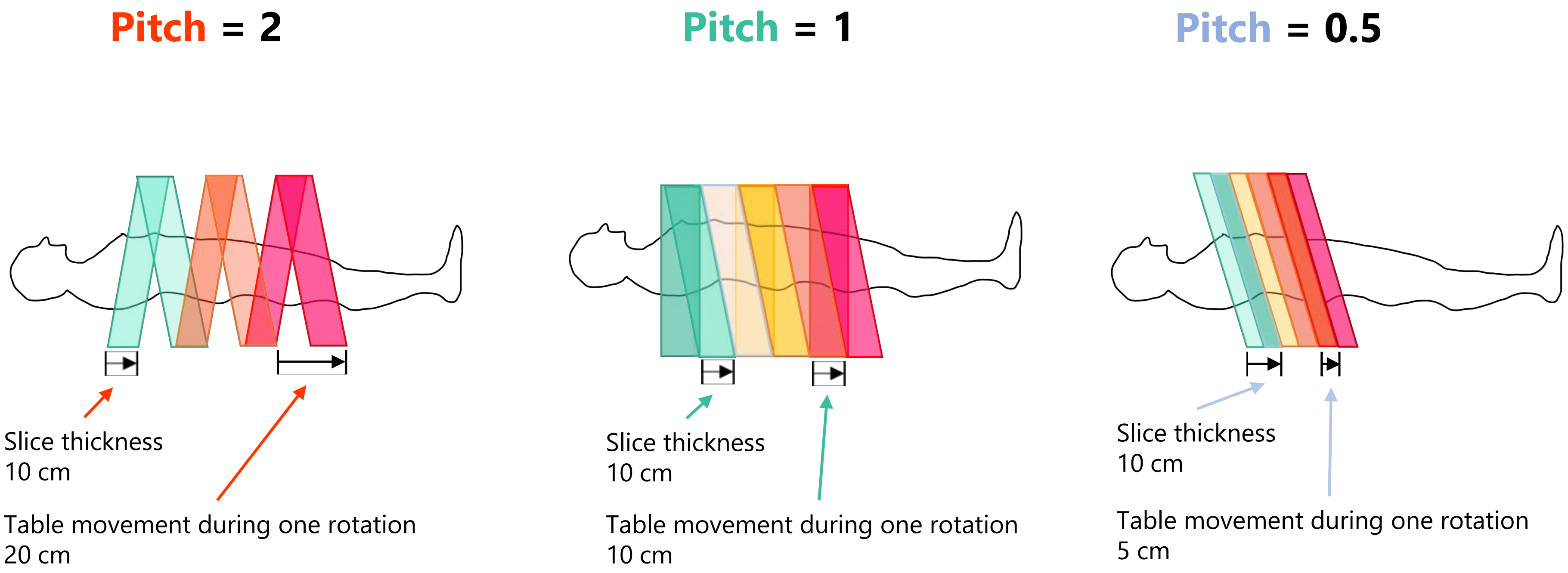
CT Image Acquisition – Pitch



- The pitch is defined as table distance traveled in one 360° gantry rotation divided by beam collimation (beam collimation = slice thickness).
- A pitch greater than 1 can be used to scan faster and to lower radiation dose on the expense of lower image quality.

Figure 6. Differences between different pitch factors
Image adapted with permission from (https://www.radiologycafe.com/frcr-physics-notes/ct-imaging/acquiring-an-image-part-1/), last accessed 31.01.2023

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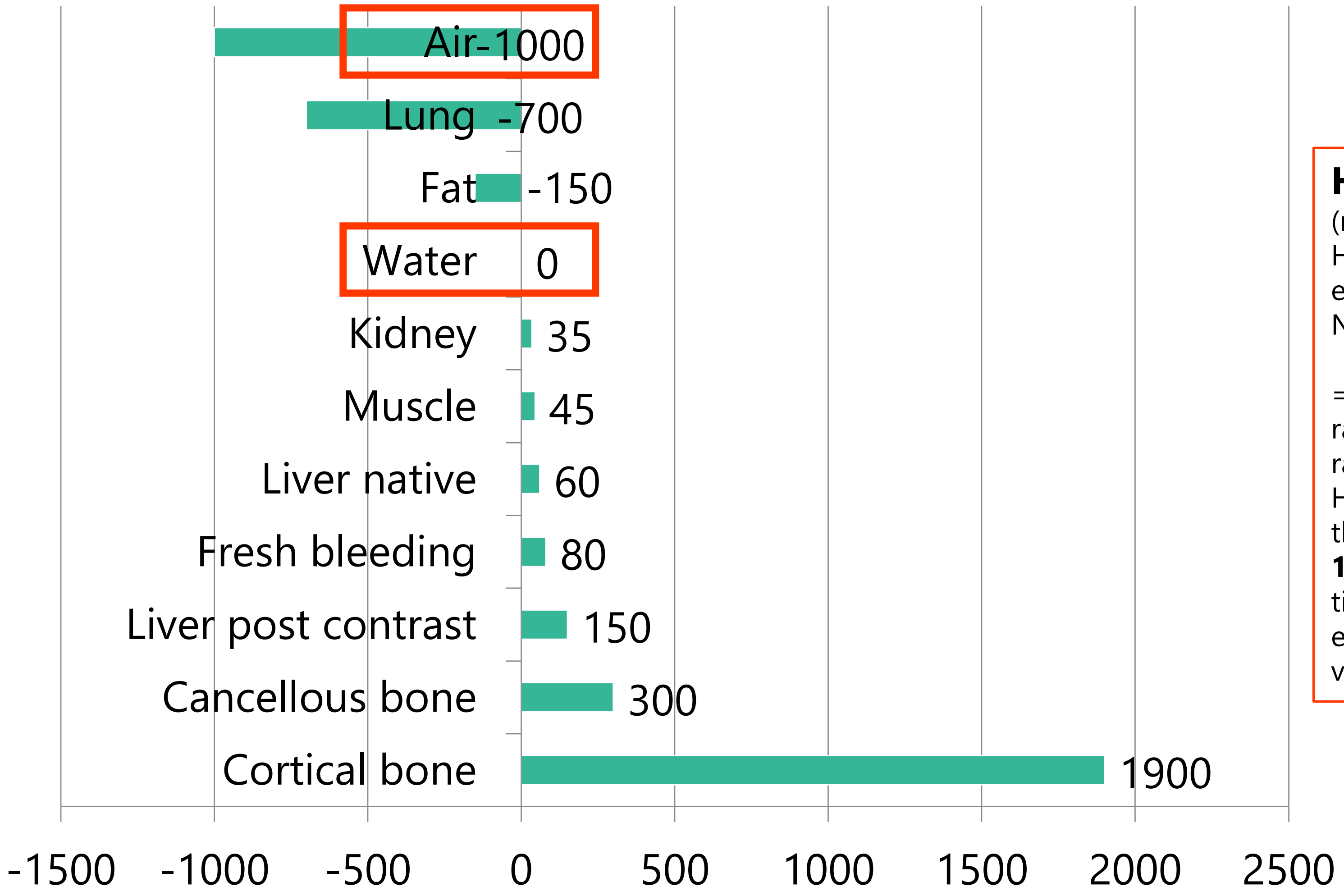
Hounsfield Units or CT Numbers



Hounsfield scale
(named after Gofrey Housfield, a biomedical engineer who invented CT, Nobel Prize laureate in 1979)

=> Serves to quantify radiodensity by defining the radiodensity of water as **0** Hounsfield units (HU), and the radiodensity of air as **-1000** HU. All other biological tissues have radiodensities expressed relatively to these values.

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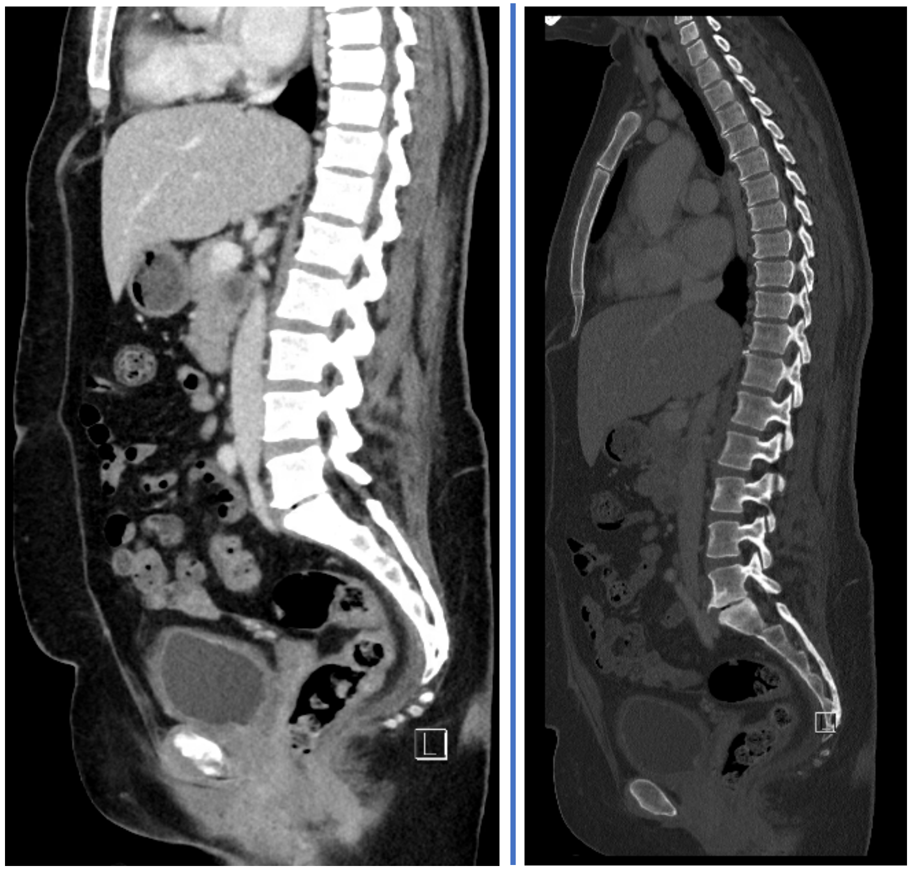
Image Reconstruction Techniques

- Image reconstruction is a mathematical process to create an image from acquired raw data

Filtered back projection (FBP)
FBP constitutes the standard reconstruction technique since the beginning of commercial computed tomography. However, it could be considered outdated because of the necessity to reduce radiation dose and to imporve spatial and temporal resolution. At lower image dose, conventional FBP is associated with a high image noise.

Iterative reconstruction (IR)
Technological advancement led to the development of IR, which reduces image noise without compromising image resolution while keeping radiation dose as low as reasonably attainable.
Most scanners use iterative reconstruction techniques for image reconstruction.

Image Reconstruction for CT – the Kernel



A Standard kernel **B Bone kernel**

Two important reconstruction parameters:

- **Kernel**
  a sharper kernel generates a higher spatial resolution, but increases the noise.
- **Slice thickness**
  controls the spatial resolution in longitudinal direction.

A Standard kernel

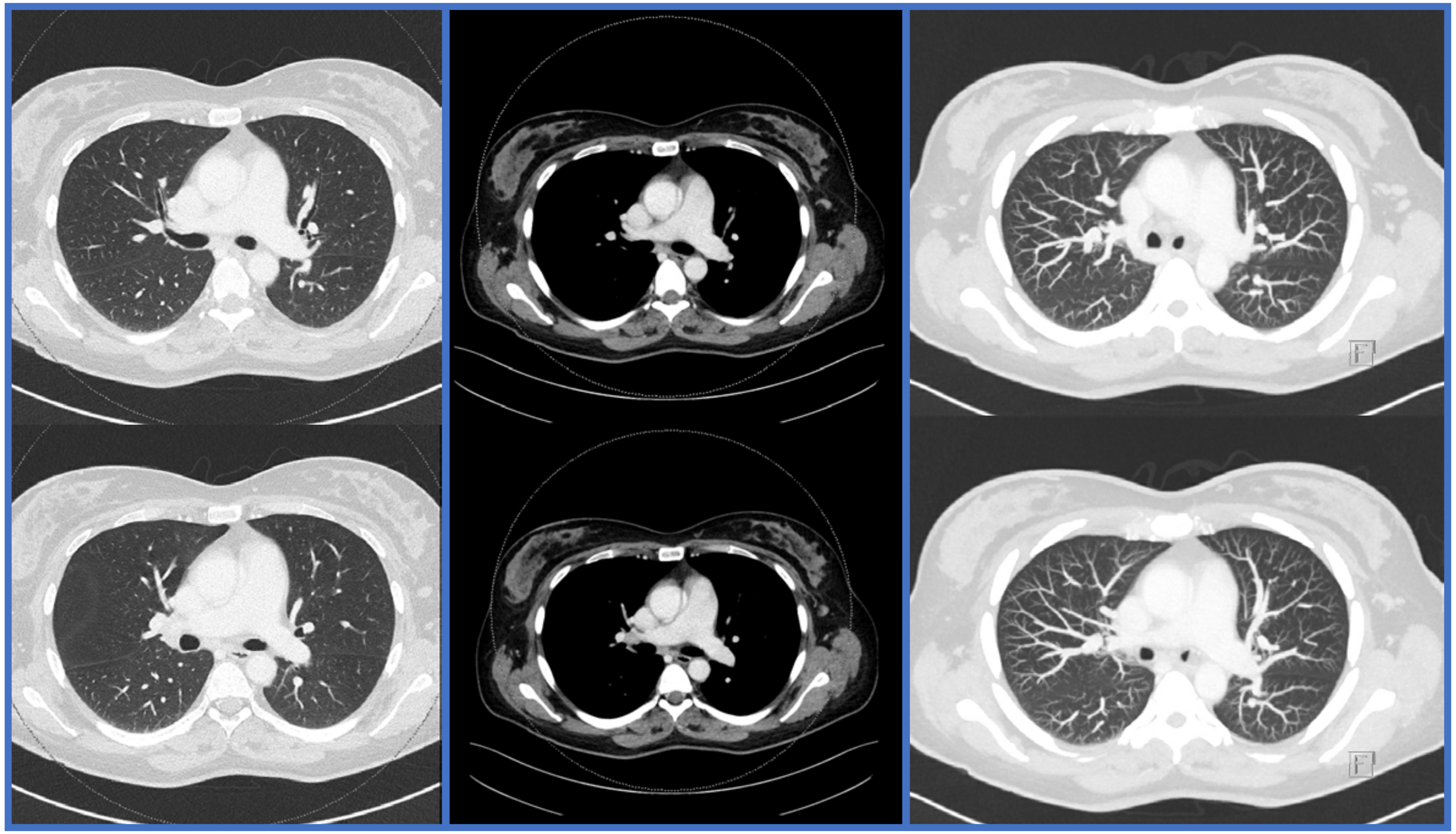
Smooth appearance of soft tissue.

B Bone kernel

Producing a sharper image with higher spatial resolution.

Figure 8. Illustration of sagittal reformatted images in the same patient using (A) standard kernel and (B) bone Kernel

Image Reconstruction for CT – Slice Thickness



1mm
Thinner slices are useful to assess the lung parenchyma.

3mm
Used in a general approach.

10 mm
Thicker slices are useful to identify lung nodules or for angiographic studies.

Figure 9. Illustration of sagittal reformatted images in the same patient using (A) standard kernel and (B) bone Kernel

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Windowing

Windowing
Displaying different ranges of CT numbers altering the contrast of the image.

Window level
The window level is the midpoint of the range of CT numbers.

Window width
The window width defines the range of CT numbers that are displayed in different shades of gray.

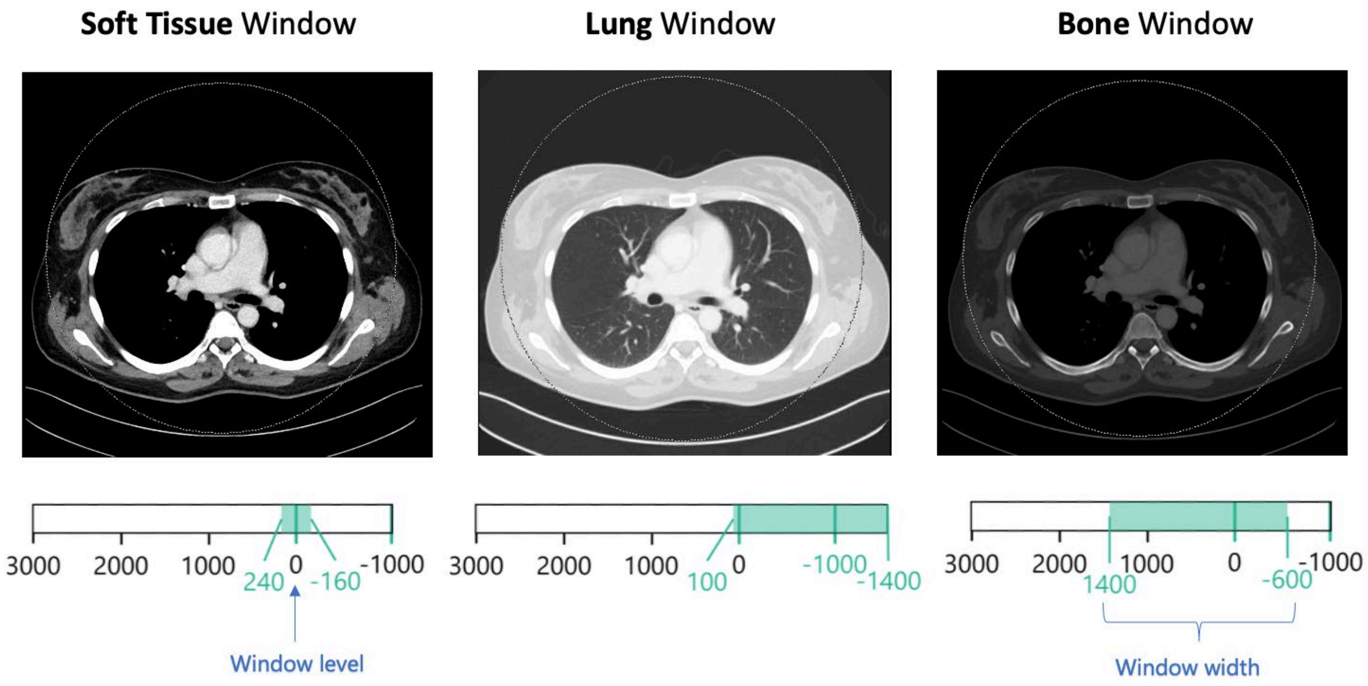

Figure 7. Soft tissue, lung and bone windows in CT

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Image Resolution

- Spatial resolution is one of the major advantages of CT, compared to other imaging. It is defined as the ability to differentiate between adjacent structures with different densities.
- Isotopic resolution: Spatial resolution has to be equal in all axes for multiplanar reconstruction.

Spatial resolution is decreased by

- Pixel size ⇧
- Focal spot size ⇧
- Magnification ⇧
- Field of View ⇧
- Soft tissue kernel ⇧
- Pitch
- Slice thickness ⇧
- Detector size ⇧
- Patient motion ⇧

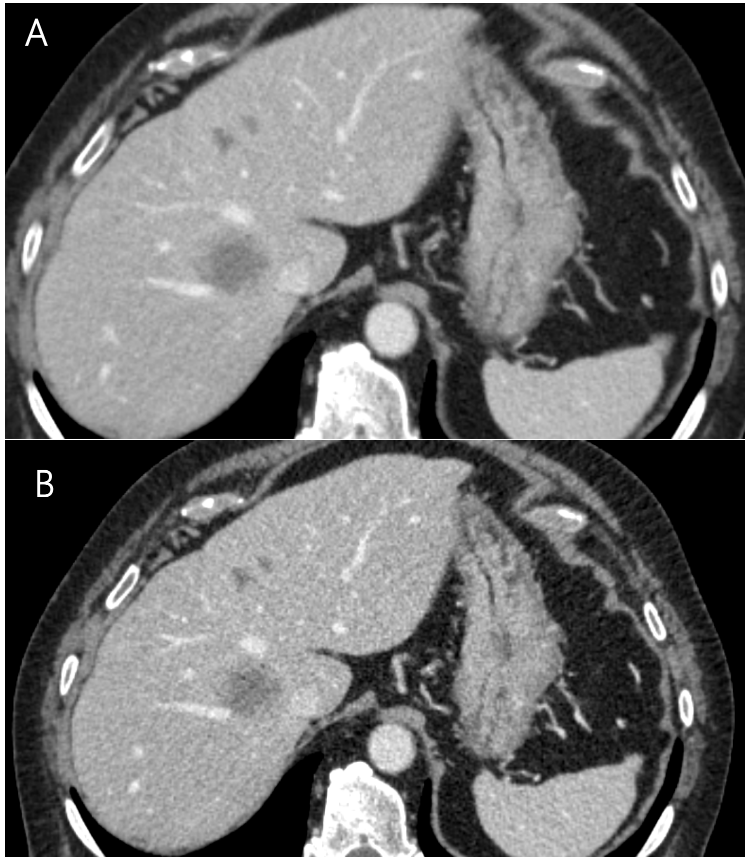

Figure 10. Comparison of spatial resolution of the upper abdomen in the same patient. Spatial resolution is better for image B due to a smaller slice thickness of 1 mm, compared to image A with a slice thickness of 5 mm. Note the better delineation of the liver metastasis and of hepatic veins. However, noise is increased in figure B

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- Contrast resolution describes the ability to differentiate between adjacent areas of different image intensity. It is defined as the number of bits per pixel value. It is dictated by many factors. Here is a selection of some of the factors, which affect contrast resolution.

Factors decreasing contrast resolution

- Inherent structure contrast ⇩
- Detector size ⇩
- Scatter radiation ⇧
- Noise ⇧
- Pitch ⇧
- Beam energy ⇧
- No use of contrast media

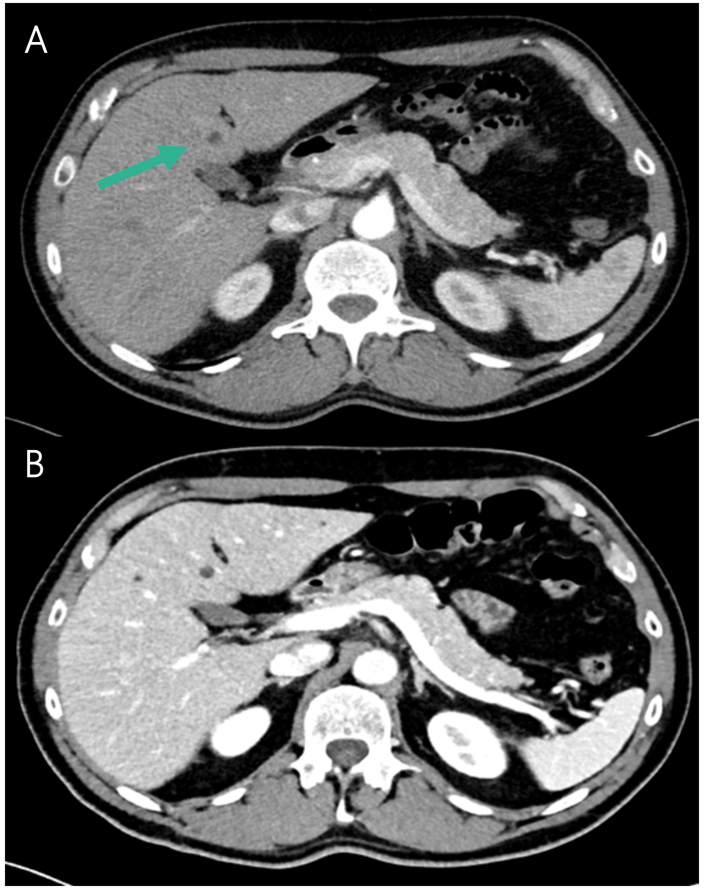

Figure 11.
Comparison of a liver cyst in the same patient. Compared to image A, image B shows a better contrast resolution and therefore allows a better characterization of the hypodense liver lesion.

Artifacts

- CT artifacts have multiple causes. In any case, knowledge of these artifacts is important as they might change the appearance of pathologies within the image or obscure relevant findings.

- Physical phenomena causing artifacts:
  - Beam hardening artifacts are frequent and caused by dense objects that absorb lower energy photons and thus leaving mainly high energy ("hard") photons for the beam.
  - Streaking artifacts are a result of beam hardening and scatter at dense objects.

  They can be reduced by a harder x-ray beam (higher kV) or metal artefact reduction software

Photon starvation is a special type of streak artifact, caused by areas of high attenuation, predominately metal implants. Due to the high attenuation, photons behind the dense structure cannot reach the detector which leads to a high noise behind the objects, appearing as streaks.

Can be reduced by increasing mAs (tube current modulation) and by using iterative reconstruction filters

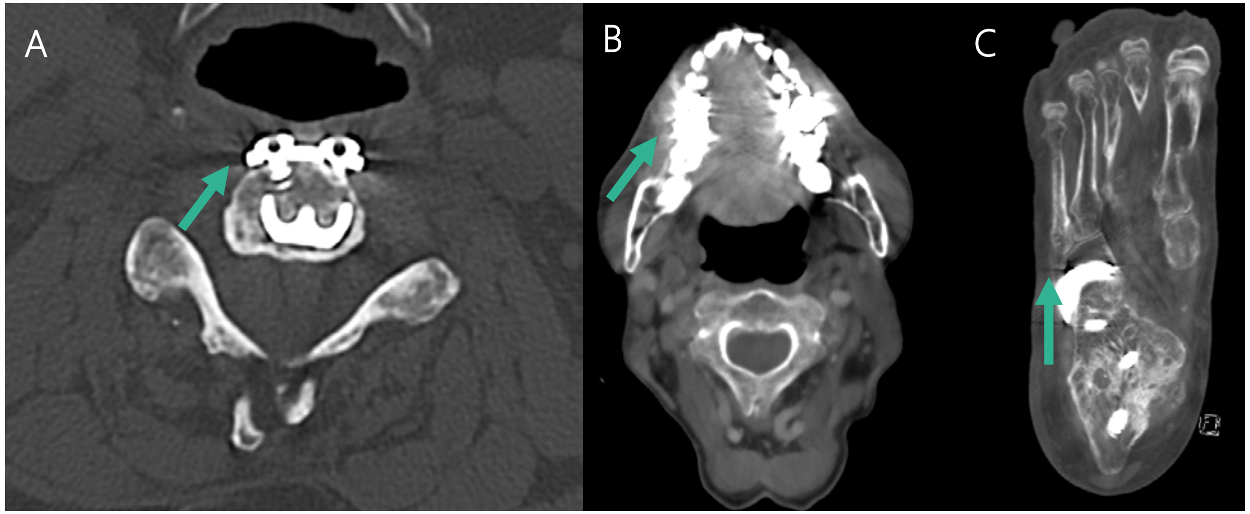

Figure 9. Photon starvation. Three examples of photon starvation due to metal implants (A-C). Especially dental implants (B) are quite common in elderly patients and can impair the visualisation of the surrounding tissue (green arrow indicating the discussed artifacts)

Patient related artefacts

- Motion artifacts: Movements during the acquisition cause streaking and blurring.
- Clothing artifacts and jewelry artifacts are more relevant in conventional radiographs. In CT-scans they can normally be identified as extracorporal, but might complicate the interpretation by causing artefacts.

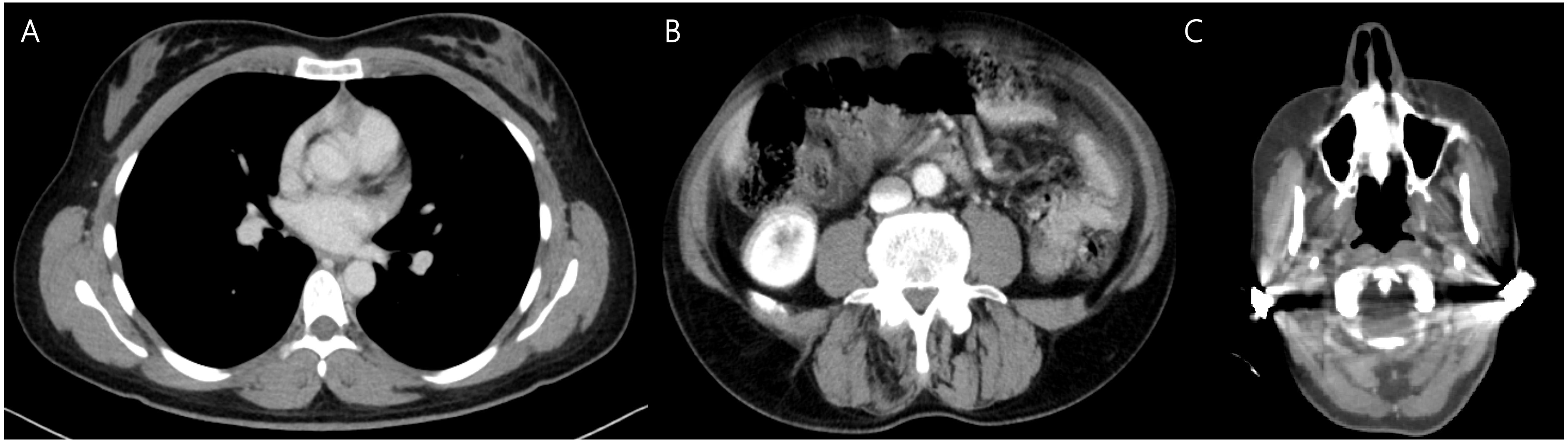

Figure 10. Patient-related artifacts. (A) Without ECG-triggered image acquisition, pulsation artifacts of the ascending aorta are common. (B) Motion artifacts can highly impair the assessability of the anatomic structures; in this case due to patient motion, the intestine and the blood vessels are hardly assessable. (C) Jewelry artifacts causing streak artifacts in a woman with earrings that could not be taken off.

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Partial volume effects occur when tissues of highly different densities are included in the same voxel as the attenuation of the beam is averaged.
Can be solved by thin-slice reconstruction

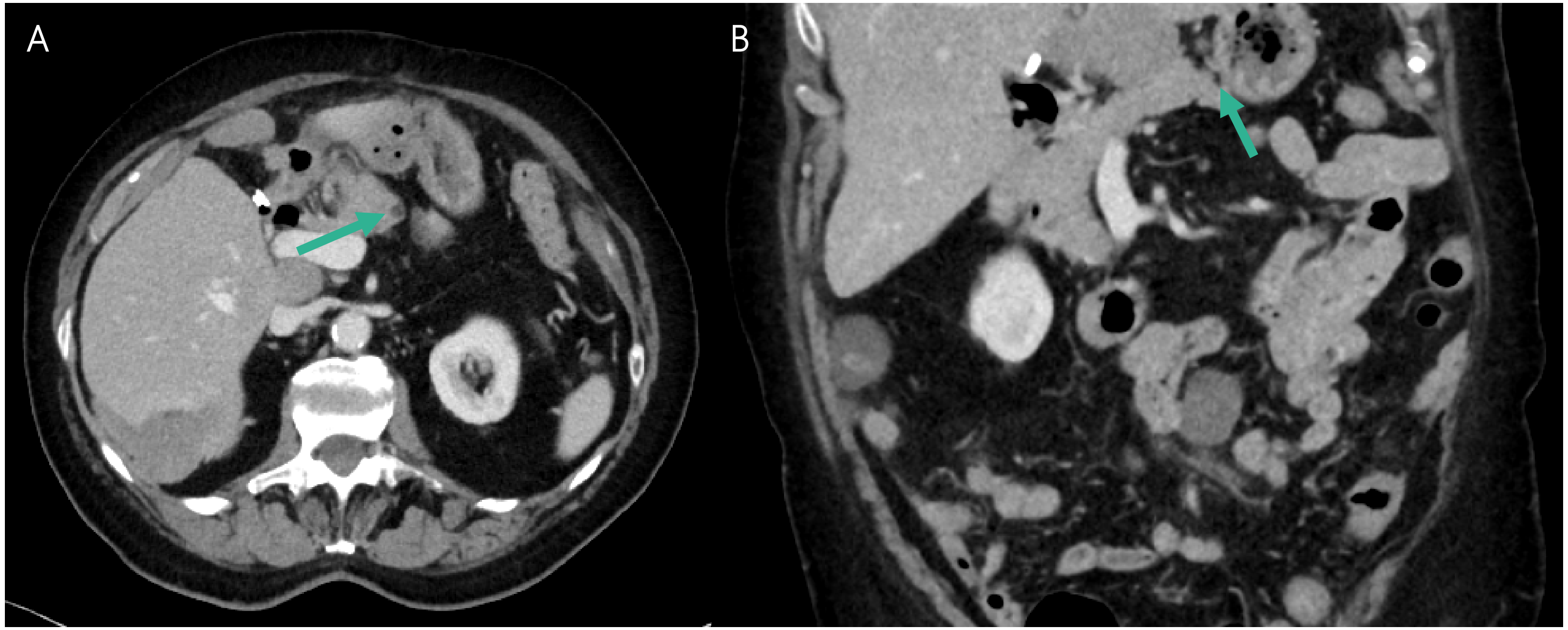

Figure 11. Partial volume effect. In a woman with ovarian cancer and peritoneal carcinomatosis, figure **A** seems to show a hypodense lesion of the pancreas (arrow). In fact, the image impression is a partial volume artefact as mesenteric fat tissue (arrow in figure B) and pancreatic parenchyma were included in one voxel. The coronal reconstruction **(B)** proves that there is no pancreatic lesion.

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Truncation artifacts occur when parts of the examined object cannot be included in the field of view . The resulting artifact appears as a rim of high attenuation at the edge of the field of view.

Cone beam artifact is an artefact only seen in multidetector CT scanners. Because of the multiple sections acquired during one rotation, the beam becomes cone shaped. As the back projection assumes a parallel beam, this causes a divergence between the real cone shape and the assumed beam configuration, resulting in a cone-shaped distortion of the beam.

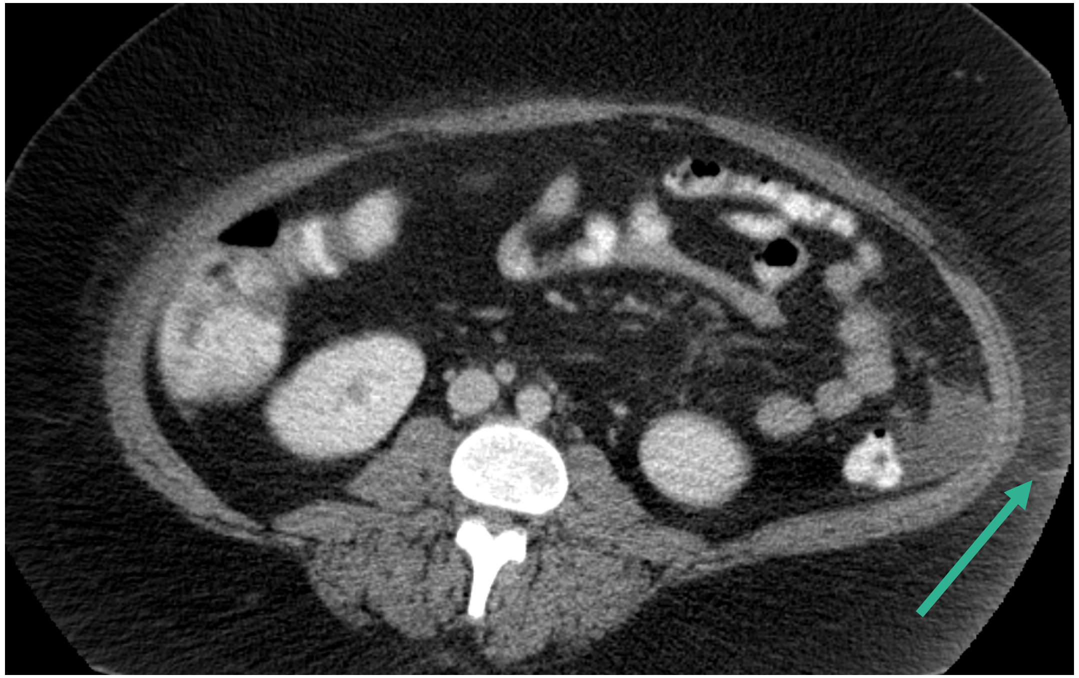

Figure 12. Truncation artifact and cone beam artifact. Axial view of an obese patient in an abdominopelvic CT scan. As the soft tissue of the patient could not be included in the field of view, a truncation artifact at the left side of the patient could be observed.

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Further CT-Artifacts

Aliasing due to undersampling, is more frequent in MRI.

Ring artefacts as a result of a miscalibrated or defect detector or detector element.

Pseudoenhancement in simple renal cysts is caused by scatter and beam hardening.

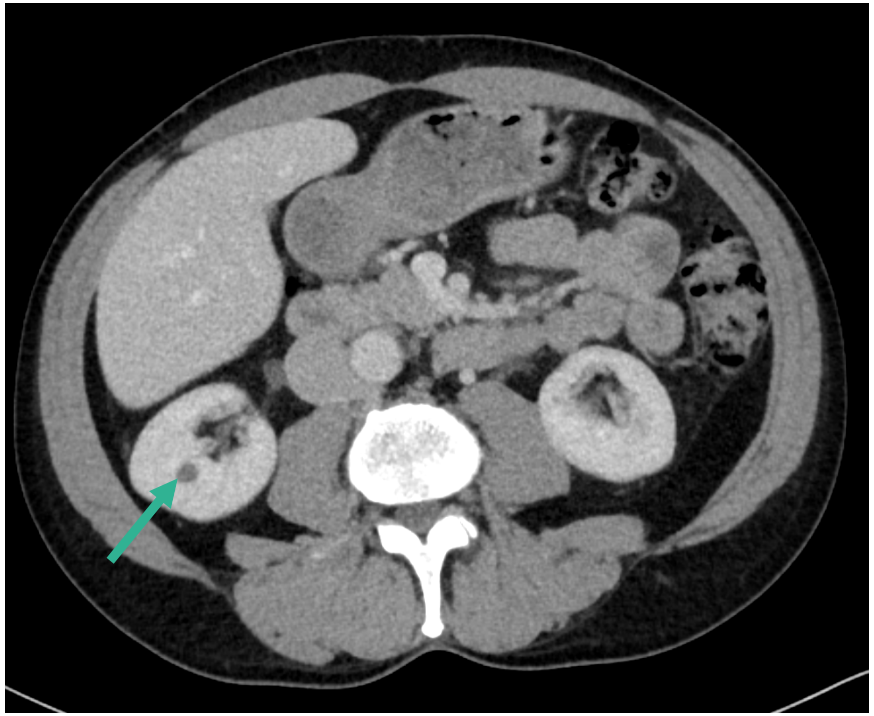

Figure 13. Pseudoenhancement. The axial images of a CT-scan of a patient with nasopharyngeal cancer show a simple, benign cyst of the right kidney. Measurement of the density showed 39 Hounsfield units. Additionally performed ultrasound showed a simple, Bosniak 1 cyst (see chapter on urogenital radiology) . Thus the elevation of Hounsefield units can be evaluated as pseudoenhancement.

Dose Parameters

Computed tomography dose index (CTDI)

- Measured in mGy
- Standardized radiation dose measurement in one slice
- Allows comparison of radiation dose output among different scanners

$CTDI_{100}$

= Average dose at the center of a standard 100 mm scan

$CTDI_w$

$$= \frac{2/3\ CTDI_{100}\ \text{periphery}}{1/3\ CTDI\ \text{center}}$$

$CTDI_{vol}$

$$= \frac{CTDI_w}{\text{Pitch}}$$

Dose length product (DLP) = $CTDI_{vol}$ * scan length (cm) (mGy * cm)

DLP considers the whole length of the examined object or patient

Dose Modulation

Tube current (mAS) modulation can be used to reduce the dosage in areas with lower attenuation. This means that mAs will not be the same for each body part; instead, photons will be reduced in low attenuating body parts. Change in mAS leads to a linear change in radiation dose.

Pitch modification changes CT dose. In a constant radiation output, increasing the pitch reduces radiation dose, while decreasing the pitch will lead to an increase of radiation dose.

Tube voltage (kV) modification leads to a nonlinear change in radiation dose for the patient. Depending on the patient´s weight, a lower kV can be chosen to reduce the overall radiation dose. Furthermore, lowering the tube voltage can improve contrast to noise ratio.

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Cross-Sectional Anatomy of the Face and Neck

Cross-sectional anatomy of the head and neck is very complex as many small anatomic structures are confined in a small space. The exact knowledge of the blood vessels, the cervical spaces and lymph node levels is important, especially in the context of inflammatory and tumorous processes.

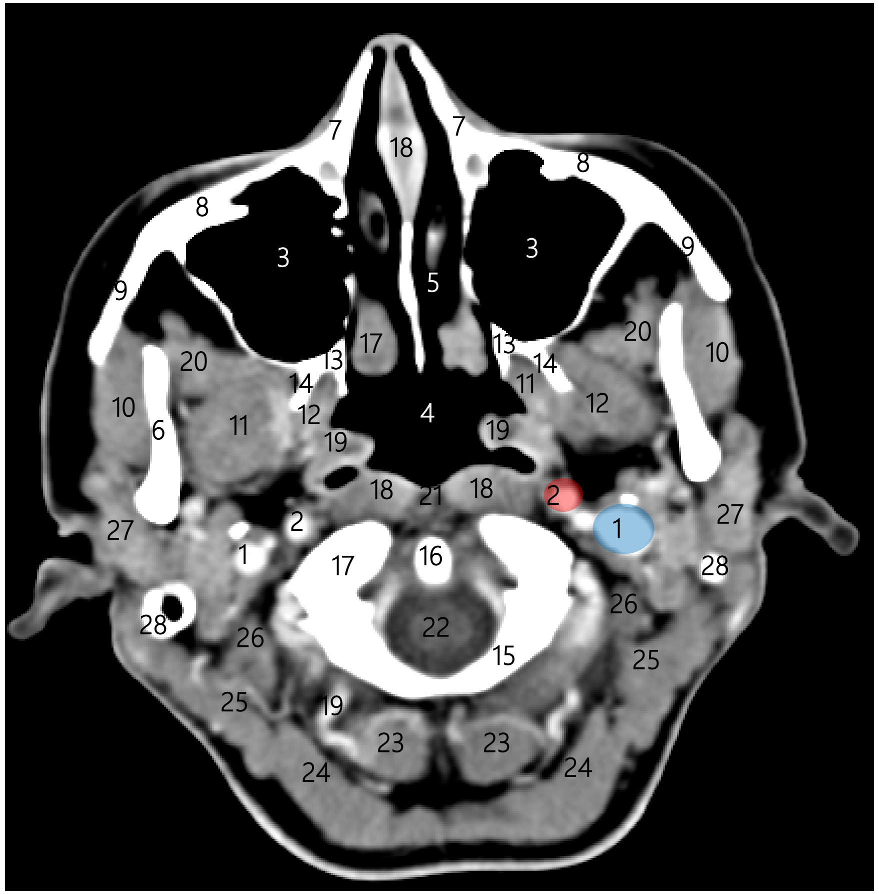

Figure 14. Cross sectional anatomy face and neck.
Axial reformatted CT image in soft-tissue window of the neck at the level of the maxillary sinus and the nasopharynx. Important anatomic structures are annotated.

1= Internal jugular vein, 2= Internal carotid artery, 3= Maxillary Sinus, 4= Nasopharynx, 5= Nasal cavity, 6= Ramus of mandible, 7= Nasal process (maxilla), 8=Anterior surface (maxilla), 9= Temporal surface (zygomatic bone), 10= Masseter muscle, 11= Medial pterygoid muscle, 12= Lateral pterygoid muscle, 13= Sphenoid bone with medial process, 14= Sphenoid bone lateral process, 15= Posterior arch of atlas, 16= Dens of axis, 17= Lateral mass of atlas, 18= Pharyngeal tonsil, 19= Salpingopharyngeal fold, 20= Temporal muscle, 21= Pharyngeal raphe, 22= Vertebral canal with spinal cord, 23= Rectus capitis posterior major muscle, 24= Semispinalis capitis muscle, 25= Splenius capitis muscle, 26= Obliquus capitis superior muscle, 27= Parotid gland, 28= Mastoid process

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Cross-Sectional Anatomy of the Neck

Cervical lymph node levels

IA: Submental nodes
IB: Submandibular nodes

II: Upper jugular lymph nodes
(IIA: Anterior upper jugular lymph nodes)
(IIB: Posterior upper jugular lymph nodes)

III: Mid-jugular space

IV: Lower jugular lymph nodes

VA: Posterior triangle above cricoid cartilage
VB: Posterior triangle below cricoid cartilage

VI: Anterior central compartment

See also chapter on head and neck imaging

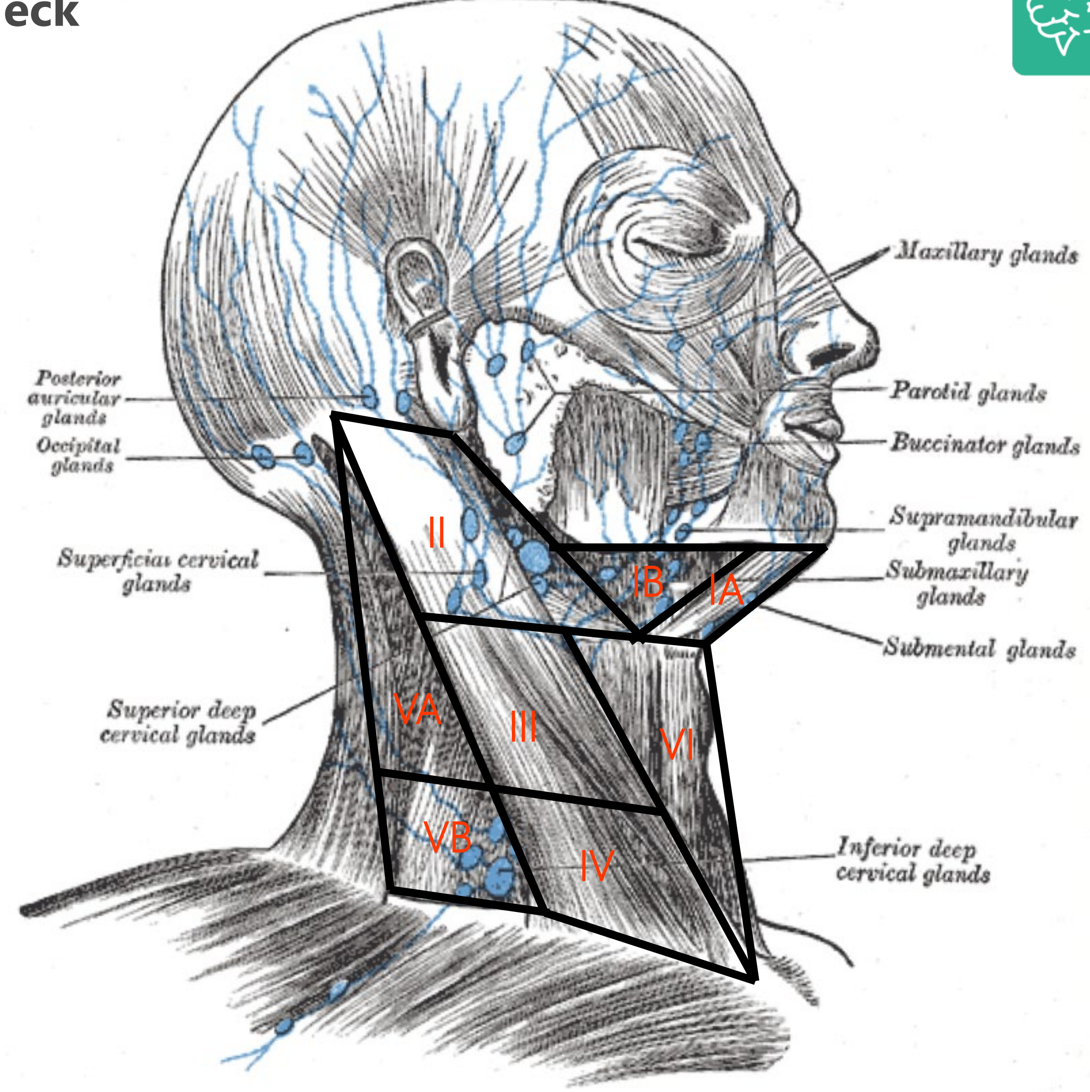

Figure 15. Cervical lymph node levels. Edited version of an image of the 20th U.S. version of Grey´s Anatomy of the human body. The version was originally published in 1918 and thus became content of public domain.

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Cross-Sectional Anatomy of the Neck

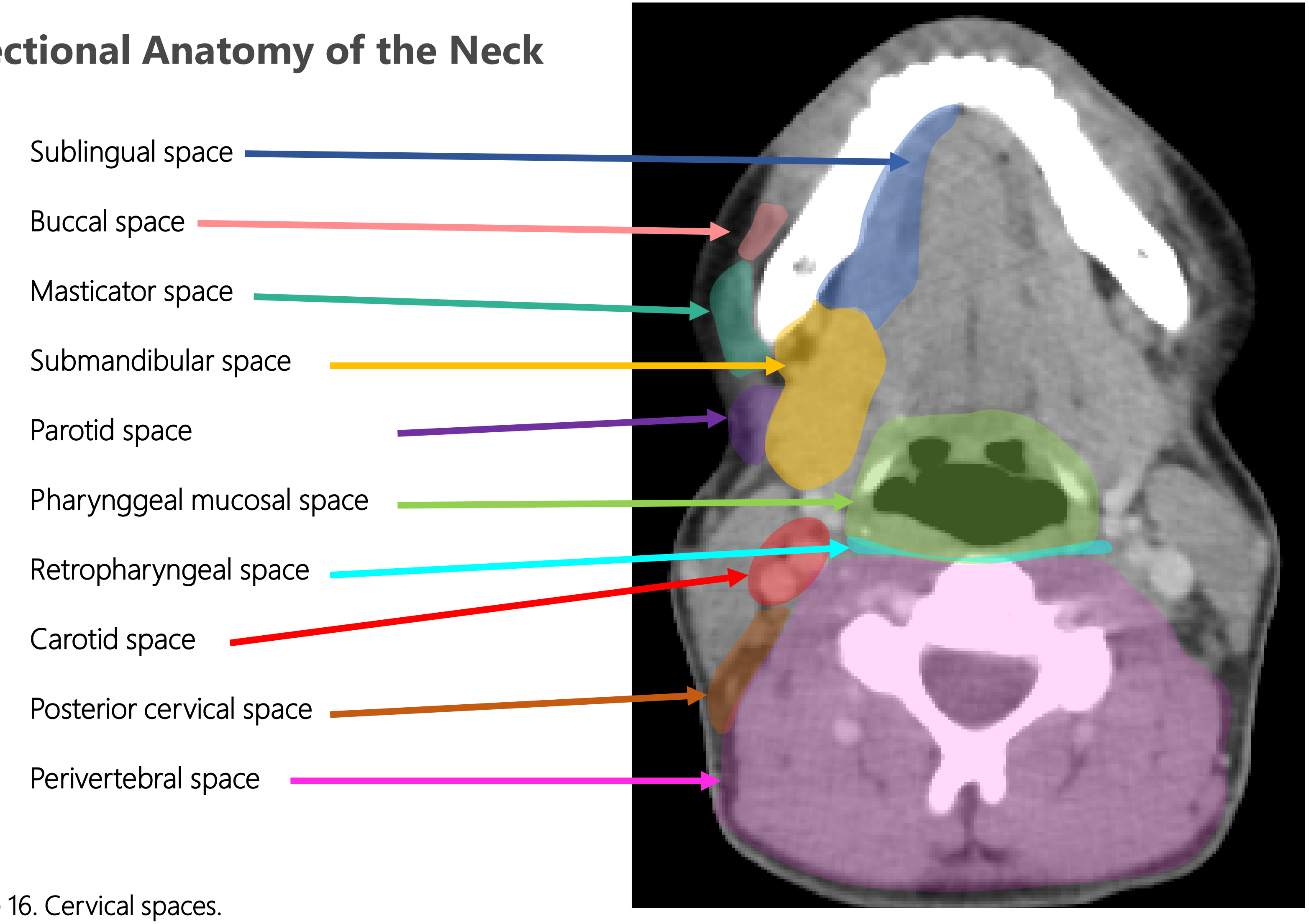

Figure 16. Cervical spaces.
Since inflammatory processes can spread via the cervical spaces, knowledge of their anatomical locations is important for clinical routine.

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Cross-Sectional Anatomy of the Neck

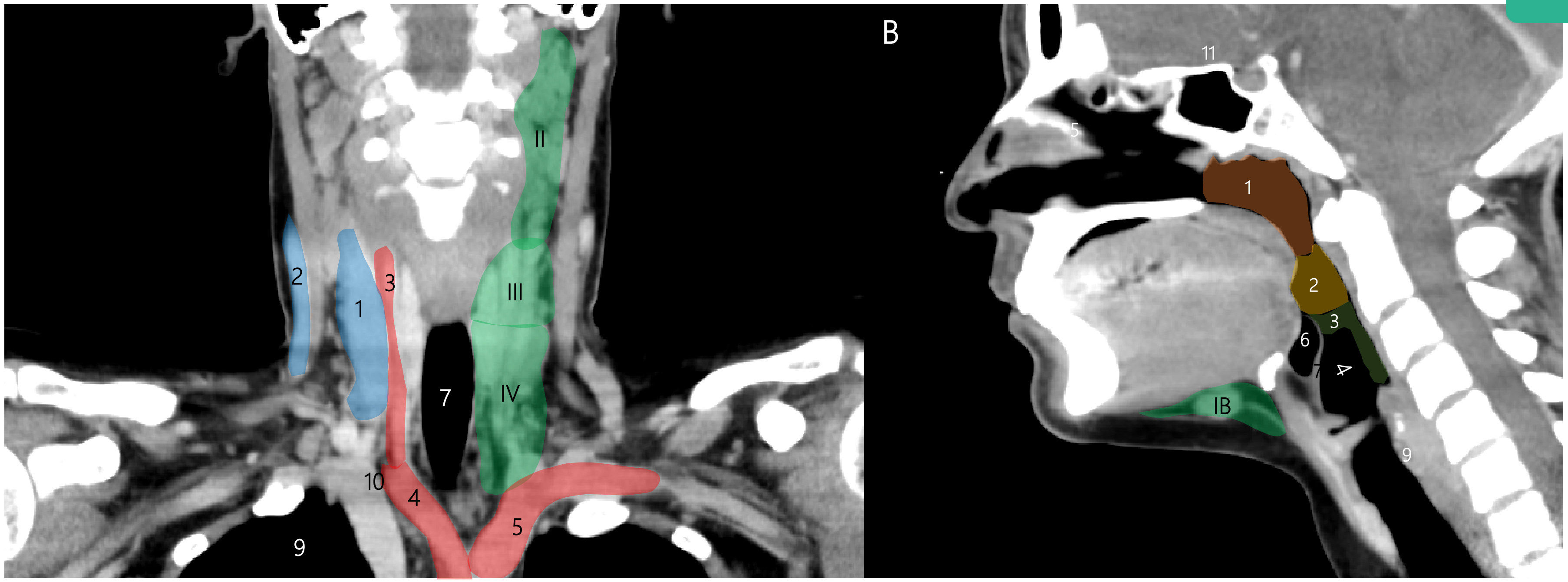

Figure 17. Coronal and sagittal reformatted CT images. Mainly due to the complexity of cervical anatomy, sagittal und coronal reconstructions are important to the reading radiologist. The coronal reconstruction (A) offers an overview over the cervical blood vessels and the lymph node level II-IV. In the sagittal reconstruction (B) the different regions of the pharynx and the laryngeal structures can be evaluated more efficiently. Additionally a submandibular lymph node is displayed (level IB).

Figure A: 1=Right internal jugular vein, 2= Right external jugular vein, 3= Right internal carotid artery, 4= Brachiocephalic trunk, 5= Left subclavian artery, 6= Thyroid gland (right lobe), 7= Trachea, 8= Mastoid process, 9=Apex of the right lung, 10= Right brachiocephalic vein

1=Nasopharynx, 2= Oropharnx, 3= Laryngopharynx, 4= Larynx, 5= Nasal cavity, 6= Epiglottis, 7= Vestibular fold, 8= Vocal fold, 9=Trachea, 10=Frontal sinus, 11= Sphenoidal sinus

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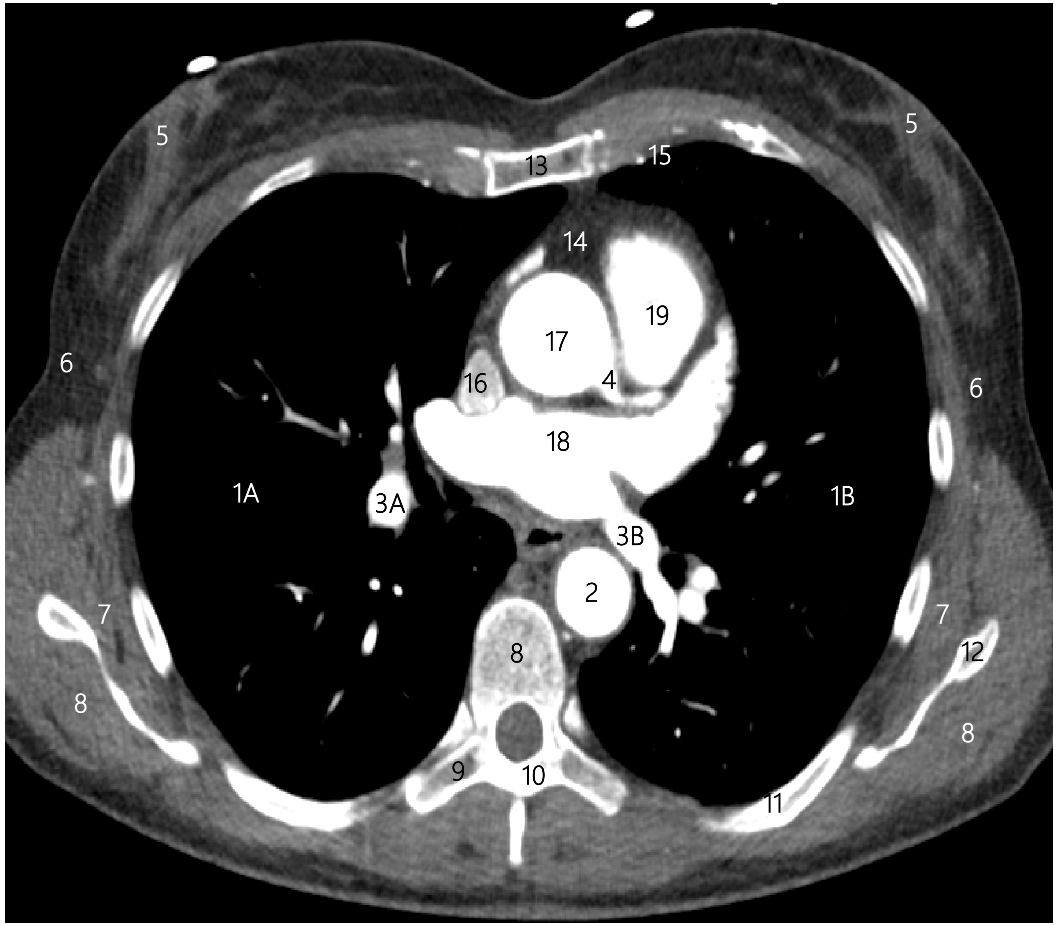
Cross-Sectional Anatomy of the Chest



1A=Right lung, 1B= Left lung, 2= Descending aorta, 3A Right pulmonary vein, 3B= Left pulmonary vein, 4=Left coronary artery, 5= breast parenchyma, 6= Axilla, 7= Subscapularis muscle, 8= Infraspinatus muscle, 9= Transverse Process, 10=Lamina, 11= Rib, 12: Scapula, 13= Sternum, 14= Mediastinal fat tissue, 15= Internal thoracic artery, 16= Superior vena cava, 17= Ascending aorta, 18= Left atrium, 19= Right ventricle

Figure 18. Cross sectional anatomy of the thorax. In the soft tissue window, mediastinal anatomic structures are illustrated. Furthermore, it is important to take into account the muscles and the subcutaneous fat tissue during image interpretation.

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Cross-Sectional Anatomy of the Chest

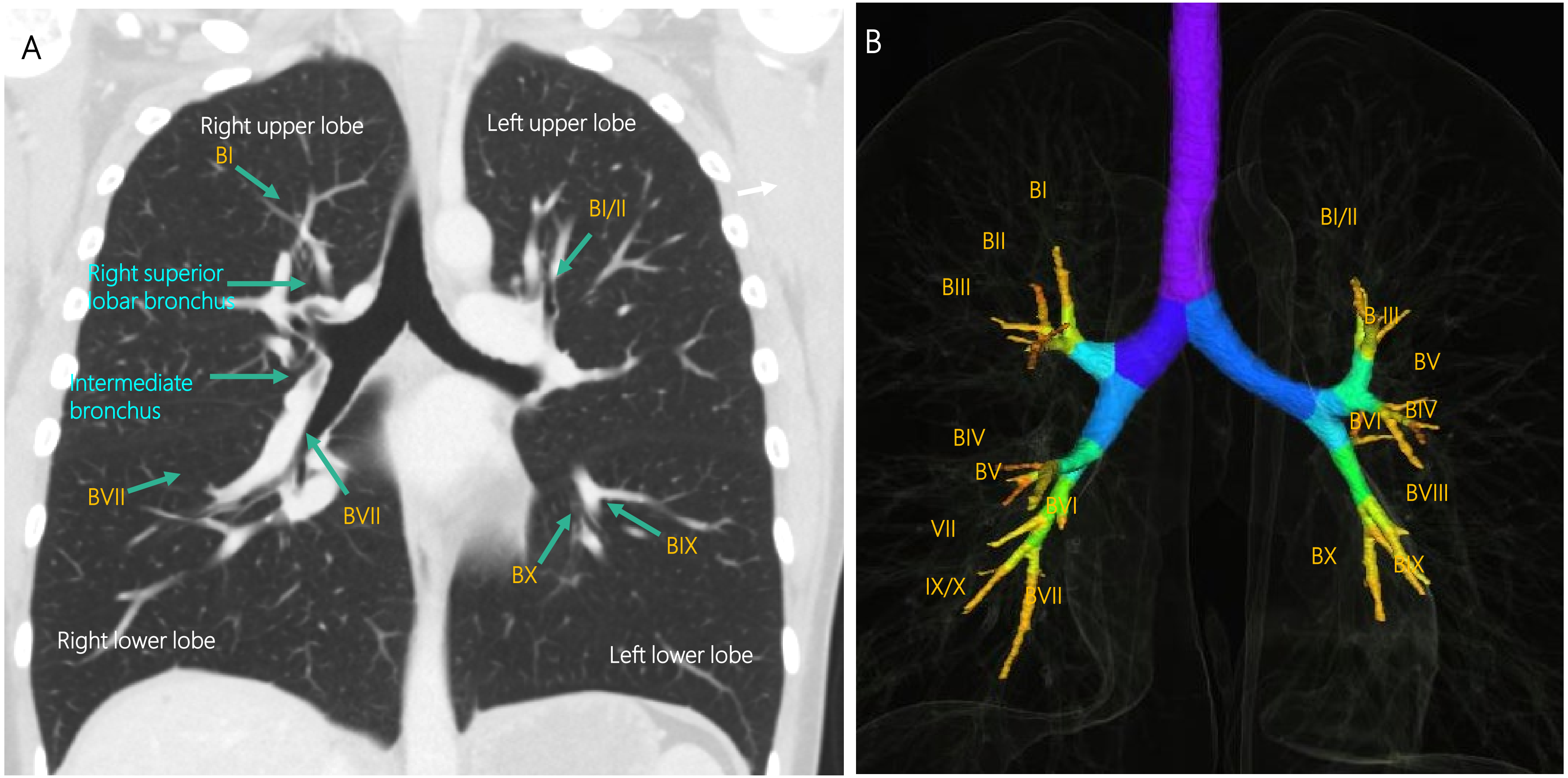

Figure 19. Cross sectional anatomy of the respiratory system. Using the lung window in a CT-Thorax scan, the lung tissue (A) and the bronchial tree (B) can be evaluated. The acquisition and reconstruction of very thin slices allows an accurate assessment of the segmental bronchi with respect to intraluminar pathologies. In figure A some segments of the bronchial tree are annotated exemplarily.

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Cross-Sectional Anatomy of the Abdomen and Pelvis

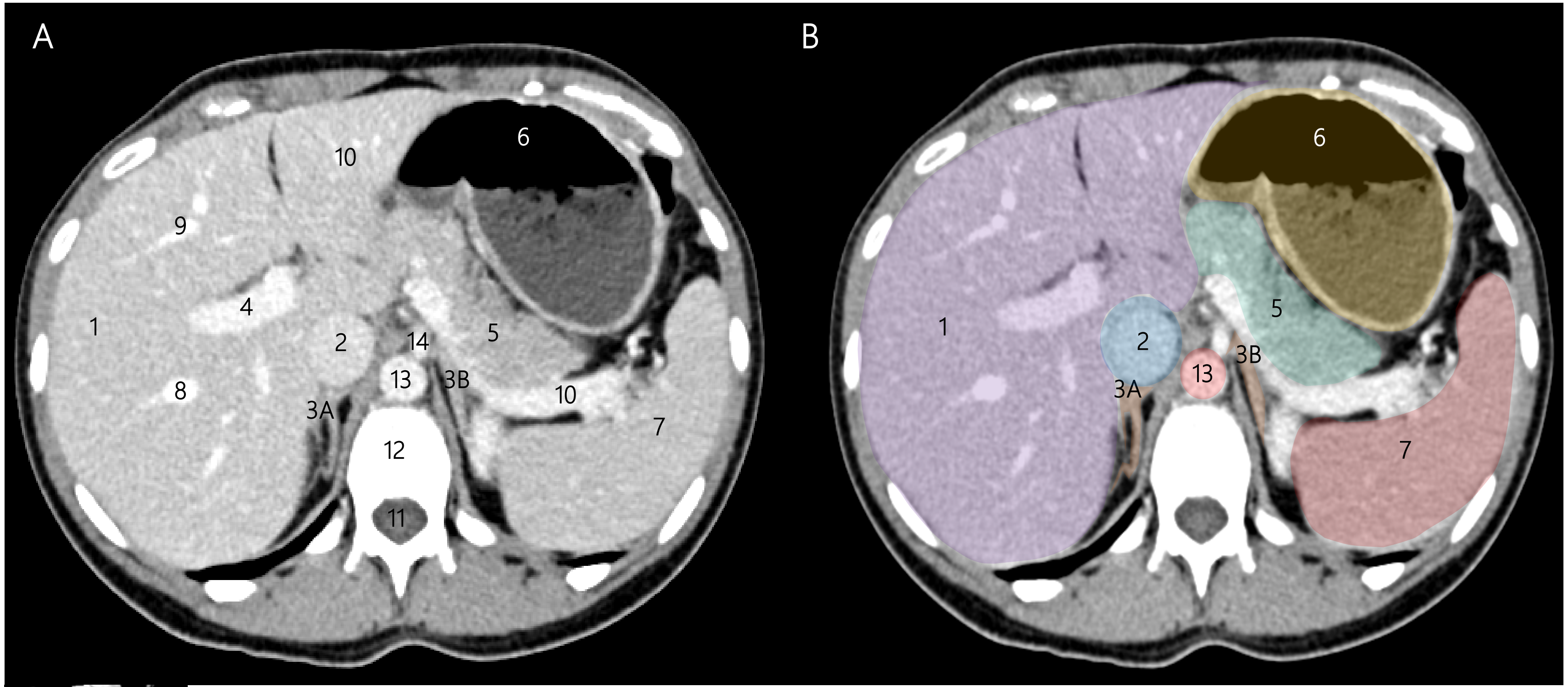
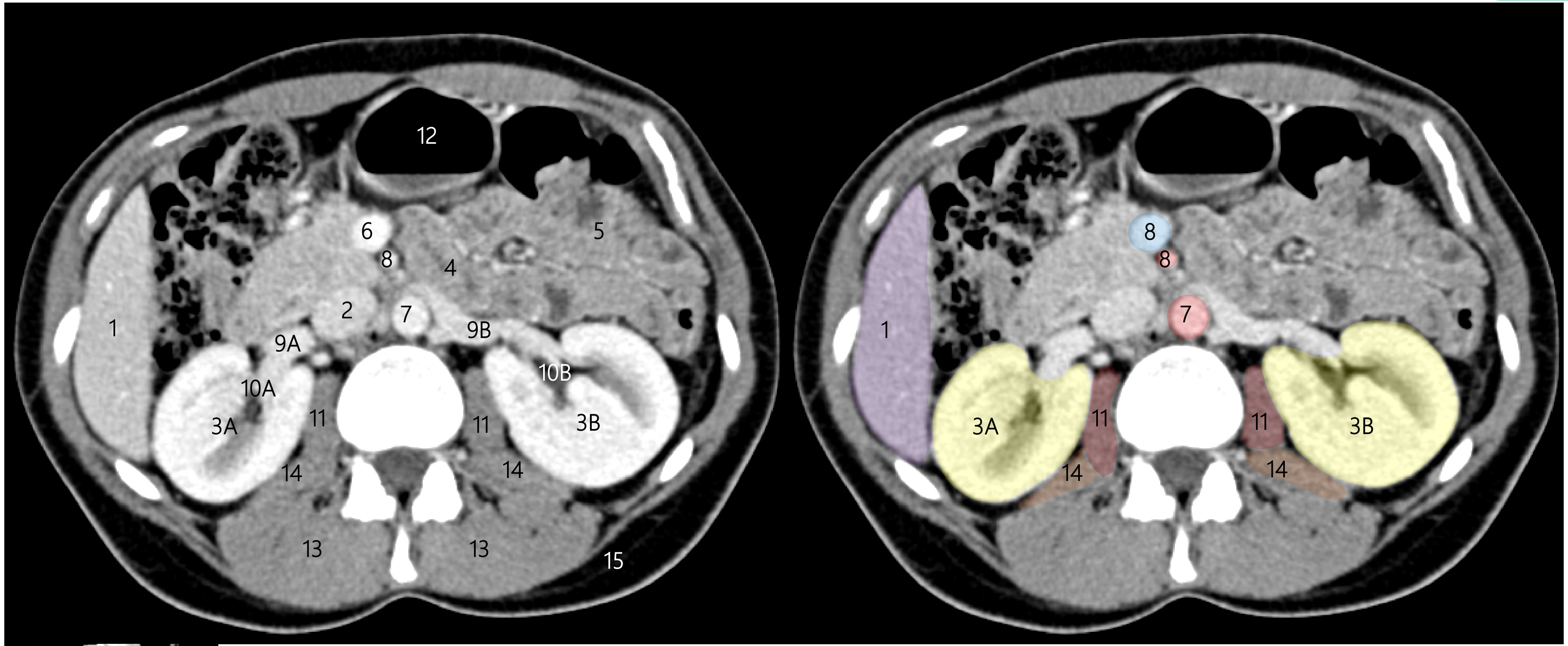


Figure 20. Cross sectional anatomy of the abdomen. Annotations of the greater blood vessels (A) and abdominal organs (B) in an axial reformatted CT image of the upper abdomen, acquired in the portal-venous phase.

1= liver, 2= Inferior vena cava, 3A= Right adrenal gland, 3B= Left adrenal gland, 4=portal vein, 5= Pancreas, 6= Stomach, 7= Spleen, 8= Right hepatic vein, 9= Middle hepatic vein, 10= left hepatic vein, 11= Vertebral canal with spinal cord, 12= Lumbar vertebrae, 13= Abdominal aorta, 14= Coeliac trunk

Chapter Outline

Cross-Sectional Anatomy of the Abdomen and Pelvis



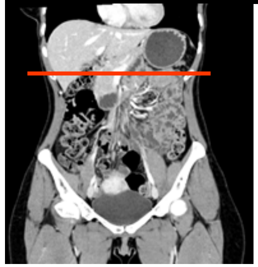


Figure 21. Cross sectional anatomy of the abdomen. Axial view of the abdominal organs at the level of the kidneys.

1= Liver, 2= Inferior vena cava, 3A= Right kidney, 3B= Left kidney, 4=Duodenum, 5= Jejunum, 6= Superior mesenteric vein, 7= Abdominal aorta, 8= Superior mesenteric artery, 9A= Right renal vein, 9B= Left renal vein, 10A= Right renal pelvis, 10B= Left renal pelvis, 11= Psoas muscle, 12= Transverse colon, 13= Erector spinae, 14= Quadratus lumborum muscle, 15= Thoracolumbar fascia

Chapter Outline

Cross-Sectional Anatomy of the Abdomen and Pelvis

Figure 22. Cross sectional anatomy of the abdomen. Coronal reformatted images and 3D reconstructions can be used to identify and monitor vascular pathologies.

1= Liver, 2= Portal vein, 3= Superior mesenteric artery, 4= Superior mesenteric vein, 5=Common hepatic artery, 6= Hepatic artery proper, 7= Right hepatic vein, 8= Middle hepatic vein, 9= Left hepatic vein, 10= External iliac vein, 11= External iliac artery, 12= Mesentery, 13= Jejunal and iliac arteries, 14= Caecum, 15= Ascending colon, 16= Gall bladder, 17= Stomach, 18= duodenum, 19= Sigmoid colon, 20= Urinary bladder, 21= Iliacus muscle, 22= Iliopsoas muscle, 23= Gluteus medius muscle, 24= Descending colon, 25= Internal oblique muscle, 26= External oblique muscle, 27= Transversus abdominis muscle, 28= Mesentery, 29= Ileum, 30= Duodenum

Chapter Outline

Cross-Sectional Anatomy of the Abdomen and Pelvis

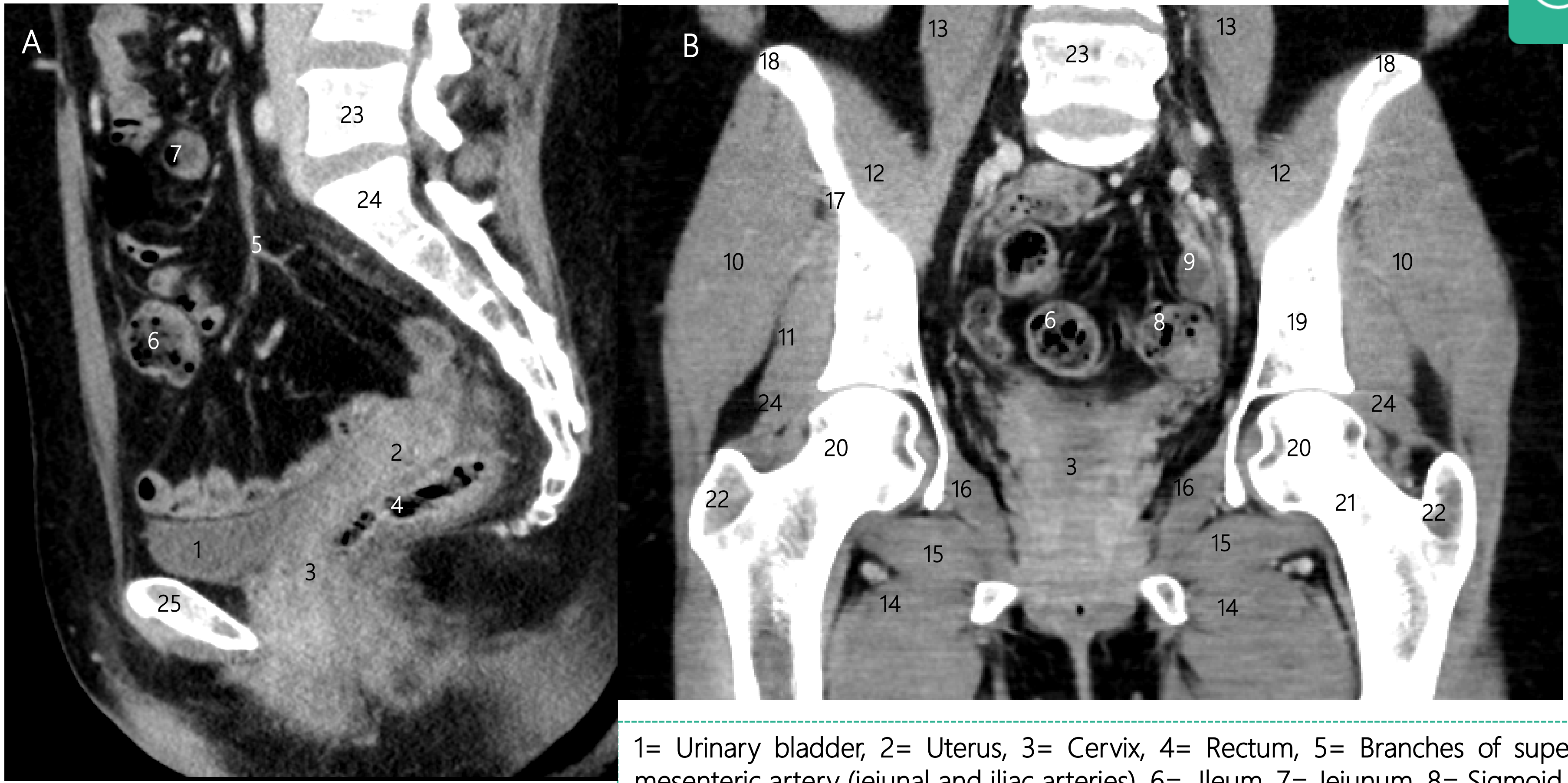


Figure 23. Cross sectional anatomy of the female pelvis. Sagittal (A) and coronal (B) reformatted CT images of the pelvic organs.

1= Urinary bladder, 2= Uterus, 3= Cervix, 4= Rectum, 5= Branches of superior mesenteric artery (jejunal and iliac arteries), 6= Ileum, 7= Jejunum, 8= Sigmoid, 9= Left ovary, 10= Gluteus medius muscle, 11= Gluteus minimus muscle, 12= Iliacus muscle, 13= Major psoas muscle, 14= Pectineus muscle, 15= Obturator externus muscle, 16= Obturator internus muscle, 17= Ala of ilium, 18= Iliac crest, 19= Ilium, 20= Femoral head/Caput femoris, 21= Femoral neck/ Collum femoris, 22= Greater trochanter, 23= Vertebra L5, 24= Sacrum.

Chapter Outline

Cross-Sectional Anatomy of the Abdomen and Pelvis

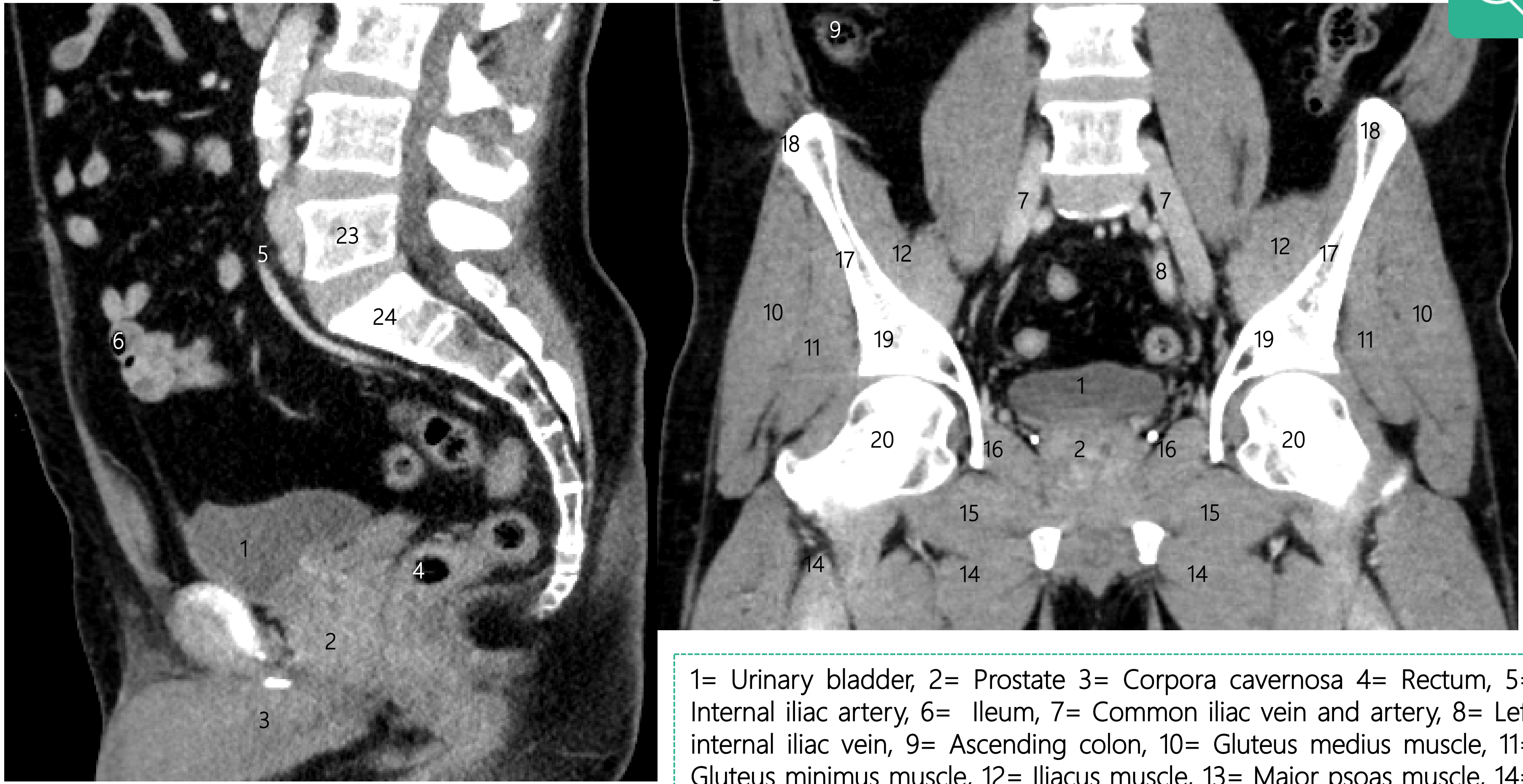


Figure 24. Cross sectional anatomy of the male pelvis. Sagittal (A) and coronal (B) reformatted CT images of the pelvic organs.

1= Urinary bladder, 2= Prostate 3= Corpora cavernosa 4= Rectum, 5= Internal iliac artery, 6= Ileum, 7= Common iliac vein and artery, 8= Left internal iliac vein, 9= Ascending colon, 10= Gluteus medius muscle, 11= Gluteus minimus muscle, 12= Iliacus muscle, 13= Major psoas muscle, 14= Pectineus muscle, 15= Obturator externus muscle, 16= Obturator internus muscle, 17= Ala of ilium, 18= Iliac crest, 19= Ilium, 20= Femoral head/Caput femoris, 21= Femoral neck/Collum femoris, 22= Greater trochanter, 23= Vertebra L5, 24= Sacrum.

Chapter Outline

Take-Home Messages

- CT is an indispensable tool in current medical care, which has undergone massive technological development.
- Understanding the differences in Hounsfield units allows differentiation between hemorrhage, calcification and normal fluid.
- Understanding the different CT-related artifacts and how to remedy them is important for every day practice
- Understanding basic cross-sectional anatomy is key for daily clinical practice.

Chapter Outline

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Chapter Outline

Test Your Knowledge

1 – Which of the following statements is true regarding CT scanner generations ?

- 1^{st} generation scanners use multiple pencil beams
- In 4^{th} generation scanners, the x-ray tube and the detector rotate around the patient
- 3^{rd} generation scanners are the mostly used scanner type nowadays
- 2^{nd} generation scanners have a stationary ring of detectors.

Chapter Outline

Test Your Knowledge

1 – Which of the following statements is <u>true</u> regarding CT scanner generations ?

- 1st generation scanners use multiple pencil beams
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- ✓ <u>3rd generation scanners are the mostly used scanner type nowadays</u>
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Chapter Outline

Test Your Knowledge

2 – Which of the following statements is true regarding Dual Energy CT (DECT) scanners ?

- acquire images at two high kV energy spectra
- can enable the separation of materials with similar attenuation
- convert x-rays directly into charged particles in contrast to the photon counting CT
- always have only one tube that rapidly switches between a low and a high energy beam

Chapter Outline

Test Your Knowledge

2 – Which of the following statements is true regarding Dual Energy CT (DECT) scanners ?

- acquire images at two high kV energy spectra
- ✓ can enable the separation of materials with similar attenuation
- convert x-rays directly into charged particles in contrast to the photon counting CT
- always have only one tube that rapidly switches between a low and a high energy beam

Chapter Outline

Test Your Knowledge

3 – Which of the following statements is true ?

- the radiodensity of water is defined as 0 Hounsfield units (HU), the radiodensity of air is defined as -1000 HU.
- spiral scanning means continuous scanning with intermittent – stop and go – table movement
- a pitch >1 can be used to scan faster but usually comes with a higher radiation dose
- The lung window has a window width of approx. -160 to 240 HU and a window level of 0 HU.

Chapter Outline

Test Your Knowledge

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- ✓ the radiodensity of water is defined as 0 Hounsfield units (HU), the radiodensity of air is defined as -1000 HU.
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- The lung window has a window width of approx. -160 to 240 HU and a window level of 0 HU.

Chapter Outline

Test Your Knowledge

4 – Which statement about windowing, kernel and slice thickness is correct:

- The bone window is most frequently used to assess soft tissue or lung pathologies
- A sharper kernel is the main parameter that generates better spatial resolution in longitudinal direction
- A slice thickness of 1 mm is usually used when assessing the abdomen.
- 10 mm slices are useful to scan for lung nodules and can help in angiographic studies

Test Your Knowledge

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- The bone window is most frequently used to assess soft tissue or lung pathologies
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Chapter Outline

Test Your Knowledge

5 – A better spatial resolution can be achieved by....

- Using a soft tissue kernel instead of an edged enhancement kernels
- An increase of magnification
- Using a larger focal spot
- Using a smaller detector

Test Your Knowledge

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Test Your Knowledge

6 - Contrast resolution in CT imaging is increased by (choose one)...

- Increasing pitch
- Decreasing detector size
- Increasing noise
- Increasing beam energy

Test Your Knowledge

6 - Contrast resolution in CT imaging is increased by (choose one)...

- Increasing pitch
- ✓ Decreasing detector size
- Increasing noise
- Increasing beam energy

Chapter Outline

Test Your Knowledge

7 – Which statement is wrong

- The pitch is defined as table distance traveled in one 360° gantry rotation divided by beam collimation
- The pitch is defined as table distance traveled in one 360° gantry rotation divided by slice thickness
- A pitch greater than 1 can be used to scan faster and to lower radiation dose on the expense of lower image quality.
- A pitch greater than 1 can be used to scan faster but leads to higher radiation dose

Test Your Knowledge

7 – Choose the wrong statement

- The pitch is defined as table distance traveled in one 360° gantry rotation divided by beam collimation
- The pitch is defined as table distance traveled in one 360° gantry rotation divided by slice thickness
- A pitch greater than 1 can be used to scan faster and to lower radiation dose on the expense of lower image quality.

X A pitch greater than 1 can be used to scan faster but leads to higher radiation dose

Test Your Knowledge

9 – The anatomic location of the cervical lymph nodes can be described in levels. Which of the following lymph nodes belong to level Ib?

- Lower jugular lymph nodes
- Submandibular lymph nodes
- Occipital lymph nodes
- Upper jugular lymph nodes

Test Your Knowledge

9 – The anatomic location of the cervical lymph nodes can be described in levels. Which of the following lymph nodes belong to level Ib?

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Chapter Outline

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