Recording devices for coronary arteriography

William M. Angus, M.D., Ph.D.

Shelton, Connecticut

The x-ray absorption patterns generated during coronary arteriography may be detected by full-size radiographic intensifying screens, which produce a light image corresponding to the absorption pattern of the modulated x-ray beam. The light image creates a latent image in the silver halide emulsion of full-size films, which are serially brought into close contact with the screens. This process, serial radiography, produces serially exposed, full-size radiographs.

X-ray absorption patterns may also be detected by the electron-optical x-ray image intensifier, which produces at its output screen a light image of relatively high intensity that, except for its reduced size, corresponds to the absorption pattern of the modulated beam. Image intensifier fluorography, the photographic recording of the light image appearing at the output screen, may be carried out by several methods: single exposure fluorography, a method of producing individual fluorographic records; serial fluorography, a method of producing fluorographic records at predetermined intervals and not intended for cine projection; and cinefluorography, a method of fluorographic recording at regular intervals intended for cine projection.

During the past 10 years it has become increasingly common to extend the definition of image intensifier fluorography to include video-fluorography, a method of producing recording via the television chain which, optically coupled to the output screen, was formerly employed only for fluoroscopy.

The advantage of serial radiography is the production of full-size radiographs that provide maximum resolution of vascular structures and can be conveniently handled and viewed. This process has two important disadvantages. First, it cannot provide dynamic information, e.g., motility patterns of the tightly grouped and overlapping coronary branches, which are frequently needed to differentiate structures and often to alert one to disease sites seen transiently. Second, the projection and progress of the series cannot be visually monitored and controlled, which frequently lead to increase in field size and number of exposures, i.e., reduction in image quality and increase in dose. These disadvantages seriously limit the application of this recording process in coronary arteriography.

Image intensifier fluorographic systems permit visual monitoring and control of recording, so that small field sizes and visual control of exposure series are practical realities. These systems are relatively lightweight and compact; hence, they can be installed in extremely mobile support systems. The events of an examination are easily observed and followed (scanned) with the use of a small field size (at the Cleveland Clinic, 9 x 12 cm).

Although single exposure and serial fluorography are superior to serial radiography in that they may be visually monitored and controlled, they share a common disadvantage in their inability to provide dynamic information. These fluorographic techniques are occasionally applied in an attempt to provide images that can be viewed conveniently in the operating room. Unfortunately, not even visual monitoring and control guarantee that a single exposure or any of a series will be exposed at precisely the correct moment; hence, the desired event may not be captured. Transmission of cinefluorographic recordings via a video link and/or photographic enlargement of individual cine frames are more reliable and practical methods of providing images to the surgeon.

Cinefluorography remains the recording method of choice for coronary arteriography. Modern systems provide adequate image quality and dynamic information at reasonable levels of x-ray exposure to the patient. Automation of exposure techniques and proper adaptation and specialization of patient handling devices have enhanced the quality of the method. Most of all, experienced fluorographers have become aware of the technical limitations of the method and have developed great expertise in overcoming them. A few of these are worth mentioning.

The adverse effects of x-ray scatter on fluorographic image quality are now more appreciated among fluorographers. Although there are a number of measures for reducing scatter, and system designers avail themselves of most, if not all of these, it may become necessary to reduce the field size and solve the problem of anatomical coverage by scanning with small field under visual control.

The film formats employed in cinefluorography have a relatively small emulsion area and a correspondingly small number of silver grains over which the image may be distributed. Maximum utilization of the emulsion area to record only that which must be re-

corded provides the best image quality at the lowest dose. This situation known as total overframing is advised when the optical coupling of the camera projects at the frame being exposed a circular image, the diameter of which is somewhat larger than the diagonal of the frame.

Video fluorography will be the recording method of choice for coronary arteriography in the future. Nearly 10 years ago, with a high resolution television chain and an electron beam recorder, it was demonstrated that television images recorded on 16-mm film were of a technical and diagnostic quality nearly equivalent to those made by the conventional 35-mm cinefluorographic method. This method was not industrialized, because its principle advantage, a substantial reduction in film cost, was thought to be economically applicable only to those few institutions performing large numbers of cinefluorographic examinations. Other and more broadly applicable advantages of the method, e.g., transmission, manipulation, processing, storage, and retrieval of fluorographic information in the form of electronic signals were not commonly available.

During the past 10 years, there has been tremendous activity in the field of electronic signal acquisition and processing as well as in the field of electronic data storage. High resolution television chains are readily available; integrated image intensifier/camera tube devices have been developed to overcome the dynamic range limitations of the past; digital signal processors are emerging that can offer noise filtration, contrast enhancement, and signal manipulations. One such method, real time x-ray subtraction, is under development at the University of Wisconsin. This method requires only the intravenous injection of a bolus of radiopaque medium, and it is hoped that it may provide a screening method for coronary atherosclerosis.

Images in the form of electronic signals will be recorded on magnetic tape and the recorded information used for processing, manipulation, and diagnosis. In the near future, archival recording will be produced on 16-mm film with an acousto-optically modulated laser recorder, a simpler, less expensive but adequate alternative to the electron beam recorder.

Within the next decade, archival recordings will surely be carried out with the laser-disc technologies recently developed for the entertainment and data processing industries. These technologies provide large storage of analog data and mass storage of digital data using relatively inexpensive and durable media that can be easily and rapidly interrogated.