Lecture 9 – CT Application

This lecture will cover:

- Equipment *(Fundamental of MI CH3 P53-58)*
  - Digital X-ray Tomosynthesis (层析X射线照相)
  - General-purpose scanner
  - Dedicated scanners: oral and maxillofacial CT, interventional CT, breast CT
  - Dual-source and dual-energy CT
  - Electron beam tomography (EBT, 电子束CT)
- Clinical application

Digital X-ray Tomosynthesis

A hybrid of planar radiography and CT

- X-ray tube moved in a vertical path
- Tens of projection images acquired during the vertical motion of X-ray source
- Small focal spot (~0.6mm)
- Short exposure pulses of X-ray
- Lower radiation dose than CT
- Higher image information content than radiography
- More sophisticated form of backprojection and iterative algorithms are used for reconstruction

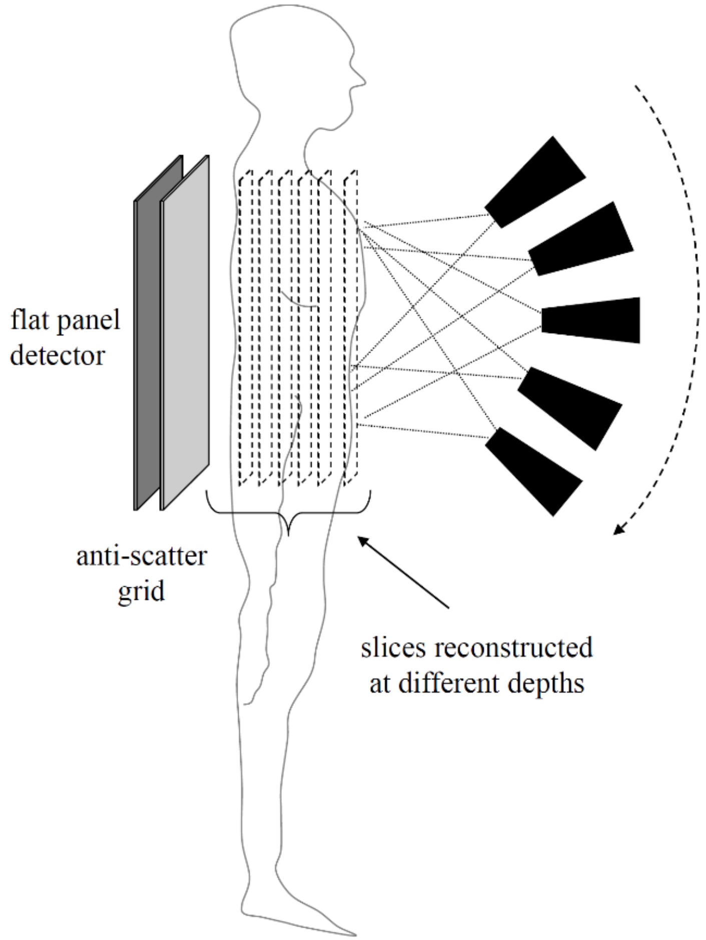


Fig. The basic technique of X-ray tomosynthesis, in which an X-ray source is rotated through a relatively small angle, with planar images being formed at each angle: the digital detector remains fixed for each scan. Image reconstruction allows slices at different depths to be formed.

General-purpose scanner

- Multiple detector rows (multi-slice CT)

  A typical 16cm of total volume will be suitable for
  - Axial scan mode
  - A cardiac scan in one single rotation

- Tilted gantry for imaging oblique slices

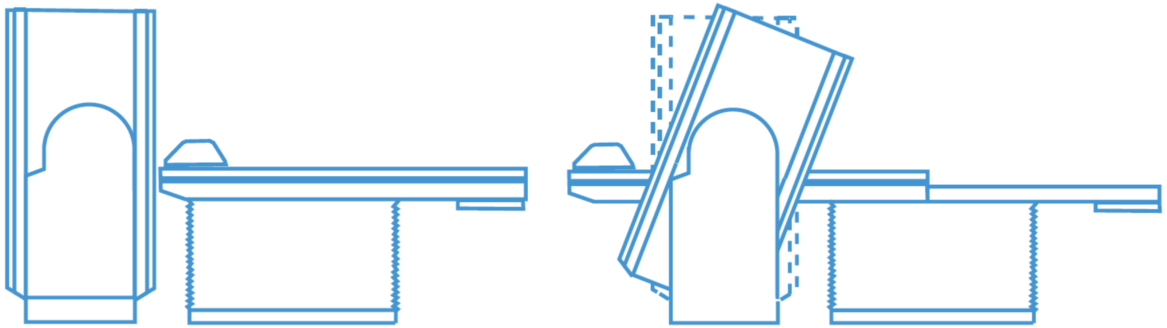


Fig. Schematic views of a helical CT scanner showing gantry tilt and table translation.

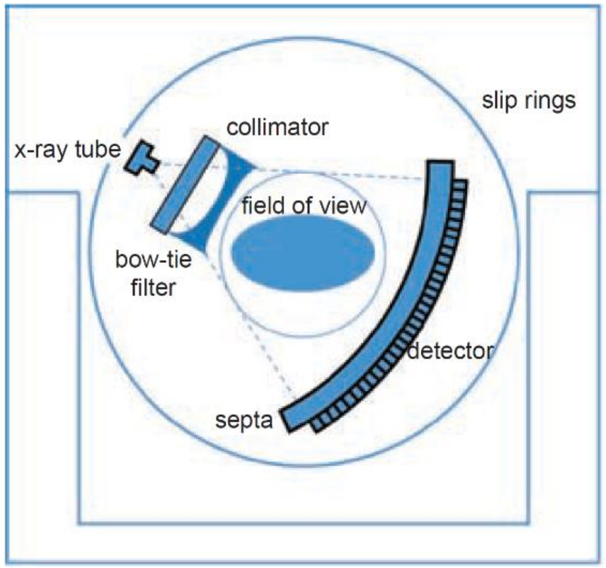


Fig. The basic internal geometry of a multi-slice helical CT scanner.

Dedicated CT scanners

- Smaller and cheaper than general-purpose CT
- Circular cone-beam scanning
- Flat panel detectors (FPD) for high resolution images
- Acquiring volumetric data in a single orbit of the X-ray tube
- Limited field of view
- Not critical scan times – acquisition time of seconds or tens of seconds

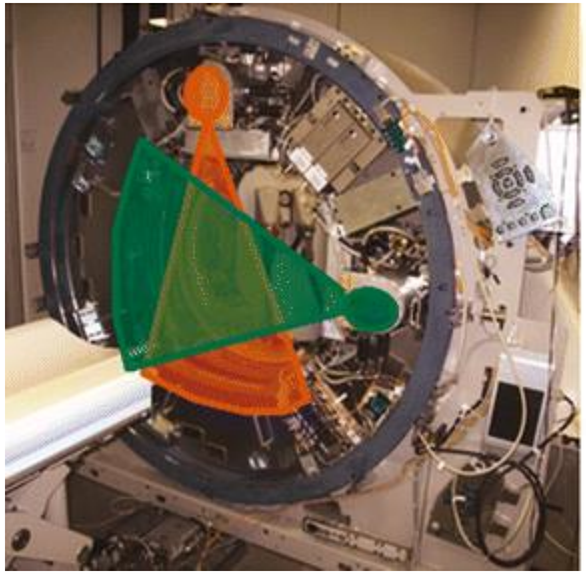
Dedicated CT scanners

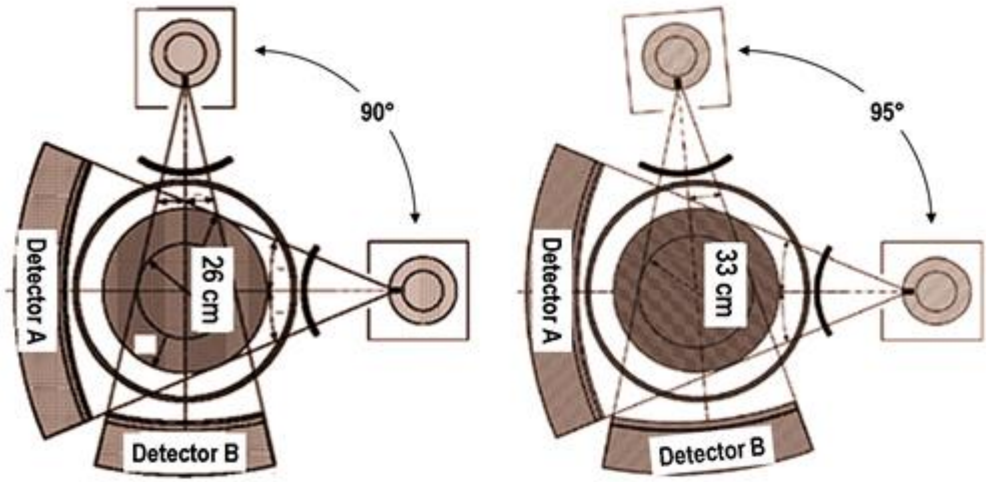
- **Oral and maxillofacial CT**
- **Interventional CT**
  - C-arm for fluoroscopy and angiography
  - Mobile scanner for spine and orthopedic surgery : O-arm
  - Portable CT for intraoperative imaging of the maxillofacial region

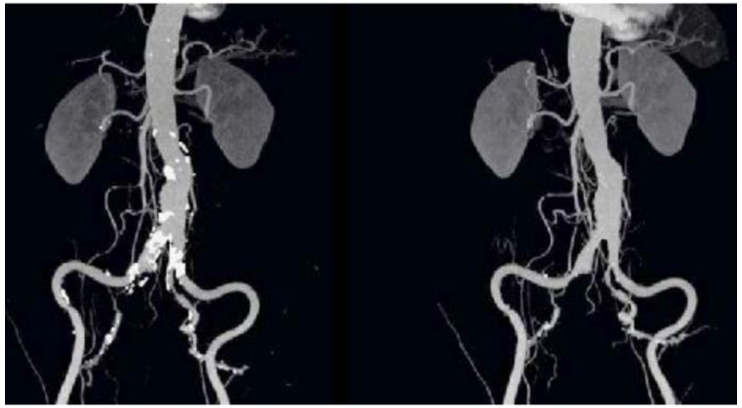
- **Breast CT**

Dual-source and dual-energy CT

- **Dual-source CT (DSCT)**
  - To achieve higher temporal resolution (twice of single source CT);
  - The second source covers two-thirds FOV of the primary source;
  - Important for cardiac imaging
- **Dual-energy CT**
  - Two different kVp (140kev and 80kev)







Electron beam tomography

Electron beam tomography (EBT, 电子束CT)

- Ultrafast CT or cardiovascular CT
- X-ray tube is integrated part of the system
- Electrons bended electromagnetically onto tungsten target rings below the patient
- X-ray from target rings directed to detectors above the patient
- Fast imaging with 17 frames/second

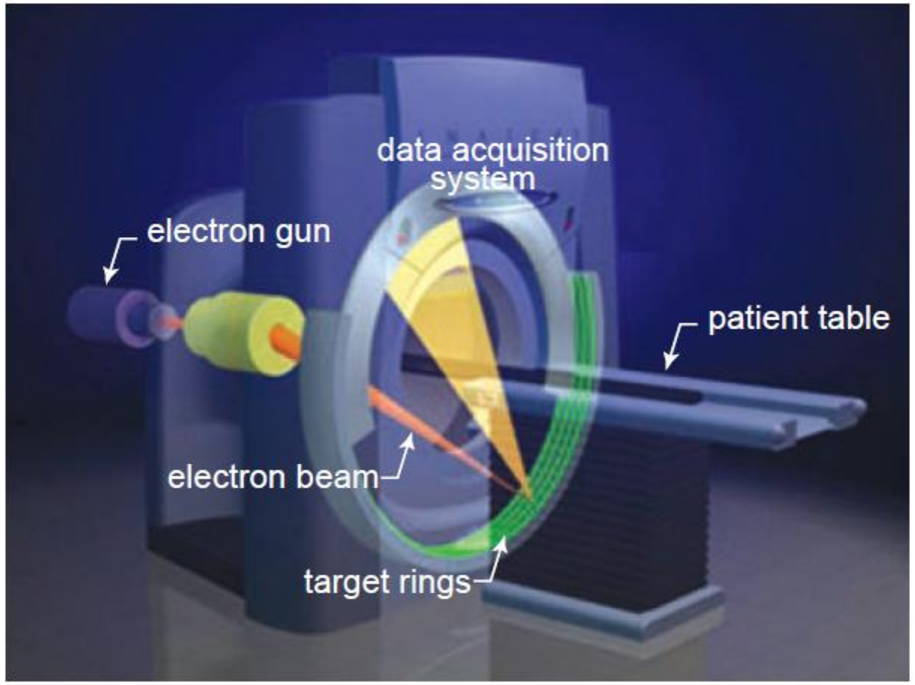


Fig. Schematic representation of an electron beam tomographic scanner. The impact of electrons on the target rings produces X-rays that are collimated and directed onto the detectors.

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Head and neck

Imaging objects: brain, maxillofacial structures, inner ear, soft tissues of the neck, etc.

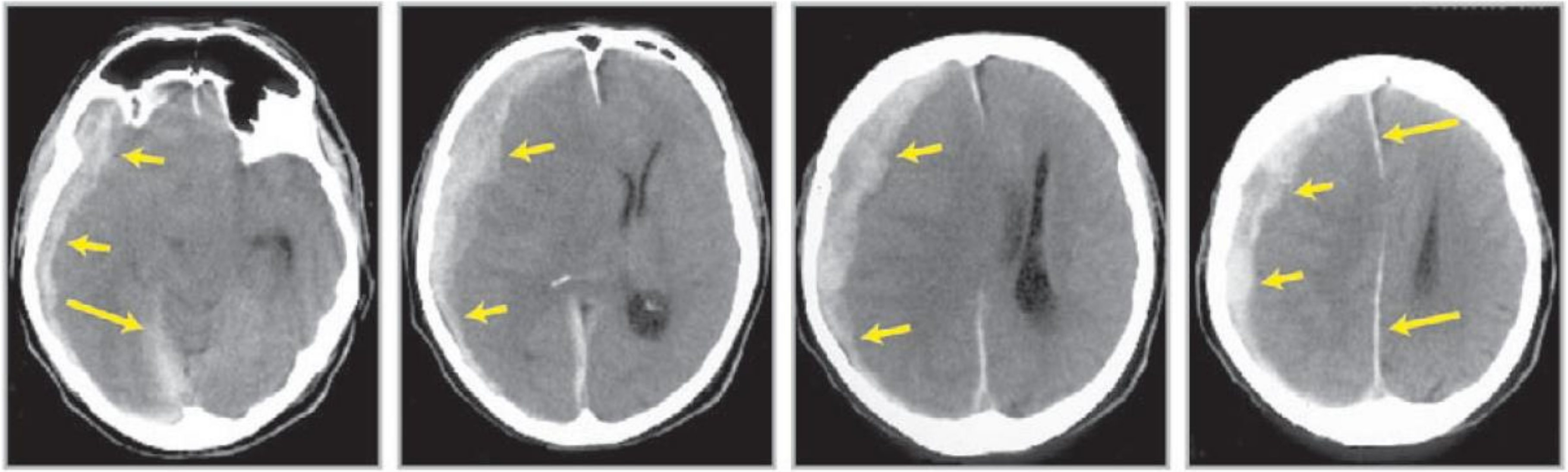
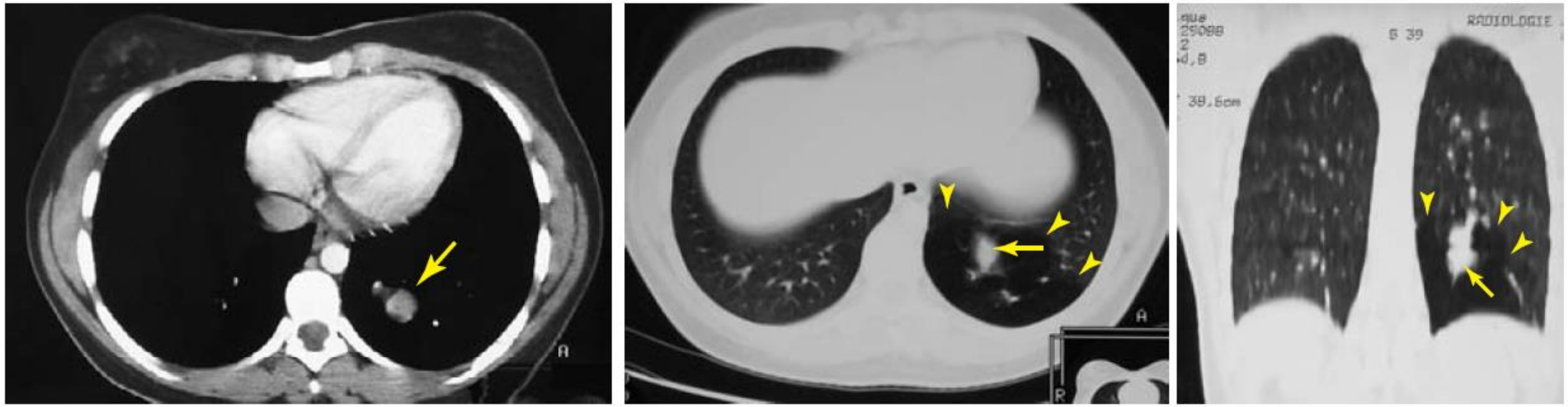


Figure 3.37 Subsequent CT slices through the brain show a subdural hemorrhage as a hyperdense region along the inner skull wall (short arrows). This blood collection causes an increased pressure on the brain structures with an important displacement of the midsagittal line (long arrows). (Courtesy of Professor G. Wilms, Department of Radiology.)

Thorax (胸腔)

Imaging objects: lungs, chest wall and mediastinum, heart and great vessels, etc.

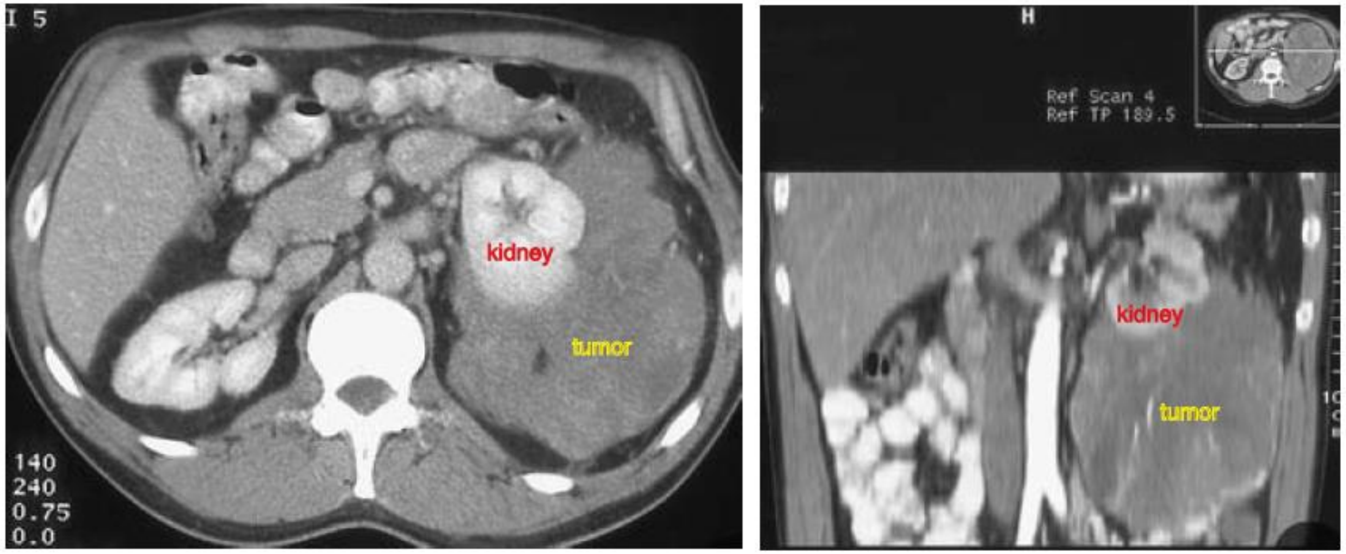


(a) (b) (c)

Figure 3.38 CT of the chest. **(a)** Mediastinal and **(b)** lung window/level settings, and **(c)** coronal resliced image. The images show a congenital malformation of the lung located in the left lower lobe. Notice the two components of the lesion: a dense multilobular opacity (arrow) surrounded by an area of decreased lung attenuation (arrow heads). (Courtesy of Professor J. Verschakelen, Department of Radiology.)

Urogenital tract (泌尿生殖器官)

Imaging objects: kidneys, adrenals, urinary bladder, prostate, retroperitoneal cavity, etc.

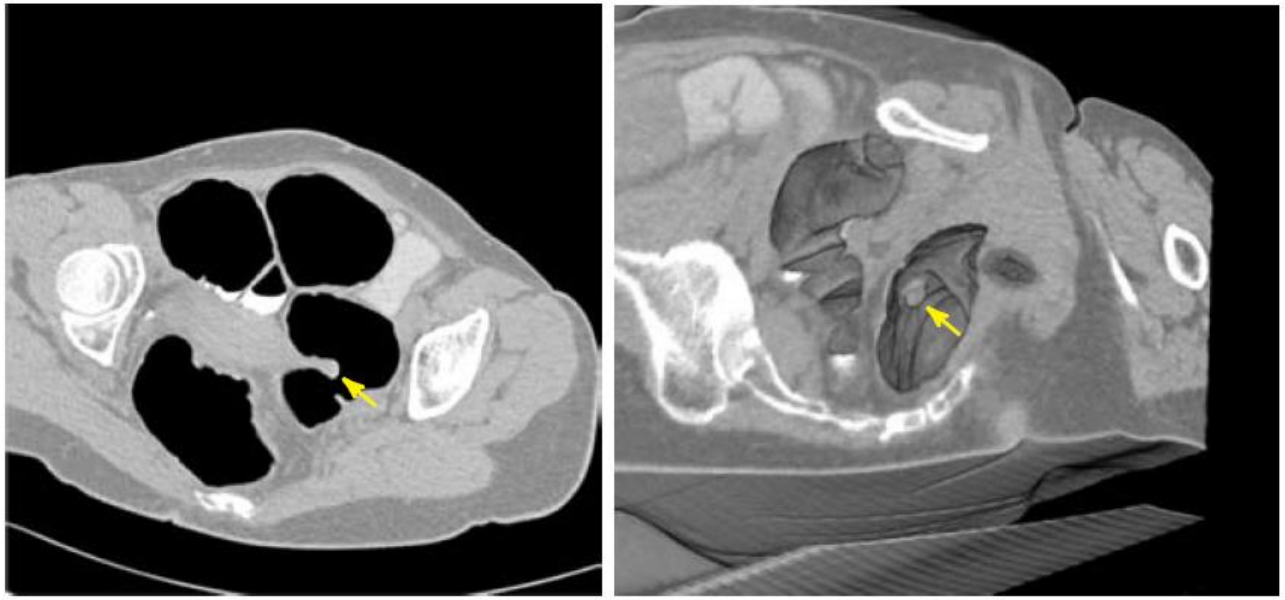


(a) (b)

Figure 3.39 **(a)** Axial CT slice through the kidney showing a perirenal liposarcoma in the nephrographic phase after intravenous injection of contrast medium. **(b)** Reformatted coronal CT slice at the level of the aorta of the same patient. (Courtesy of Professor R. Oyen, Department of Radiology.)

Abdomen (腹部)

Imaging objects: gastrointestinal tract, liver, pancreas, peritoneal cavity, spleen, etc.

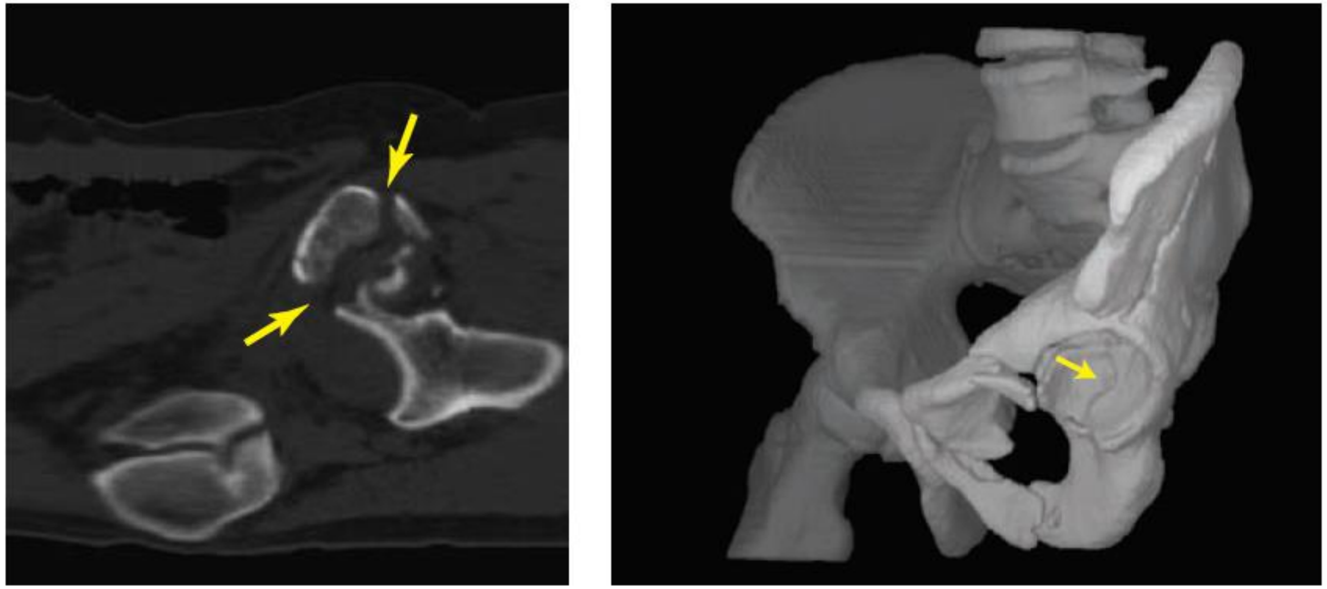


(a) (b)

Figure 3.40 **(a)** A CT slice through the colon shows a polyp (arrow). **(b)** A virtual colonoscopy program creates a depth view of the colon with polyp (arrow) and allows the clinician to navigate automatically along the inner wall. (Courtesy of Dr. M. Thomeer, Department of Radiology, and G. Kiss, Lab. Medical Image Computing.) 3D visualization is discussed further in Chapter 8.

Musculoskeleton system (骨骼)

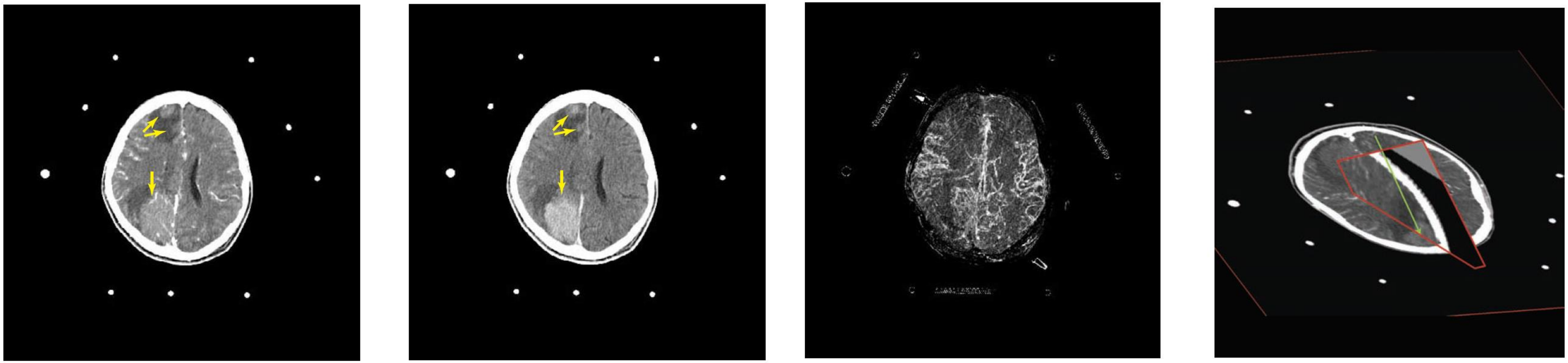
Imaging objects: bone fractures, calcium studies, soft tissue tumors, muscle tissue, etc.



(a) (b)

Figure 3.41 **(a)** On a sagittal reformatted CT image, an anteroposterior course of an acetabular fracture is visible. **(b)** A 3D view on the acetabular surface more clearly localizes the transtectal course of the fracture extending into the posterior column. (Courtesy of Professor M. H. Smet, Department of Radiology, and Professor J. Van Cleynenbreugel, Lab. Medical Image Computing.)

CT angiography (CTA)



(a) (b) (c) (d)

Figure 3.42 CT images through the brain used for neurosurgical planning. **(a)** CT slice immediately after contrast injection. The arrows show brain lesions surrounded by oedema. The nine bright spots around the patient are markers used for surgical planning. (More details are presented in Chapter 8.) **(b)** Late postcontrast image. After 10 minutes the tumoral lesions have absorbed the contrast and light up in the image. **(c)** By subtracting the CT images before and immediately after contrast injection, the cerebral blood vessels are visualized. In this image, the whole vessel tree is shown by a maximum intensity projection (MIP), explained in Chapter 4, p. 87. **(d)** All these images are used subsequently to calculate a safe trajectory (long arrow) through the blood vessels and toward one of the lesions in order to take a biopsy of the tumoral tissue. (Courtesy of Professor B. Nuttin, Department of Neurosurgery.)