Anatomy of the Heart by Multislice Computed Tomography
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A CD-Rom with video clips is included at the back of the book.
Anatomy is perhaps the simplest of medical sciences, requiring little more than some curiosity plus careful observation of things as they are.

The new multislice computed tomography (MSCT) machines produce a volume data set with the highest isotropic spatial resolution ever seen. The 0.6-mm “pixel” (picture element) that CT has traditionally delivered in axial planes (x and y dimensions) is also extended to the z dimension as well. The spatial resolution of these new machines is such that they can scan a 10-mm diameter piece of heart in 20 axial sections to produce nearly 4000 pixels for each slice. In other words, these scanners are capable of digitizing the anatomy of a 70-kg human body into over half a billion individual voxels (volume elements).

Given this high spatial resolution, MSCT offers superb 3D images of the entire heart and great vessels. Relationships between cardiac structures can be shown as never before. Electronic casts and electronic dissections of the heart in any plane can show the internal and external cardiac structures.

As a result, the anatomy of the heart and great vessels can be understood easily by young doctors, medical students and nurses. This atlas has been made for them.

MSCT is unique in its ability to image coronary arteries and it is likely to become one of the most used cardiac imaging techniques. Images of coronary vessels provided by MSCT can be interpreted both from radiological and cardiological standpoints. Indeed, radiologists are often not sufficiently familiar with cardiac anatomy, whereas cardiologists often lack adequate familiarity with the axial, coronal or sagittal planes used for visualization of cardiac MSCT images. This atlas has also been made to clarify the anatomy for both specialties.

The atlas is divided into 10 chapters. In each chapter, the body planes, cardiac planes and cardiac structures, such as cardiac chambers, cardiac valves, septa, coronary arteries and coronary veins, are displayed from many perspectives to give the reader a wider vision of living cardiac anatomy.
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Video clips on CD-ROM

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All video clips are referenced in the text where you see this symbol.
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CHAPTER 1

Basic Principles

The images of this atlas are derived by a multislice computed tomography (MSCT) machine using the post-processing algorithms available. A brief, basic description of how the machine works and how the algorithms produce different image modalities is given in this introductory section. For more comprehensive descriptions of the post-processing algorithms see “Suggested reading”.

The machine

The CT scanner has a ring with an x-ray tube on one side and detectors on the opposite side. This tube-detector unit rotates around the patient during data acquisition. The information (x-ray attenuation) obtained from the detectors during this rotation is processed through a computer, which can calculate the exact attenuation of a given point (pixel) in the examined volume. The width and length of a pixel depend on the size of the detector. With modern spiral CT (Fig. 1.1), the table moves through the ring so that the machine acquires data in a spiral trajectory during tube-detector unit rotation. This makes it possible to acquire attenuation information for a given point in a volume (three-dimensional, 3D) instead of a slice (two-dimensional, 2D). The volume element (voxel) has equal length in all three axes (x, y and z: isotropic voxel); this is important for reconstruction of images in different planes. To speed up data acquisition (and table movement) it is possible to calculate the attenuation information of one voxel from the detector data of less than one complete rotation (a 180° rotation is enough for a good image).

The acquisition time depends on the number of detectors, rotation speed of the tube-detector unit, length of volume examined and speed of table movement.

Post-processing imaging modalities

Axial images

Axial images are the basic generated images used in MSCT. Axial images can be viewed directly for interpretation or used to create multiplanar or 3D images.

Multiplanar reconstruction (MPR)

Multiplanar reconstruction is the process of using data from axial MSCT images to create “non-axial” two-dimensional images. MPR images are generated from a plane of only one voxel in thickness transecting a set of axial images. In principle any plane can be generated from the volume data set but, by convention, the most used planes are the body planes (axial, sagittal and coronal) (see Chapter 2). Cardiac planes (parallel to the long axis of the left ventricle) are useful to evaluate the heart anatomy, and oblique planes (at any angulation) to display individual structures such as mitral leaflets or the aortic root (Fig. 1.2; see also Chapters 2 and 3).

Curved multiplanar reconstruction (cMPR)

This display modality produces a flattened representation of a curved plane. This modality is useful for the visualization of coronary arteries: a cMPR is reconstructed along the curved course of the vessel. All curved structures are represented on a flat plane. Because the plane is defined by the course of the coronary vessel of interest, the anatomical relationships of all other structures around the vessel are distorted (Fig. 1.3).
Anatomy of the heart by multislice computed tomography is useful to evaluate small tortuous structures that are hyperdense (i.e., of higher density) compared with their surrounding structures (i.e., contrast-enhanced coronary vessels surrounded by fat). This display modality resembles the images of

Maximum intensity projection (MIP)

With this modality several voxels are stacked one on top of the other, so that slices thicker than one voxel are reconstructed. With MIP, only the voxels with the highest density are visualized. MIP is useful to evaluate small tortuous structures that are hyperdense (i.e., of higher density) compared with their surrounding structures (i.e., contrast-enhanced coronary vessels surrounded by fat). This display modality resembles the images of
Furthermore, an opacity value can be assigned to each voxel. By increasing or decreasing their opacity values the corresponding voxels become respectively more transparent or more opaque. The opacity setting can be arbitrarily selected according to the requirement of the observer. This display modality is useful for evaluating the coronary tree anatomy and its relationship with encased cavities (Fig. 1.7). Moreover, by making the coronary tree and the myocardium completely transparent and increasing the opacity of the intracavitary contrast, a high-resolution “electronic cast” of the cavities is produced (Fig. 1.8).

**Virtual endoscopy**
Another modality of imaging called “virtual endoscopy” can be obtained by making the contrast of the cavities transparent and the walls opaque. The viewpoint of the observer is within the cavity and can be moved in any direction. Although the clinical value of this modality in pathological states is not well defined, the comprehensive images are very useful for anatomical purposes (Fig. 1.9).

**Endocardial surface modality**
In this modality the contrast is made transparent and the endocardial surface of the wall is displayed. Cropping the entire volume data set in any desired planes makes visualization of the endocardial surfaces possible from any perspective (Fig. 1.10).
Figure 1.6 3D volume rendering is the most common method of display and assumes external visualization of an object, much like viewing a statue in a museum. 3D display is based on the assumption that light rays reaching our eyes are parallel, similar to seeing objects from a great distance. With this method a countless number of perspectives can be selected (a–d). LAD = left anterior descending coronary artery.
Figure 1.7 By increasing the opacity value of the coronary tree, decreasing the opacity of contrast inside the cavities and making the myocardium completely transparent, clear images of the coronary tree arborization and its relationship with encased cavities can be obtained.

Figure 1.8 “Electronic casts” of the left heart cavities. The relationships between cavities are easily appreciated. LV = left ventricle; LA = left atrium; Ao = aorta.

Figure 1.9 Virtual endoscopy. The perspective is inside the left atrium. The mitral valve annulus (red dotted circle), the left ventricle (LV) as well as the left atrial appendage (LAA) can be seen. Rather than light rays being parallel, projected light rays are focused to converge on the viewpoint, simulating natural light convergence on the human retina. The resulting distortion facilitates perception of distance on the basis of object size. Objects near the viewpoint appear large, whereas objects farther away appear small.

Figure 1.10 3D endocardial surface modality. The posterior endocardial surfaces of right atrium (RA), right ventricle (RV), left atrium (LA) and left ventricle (LV) are displayed viewed from an antero-superior perspective. LAA = left atrial appendage.
Suggested reading


