Tfy-99.4280 Medical Imaging Methods

Problems for examination on March 17, 2009

1. Positron Emission Tomography is one of the most efficient imaging methods in cancer diagnostics. Explain the physical and technical working principle of a PET scanner. List the inherent weaknesses of this method.

2. Discuss key challenges of medical imaging of human lungs. Which of the imaging method you have learned about is most suitable for lung imaging, and which one least. Give some arguments to justify your choice.

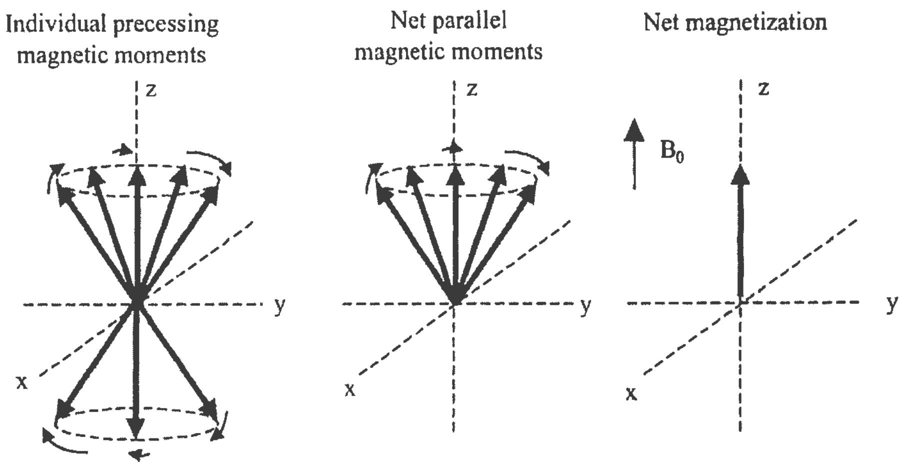
3. Assume quantifying the blood flow in human ascending aorta with an ultrasonic imaging device using a transducer frequency of 5 MHz. Let the diameter of the aorta in the region of interest be 22 mm. If the heart rate is 80 beats/min and the cardiac output 4 liters/min estimate what is the maximum Doppler frequency shift obtainable in optimal imaging direction.

4. In MRI the time evolution of x, y and z components of magnetization of the proton system after an RF pulse can be presented by 3 coupled differential equations. How this set of equations is called? Draw a picture illustrating how M_z and M_y develop after a 90^o pulse.

5. Let a spherical object have a uniform attenuation coefficient μ for X-rays. Assume a set-up where this object is illuminated by a homogenous beam of collimated X-rays and the transmitted radiation detected by a 10 x 10 square array of linear x-ray detector elements. The width of the array equals the diameter of the sphere. Calculate approximation for the output signal of each detector element.

- **The attached selected lecture material is at your disposal**
- **You may answer in English, Finnish or Swedish**

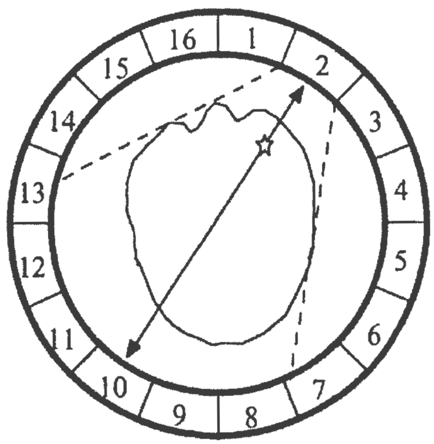
Protons in external magnetic field



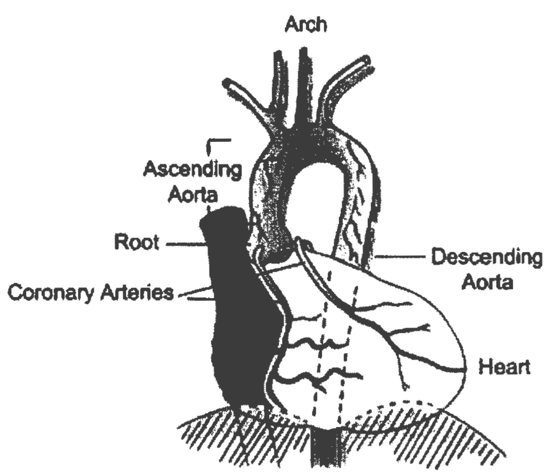
$$\frac{dM_x}{dt} = \gamma M_y \left(B_0 - \frac{\omega}{\gamma}\right) - \frac{M_x}{T_2}$$

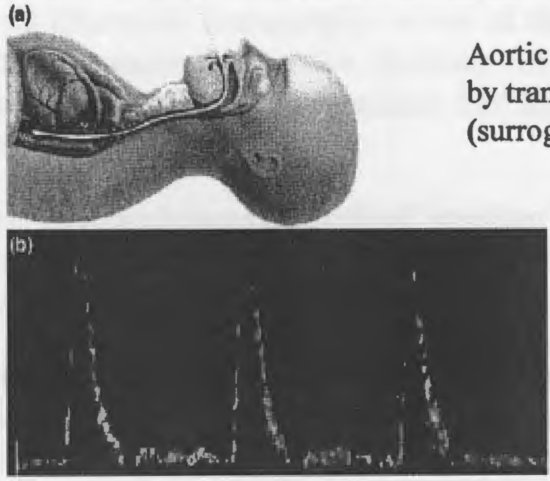
$$\frac{dM_y}{dt} = \gamma M_z B_1 - \gamma M_x \left(B_0 - \frac{\omega}{\gamma}\right) - \frac{M_y}{T_2}$$

$$\frac{dM_z}{dt} = -\gamma M_y B_1 - \frac{M_z - M_0}{T_1}$$



Structure of the Aorta





Aortic blood flow velocity (m/s) by trans-esophageal Doppler (surrogate of **cardiac output**)

For getting blood volume flow (liters/sec), the aortic diameter is also needed, but can also be measured by US