GENERAL PRINCIPLES OF X-RAY CONTRAST MEDIA

Contrast in an X-ray image is brought about by differences in absorption of X-rays by the tissues being irradiated. Absorption is dependent on the atomic number of the atoms present in the molecules, the concentration of these molecules and the thickness of the irradiated slice. When a chest radiograph is obtained , the bones, the aeriferous lungs, the heart and other tissues provide adequate natural contrast. In other body regions such as the abdomen, however, the composition of the organs is so similar that the differences in absorption are too small and other measures are required to enhance the differences in absorption and make the organs visible; (fig. 1). The introduction of substances of very low density (gases) into organs or surrounding structures reduces absorption, and such substances are called negative contrast media (CM). Substances with a high X-ray density contain atoms of higher atomic numbers (barium or iodine). Such preparations increase the absorption of X-rays in the body and are, therefore, known as positive CM (table 1)

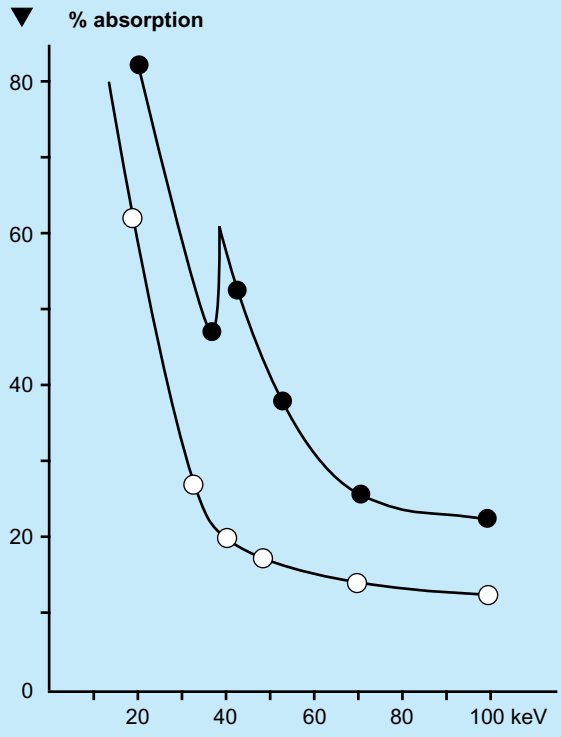

Fig. 1. Absorption of X-rays in % by water (~ soft tissue, ○—○) and an aqueous CM solution with 20 mg iodine/ml (●—●) with slice thickness of 1 cm in relation to the energy of the X-rays (50 keV are achieved at about 100 kV tube voltage)

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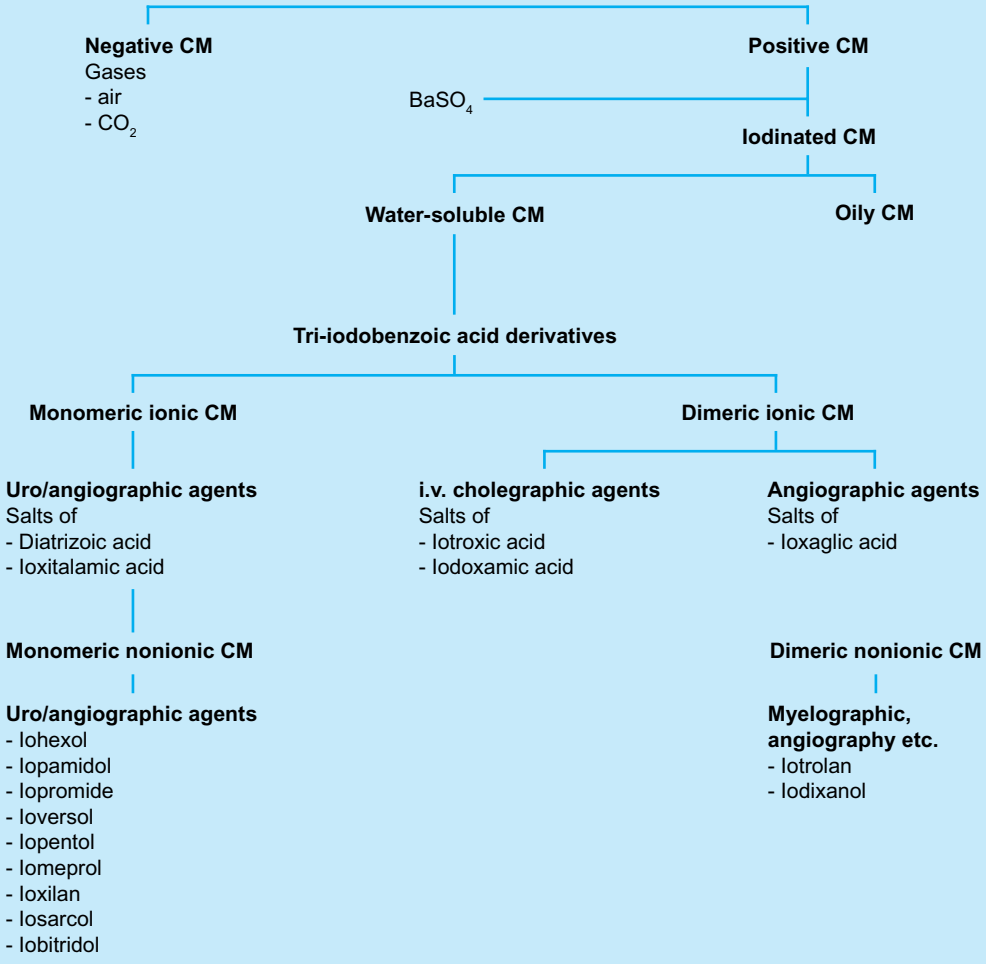

Table 1. Classification of X-ray contrast media (CM)

Physical Principles

Contrast medium absorption primarily depends on the mass absorption coefficient of the elements present in the molecules and applied the X-ray energy spectrum. Secondarily, it also depends on the concentration of these molecules in the tissues. Elements with mid-range atomic numbers of 50-60 (e.g., iodine and barium) are suitable for contrast medium preparations. For CT, where higher tube voltages are used, elements with higher atomic numbers such as lanthanoids, tungsten and bismuth are theoretically better suited. Atoms with a higher atomic mass than iodine attenuate more effectively X-rays per atom than iodine at X-ray energies close to 120 KeV as typically used in CT examinations.

CT displays the spatial distribution of the attenuation coefficient as a so-called CT value (in Hounsfield units, HU) relative to the attenuation of water. Water and water-equivalent tissues have a CT value of 0 HU and air has a value of -1000 HU.

The CT values of air and water are fixed points on the CT value scale and are independent of the X-ray energy applied. Conversely, the CT values of bone and contrast media depend on the applied X-ray energy and increase with decreasing tube voltages as the difference to the absorption of water increases.