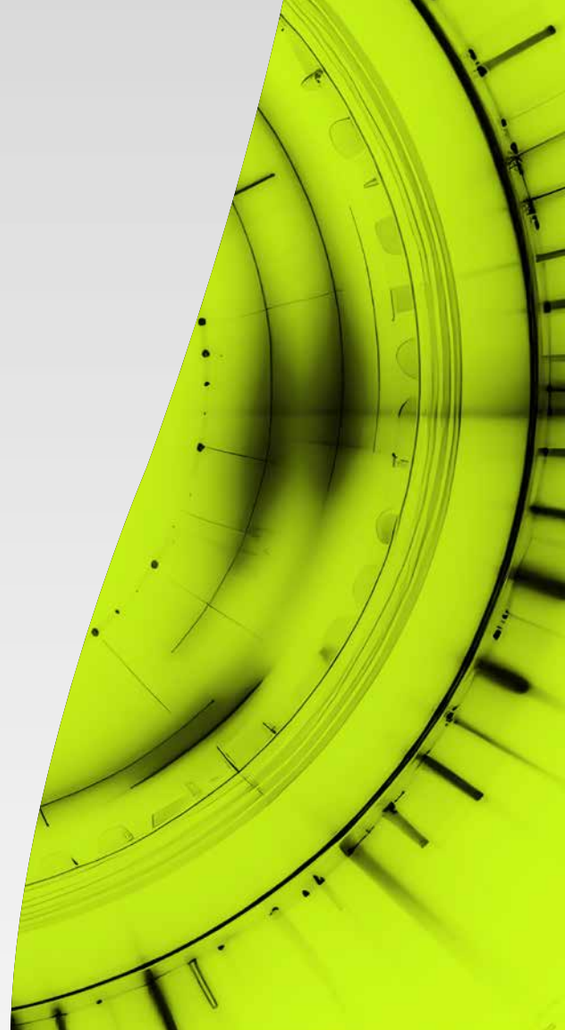
MODERN RADIOLOGY eBook

Computed Tomography

计算机断层扫描



EUROPEAN SOCIETY OF RADIOLOGY

Preface

Modern Radiology is a free educational resource for radiology published online by the European Society of Radiology (ESR). The title of this second, rebranded version reflects the novel didactic concept of the ***ESR eBook*** with its unique blend of text, images, and schematics in the form of succinct pages, supplemented by clinical imaging cases, Q&A sections and hyperlinks allowing to switch quickly between the different sections of organ-based and more technical chapters, summaries and references.

Its chapters are based on the contributions of over 100 recognised European experts, referring to both general technical and organ-based clinical imaging topics. The new graphical look showing Asklepios with fashionable glasses, symbolises the combination of classical medical teaching with contemporary style education.

Although the initial version of the ***ESR eBook*** was created to provide basic knowledge for medical students and teachers of undergraduate courses, it has gradually expanded its scope to include more advanced knowledge for readers who wish to 'dig deeper'. As a result, *Modern Radiology* covers also topics of the postgraduate levels of the *European Training Curriculum for Radiology*, thus addressing postgraduate educational needs of residents. In addition, it reflects feedback from medical professionals worldwide who wish to update their knowledge in specific areas of medical imaging and who have already appreciated the depth and clarity of the ***ESR eBook*** across the basic and more advanced educational levels.

I would like to express my heartfelt thanks to all authors who contributed their time and expertise to this voluntary, non-profit endeavour as well as Carlo Catalano, Andrea Laghi and András Palkó, who had the initial idea to create an ***ESR eBook***, and - finally - to the ESR Office for their technical and administrative support.

Modern Radiology embodies a collaborative spirit and unwavering commitment to this fascinating medical discipline which is indispensable for modern patient care. I hope that this ***educational*** tool may encourage curiosity and critical thinking, contributing to the appreciation of the art and science of radiology across Europe and beyond.

Minerva Becker, Editor
Professor of Radiology, University of Geneva, Switzerland

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章节大纲：

前言

*《现代放射学》*是由欧洲放射学协会 (European Society of Radiology,ESR) 在线发布的免费放射学教育资源。第二版（更名版）标题反映了 ***ESR 电子书*** 新颖的教学概念，它以简洁页面的形式巧妙地融合文本、图像和示意图，并辅以临床影像学案例、问答部分和内容超链接，使读者能够在各基于器官的部分、更具技术性的章节、摘要以及参考文献之间快速切换浏览。

其章节以 100 多名公认欧洲专家的优秀稿件为根基，涉及各类一般技术和基于器官的临床影像学主题。同时采用了全新的图形外观，展示了佩戴时尚眼镜的 Asklepios，象征着传统医学教学与现代风格教育的结合。

虽然初版 ***ESR 电子书***旨在为医学生和本科生教师提供医学基础知识，但现已逐渐扩充其知识领域，为希望“深入挖掘”的读者提供了更多高阶技术知识。因此，*《现代放射学》*还涵盖了*欧洲放射学培训课程*研究生水平的各类主题，旨在解决住院医师的研究生教育需求。此外，书中还囊括了全球医疗专业人士的反馈，他们希望更新自己在医学影像特定领域的知识，并对 ***ESR 电子书***在基础和高等教育水平上的深度和清晰度表示高度赞赏。

我要衷心感谢所有为这项非营利活动自愿贡献时间和专业知识的作者，以及最初提出创作 ***ESR 电子书***的 Carlo Catalano、Andrea Laghi 和 András Palkó，最后还要感谢 ESR 办公室所提供的技术和行政支持。

*《现代放射学》*充分体现了医者的协作精神和对这门热门医学学科坚定不移的承诺，这是现代患者护理必须具备的优秀精神品质。我希望这款***教育***工具能够激励各位始终保持好奇心和批判性思维，从而促进整个欧洲乃至欧洲以外地区对放射学艺术和科学的认识。

Minerva Becker，编辑
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This is a translation of the Chapter of the **Modern Radiology eBook.**

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NOTE FROM THE COORDINATORS:
Thank you to Chinese radiology experts for bridging languages and open the world-class English resource by ESR to every Mandarin-speaking student, fueling global radiology talent with a single click

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翻译致谢

本章节为《现代放射学电子书》的部分译文。

原文标题：
计算机断层扫描

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中华医学会放射学分会

译者寄语：
感谢中国放射学专家们的倾力奉献！你们跨越了语言的鸿沟，将欧洲放射学会 (ESR) 的世界级学术宝库呈献给广大中文学子。如今，前沿智慧一键即达，为全球放射学人才的蓬勃发展注入了强劲动力。

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>▪< FURTHER KNOWLEDGE

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<∞> REFERENCES

<?> QUESTIONS

/ Computed Tomography

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/ 计算机断层扫描

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<?> 问题

MODERN RADIOLOGY eBook

Based on the ESR Curriculum for Radiological Education

Computed Tomography

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Computed Tomography

CHAPTER OUTLINE:

计算机 断层扫描

章节大纲：

计算机 断层扫描

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Chapter Outline

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  - CT Generations
  - Dual-Energy CT
  - Photon Counting CT
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  - Axial vs Helical Scanning
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章节大纲

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- 核心要点
- 参考文献
- 知识测试

The CT Scanner

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计算机断层扫描

章节大纲：

CT 扫描仪

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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CT 扫描仪

章节大纲：

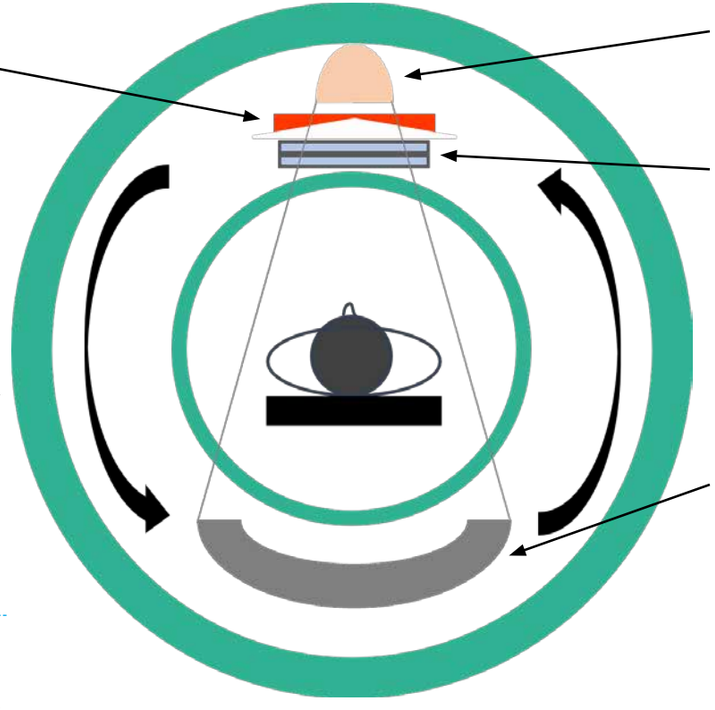
- CT 扫描仪包括以下主要组件：
  - X 射线管
  - 机架，装有对 X 射线敏感的探测器。X 射线探测器位于 X 射线源的正对面。
  - 计算机
- 图像的生成原理与常规 X 线片相同（见常规 X 线片章节），但 X 射线源围绕机架旋转（与使用固定 X 射线管的常规 X 线片不同）。
- 在 CT 检查过程中，患者躺在扫描床上，该床在 X 射线管围绕患者旋转时通过机架（请参阅图 1）。
- 根据适应症，可口服或静脉注射给予对比剂（请参阅《对比剂》中的章节）。

Filter

Removes low energy X-rays (unnecessary photons), which optimises 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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章节大纲：

过滤器

去除低能量 X 射线（不必要的光子），可优化射束能谱，并实现较低剂量扫描。

X 射线管

X 射线源。

准直器

限制散射辐射并减小患者剂量。

机架

实现扫描仪组件的旋转。

探测器阵列

- 闪烁体将 X 射线转化为光子。
- 光电二极管将光子转化为电信号。

图 1

CT 扫描仪的组件
经许可改编自（https://www.radiologycafe.com/frcr-physics-notes/ct-imaging/ct-equipment，最后访问时间 2023 年 1 月 31 日）

/ CT Scanner Generations

>|< COMPARE

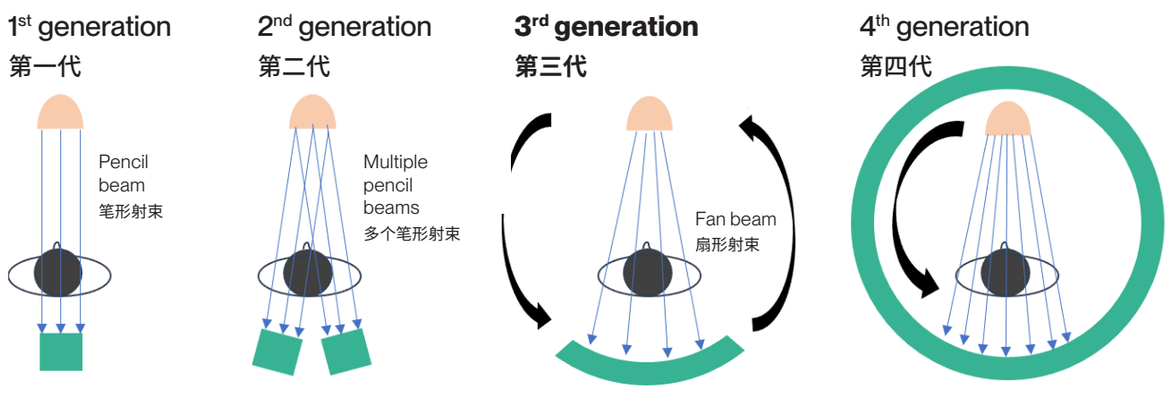

FIGURE 2

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

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.

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CHAPTER OUTLINE:

/ 计算机断层扫描

/ CT 扫描仪迭代

>|< 比较

章节大纲：

第三代扫描仪

- 目前最常用的 CT 扫描仪。
- X 射线管和探测器围绕患者旋转。
- 探测器排覆盖扇形射束的整个宽度。

图 2

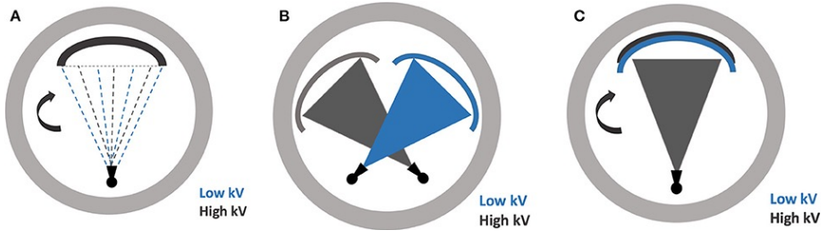
各代 CT 扫描仪之间的差异
经许可改编自（https://www.radiologycafe.com/frcr-physics-notes/ct-imaging/ct-equipment，最后访问时间 2023 年 1 月 31 日）

/ Dual Energy CT (DECT)

>|< COMPARE

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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CHAPTER OUTLINE:

/ 计算机 断层扫描

/ 双能 CT(DECT)

>|< 比较

章节大纲：

双能 CT(DECT)

- **原理**：以两种不同的能量频谱采集图像。
- **优势**：可分离具有不同原子序数但衰减相似的材料。
- **组成**：3 种不同类型的 DECT 扫描仪 (A-C)。

快速能量转换

X 射线管可在低能量射束和高能量射束之间快速切换。

双源技术

两套正交放置的管探测器系统独立运行。

多层探测器

能够区分高能级和低能级的“夹心”探测器(内层和外层)。

图 3

双能技术示意图。

/ Photon Counting CT

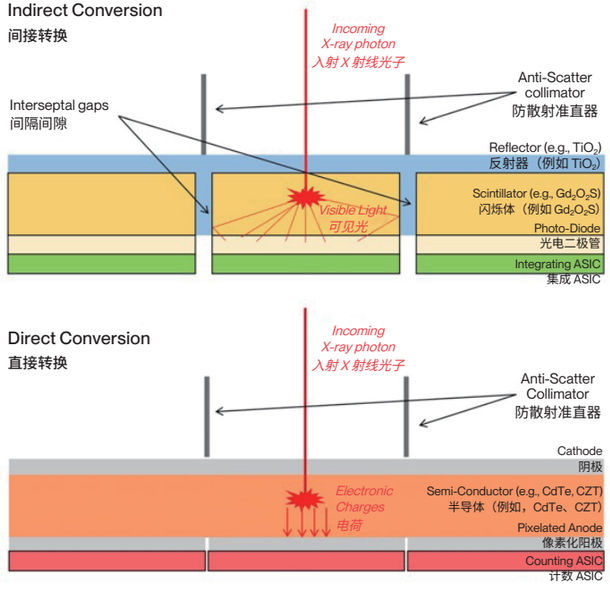

FIGURE 4

Photon-Counting detector technology.

>|< COMPARE

/ **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 artefacts

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CHAPTER OUTLINE:

/ 计算机断层扫描

章节大纲：

/ 光子计数 CT

>|< 比较

/ **原理**：不像传统能量集成探测器那样通过闪烁体进行间接转换（上图），而是将 X 射线**直接转换**为带电粒子（下图）。

/ **光子计数**：入射光子单独计数，并根据其能量级别划分为不同的光子单元。

优点：

+ 高对比度噪声比
+ 高空间分辨率
+ 可能降低辐射剂量和金属伪像
+ 采集来自单个 X 射线能量源的多能量图像

图 4

光子计数探测器技术。

CT Image Acquisition

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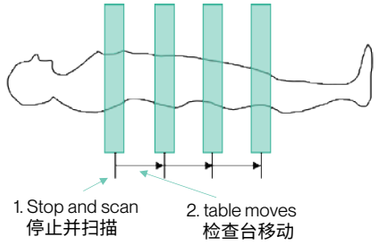
章节大纲：

CT 图像采集

/ CT Image Acquisition – Axial vs. Helical Scanning

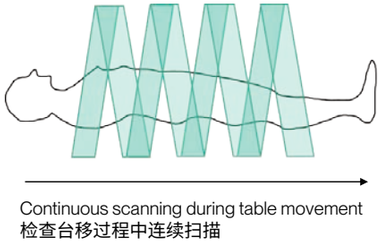
Axial Scanning
轴向扫描



Axial Scanning

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

Helical Scanning
螺旋扫描



Helical ("Spiral") Scanning

Continuous scanning with simultaneous table movement.

ADVANTAGES:

+ 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

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/ CT 图像采集 - 轴向扫描与螺旋扫描

章节大纲：

轴向扫描

1. 采集单层
2. 检查台移动到下一个位置
3. 采集另一层

螺旋扫描

检查台同步移动，连续扫描。

优点：

+ 避免呼吸性错位（一次呼吸期间完成全扫描）
+ 给予一次对比剂完成多期扫描
+ 重叠部分可提供更好的 CT 图像重建

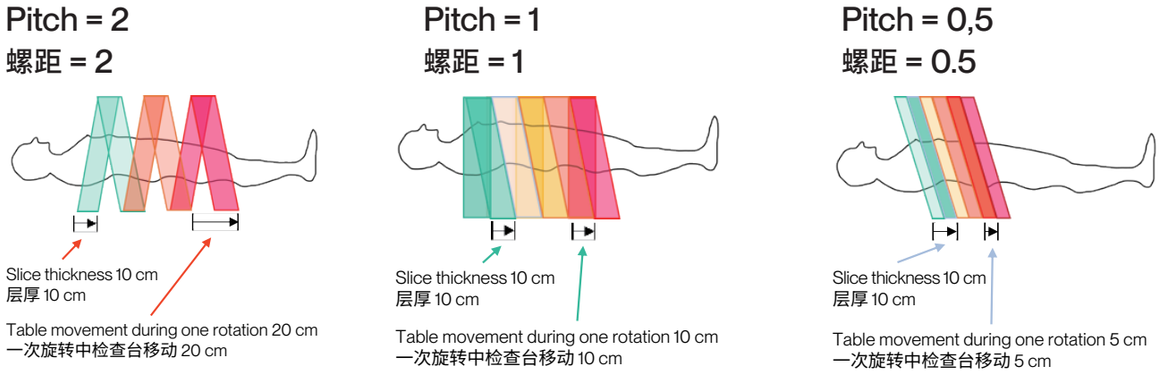
图 5

轴向扫描与螺旋扫描之间的差异

经许可改编自（https://www.radiologycafe.com/frcr-physics-notes/ct-imaging/acquiring-an-image-part-1/），最后访问时间 2023 年 1 月 31 日

/ CT Image Acquisition – Pitch

>|< COMPARE



<!> ATTENTION

- The pitch is defined as table distance travelled 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.

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章节大纲：

/ CT 图像采集 - 螺距

>|< 比较

<!> 注意

- 螺距定义为在一次 360° 机架旋转中检查台移动的距离除以射束准直（射束准直 = 层厚）。
- 螺距大于 1 可加快扫描速度并降低辐射剂量，但会降低图像质量。

图 6

不同螺距因子之间的差异。

经许可改编自（https://www.radiologycafe.com/frcr-physics-notes/ct-imaging/acquiring-an-image-part-1/），最后访问时间 2023 年 1 月 31 日

Hounsfield Units

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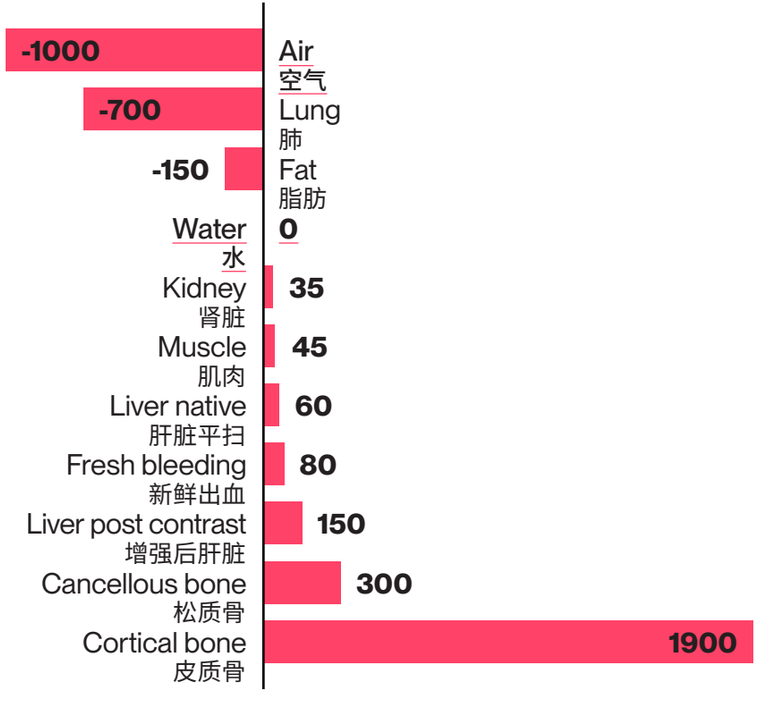
章节大纲：

亨氏单位

/ 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.

/ Computed **Tomography**

CHAPTER OUTLINE:

/ 计算机 **断层扫描**

章节大纲：

/ 亨氏单位或 CT 值

亨氏量表

（以 Gofrey Housfield 名字命名，他是 1979 年诺贝尔奖得主、发明 CT 的生物医学工程师）。

> 用于将水的放射密度定义为 **0** 亨氏单位 (HU)，将空气的放射密度定义为 **-1000** HU，从而量化放射密度。所有其他生物组织的放射密度均相对于这些基准值表示。

Image Reconstruction and Windowing

Computed Tomography

CHAPTER OUTLINE:

图像重建和窗技术

计算机断层扫描

章节大纲：

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.

CHAPTER OUTLINE:

图像重建技术

章节大纲：

图像重建是根据所采集的原始数据创建图像的数学过程。

滤波反投影（Filtered back projection，FBP）

自商用 CT 问世以来，FBP 就成为了标准的重建技术。然而，由于需要降低辐射剂量和提高空间和时间分辨率，这项技术可能已被视为过时技术。在低剂量成像条件下，常规的滤波反投影 (FBP) 会导致较高的图像噪声。

迭代重建（Iterative reconstruction，IR）

技术进步推动了迭代重建 (IR) 的发展，此技术可以在不影响图像分辨率的情况下降低图像噪声，同时将辐射剂量保持在可合理达到的最低水平。

大多数扫描仪使用迭代重建技术进行图像重建。

/ Image Reconstruction for CT – the Kernel

A Standard kernel
标准卷积核

B Bone kernel
骨卷积核

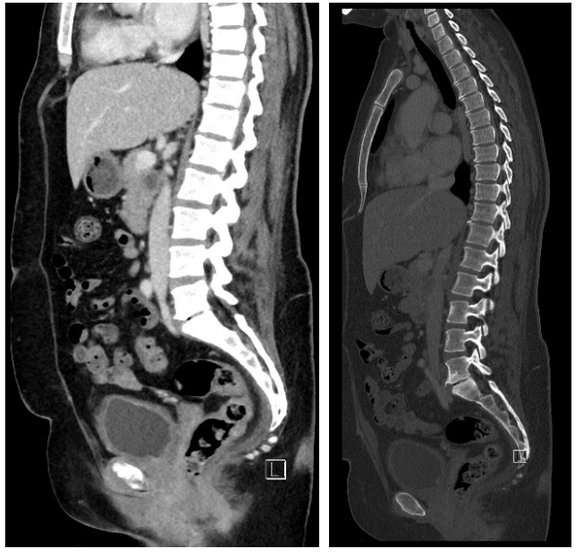


FIGURE 7

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

Two important reconstruction parameters:

/ **Kernel**
a sharper kernel generates a higher spatial resolution, but increases the noise.

/ **Slice thicknes**
scontrols 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.

/ Computed Tomography

CHAPTER OUTLINE:

/ 计算机断层扫描

章节大纲：

/ CT 的图像重建 – 卷积核

两个重要的重建参数：

/ **卷积核**
更清晰的卷积核能生成更高的空间分辨率，但同时会增加图像噪声。

/ **层厚**
控制纵向的空间分辨率。

A 标准卷积核

软组织外观光滑。

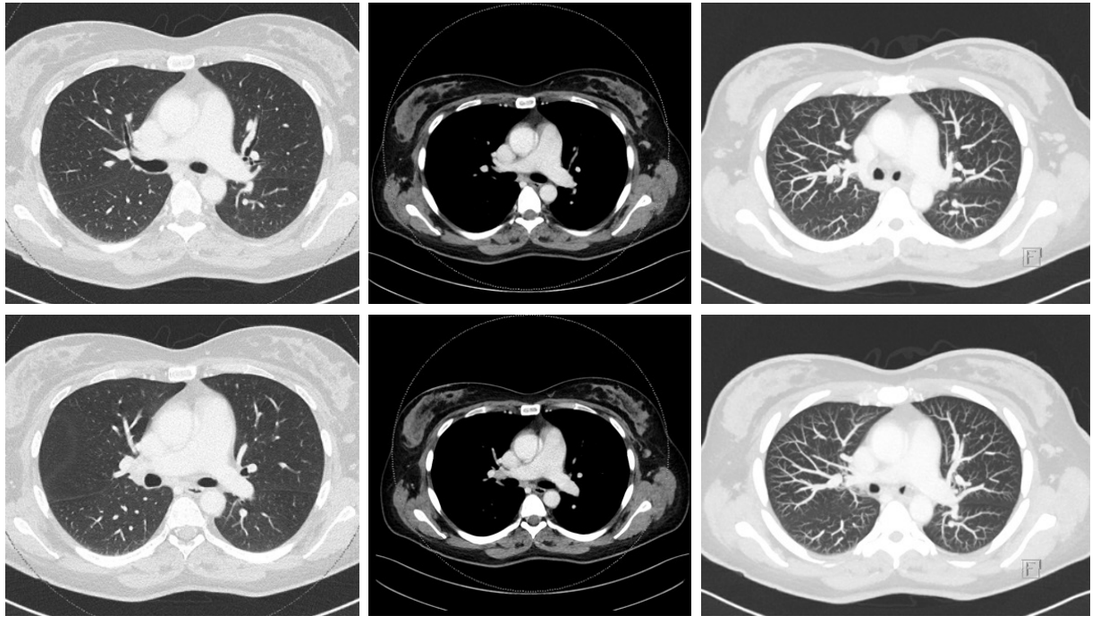
B 骨卷积核

以更高的空间分辨率生成更清晰的图像。

图 7

同一患者矢状位重组图像的对比示意图：(A) 标准卷积核；(B) 骨卷积核。

/ Image Reconstruction for CT – Slice Thickness



1mm

Thinner slices are useful to assess the lung parenchyma.

3mm

Used in a general approach.

10mm

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

FIGURE 8

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

/ Computed Tomography

CHAPTER OUTLINE:

/ 计算机断层扫描

/ CT 的图像重建 – 层厚

章节大纲：

1 mm

更薄的层厚有助于评估肺实质。

3 mm

用于一般情况。

10 mm

较厚的层有助于识别肺结节或用于血管造影检查。

图 8

同一患者矢状位重组图像的对比示意图：(A) 标准卷积核；(B) 骨卷积核。

/ 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.

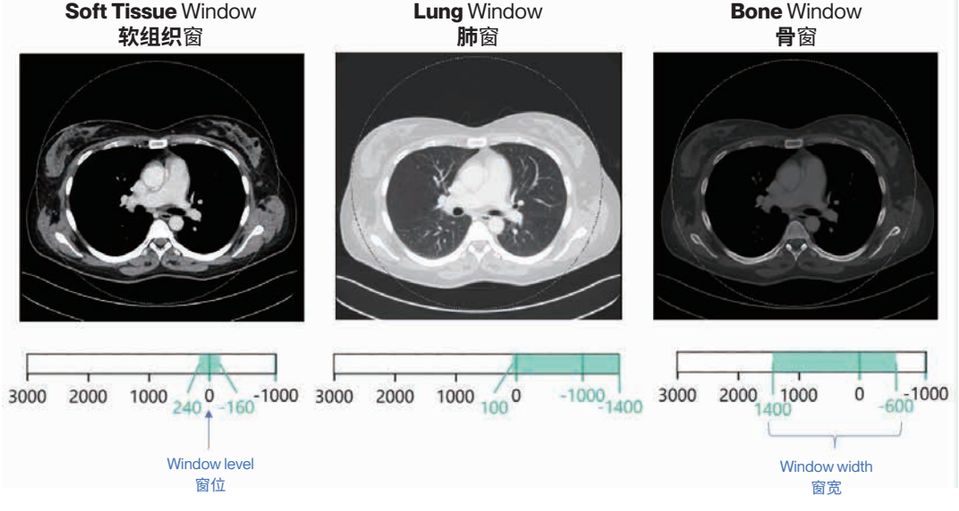


FIGURE 9

Soft tissue, lung and bone windows in CT.

/ Computed Tomography

CHAPTER OUTLINE:

/ 计算机断层扫描

章节大纲：

/ 窗技术

窗技术

通过调节 CT 值显示范围，改变图像对比度。

窗位

窗位是 CT 值范围的中点。

窗宽

窗宽定义以不同灰度显示的 CT 值范围。

图 9

CT 中的软组织窗、肺窗和骨窗。

Image Resolution

Computed Tomography

CHAPTER OUTLINE:

计算机断层扫描

章节大纲：

图像分辨率

/ 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.

<!> ATTENTION

Spatial resolution is decreased by

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

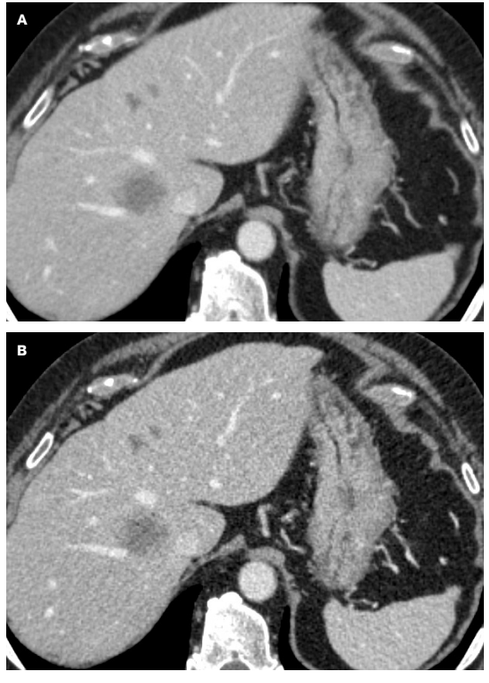


FIGURE 10

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**.

/ Computed **Tomography**

CHAPTER OUTLINE:

/ 计算机 **断层扫描**

章节大纲：

/ 图像分辨率

/ 与其他影像学相比，**空间分辨率**是 CT 的主要优点之一。空间分辨率是指区分密度不同的相邻结构的能力。

/ **各向同性分辨率**：对于多平面重建，所有方向的空间分辨率必须一致。

<!> 注意

空间分辨率降低的原因包括

/ 像素大小 ▲
/ 焦点大小 ▲
/ 放大率 ▲
/ 视野 ▲
/ 软组织卷积核
/ 螺距 ▲
/ 层厚 ▲
/ 探测器尺寸 ▲
/ 患者移动 ▲

图 10

同一患者上腹部空间分辨率的比较。图像 **B** 的空间分辨率更高，因为与层厚为 5 mm 的图像 **A** 相比，其层厚为 1 mm。请注意，其对肝转移和肝静脉的显影更好。然而，图 **B** 中噪声增加。

/ **Contrast resolution d**escribes 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.

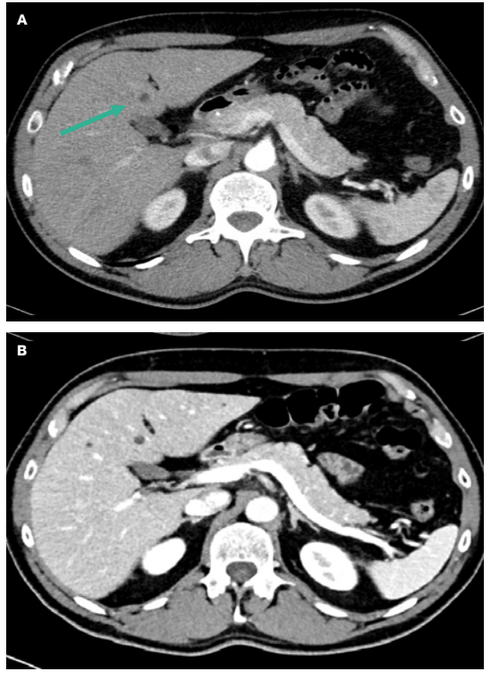


FIGURE 11

Comparison of a liver cyst (arrow) in the same patient. Compared to image **A**, image **B** shows a better contrast resolution and therefore allows a better characterisation of the hypodense liver lesion.

<!> ATTENTION

Factors decreasing contrast resolution

- / Inherent structure contrast ▼
- / Detector size ▼
- / Scatter radiation ▲
- / Noise ▲
- / Pitch ▲
- / Beam energy ▲
- / No use of contrast media

/ Computed Tomography

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/ 计算机断层扫描

/ 对比度分辨率是指区分相邻区域不同密度差异的能力。它被定义为每像素值的位数，由许多因素决定。以下是影响对比度分辨率的一些因素。

章节大纲：

<!> 注意

降低对比度分辨率的因素

- / 固有结构对比 ▼
- / 探测器尺寸 ▼
- / 散射辐射 ▲
- / 噪声 ▲
- / 螺距 ▲
- / 射束能量 ▲
- / 未使用对比剂

图 11

同一患者肝囊肿（箭头）的比较。与图像 **A** 相比，图像 **B** 显示的对比度分辨率更好，因此使肝脏低密度病变的显示更清晰。

Artefacts in CT

Computed Tomography

CHAPTER OUTLINE:

计算机断层扫描

章节大纲：

CT 中的伪像

/ Artefacts

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

<!> ATTENTION

/ Physical phenomena causing artefacts:

/ **Beam hardening artefacts** are frequent and caused by dense objects that absorb lower energy photons and thus leaving mainly high energy ("hard") photons for the beam.

/ **Streaking artefacts** are a result of beam hardening and scatter at dense objects. They It can be reduced by a harder X-ray beam (higher kV) or metal artefact reduction software.

<!> ATTENTION

Photon starvation is a special type of streak artefact, 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.

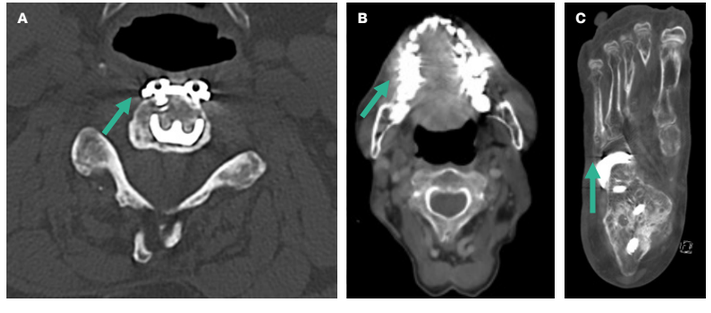


FIGURE 12

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 artefacts).

/ Computed **Tomography**

CHAPTER OUTLINE:

/ 计算机 **断层扫描**

/ 伪像

章节大纲：

/ CT 伪像有多种原因。无论如何，了解这些伪像至关重要，因为它们可能改变图像中病变的显示，甚至掩盖关键诊断征象。

<!> 注意

光子饥饿是一种特殊类型的条纹伪像，主要由高衰减区域（尤其是金属植入物）引起。由于高衰减，致密结构后面的光子无法到达探测器，导致物体后面出现高噪声，表现为条纹。

此类伪像可通过增加 mAs（管电流调制）和使用迭代重建滤波器减轻。

<!> 注意

/ 导致伪像的物理现象：

/ **射束硬化伪像**很常见，其成因是高密度物体优先吸收低能光子，导致剩余射束主要由高能（"硬"）光子组成。

/ **条纹伪像**是由高密度物体引起的射束硬化和散射共同作用的结果。它们可通过更硬的 X 射线射束（更高 kV）或金属伪像减少软件来减轻。

图 12

光子饥饿。金属植入物导致光子饥饿的三个示例 (A-C)。特别是种植牙（B）在老年患者中很常见，并且会影响周围组织的观察（绿色箭头表示所讨论的伪像）。

Patient related artefacts

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

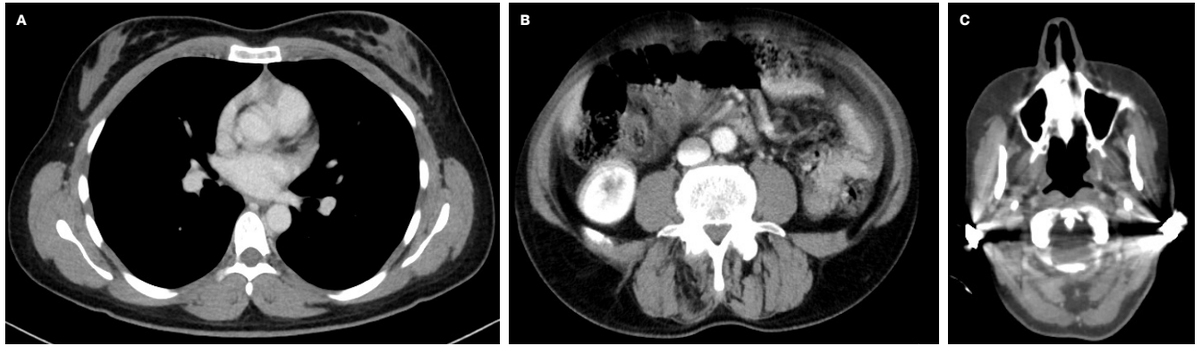


FIGURE 13

Patient-related artefacts. (**A**) Without ECG-triggered image acquisition, pulsation artefacts of the ascending aorta are common. (**B**) Motion artefacts 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 artefacts causing streak artefacts in a woman with earrings that could not be taken off.

Computed Tomography

CHAPTER OUTLINE:

计算机断层扫描

章节大纲：

患者相关伪像

- **移动伪像：**采集过程中的移动会导致条纹和模糊。
- **服装伪像**和**首饰伪像**在常规 X 光片中更为常见。在 CT 扫描中，这些（衣物/首饰）通常可被识别为体外物体，但其产生的伪像可能使图像解读复杂化。

图 13

患者相关伪像。(**A**) 若未采用 ECG 触发图像采集，升主动脉的搏动伪像很常见。(**B**) 移动伪像可严重影响解剖结构的可评估性；在这种情况下，由于患者移动，肠和血管几乎无法评估。(**C**) 女性患者佩戴无法取下的耳环时，首饰产生的条纹伪像问题。

<!> ATTENTION

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.

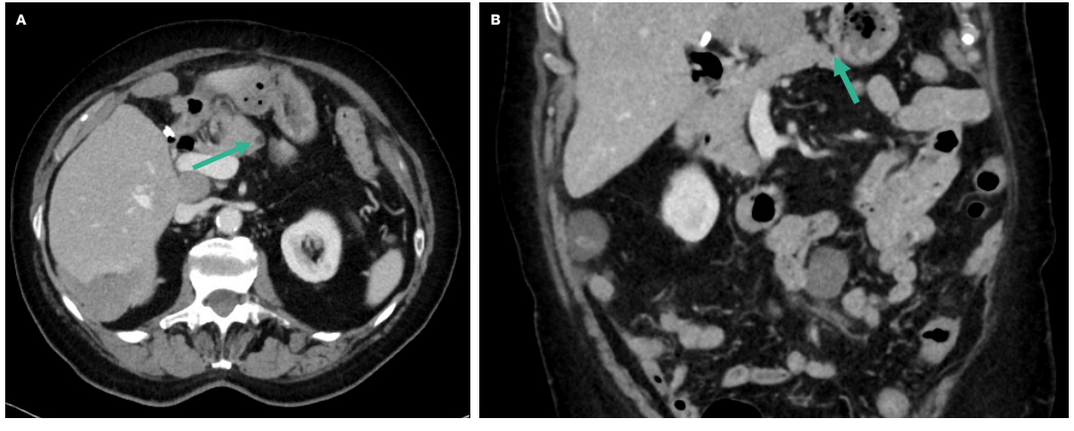


FIGURE 14

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.

Computed Tomography

CHAPTER OUTLINE:

计算机断层扫描

章节大纲：

<!> 注意

部分容积效应是指当密度差异显著的组织被包含在同一体素内时，射束的衰减值会被平均化的现象。

此现象可通过薄层重建解决。

图 14

部分容积效应。患卵巢癌和腹膜癌病的女性，图 **A** 似乎显示胰腺低密度病变（**箭头**）。实际上，该图像表现属于部分容积伪像，系因肠系膜脂肪组织（**图 B 箭头所示**）与胰腺实质被包含在同一体素内所致。冠状位重建 (**B**) 证明并无胰腺病变。

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

Cone beam artefact 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 15

Truncation artefact and cone beam artefact. 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 artefact at the left side of the patient could be observed.

Computed Tomography

CHAPTER OUTLINE:

计算机断层扫描

章节大纲：

当部分被检查物体无法被纳入视野时，就会出现**截断伪像**。此类伪像表现为视野边缘的高衰减环状影。

锥形束伪像是一种仅在多排螺旋 CT 扫描仪中出现的伪像。由于在一次旋转过程中采集多个截面，射束呈锥形扩散。由于反投影假定平行射束，这会导致实际锥形形状与假定射束配置之间产生差异，从而导致射束发生锥形失真。

图 15

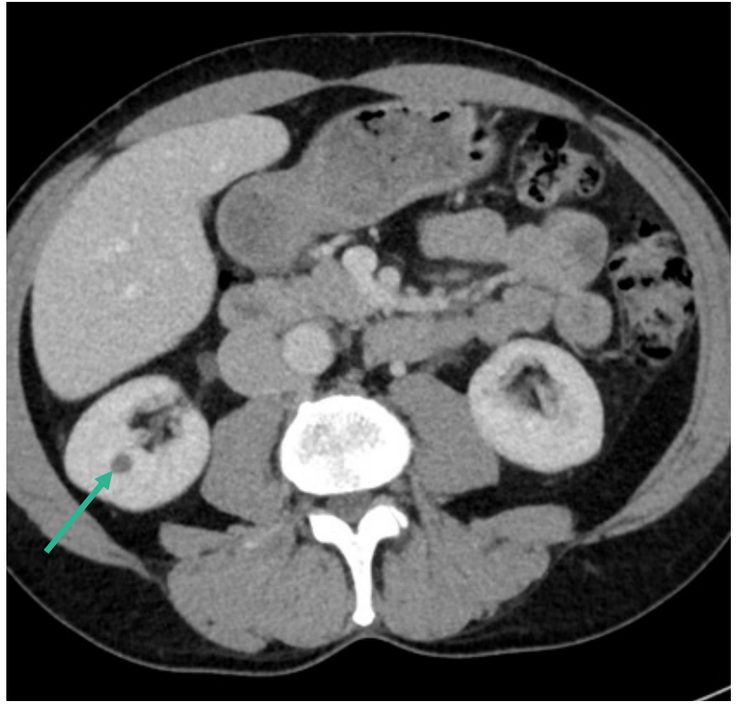
截断伪像和锥形束伪像。肥胖患者腹部盆腔 CT 扫描的轴位图像。由于患者的软组织无法包括在视野中，因此可在患者左侧观察到截断伪像。

/ Further CT-Artefacts

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.



<!> ATTENTION

FIGURE 16

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.

/ Computed **Tomography**

CHAPTER OUTLINE:

/ 计算机 **断层扫描**

/ 更多 CT 伪像

章节大纲：

由于取样不足导致的混叠在 MRI 中更为常见。

由校准不当或探测器/探测器元件缺陷引起的**环形伪像**。

单纯性肾囊肿的**伪增强**由散射和射束硬化引起。

<!> 注意

图 16

伪增强。一例鼻咽癌患者的 CT 扫描轴位图像显示右肾有单纯性良性囊肿。密度测量结果显示为 39 亨氏单位。进一步超声检查显示单纯性 Bosniak 1 级囊肿（请参阅《泌尿生殖系统放射学》中的章节）。因此，亨氏单位的升高可视为伪增强。

Dose Parameters

Computed Tomography

CHAPTER OUTLINE:

计算机断层扫描

章节大纲：

剂量参数

/ Dose Parameters

Computed tomography dose index (CTDI)

- / Measured in mGy
- / Standardised 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
= 标准 100 mm 扫描中心的平均剂量

$CTDI_w$

$$\frac{\text{2/3 } CTDI_{100} \text{ periphery / 2/3 } CTDI_{100} \text{ 外周均值}}{\text{1/3 CTDI center / 1/3 CTDI 中心值}}$$

$CTDI_{vol}$

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

Dose length product (DLP) = $CTDI_{vol}$ * scan length (cm) (mGy * cm)
剂量长度乘积 (DLP) = $CTDI_{vol}$ * 扫描长度 (cm) (mGy * cm)

DLP considers the whole length of the examined object or patient
DLP 考虑被检查对象或患者的总长度

/ Computed Tomography

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章节大纲：

/ 剂量参数

计算机断层扫描剂量指数（Computed tomography dose index，CTDI）

- / 以 mGy 为单位测量
- / 单层标准辐射剂量测量
- / 可比较不同扫描仪之间的辐射剂量输出

/ 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.

/ 剂量调制

管电流 (mAs) 调制可用于减少较低衰减区域的剂量。这意味着每个身体部位的 mAs 需差异化设置，而低衰减身体部位的光子量将减少。mAS 的变化导致辐射剂量呈线性变化。

修改螺距会更改 CT 剂量。在恒定辐射输出中，增大螺距会降低辐射剂量，而减小螺距将导致辐射剂量增加。

修改管电压 (kV) 导致患者的辐射剂量出现非线性变化。根据患者体重，可选择较低的 kV 以减少总辐射剂量。此外，降低管电压可以改善对比度噪声比。

Cross-sectional Anatomy

Computed Tomography

CHAPTER OUTLINE:

计算机断层扫描

章节大纲：

横断面解剖结构

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.

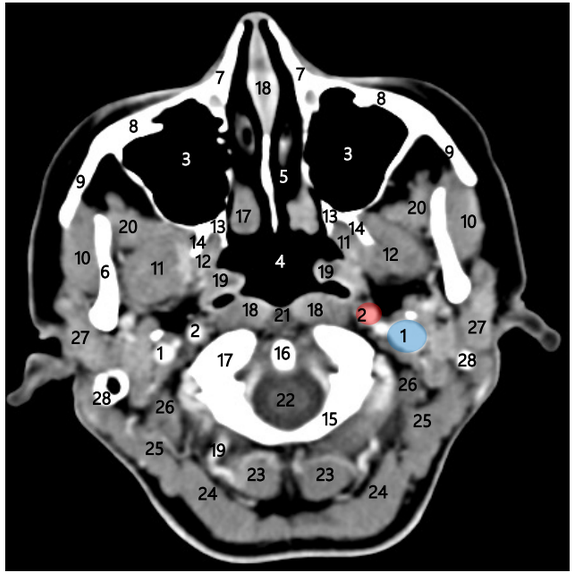

FIGURE 17

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.

Computed Tomography

CHAPTER OUTLINE:

计算机断层扫描

章节大纲：

面部和颈部的横断面解剖结构

由于许多微小解剖结构局限在狭小的空间内，头颈部的横断面解剖结构非常复杂。准确了解血管、颈部间隙和淋巴结非常重要，尤其是在炎症与肿瘤性病变的诊疗中。

图 17

面部和颈部的横断面解剖结构。
上颌窦和鼻咽水平的颈部软组织窗轴位重建 CT 图像。重要的解剖结构已标注。

1=颈内静脉，2=颈内动脉，3=上颌窦，4=鼻咽，5=鼻腔，6=下颌支，7=鼻突（上颌骨），8=前表面（上颌骨），9=颞面（颧骨），10=咬肌，11=翼内肌，12=翼外肌，13=蝶骨及内侧突，14=蝶骨外侧突，15=寰椎后弓，16=枢椎齿突，17=寰椎侧块，18=咽扁桃体，19=咽鼓管咽襞，20=颞肌，21=咽缝，22=椎管及脊髓，23=头后大直肌，24=头半棘肌，25=头夹肌，26=上斜方肌，27=腮腺，28=乳突。

/ 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.

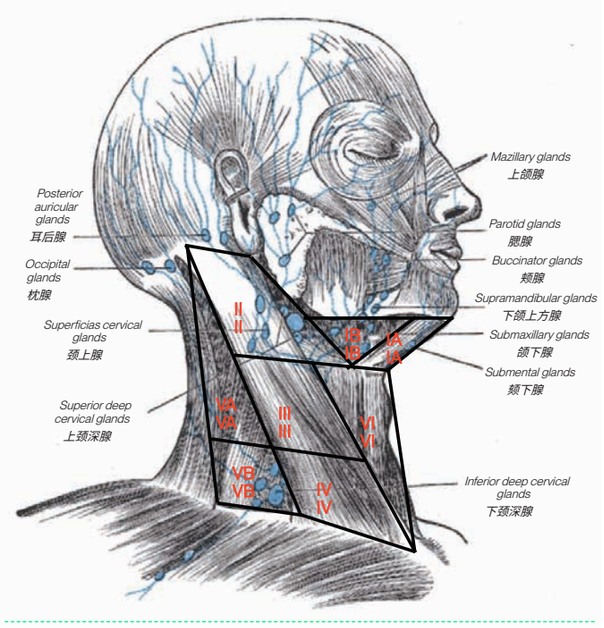

FIGURE 18

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.

/ Computed Tomography

CHAPTER OUTLINE:

/ 计算机断层扫描

章节大纲：

/ 颈部横断面解剖结构

颈部淋巴结水平

IA：颏下淋巴结
IB：下颌下淋巴结

II：颈内静脉上淋巴结
（IIA：颈内静脉前上淋巴结）
（IIB：颈内静脉后上淋巴结）

III：颈内静脉中区

IV：颈内静脉下淋巴结

VA：环状软骨上方的颈后三角
VB：环状软骨下方的颈后三角

VI：前中央间隔

>另请参阅《头部和颈部成像》中的章节。

图 18

颈部淋巴结水平。《Grey´s Anatomy of the human body》（美国第 20 版）修订版图像。该版本最初出版于 1918 年，因此内容已进入公有领域。

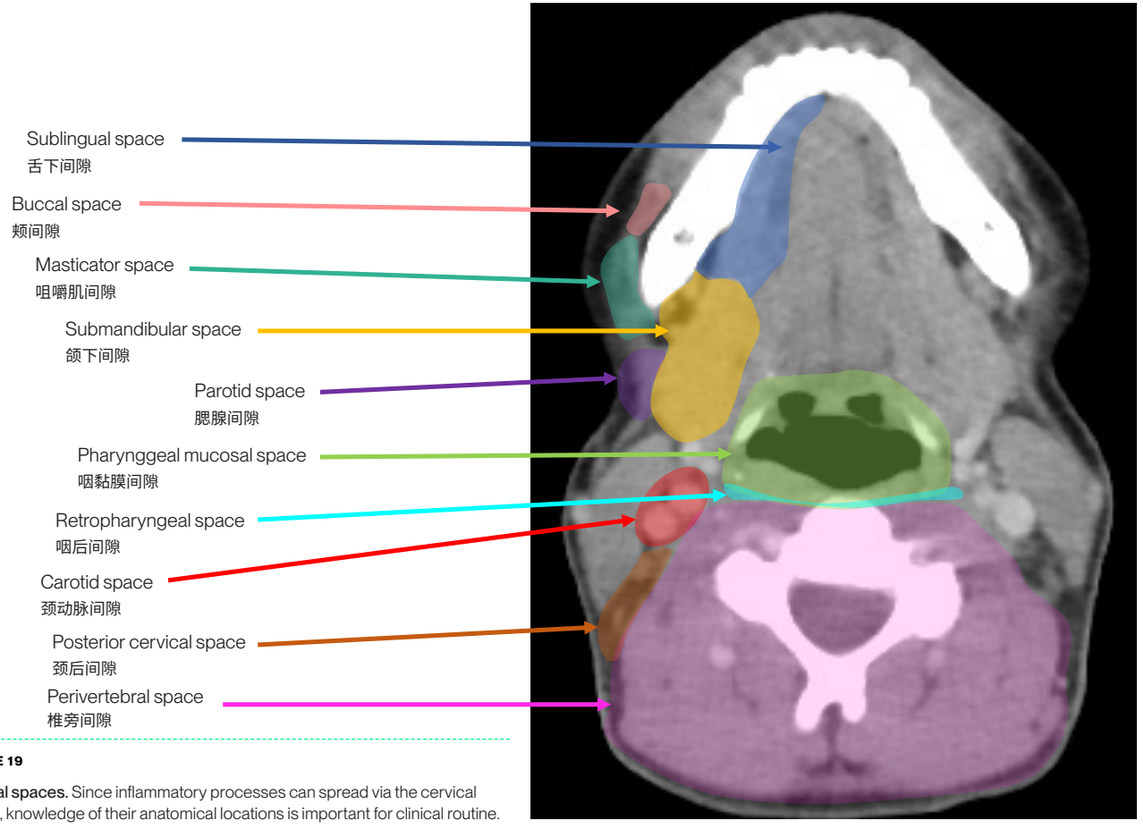

FIGURE 19

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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章节大纲：

图 19

颈部间隙。由于炎症过程可通过颈部间隙扩散，因此了解其解剖位置对于临床常规诊疗非常重要。

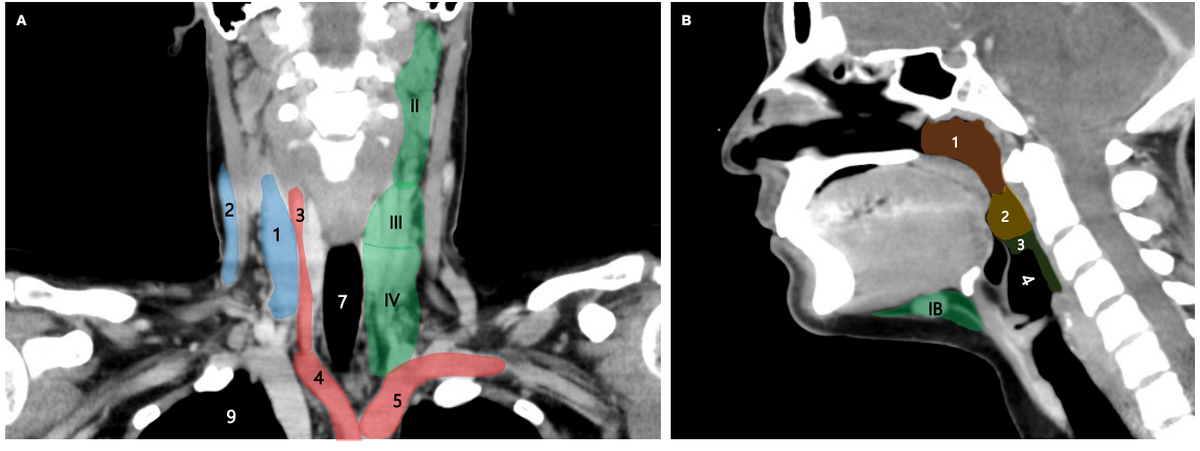

FIGURE 20

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.

Figure B: 1=Nasopharynx, 2= Oropharnx, 3= Laryngopharnyx, 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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章节大纲：

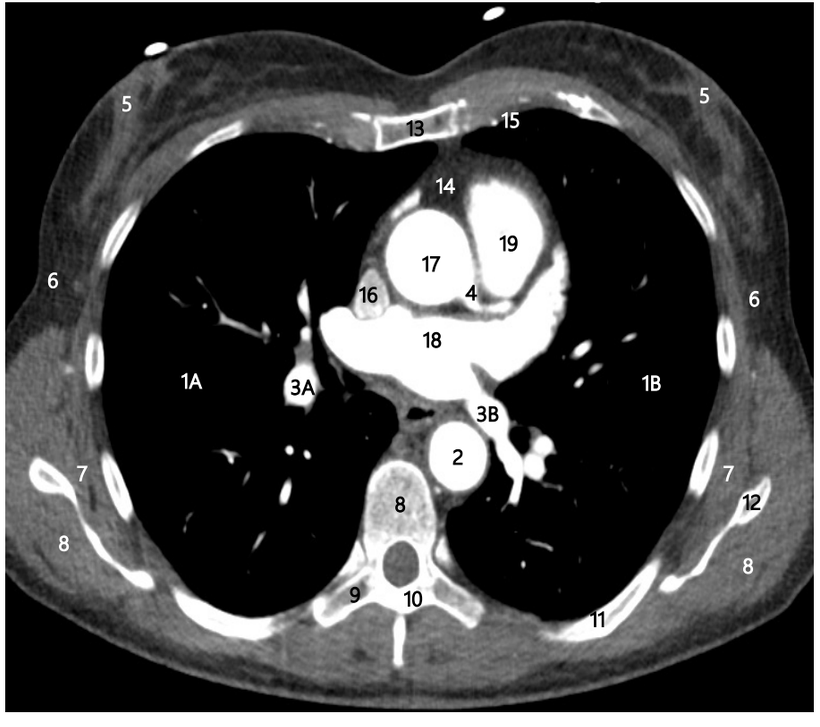
图 20

冠状位和矢状位重建 CT 图像。主要由于颈部解剖结构的复杂性，矢状位和冠状位重建图像对放射科医生的阅片至关重要。冠状位重建 (A) 可整体显示颈部血管和II-IV 区淋巴结。在矢状位重建 (B) 中，可以更有效地评估咽和喉结构的不同区域。此外，图中还显示了下颌下淋巴结（IB 区）。

图 A：1=右颈内静脉，2=右颈外静脉，3=右颈内动脉，4=头臂干，5=左锁骨下动脉，6=甲状腺（右叶），7=气管，8=乳突，9=右肺尖，10=右头臂静脉。

图 B：1=鼻咽，2=口咽，3=喉咽，4=喉，5=鼻腔，6=会厌，7=前庭襞，8=声带，9=气管，10=额窦，11=蝶窦。

/ Cross-Sectional Anatomy of the Chest



<∞> REFERENCE

> See also eBook chapter on Chest Imaging

FIGURE 21

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.

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.

/ Computed Tomography

CHAPTER OUTLINE:

/ 胸部横断面解剖结构

/ 计算机断层扫描

章节大纲：

<∞> 参考文献

> 另请参阅《胸部影像学检查》电子书章节

图 21

胸腔的横断面解剖结构。在软组织窗中，示出了纵隔的解剖结构。此外，解读图像时还应考虑肌肉和皮下脂肪组织。

1A=右肺，1B=左肺，2=降主动脉，3A=右肺静脉，3B=左肺静脉，4=左冠状动脉，5=乳腺实质，6=腋窝，7=肩胛下肌，8=冈下肌，9=横突，10=椎板，11=肋骨，12=肩胛骨，13=胸骨，14=纵隔脂肪组织，15=胸廓内动脉，16=上腔静脉，17=升主动脉，18=左心房，19=右心室。

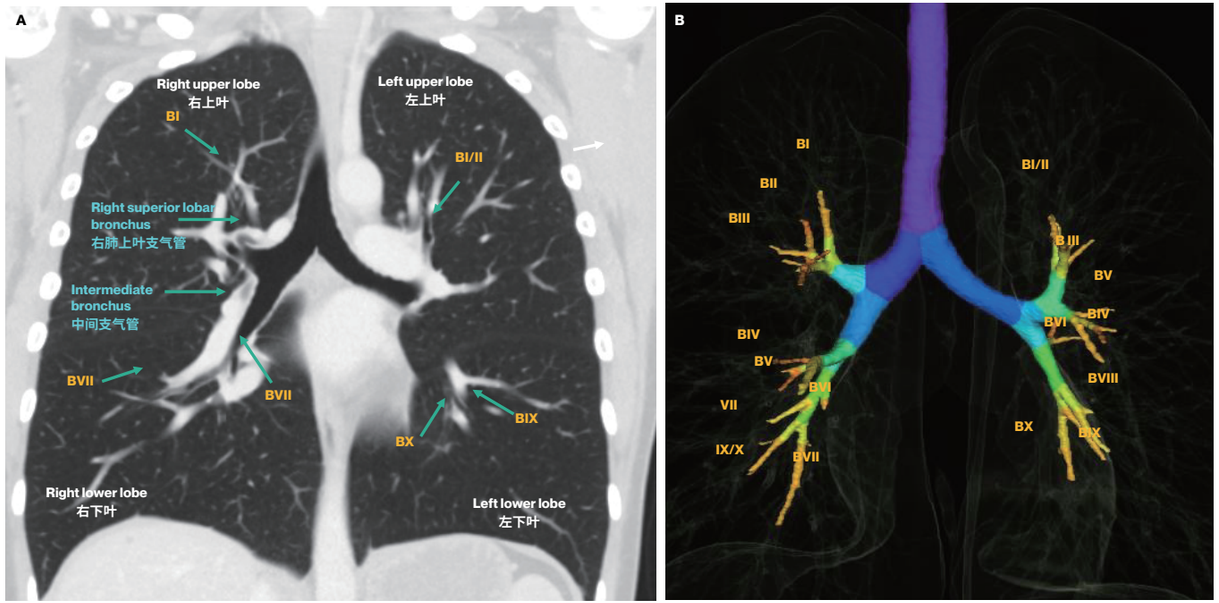


FIGURE 22

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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章节大纲：

图 22

呼吸系统的横断面解剖结构。在胸部 CT 扫描中使用肺窗，可以评估肺组织 (**A**) 和支气管树 (**B**)。采集和重建非常薄的层厚，可准确评估肺段支气管与管腔内病变的关系。图 **A** 中对支气管树的一些节段进行了示例性注释。

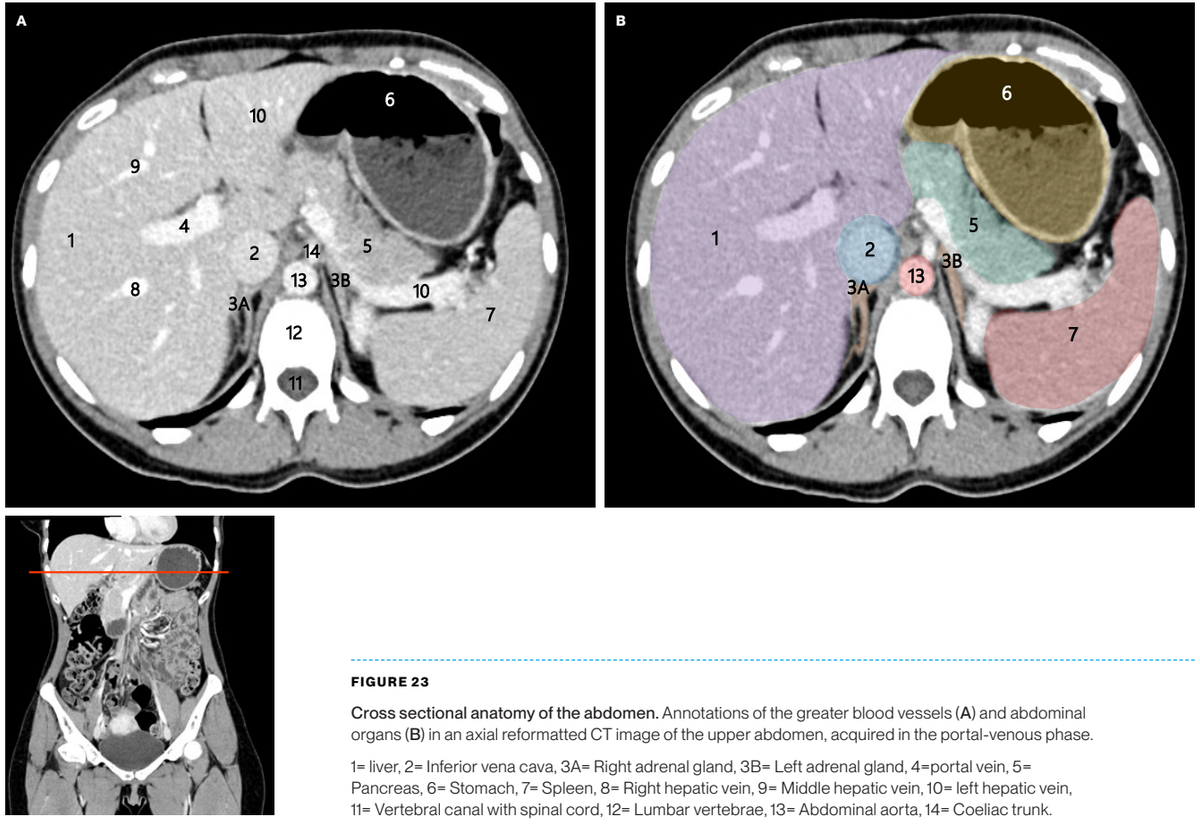

FIGURE 23

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.

Computed Tomography

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章节大纲：

图 23

腹部的横截面解剖结构。在门静脉期采集的上腹部轴位重建 CT 图像中大血管 (A) 和腹部器官 (B) 的注释。

1=肝脏，2=下腔静脉，3A=右肾上腺，3B=左肾上腺，4=门静脉，5=胰腺，6=胃，7=脾脏，8=肝右静脉，9=肝中静脉，10=肝左静脉，11=椎管及脊髓，12=腰椎，13=腹主动脉，14=腹腔干。

/ CT Anatomy of the Abdomen and Pelvis

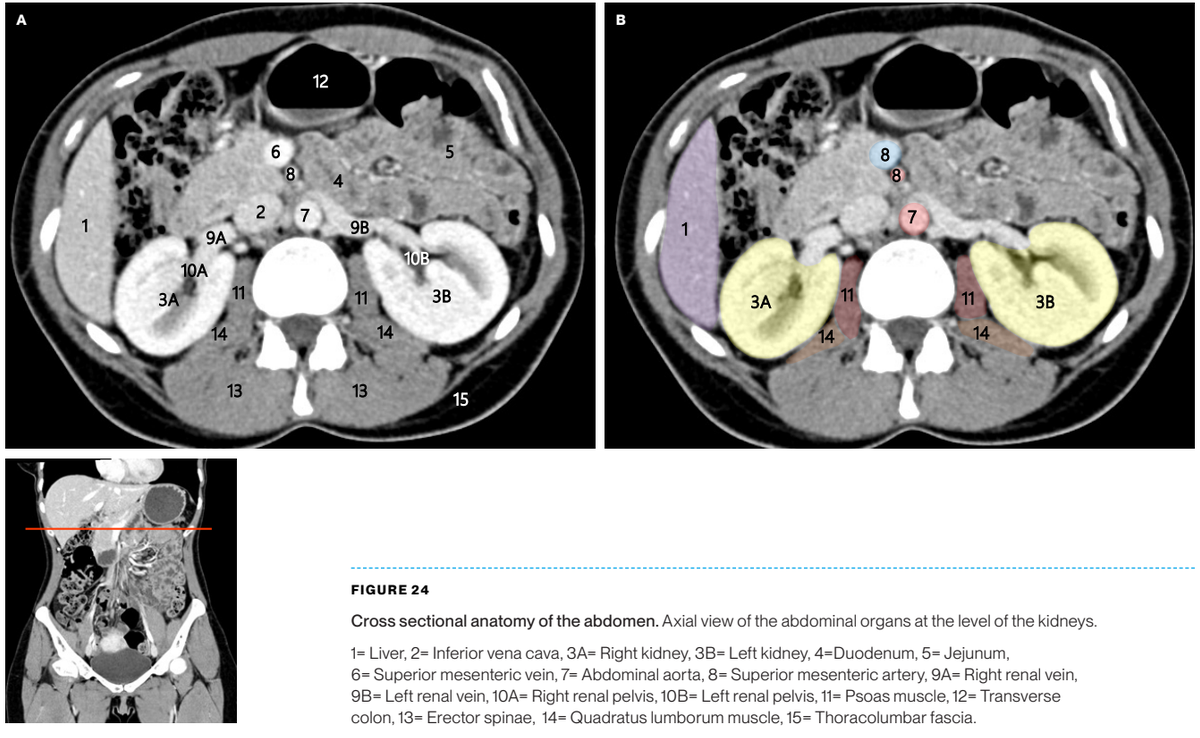

FIGURE 24

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.

/ Computed Tomography

CHAPTER OUTLINE:

/ 腹部和盆腔的 CT 解剖结构

/ 计算机断层扫描

章节大纲：

图 24

腹部的横截面解剖结构。肾脏水平腹部器官的轴位视图。

1=肝脏，2=下腔静脉，3A=右肾，3B=左肾，4=十二指肠，5=空肠，6=肠系膜上静脉，7=腹主动脉，8=肠系膜上动脉，9A=右肾静脉，9B=左肾静脉，10A=右肾盂，10B=左肾盂，11=腰大肌，12=横结肠，13=竖脊肌，14=腰方肌，15=胸腰筋膜。

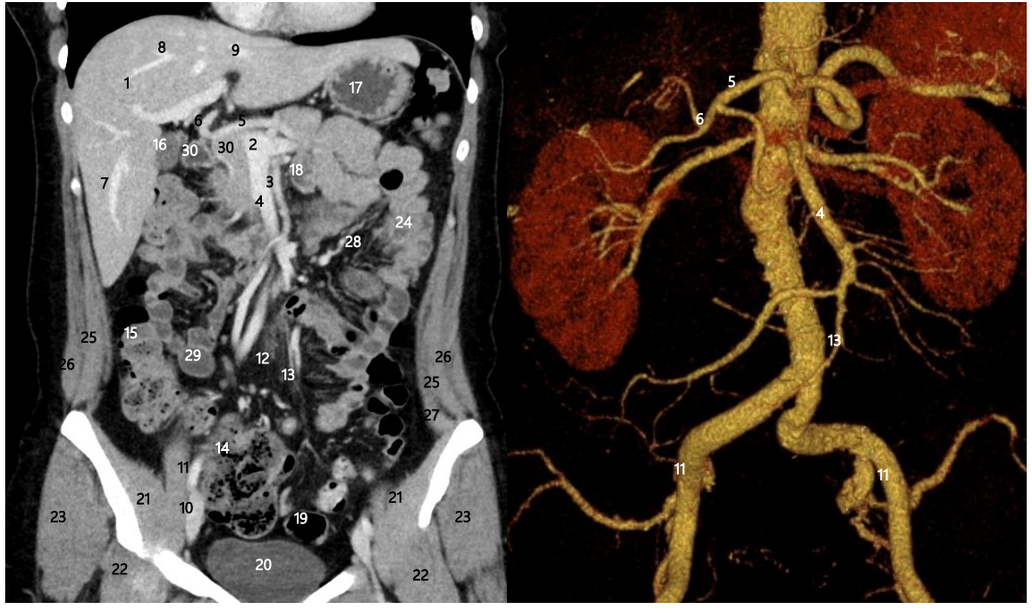

FIGURE 25

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.

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章节大纲：

图 25

腹部的横截面解剖结构。冠状位重建图像和 3D 重建可用于识别和监测血管病变。

1=肝脏，2=门静脉，3=肠系膜上动脉，4=肠系膜上静脉，5=肝总动脉，6=肝固有动脉，7=肝右静脉，8=肝中静脉，9=肝左静脉，10=髂外静脉，11=髂外动脉，12=肠系膜，13=空肠动脉和髂动脉，14=盲肠，15=升结肠，16=胆囊，17=胃，18=十二指肠，19=乙状结肠，20=膀胱，21=髂肌，22=髂腰肌，23=臀中肌，24=降结肠，25=腹内斜肌，26=腹外斜肌，27=腹横肌，28=肠系膜，29=回肠，30=十二指肠。

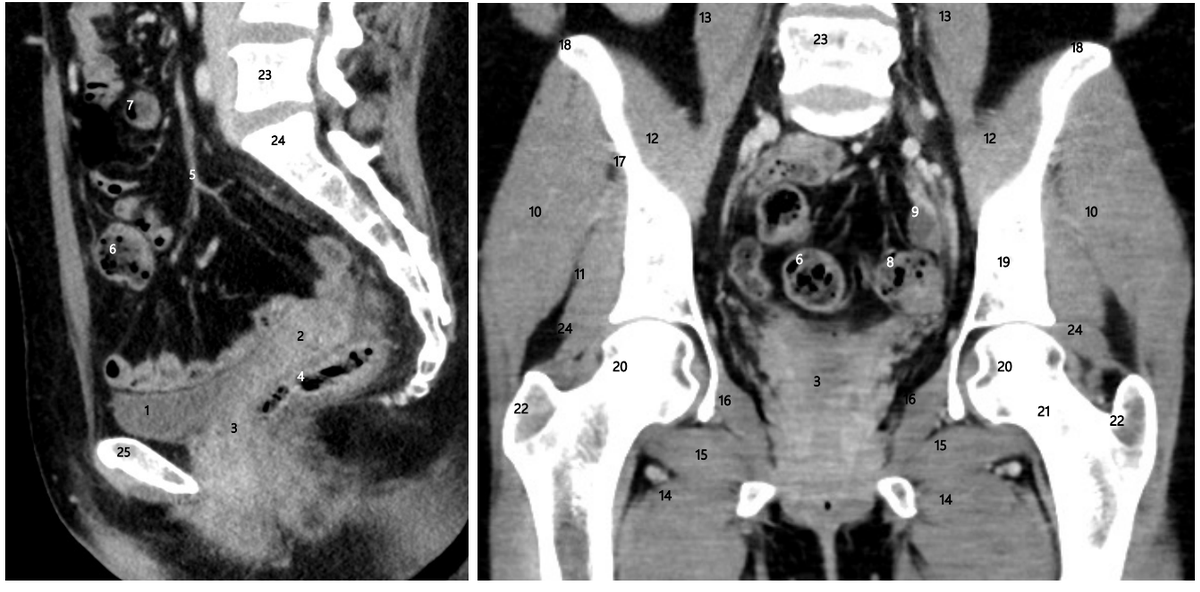

FIGURE 26

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.

Computed Tomography

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章节大纲：

图 26

女性盆腔的横断面解剖结构。盆腔器官的矢状位 (**A**) 和冠状位 (**B**) 重建 CT 影像。

1=膀胱，2=子宫，3=子宫颈，4=直肠，5=肠系膜上动脉分支（空肠动脉和髂动脉），6=回肠，7=空肠，8=乙状结肠，9=左卵巢，10=臀中肌，11=臀小肌，12=髂肌，13=腰大肌，14=耻骨肌，15=闭孔外肌，16=闭孔内肌，17=髂骨翼，18=髂嵴，19=髂骨，20=股骨头，21=股骨颈，22=大转子，23=第 5 腰椎，24=骶骨。

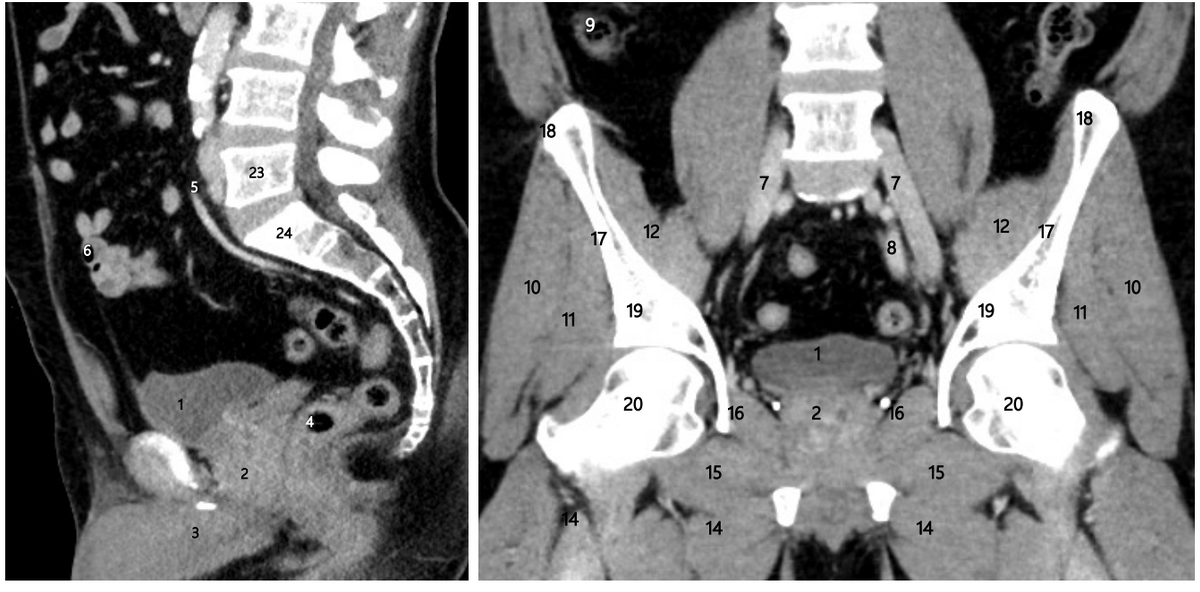

FIGURE 27

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.

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章节大纲：

图 27

男性盆腔的横断面解剖结构。盆腔器官的矢状位 (A) 和冠状位 (B) 重建 CT 影像。

1 = 膀胱，2 = 前列腺，3 = 阴茎海绵体，4 = 直肠，5 = 髂内动脉，6 = 回肠，7 = 髂总静脉和动脉，8 = 左髂内静脉，9 = 升结肠，10 = 臀中肌，11 = 臀小肌，12 = 髂肌，13 = 腰大肌，14 = 耻骨肌，15 = 闭孔外肌，16 = 闭孔内肌，17 = 髂骨翼，18 = 髂嵴，19 = 髂骨，20 = 股骨头，21 = 股骨颈，22 = 大转子，23 = 第 5 腰椎，24 = 骶骨。

/ 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 artefacts and how to remedy them is important for every day practice.
- Understanding basic cross-sectional anatomy is key for daily clinical practice.

/ Computed Tomography

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/ 计算机断层扫描

章节大纲：

/ 核心要点

- CT 是现代医疗中不可或缺的工具，其技术已历经重大发展。
- 理解亨氏单位的差异有助于区分出血、钙化和正常液体。
- 了解不同的 CT 相关伪像以及如何纠正它们对于日常临床实践非常重要。
- 了解基本的横断面解剖结构是日常临床实践的关键。

References

- https://radiopaedia.org/articles/pitch-ct (Last accessed 31.01.2023)
- https://radiopaedia.org/articles/spatial-resolution-ct (Last accessed 31.01.2023)
- https://radiopaedia.org/articles/contrast-resolution (Last accessed 31.01.2023)
- https://radiopaedia.org/articles/iterative-reconstruction-ct (Last accessed 31.01.2023)
- https://www.radiologycafe.com/frcr-physics-notes/ct-imaging/ct-image-quality/ (Last accessed 28.02.2023)
- Padole A, Ali Khawaja RD, Kalra M, et al. CT radiation dose and iterative reconstruction techniques. AJR 2015; 204:W384-W392.
- Silverman PM et al. (2001). Common Terminology for Single and Multislice Helical CT. American Journal of Roentgenology. 2001;176: 1135-1136
- Atlı, E., et al. (2021). Radiation doses from head, neck, chest and abdominal CT examinations: an institutional dose report. Diagn Interv Radiol 27(1) 147-151.
- Mayo-Smith, W. W., et al. (2014). How I do it: managing radiation dose in CT. Radiology 273(3) 657-672.
- Willemink, M. J. and P. B. Noël (2019). The evolution of image reconstruction for CT-from filtered back projection to artificial intelligence. Eur Radiol 29(5) 2185-2195.
- Zinsser, D., et al. (2018). Dose Reduction and Dose Management in Computed Tomography - State of the Art. Rofo 190(6) 531-541.

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参考文献

章节大纲：

- https://radiopaedia.org/articles/pitch-ct (Last accessed 31.01.2023)
- https://radiopaedia.org/articles/spatial-resolution-ct (Last accessed 31.01.2023)
- https://radiopaedia.org/articles/contrast-resolution (Last accessed 31.01.2023)
- https://radiopaedia.org/articles/iterative-reconstruction-ct (Last accessed 31.01.2023)
- https://www.radiologycafe.com/frcr-physics-notes/ct-imaging/ct-image-quality/ (Last accessed 28.02.2023)
- Padole A, Ali Khawaja RD, Kalra M, et al. CT radiation dose and iterative reconstruction techniques. AJR 2015; 204:W384-W392.
- Silverman PM et al. (2001). Common Terminology for Single and Multislice Helical CT. American Journal of Roentgenology. 2001;176: 1135-1136
- Atlı, E., et al. (2021). Radiation doses from head, neck, chest and abdominal CT examinations: an institutional dose report. Diagn Interv Radiol 27(1) 147-151.
- Mayo-Smith, W. W., et al. (2014). How I do it: managing radiation dose in CT. Radiology 273(3) 657-672.
- Willemink, M. J. and P. B. Noël (2019). The evolution of image reconstruction for CT-from filtered back projection to artificial intelligence. Eur Radiol 29(5) 2185-2195.
- Zinsser, D., et al. (2018). Dose Reduction and Dose Management in Computed Tomography - State of the Art. Rofo 190(6) 531-541.

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Computed Tomography

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<?> QUESTION

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

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

/ 知识测试

<?> 问题

1 关于各代 CT 扫描仪，以下哪种说法**正确**?

- ☐ 第一代扫描仪使用多个笔形射束
- ☐ 在第四代扫描仪中，X 射线管和探测器绕患者旋转
- ☐ 第三代扫描仪是目前最常用的扫描仪类型
- ☐ 第二代扫描仪的探测器呈固定环形

/ Test Your Knowledge

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/ Test Your Knowledge

<?> QUESTION

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

/ 知识测试

<?> 问题

2 关于双能 CT (DECT) 扫描仪，以下哪种说法**正确**?

- ☐ 以两种高 kV 能量频谱采集图像
- ☐ 能够分离具有相似衰减的物质
- ☐ 与光子计数 CT 不同，将 X 射线直接转换为带电粒子
- ☐ 始终只有一个可在低能量和高能量射束之间快速切换的球管

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/ Test Your Knowledge

<?> QUESTION

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

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<?> 问题

3 以下哪种说法 **正确**?

- ☐ 水的放射密度定义为 0 亨氏单位 (HU)，空气的放射密度定义为 -1000 HU
- ☐ 螺旋扫描是指扫描连续进行，同时检查台间歇性移动，即有停顿和前进的过程
- ☐ 螺距 >1 可用于加快扫描速度，但通常伴随较高的辐射剂量
- ☐ 肺窗的窗宽约为 -160 至 240 HU，窗位为 0 HU

Test Your Knowledge

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/ Test Your Knowledge

<?> QUESTION

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

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<?> 问题

4 关于窗技术、卷积核和层厚，哪种说法是正确的：

- ☐ 骨窗最常用于评估软组织或肺部病变
- ☐ 更锐利的卷积核是生成更好的纵向空间分辨率的主要参数
- ☐ 评估腹部时，通常使用 1 mm 的层厚
- ☐ 10 mm 层厚可用于扫描肺结节，并有助于血管造影研究

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/ Test Your Knowledge

<?> QUESTION

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

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<?> 问题

5 通过以下哪种方式可获得更好的空间分辨率...

- ☐ 使用软组织卷积核而非边缘增强卷积核
- ☐ 增加放大率
- ☐ 使用更大的焦点
- ☐ 使用更小的探测器

Test Your Knowledge

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<?> QUESTION

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

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

/ Computed Tomography

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章节大纲：

<?> 问题

6 通过以下哪种方式可增加 CT 成像中的对比度分辨率（单选）...

- ☐ 增大螺距
- ☐ 减小探测器尺寸
- ☐ 增大噪声
- ☐ 增加射束能量

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/ Test Your Knowledge

<?> QUESTION

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

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章节大纲：

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7 以下哪种说法错误?

- ☐ 螺距定义为在一次 360° 机架旋转中检查台移动的距离除以射束准直宽度
- ☐ 螺距定义为在一次 360° 机架旋转中检查台移动的距离除以层厚
- ☐ 螺距大于 1 可加快扫描速度并降低辐射剂量，但会降低图像质量
- ☐ 螺距大于 1 可加快扫描速度，但会导致辐射剂量升高

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Test Your Knowledge

<?> QUESTION

8 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

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章节大纲：

<?> 问题

8 颈部淋巴结的解剖学位置可以分区描述。下列哪个淋巴结属于 IB 区？

- ☐ 颈内静脉下淋巴结
- ☐ 颌下淋巴结
- ☐ 枕淋巴结
- ☐ 颈内静脉上淋巴结

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