Intravenous Coronary Angiography with Synchrotron Radiation: Experience in 366 Patients

W. R. Dix, T. Dill, M. Jung, M. Lohmann, B. Reime, and R. Ventura
HASYLAB at DESY, Notkestrasse, Hamburg, Germany

Worldwide efforts have been made to image coronary arteries by non-invasive or minimally invasive techniques. One method under development is dichromography. It represents a digital subtraction angiography method based on the subtraction of two images at different energies. Dichromography allows imaging of small, fast-moving objects like the coronary arteries, inclusive distal parts, and sidebranches after intravenous injection of contrast media down to a diameter of less than 1 mm. Two images with monochromatic x-rays just below and above the absorption K-edge of the iodine-containing contrast agent at 33.17 keV are simultaneously obtained and logarithmically subtracted. Monochromatic x-rays of sufficient intensity to visualize coronary arteries of 1 mm in diameter with an extremely low iodine mass density of 1 mg/cm^2 are only provided by synchrotron radiation.

At the Hamburger Synchrotronstrahlungslabor HASYLAB at DESY in Hamburg, Germany, the system NIKOS was developed for dichromography. This line scan system consists of six main parts: a wiggler beamline, a two-beam monochromator, a safety system, a scanning device with a scat for the patient, a two-line detector with low noise and high dynamic range, and a computer system.

After experimental studies in dogs, patient studies have been conducted since 1990. Results of 136 patients in pre and pilot studies demonstrate the feasibility and safety of the method as well as high diagnostic accuracy. In all cases, follow up investigations after bypass surgery or interventions like angioplasty, rotablation, and/or stent implantation were performed.

From June 1997 to June 1998, a large scale study with 230 patients was performed. The aim was to validate diagnostic sensitivity and specificity compared to selective coronary angiography. Thirty milliliters of contrast agent were injected into the brachial vein via an introducer sheath (94% of the cases) or into the superior vena cava (7% of the cases), respectively. Two series with two to four images each were taken under different projection angles. The scan speed was 50 cm/s. A preliminary evaluation gives a diagnostic imaging quality between 80% and 95% depending on the target vessel. Comparison with angiograms from selective coronary angiography shows concordance in 82% of available 121 cases. A great advantage of the method compared to competitive ones (MRI, EBT) is that restenoses in stents become clearly visible.

The acceptance of the method by the patients is very high. Nevertheless, widespread use of the method will be possible only if compact sources for hospitals become available. A design study is in progress at DESY.