STUDIES ON HUMAN CAPILLARIES: *III. Observations in Cases of Auricular Fibrillation*

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J Clin Invest. 1926;2(4):365-374. https://doi.org/10.1172/JCI100052.

STUDIES ON HUMAN CAPILLARIES

III. Observations in Cases of Auricular Fibrillation

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(Received for publication February 19, 1926)

In a study of the adjustment of the circulatory mechanism to different abnormal conditions in the heart the changes induced by circulatory failure are of special interest. As auricular fibrillation is an important cause of heart failure the study of cases of this nature is particularly important.

The first microscopic studies of the capillaries in living subjects in heart disease were made by Weiss (1) who found that in cases with good compensation the capillaries resembled those of normal individuals. In the early stages of mitral stenosis however a distinct slowing of the stream was often observed while in some cases of pulmonary stenosis there was very marked stasis. Advanced cases of cardiac decompensation showed marked dilatation of the venous limb, a tendency to tortuosity of the capillaries and a dark red color of the tissues in which the capillary loops were situated. The color of the latter varies with the intensity of color of the blood flowing in the deeper lying vessels. The blood stream was slow and discontinuous and the flow had a granular appearance. The subpapillary plexus was more distinct than in normal subjects. These findings were confirmed by Schur (2), Jurgensen (3), Neumann (4), Secher (5), Friedlander and Lenhart (6). Secher (5) stated that early cases of mitral stenosis showed a normal picture. Marked stasis was described by Rominger (7) in a case of pulmonary stenosis. Hisinger-Jagerskiold (8) carried out an extensive study in cases of heart disease of valvular and myocardial origin in some of which the pulse was regular and in others irregular. He stated

that cases with full compensation or with only slight decompensation presented a normal picture whereas in decompensated cases changes took place. Those cases which exhibited edema or cyanosis of the periphery showed changes of the sort associated by Weiss with marked circulatory failure. He differentiated a group of cases in which these phenomena were absent although there was marked congestion of the internal organs. In such cases the color of the loops was normal and the background light red. Some of the loops were smaller than normal and all the loops were well filled. The stream was sometimes rapid and sometimes slow. This picture resembled that which the author had observed in cases of anemia. The various changes seen were independent of the character of the pulse and altered with the state of compensation. In his opinion the different pictures were dependent on changes of blood volume.

The results to be reported are based on the study of seven cases of auricular fibrillation of rheumatic origin except one which was associated with hyperthyroidism. Cinematographic observations of the capillaries at the nail fold were made in these cases at frequent intervals over a prolonged period. Cardiac decompensation was well marked in all but its severity varied. Observations were made during the period when patients were not under the influence of digitalis and also during the course of digitalis administration until full digitalization was established. Details of the technique of taking the photographs and the methods employed in their study have been reported in previous papers of this series (9, 10). As the rate of the pulse in auricular fibrillation is very unstable patients remained at rest in quiet surroundings until variations in the pulse rate were reduced to a minimum and remained practically constant for a considerable period.

The main interests in the present investigation were to study whether the size of the loops and the variations in their caliber varied from those which had been observed in the normal individuals which had been investigated; whether there was any evidence of contractility of the capillaries themselves or whether changes of a pulsatory nature due to the heart beat were present; whether the blood flow varied from that seen in normal individuals; and finally whether any changes observed were altered by digitalization.

OBSERVATIONS

The size of the loops. A marked variation in the size of the loops was present in all cases. It differed in the different subjects and was also markedly altered by the state of decompensation. The milder degrees of decompensation showed a picture closely resembling normal but the loops were usually definitely enlarged in those cases which showed severe circulatory failure. The venous limb of the loop was more affected than the arterial although in the more severe grades this was also involved. The size of the loops was so variable that one is unable to give figures of any value of their size. The caliber of the arterial limb at the point selected for measurement averaged 0.016 mm. in most of the loops measured while that of the venous was 0.018 mm. In many instances larger and smaller capillaries were measured but the variations which are described below were of the same nature in all.

Variations in caliber. Changes in caliber took place in the same subject from moment to moment in both the arterial and venous limbs to about an equal degree (figs. 1 and 2). No two capillaries were alike in the time and extent of these changes and individual differences were evident between the various subjects studied. Although these changes were present the total breadth of the limbs remained practically the same from day to day. Similar changes of caliber had been observed in the capillaries of normal subjects but those seen in auricular fibrillation were more extensive. The degree of decompensation also had a pronounced influence; the more marked the decompensation the more marked the variations in caliber.

Evidence of independent contractility of the capillaries. The curves which were prepared in the manner previously described have been carefully studied to see whether (1) a peristaltic wave of the capillaries or (2) local rhythmical contractions similar to those of the heart itself were present. It seemed that if the "peripheral heart" really existed its action might play an important part in the circulatory mechanism in heart failure. No evidence has been found in favor of these hypotheses as the changes took place irregularly and showed no tendency to rhythmicity such as ought to be present if these factors were operative (fig. 3).

Evidences of pulsation due to the heart beat. In auricular fibrillation

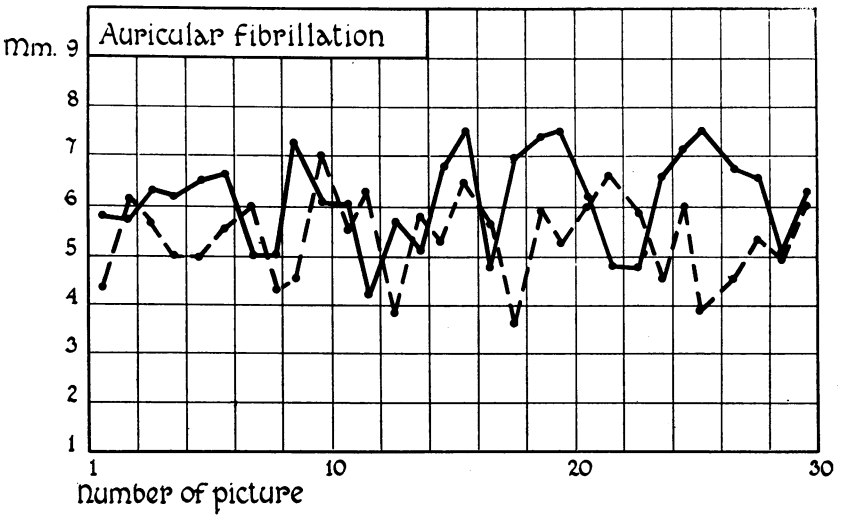

FIG. 1. CHANGES IN CONSECUTIVE PICTURES IN THE DIAMETER OF THE ARTERIAL AND VENOUS LIMBS OF A CAPILLARY IN A CASE OF AURICULAR FIBRILLATION. × 350

•———• arterial. •– – –• venous

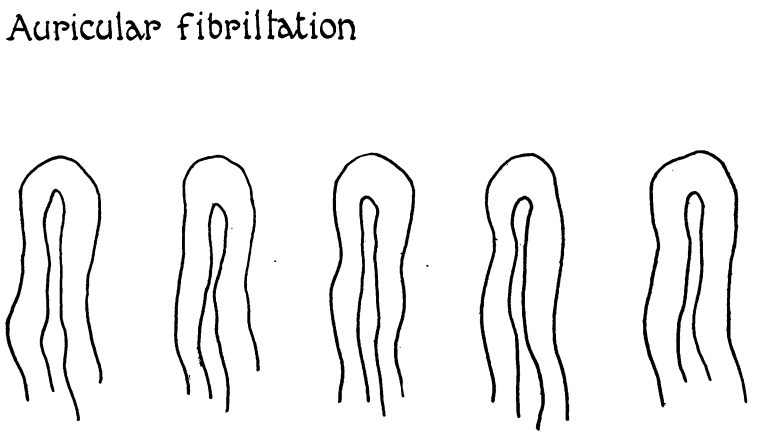

FIG. 2. TRACINGS OF FIVE CONSECUTIVE PICTURES OF A CAPILLARY LOOP IN A CASE OF AURICULAR FIBRILLATION. × 350

it is much more difficult than in cases with normal rhythm to be certain that changes which take place irregularly are not induced by cardiac contraction which forces blood into the small vessels as in the former condition the cardiac contractions themselves vary in time and force. This would apply particularly in those cases in which the heart was very irregular both in time and force. In a few cases marked decompensation was present but the ventricular rate was slow and the irregularity in the time and force of the heart beats was slight. One would expect that if pulsation in the capillaries due to the irregular

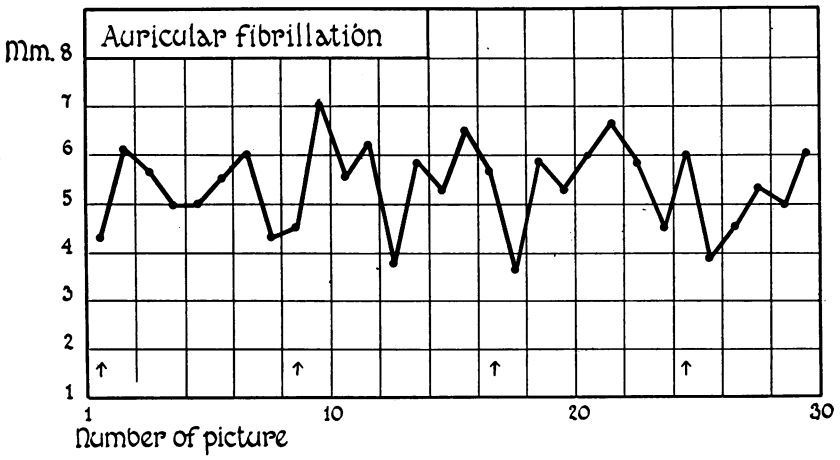

FIG. 3. CHANGES IN THE DIAMETER OF THE ARTERIAL LIMB OF A CAPILLARY IN A CASE OF AURICULAR FIBRILLATION WITH A SLOW VENTRICULAR RATE. × 350

↑ —— ↑ the approximate duration of each cardiac cycle

heart beat observed in auricular fibrillation were the mechanism involved the cases which showed the least irregularity of the cardiac contraction would show less violent fluctuation in the capillary changes. No difference could be detected as whatever changes took place were indeed equally irregular in both. As further evidence against this being the mechanism present two cases of marked cardiac decompensation with regular, rather than irregular, rhythm might be cited in which like changes were seen to those in cases of auricular fibrillation with a comparable degree of decompensation (fig. 4).

Blood flow. The blood flow was studied by inspection over prolonged periods. The rate of flow was continuously changing in the same capillary from moment to moment. All the capillaries in the

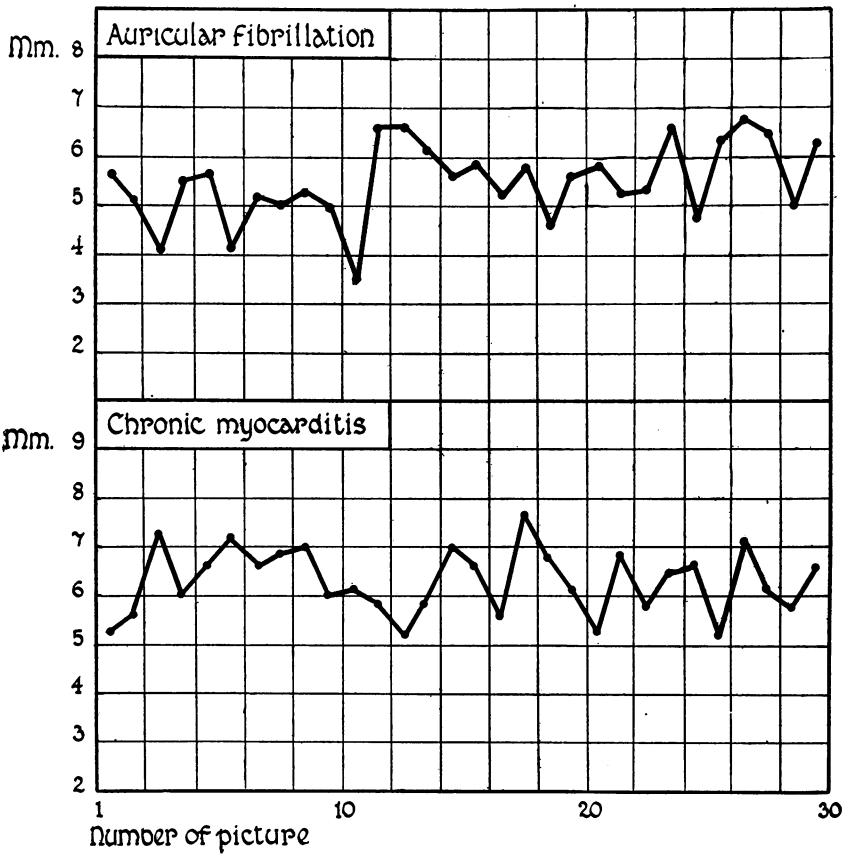

FIG. 4. CHANGES IN THE DIAMETER OF THE ARTERIAL LIMB OF A CAPILLARY IN A CASE OF AURICULAR FIBRILLATION AND SIMILAR CHANGES IN A CASE OF CHRONIC MYOCARDITIS WITH REGULAR RHYTHM WHICH SHOWED A COMPARABLE DEGREE OF CARDIAC DECOMPENSATION. × 350

same field differed from one another. In most capillaries the stream was much slower than had been observed in normal individuals. The slowing of the stream varied with the degree of decompensation. In the most marked cases the stream in almost all the capillaries was very

slow and in many stasis was present which often lasted for a considerable time. The flow was very irregular; a capillary might show at one moment stasis and the next moment the stream in it might be very rapid. Gaps in the corpuscular stream were often seen giving the granular appearance of the stream which has been described by pre-

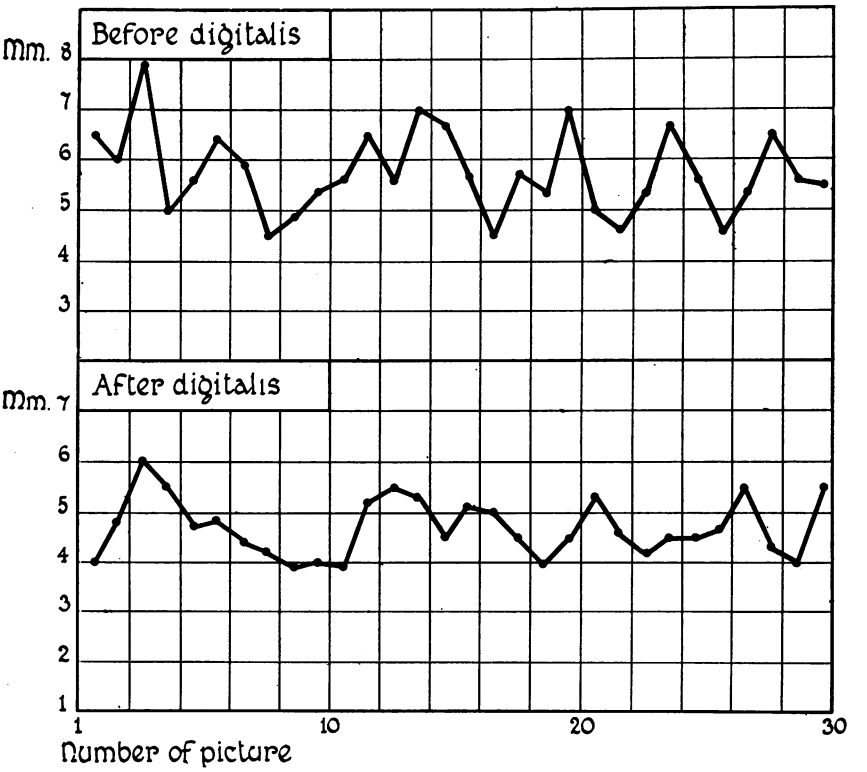

FIG. 5. CHANGES IN THE DIAMETER OF THE ARTERIAL LIMB OF A CAPILLARY IN A CASE OF AURICULAR FIBRILLATION BEFORE AND AFTER DIGITALIZATION. × 350

vious authors. In some cases a backward flow from the venous to the arterial limb was momentarily present.

Digitalis. All cases have been studied daily during the period at which they were coming under the influence of digitalis. Most of the cases as the result of digitalization showed definite changes in the

capillary circulation which varied with the extent to which the efficiency of the circulation was improved. Very little difference was seen in the average breadth of the arterial and venous limbs. When the venous limb was very large, however, before digitalization it was sometimes reduced in size to a slight extent. The extent of the variations in caliber which have been described was reduced in all those cases which were improved by digitalis (fig. 5). In a subject in whom full compensation was established the changes approximated closely to those observed in normal individuals. The blood flow improved in a corresponding manner. The rate of flow in the individual capillaries became more nearly similar; the frequency and duration of stasis were reduced and a granular appearance of the stream was less frequently present.

DISCUSSION

The variations which took place in the caliber of the capillaries in auricular fibrillation were of the same nature as those which took place in normal subjects except that the magnitude of these changes was increased. The degree to which this was so did not depend on the heart rate or on the irregularity of the pulse. It appeared to be dependent solely on the extent to which the circulation was inefficient as judged by other, more general, criteria. This was shown clearly by the correspondence between the extent of the changes and the clinical condition of the patient in cases in which the rate and rhythm of the pulse remained practically unaltered. When the state of decompensation was relieved by digitalis a lessening of the variations in caliber took place. The type of change in the subjects in which compensation was fully established approximated closely to normal.

The blood flow in the capillaries in cases of cardiac decompensation presents a striking picture. The circulation is known to be inefficient but a beautiful demonstration of the extent to which this is so is given by the observation of the flow in these small vessels. In a marked case stasis may be present in a majority of the capillaries all the time although not permanently in the same capillary. The correspondence between the improvement of the blood flow and the subjective symptoms of the patient is striking.

As is well known capillaries can contract under suitable stimuli.

It was thought possible that the existence of the state of heart failure might provide such a stimulus. Previous observations in the present series had given no evidence of independent contractility of the capillaries in normal subjects (10). Nor has any evidence been obtained of such a mechanism in cases of heart failure.

The explanation of the changes is in doubt. If they are due to active contraction of the capillaries which seems to us most improbable, these contractions must take place in a very irregular manner. The probability is that the mechanism involved in their production is the same in both normal individuals and in patients with cardiac decompensation. The possible factors involved in normal subjects has previously been discussed (10). Whatever difference exists between the behavior of the capillaries in normal individuals and in cases of auricular fibrillation is probably to be accounted for by the inefficiency of the heart itself.

CONCLUSIONS

1. The caliber of the arterial and venous limbs of the capillaries at the nail fold has been studied by means of cinematography in seven cases of auricular fibrillation both before and after digitalization.

2. Changes of caliber of about equal magnitude took place in the arterial and venous limbs from moment to moment. The behavior of the various capillaries in the same subject differed from one another. The extent of the changes during the stage of decompensation was much greater than had been observed in normal subjects but as compensation became established under digitalis the variations became less marked.

3. The magnitude of these changes was dependent on the state of cardiac decompensation and had no relation to the rate or amount of irregularity of the pulse.

4. There was no evidence that these changes were due to a peristaltic wave of contraction, a local rhythmic contractile action of the capillary or a pulsatile motion conveyed to the blood stream and so to the capillary wall by the heart beat. The mechanism of their production is uncertain.

5. The blood flow in the capillaries has been studied by inspection. The rate apparently varied from subject to subject and from capillary

to capillary in the same subject. In cases of marked decompensation the stream was slow in most of the capillaries and had a granular appearance while in many, stasis was present. As compensation became established there was a corresponding improvement in the blood flow.

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