The Use of Cinefluorography in Acquired Heart Disease

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CINEFLUOROGRAPHY, the process of taking motion pictures of the fluoroscopic screen of the image amplifier, is now the best method for detecting and recording calcifications and pulsations of the heart and will soon enjoy similar acceptance in angiography.1 Our purpose here is to describe this method, its clinical usefulness, and its limitations.

Equipment

The cinefluorograph is a standard fluoroscopic unit combined with an image amplifier tube and a motion picture camera. The amplifying tube produces a bright fluoroscopic image that can be photographed on motion picture film.

Several types of cinefluorographic units are commercially available.2 When selecting a cinefluorograph, one should consider the importance of picture detail. Good detail can be obtained on a 5-inch image amplifier equipped with a 16-mm. camera. The 8- and 9-inch units recording on 16-mm. film do not seem to have as good detail as the 5-inch unit. This limitation can be corrected by changing to a camera lens of different focal length to magnify the image on the 16-mm. film frame (overframing) or by using 35-mm. film. The cinefluorograph may be combined with a television monitor so that several doctors may view the image simultaneously. For the best detail, however, the camera should record the amplifier’s image rather than the image of the television monitor.

In the examination of children, the larger field cinefluorograph is used for forward cineangiocardiography while the smaller 5-inch unit is restricted to routine cardiac cinefluorography and selective cineangiocardiography.

The amplification factor of the image is also important. If it is a high value (between 700 and 1,000 in the Westinghouse scale of brightness) the radiation dose necessary to produce a high quality film is less.

Either 16- or 35-mm. film may be used. Although more detail is present on the 35-mm. film, the equipment needed to develop and project the film is extremely costly. For this reason, 16-mm. film is more practical for routine use in most hospitals. Packaged in 100-foot rolls, the 16-mm. Kodak Linagraph Shellburst film can be developed in the standard x-ray darkroom with ordinary radiographic developing and fixing solutions. Usually 30 feet of film per cardiac examination at the rate of 15 frames per second will be sufficient.

Radiation Dosage

The amount of radiation dosage varies with the size of the heart and the density and thickness of the patient’s tissue. At 110 kilovoltage the milliamperage fluctuates between 5 and 15 milliamperes for an average patient, resulting in a total radiation exposure of about 20 roentgens in air. This dose is delivered to a constantly changing skin field through a portal 4 3/4 inches in diameter. Because radiation should be limited sharply in young individuals, careful scrutiny with the use of the image amplifier only, will reveal abnormal pulsations of the heart border.
Figure 1
Right anterior oblique view showing position of the coronary arteries.

Only the mid-cardiac mass need be cinefluorographed for calcifications. This selectivity of filming results in very low radiation dosage.

Technic at Examination
Our cinefluorographic technic for examining the heart for calcifications and pulsations is as follows: 1. In the posteroanterior view the pulsations of the right cardiac border and the great vessels are recorded beginning at the diaphragm and moving upward to include the superior vena cava and azygos vein. In this film sequence, the pulsations of the right border of the heart and calcifications in the pericardium, right coronary artery, and ascending aorta can be noted. 2. In this same view the pulsations of the left border of the heart from the left subclavian artery down to the left hemidiaphragm are filmed. The characteristic pulsations of aortic insufficiency, fibrillation of the left atrial appendage, and the paradoxical pulsations of an aneurysm of the left ventricle may be shown. In this same sequence, calcifications in the arch of the aorta, pulmonary artery, left coronary artery, and myocardium of the left ventricle are revealed. 3. In the right anterior oblique position, a recording from the diaphragm to the pulmonary artery and thence down the left heart border to the diaphragm shows calcifications in the mitral and aortic valves and in right and left coronary arteries (fig. 1). 4. In the left anterior oblique projection, the pulsations of the right atrium and ascending aorta are recorded followed by a sequence through the mid-cardiac silhouette, including the right coronary artery, aortic valve, and left coronary artery. 5. In this same position, the pulsation of the posterior border of the heart is recorded. This view also includes the mitral valve area. 6. Finally, in the right lateral projection, beginning in the inferoposterior part of the cardiac silhouette, a sequence is obtained that crosses the mitral and aortic area to the retrosternal area of the heart. This view is best for the observance of the movement of the calcified leaflets of the aortic valve. Occasionally, a calcified right coronary artery may be seen in the anterior half of the heart, a calcified anterior descending or circumflex coronary branch in the superior half of the heart, and a calcified mitral valve in the inferoposterior portion of the heart.

Identification of Intracardiac Calcifications
In order to detect and to locate accurately small intracardiac calcifications, a definite sequence of cinefluorography including all the cardiac positions outlined previously should be used. For example, in the left anterior oblique projection a small fleck of calcium in the anterior descending branch of the left coronary artery might easily be mistaken for a fleck of calcium in the aortic valve. In the right anterior oblique view, however, this coronary calcification will be projected out near the left heart border, the characteristic position of the anterior descending branch of the left coronary artery (fig. 2).

In addition to location, other important factors aiding in the detection and localization of intracardiac calcifications are the movement and form of these calcium deposits. For example, calcified coronary arteries appear as
linear and curved calcifications that pulsate in unison with the heart and aortic borders. These may be differentiated from pericardial calcifications in that these pericardial calcifications run parallel to the heart surface in at least one view and move only slightly with the heart border. Calcified heart valves on the other hand may have a structureless appearance. The calcium often is clumped and not linear in appearance. The annuli of the aortic and mitral valves may cause considerable difficulty if only slightly calcified. If well calcified, then their location, "U" shape, and reduced movement will help in identification.

Calcification within the cardiac silhouette can be localized in still another way. Considerable fat is present in the atrioventricular groove of the heart. On the cinefluorogram in the left anterior oblique view, this fat appears as a radiolucent, pulsating line between the right atrium and right ventricle. The main right coronary artery is located in this black line. Flecks of calcium seen here are thus identified as flecks within the right coronary artery. Similarly in the right anterior oblique view the circumflex branch is seen in the fat deposited in the posterior portion of the atrioventricular groove, and the anterior descending branch in the fat deposited between the right ventricle and the left ventricle. In the lateral view, the anterior border of the aorta can often be located by the adjacent fat deposit. This identifying deposit can aid in identifying calcification of the aortic valve leaflet.

There are many factors aside from the small size of the intracardiac calcifications that may interfere with the detection of these calcium deposits by cinefluorography; these are obesity, cardiomegaly, pulmonary congestion and effusion, pulmonary and pleural disease of noncardiac origin, failure to examine the heart in all positions, and inattentiveness or inexperience of the observer.

**Coronary Artery Calcification**

The significance of calcification in the aortic or mitral valve is well known. On the other hand, the significance of coronary artery calcification is not widely known. The correlation of coronary artery calcification with clinical arteriosclerotic heart disease has recently been investigated with cinefluorography of the heart to detect and evaluate the coronary calcifications. Previous radiologic studies, without the aid of cinefluorography, have been unable to confirm such correlation.

In our study of 60 men, 15 in each decade from ages 40 to 80, with normal hearts as far as could be determined by history, physical examination, electrocardiogram, and chest film, 25 per cent were found to have coronary calcification at cinefluorography. The peak incidence was in the 60- to 69-year group.

In another group consisting of 630 consecutive cardiac cinefluorographies on men mainly between ages 40 and 70 with various types of known or suspected heart disease, 150 (23.8 per cent) had coronary calcification. Of the 150 patients with coronary calcification 58 per cent had arteriosclerotic heart disease by clinical evaluation as compared with 39 per
cent of a comparable group without coronary calcification at cinefluorography.

There was a further direct relation between the number of major coronary branches calcified at cinefluorography and the incidence of clinically manifested arteriosclerotic heart disease. In the 150 patients with coronary artery calcifications mentioned above, the majority of whom were between 40 and 70 years, the incidence of ischemic heart disease increased from 52 per cent in those with one major coronary artery calcified to 83 per cent in those with three major branches calcified.

As part of this investigation 21 autopsy protocols of patients with cardiac cinefluorography were reviewed. Of 15 patients with coronary calcification at cinefluorography, 13 had moderate to heavy atherosclerosis of the coronary arteries at postmortem examination. Ten also had cardiac enlargement of various degrees that, however, did not seem to interfere with the detection of coronary calcification at cinefluorography.

Our conclusions were as follows: 1. Careful cinefluorography of the heart detects a high number of coronary artery calcifications. 2. Autopsies show that the presence of coronary calcification on cinefluorography indicates considerable coronary atherosclerosis. 3. There is a much higher incidence of angina and myocardial infarction in men when coronary calcification is detected at cinefluorography. 4. There appears to be a high correlation between coronary calcification at cinefluorography and clinically manifested arteriosclerotic heart disease if heart disease is evident or suspected. The cinefluorographic evidence of coronary calcification by itself, however, is unreliable in predicting the presence of symptomatic ischemic heart disease.

Since coronary arteriography at present is still unsuitable for routine use due to the complexity of the equipment and the hazard to the patient, the detection of coronary calcification by the relatively simple, rapid, and innocuous method of cinefluorography may be the most efficient screening procedure for the detection of potential arteriosclerotic heart disease at a time when no electrocardiographic changes or signs and symptoms are present to indicate the extent of coronary atherosclerosis.

**Cardiac Fat Lines**

Cinefluorography lends itself very readily to the study of pulsating fat lines about the heart. These fat lines appear as thin, radiolucent lines representing subepicardial fat. By the study of these fat lines the enlarged cardiac silhouette resulting from pericardial effusion can now be distinguished from that caused by myocardial dilatation.

Normally the fat line is only 2 mm. from the left lateral border of the heart. It is difficult to see, and it pulsates with the same ampli-
Pulsations of the Heart and Great Vessels

Cinefluorography is the best method for recording pulsations. Pulsations, moving at right angles to each other, can be recorded simultaneously. The duration of recording is not limited as in roentgenkymography. As yet, the electrokymograph is an experimental tool. Eventually, it should prove valuable for quantitating the amplitude of pulsations of the heart and great vessels.

Pulsations of the various chambers and vessels of the heart are useful in the radiographic diagnosis of heart disease. For instance, when the heart is normal in size and shape in a patient with early aortic insufficiency, it can only be recognized radiographically by the presence of an increased amplitude of pulsation of the aorta.

The paradoxical pulsation of the left heart border associated with a ventricular aneurysm, the decreased amplitude of pulsation associated with a pericardial effusion or myocardial insufficiency, and the increased amplitude of pulsation associated with bradycardia, are findings that may be valuable in the final radiographic diagnosis.

Adhesions of the Pleuropericardium

Cinefluorography is also the best method for recording adhesions of the pleuropericardium. Adhesions about the heart have been neglected as a finding in radiographic diagnosis. In a preliminary survey of 120 Veterans Administration Hospital patients with cinefluorographic evidence of pleuropericardial adhesions, 38 per cent had a discharge diagnosis or manifestation of arteriosclerotic heart disease. Of 50 patients with both coronary calcifications and pleuropericardial adhesions, 48 per cent had findings of arteriosclerotic heart disease.

Angiocardiography

The use of cinefluorography for forward angiocardiography is still not accepted by most cardiorengeologists. They hold that the detail of the roentgenogram and the convenience of studying standard films outweigh the advantage of visualizing the contrast agent moving through the different chambers and vessels of the heart. Only for selective angiocardiography in children is the small 5-inch cinefluorograph diagnostically feasible. Eventually a large 2-plane cinefluorograph will replace the rapid cassette changers of today.

Disadvantages

There are several minor disadvantages inherent in the cinefluorographic method. When using a small-field image amplifier, inexperienced doctors may find it difficult to establish at what structure they are looking or where a calcification is localized. The larger image amplifiers or television-type cinefluorographs should eliminate this confusion. The major drawback of the larger cinefluorographs is their initial cost. Also to use the full capability of the larger image amplifier, 35-mm. film is necessary, which in itself is more expensive. Some may object to the additional bulk of even the smaller image-amplifier tube. The benefits of the added information, however, far outweigh these minor disadvantages.

Summary

The additional important information obtained through cinefluorography warrants the use of this method in acquired heart disease. It is superior to all other methods for recording cardiac pulsations and calcifications. Its unique advantage for recording fat lines about the heart is extremely important. As the equipment improves, biplaned cinecardiography will be part of the armamentarium of all cardiac laboratories.
A particularly striking instance of Sydenham's penetrating observation and of his gift of graphic description is his account of St. Vitus' dance, now known universally as Sydenham’s chorea: “St. Vitus's dance is a sort of convulsion which attacks boys and girls from the tenth year until they have done growing. At first it shows itself by a halting, or rather an unsteady movement of one of the legs, which the patient drags. Then it is seen in the hand of the same side. The patient cannot keep it a moment in its place, whether he lay it upon his breast or any other part of his body. Do what he may, it will be jerked elsewhere convulsively. If any vessel filled with drink be put into his hand, before it reaches his mouth he will exhibit a thousand gesticulations like a montebank.”—DAVID RIESMAN, M.D. Thomas Sydenham, Clinician. New York, Paul B. Hoeber, Inc., 1926, p. 31.
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