ABSTRACT

A ROENTGEN VIDEO ABSORPTIOMETRIC SYSTEM

FOR THE MEASUREMENT OF LUNG TUMOR MASS

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Knowledge of the growth rate of untreated lung tumors can contribute to understanding of the disease, treatment planning, estimation of the patient's survival time, and determination of the period at risk following therapy. Tumor mass measurements made during and after therapy can aid in evaluating its efficacy.

A roentgen video absorptiometric (RVA) system was developed to measure changes in mass of known lung tumors with greater sensitivity than has been obtained from radiographic measurements. A tumor mass index M^* was derived by comparing x-ray transmission through the tumor to that through the tissue adjacent to the tumor; exponential attenuation was assumed in deriving M^*. The x-ray source was a fluoroscopic x-ray generator and the detector was an image intensifier/TV camera assembly. Data were acquired by computer controlled digitization of the video signal and stored on digital tape cassettes for subsequent computer analysis. Measurements on humans were not performed as part of this work. Most measurements were performed on a chest phantom composed of a cork block sandwiched between two polystyrene slabs; lucite cylinders with diameters of 0.35 to 2.5 cm were embedded in the cork to

simulate tumors.

The x-ray generator was typically operated at 110 kVp, 3 mA, and the beam was filtered with 0.2 mm of brass. The detected scattered radiation was reduced by minimizing the x-ray field size and maintaining a 10 cm gap between the phantom exit surface and the image intensifier input. The TV camera target voltage and amplifier gain were selected to minimize saturation and dark current. Linearity between measured values of M^* for the lucite cylinders in the chest phantom and their mass determined by weighing demonstrated the validity of the assumption of exponential x-ray attenuation.

The x-ray kVp and mA and the TV camera target voltage and output waveform were monitored to obtain reproducible measurement conditions. The fluoroscopic image was used to precisely position an object in the x-ray beam. The calculation of M^* neither strongly depended on the definition of the tumor's boundary nor incorporated assumptions about its geometry.

The RVA system precision was evaluated by measuring M^* for the lucite cylinders in the chest phantom 16 times over a 3-month period. Coefficients of variation of M^* were 2.6%, 1.8%, and 5.3% for the 2.5, 2.0, and 1.0 cm diameter cylinders, respectively. The uncertainty in these measurements due to the combined variations in x-ray kVp, mA, and field size was about ±1%. Random fluctuations in the data were reduced by averaging digitizations from 30 video frames; the uncertainty in M^* due to photon counting statistics was estimated as $\lesssim$ 1%. The uncertainty due to the data analysis procedure was also estimated as $\lesssim$ 1%.

The uncertainty in M^* due to repositioning errors was reduced by eliminating or minimizing sources of nonuniformity in the image including nonuniform x-ray attenuation by the mirror-filter assembly in the x-ray collimator, vignetting in the lenses coupling the image intensifier to the TV camera, and orientation of the camera tube alignment magnets.

Patient exposure during a measurement session was estimated from thermoluminescent dosimetry on an anthropomorphic phantom. During an initial session at which the system parameters required for data acquisition were determined, the exposure at the phantom's entrance surface was about 3 R. During a follow-up session at which most parameters were reset to previously used values before irradiating the phantom, the exposure was about 1.3 R. The exposed area was at most 3% of that exposed during a chest radiograph.

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