THE USE OF ANGIOCARDIOGRAPHY IN PHYSIOLOGICAL EXPERIMENTS

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The method of contrast angiocardiography, now widely used in clinical practice for the diagnosis of congenital and acquired lesions of the heart and great vessels, has received the attention it deserves in experimental research.

A serious obstacle to the large-scale use of the method of serial contrast radiography of the heart and great vessels is that we lack a special apparatus produced commercially. Several accessories have accordingly been described, designed to take serial films and to be used in conjunction with Soviet x-ray apparatus.

One such attachment has been suggested by I. S. Amosov (Department of Roentgenology and Radiology of the S. M. Kirov Military Medical Academy).

This apparatus is designed to operate the x-ray apparatus with a Warren motor (making one revolution per minute), on the shaft of which are mounted two ebonite disks with 60 metal teeth. Rotation of these disks closes contacts for switching on the high voltage and taking the x-ray photograph, after which the motor operates an electromagnet which releases the brake, so that the cassette holder is moved through a distance of 10 cm, as required for the next photograph. We have employed the same principle.

We have designed and constructed an apparatus with the following modifications: firstly, we have replaced the weight-operated traction system for the cassette holder by a simpler and more foolproof spring mechanism. For smoothness and ease of movement of the cassette holder, this is fitted with ball bearings, and metal runners are mounted on the wooden frame. Instead of a cramp and screw for fixing the apparatus to the x-ray table, for greater simplicity and convenience of mounting and dismounting three brackets are provided, which are fixed by means of screws on the table. We have lengthened the frame itself and have made a special cassette, in which two films can be inserted instead of one. We can thus obtain a series of eight roentgenograms (instead of four as in Amosov's apparatus). Subsequently, by lengthening the cassette and inserting three films we have been able to obtain a series of nine roentgenograms (Fig. 1). The size of each roentgenogram is 40 × 10 cm instead of 30×10 cm. This is of considerable importance, for the extra 10 cm enables visualization of not only the heart and great vessels but also the kidneys, ureters and urinary bladder of the experimental animals on the same film. It thus becomes possible to study simultaneously the excretory function of the urinary system.

The animal (rabbit or cat) is fixed in the horizontal position, prone, on a special table. Under local anesthesia (4 ml of 2% novocain solution) the jugular (or another) vein is exposed and opened between ligatures. Into the proximal end of the vein is introduced a sterile vinyl chloride catheter, filled with cardiotrast solution.

*Deceased.

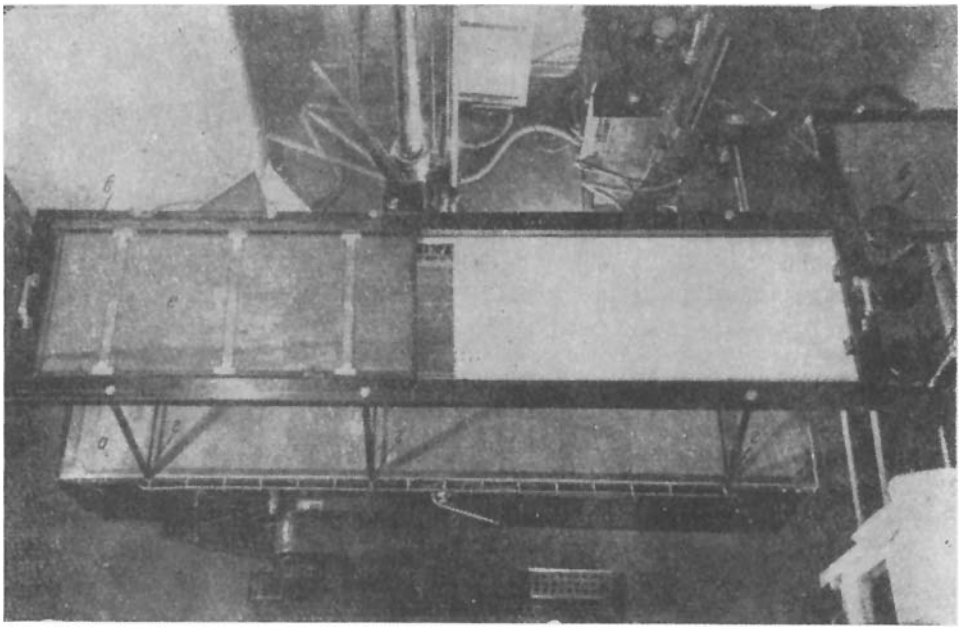

Fig. 1. View of a serial angiocardiography attachment from above. a) Table of URDd 110 k 4 model 1 x-ray apparatus in horizontal position; b) cassette holder; c) spring device for traction; d) brackets; e) fixing screws; f) special cassette.

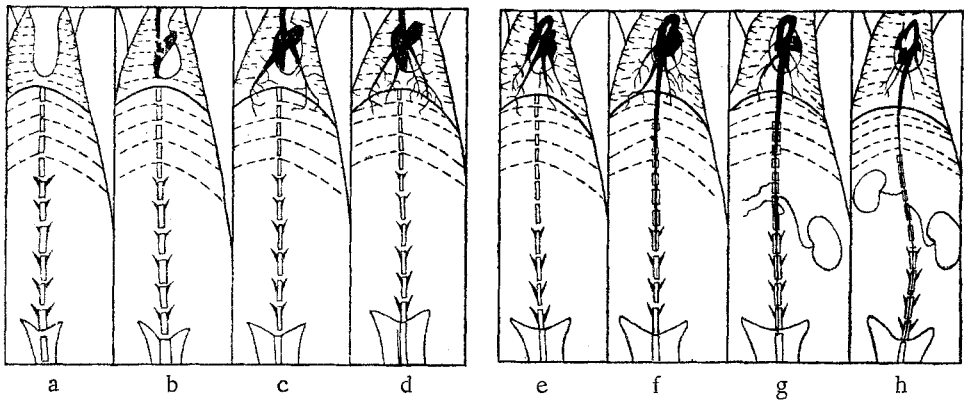

Fig. 2. Serial angiocardiogram of a healthy rabbit. a) Inspection roentgenogram of the chest and abdomen of a healthy rabbit before injection of cardiotrast; b) beginning of injection of cardiotrast, which is entering the right atrium along the superior vena cava from the catheter; c) the same 1.15 sec after the beginning of the injection of cardiotrast. Filling of the right atrium, right ventricle, arch of the pulmonary artery and the pulmonary arteries; d) the same after 2.3 sec. Beginning of filling of pulmonary veins; e) the same after 3.45 sec. The contrast material fills all the chambers of the heart, pulmonary arteries and pulmonary veins. The cardiotrast has reached the arch of the aorta; f) angiocardiogram taken 5 sec after the first film. Cardiotrast can be seen in the pulmonary artery, considerably more in the pulmonary veins, the left atrium and the left ventricle, and there is also filling of the aortic arch and the thoracic and abdominal divisions of the aorta; g) the same after 6 and 15 sec. Traces of contrast material are seen in the pulmonary veins and the left divisions of the heart. The aorta (thoracic and abdominal divisions) are filled throughout their whole extent. The renal arteries can be seen; h) angiocardiogram taken 7.30 sec after the beginning of injection of the contrast material. Cardiotrast is present in the aorta and renal arteries.

For the x-ray examination the animal is placed on the table opposite the cutout portion of the lead shield, after which an inspection roentgenogram is taken. Two seconds later 5 ml of a 35% solution of cardiotrast is injected through the catheter into the vein and the serial angiocardiography is carried out at the same time. After the completion of the experiment the proximal end of the vein is ligated; silk sutures are inserted into the aponeurosis and skin. In the region of the operation wound 50,000 units of penicillin is introduced.

By this method it is possible to determine the time of filling of the chambers of the right heart, the pulmonary veins, pulmonary arteries, the beginning of filling of the left ventricle, the beginning of filling of the arch of the aorta, the descending and abdominal portions of the aorta and the large arteries with contrast material, and also the time of complete evacuation of contrast material from the left ventricle.

It is possible to measure the width of the lumen of the thoracic and abdominal divisions of the aorta, the pulmonary veins and arteries, the individual chambers of the heart and also to determine the size of the heart itself.

By the method of serial angiocardiography it is possible to determine the time of passage of contrast material into the kidneys, of their complete emptying and of the filling of the urinary bladder.

We have studied the roentgenographic picture of the blood flow in 30 healthy rabbits and four cats, which were then tested again after receiving various doses of adrenalin, carbachol, morphine, novocain and other substances. We also carried out observations showing significant changes in the blood flow in anaphylactic shock and also after trauma to the limb of an animal.

By way of example we show a series of angiocardiograms of a healthy rabbit (Fig. 2).

For the more intensive study of some aspects of the circulation of the blood, angiocardiographic investigation should be combined with simultaneous recording of the pulse, the electrocardiogram and the pressure within the chambers of the heart and the vessels. The first results which we have obtained in this direction from combined investigation are promising.

SUMMARY

A simple device, suggested by I. S. Amosov and modified by the authors, made it possible to record 9 serial angiocardiograms, 10 x 40 cm in size, in 8 sec. This proved to be a sufficient number for serial angiocardiography (rabbits, cats) in the assessment of the circulation.

Soviet cardiotrast was used as a contrast medium. The study of these serial angiocardiograms enables the time of filling by the contrast medium of the cardiac cavities, pulmonary veins and arteries, as well as of aorta and large arteries to be determined. The width of the lumen of the great vessels and the individual heart chambers could also be studied. The time when the contrast substance enters and leaves the kidney, as well as the time of filling of the urinary bladder may also be assessed. Various changes occurring in the blood flow as the result of action of different pharmacological substances, in anaphylactic shock or injury of the extremity and distinctly seen on the serial angiocardiograms.