MICRO-ANGIOGRAPHY FOR TUMOR VESSEL IMAGING

According to the vital statistics in Japan reported by the Ministry of Health and Welfare, cancer continues to rank first among the causes of deaths. In 1998, cancer accounted for 30.3 % of total deaths. The death rates of heart and cerebrovascular diseases are half of that of cancer . It is thus clear that the prevention, diagnosis, and treatment of cancer must be considered a national priority in Japan.

The medium length bending-magnet beamline **BL20B2** has been designed mainly for medical applications using biological specimens and small animals. The construction of this beamline was completed in June 1999, and it has been operational for users since October 1999. Areas of research in medical applications are micro-tomography, refraction-contrast imaging and micro-angiography.

Three-dimensional visualization of human tissue specimens with and without lesion has been performed by 3-D micro-tomography with image pixel sizes of 6-24 μm. Micro-tomography can be used on biopsy specimens in order to obtain accurate diagnoses.

Refraction-contrast using a long object-to-detector distance has been applied to high-contrast imaging of the respiratory system for diagnosis of lung disease [1]. Images of the lung are expected to have high refraction contrast because of the marked difference in density between lung tissue and air.

Micro-angiography can be used for visualization of tumor-induced small blood vessels. A tumor stimulates the growth of small blood vessels in order to receive adequate nutrients or growth. It has been proposed that tumor-induced small vessels are an intrinsic part of tumor development and progression. The growth rate of tumors is slow before blood vessel formation and is rapid once vascularization is established [2].

Radiographic depiction of tumor-induced small vessels that supply a space-occupying lesion is a useful tool for the diagnosis of malignant tumors. However, radiography with a conventional hospital angiography system has considerable limitations in providing images of blood vessels with diameters of blood vessels with diameters of less than 200 μm. The micro-angiography technique made available using a synchrotron radiation source, can overcome the limitations by using a parallel-monochromatized X-ray beam.

The experimental setup for the micro-angiography at BL20B2 is shown in Fig. 1. The full length of the beamline is 215 meters from the X-ray source to the end station. The X-ray beam produced by the bending magnet passes out of the experimental hall surrounding the storage ring

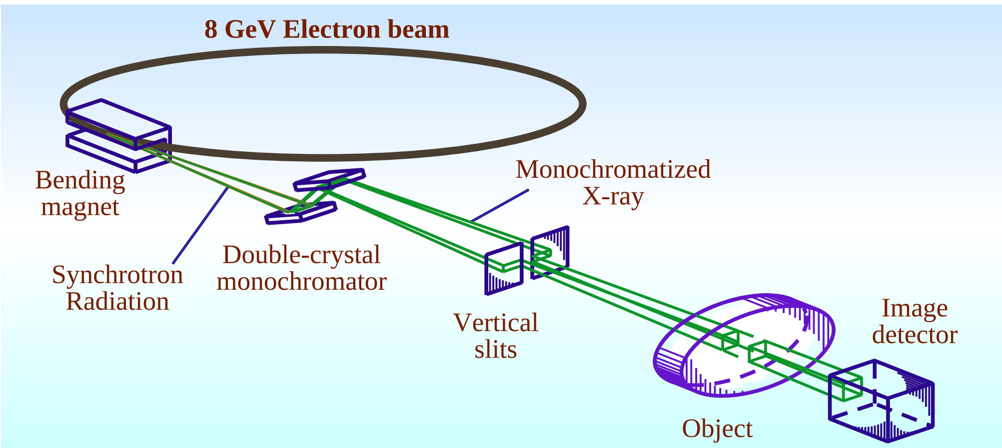

Fig. 1. Experimental setup for the micro-angiography at BL20B2.

and enters a satellite laboratory, the Biomedical Imaging Center. Different experiments are performed in the experimental hall and the Biomedical Imaging Center.

A fan-shaped beam with a cross-section size of 50 mm width by 5 mm height is produced at the experimental hutch in the experimental hall. On the contrary, a 200 mm × 20 mm beam is obtained 200 meters from the source in the Biomedical Imaging Center. In the future, two other medium-length beamlines using insertion devices will be available in the Biomedical Imaging Center.

Two CCD camera systems with a fluorescent-screen lens-coupling approach were used for taking images of specimens fixed in formalin. One CCD system has a 24 μm equivalent pixel size projected onto the screen area and an input field size of 24 × 24 mm^2. The other system has a 6 μm equivalent pixel size and a 6 × 6 mm^2 input field.

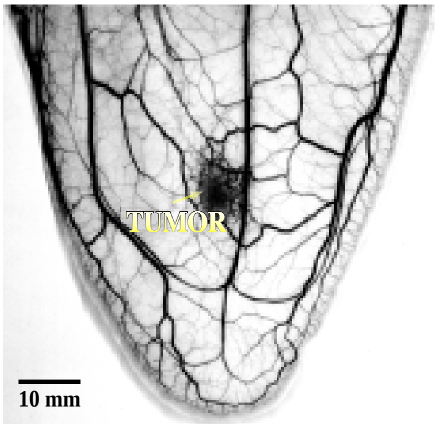

Fig. 2. Radiographic image of rabbit auricle taken by a conventional X-ray tube and film/screen system.

Figure 2 shows a radiographic image of rabbit auricle taken by a conventional X-ray tube and film/screen system at Kawasaki Medical School after arterial injection of barium contrast material. Tumor tissue fed by small blood vessels is shown on the image [3].

An SR radiographic image of the same auricle specimen in Fig. 3 was taken by the 24 μm pixel detector. The growth pattern of the tumor is clearly

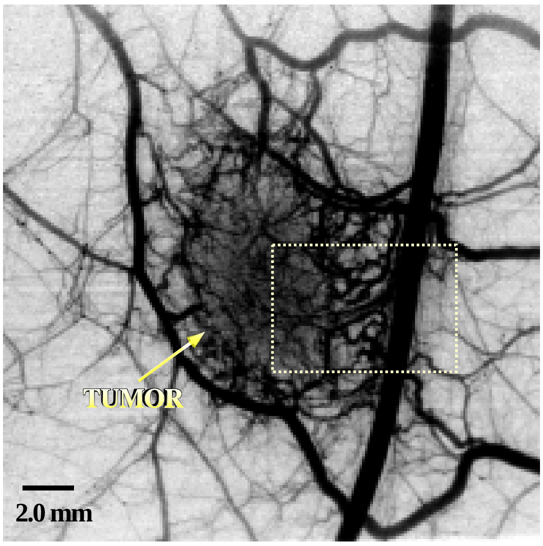

Fig. 3. An SR radiographic image of the auricle specimen obtained by the 24 μm pixel size detector.

visualized. The image was obtained in the Biomedical Imaging Center using a 20 × 20 mm^2 X-ray imaging field at an energy of 37.6 keV just above the barium *K*-edge energy. The cross-section size of the beam was adjusted by vertical slits, as shown in Fig. 1.

Figure 4 shows a magnified image of rectangular area in Fig. 3. The rectangular image in Fig. 4 was produced by connecting two square images obtained by the 6 μm pixel detector in the experimental hall. Tumor-induced vessels form a complex structure surrounding the tumor tissue. SR images in Figs. 3 and 4 show that radiographic depiction of tumor-induced vessels is a useful tool for the accurate diagnosis of early-stage tumors [4].

A real-time imaging system for *in vivo* micro-angiography is under development and will consist of an X-ray direct-detection pickup-tube camera and a digital image storage system. The direct-detection tube camera has been used for live X-ray topography [5]. The new pickup-tube camera will have a high-resolution feature, similar to a high-definition television system [4]. The new system will be used for *in vivo* real-time imaging of tumor-induced blood vessels in animal experiments with spatial resolution of around 10 μm.

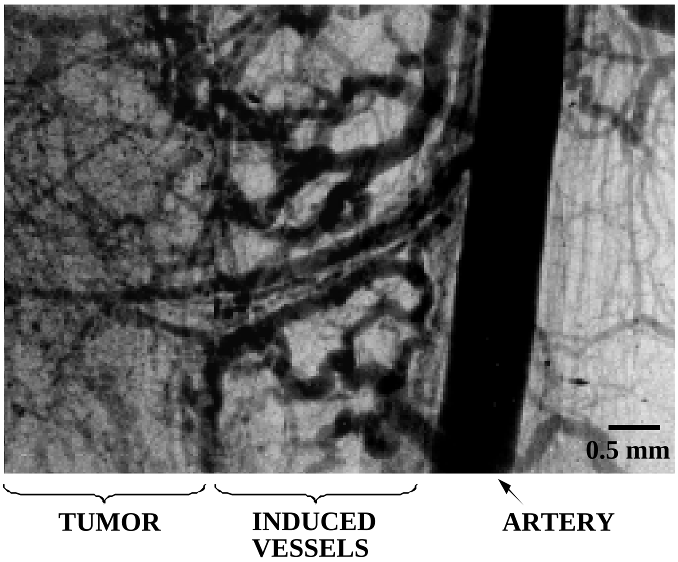

Fig. 4. The auricle image obtained by the 6 μm pixel detector.

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