ESTIMATION OF THE CARDIAC OUTPUT AS A MEASURE OF ITS EFFICIENCY.

BY

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THE clinical estimation of the cardiac output depends mainly upon the fact that we are able to observe the extent to which the heart is able to distend the two largest elastic viscera of the body—namely, the lungs and the liver; for a variation in their degree of distension must, owing to their elasticity, result in a variation in their size and in the tenseness of their tissues. Owing to a difference in the density and in the anatomical relationships of these two organs, there is a difference in the clinical method whereby the degree of their distension with blood can be estimated.

The Size of the Lungs as a Measure of Cardiac Output.

The great elasticity of the lungs ensures that a considerable variation in their size must accompany any serious variation in the volume of blood in their blood vessels. A lessened cardiac output due to cardiac inefficiency is followed by a recognizable diminution in their size, and, vice versa, an increased distension with blood (as in chronic venous congestion) is followed by a recognizable increase in their size. The accessibility of the lungs to physical examination renders it easy to note these changes, and in the absence of variations in circulation due to vasomotor control makes the information gained reliable as an indication of the cardiac output.

Owing to the relative rigidity of the thoracic walls any variation in the size of the lungs must result in an alteration in the average level of the diaphragm, and in the degree of hollowing of the suprascapular fossae. These variations in the level of the diaphragm are easily detected, when a patient is recumbent, by percussing out the upper border of the liver dullness on the right side and of the gastric resonance on the left side, for there is almost always enough air in the stomach to admit of the lower level of the cardiac dullness being defined by percussion when the patient is in this attitude. Clinical cases, with diagrams illustrating variations in the level of the diaphragm, are given in my book *The Early Diagnosis of Heart Failure* (pp. 168-178, also 182-183 and 195-199).

Degree of Distension of the Liver as a Measure of Cardiac Output.

In the case of the liver the relative density of its tissue does not favour much variation in its size with variations in its distension with blood; but the configuration of its lower portions, together with their anatomical relationships with the subjacent air-containing viscera, do constitute a very delicate clinical guide to the degree of distension of the liver tissues.

To make this point clear it is necessary to remember the principles which underlie the practice of percussion of a solid body which overlies a resonant, air-containing viscus. If the solid body be elastic and distensible (such as the liver) percussion over it will elicit the resonant note of the subjacent viscus if its tissue be either tensely distended or if it be relaxed, for in either case it will transmit the vibrations of the percussion stroke just as any other hard solid or soft solid body would. When, however, it is sufficiently distended to possess a certain amount of definite elasticity it will be capable of absorbing the vibrations due to the percussion stroke, and thus preventing them from eliciting the resonance of the subjacent cavity; and therefore percussion over such an elastic solid will then give a dull note, if its thickness is sufficiently great in proportion to the force of the percussion stroke.

Now it is a fortunate fact clinically that the liver tissue, when normally distended with blood, does possess to its maximal extent that degree of elasticity which is necessary for the absorption of percussion vibrations, for, as we know well, in the case of a gentle percussion stroke liver tissue half an inch or less in thickness is capable of giving a dull note on percussion when overlying resonant viscera. A very

slight lessening of its distension, however, such as characterizes a slight degree of cardiac inefficiency, is sufficient to lessen this power and prevent the thinner portions of the liver from giving a dull note when overlying the stomach or intestines. This statement can easily be put to clinical proof. If a series of patients be examined who are suffering from the slighter degrees of cardiac inefficiency which cause the lassitude so commonly observed after influenza and similar infective conditions, it will be found that in the majority there is distinct curtailment of the area over which an absolutely dull liver note would be obtainable in a similar series of healthy persons.

In cases of really severe myocardial weakness the absolute liver dullness often does not reach the middle line of the costal arch, and in very severe cases may be unobtainable internal to the right of the nipple line.

As further proof of the accuracy of this method of gauging the cardiac output it will be found, on carefully mapping out the area of absolute liver dullness in such cases, that as soon as improvement sets in the area of absolute liver dullness enlarges day by day until it once more returns to the normal size.¹

Diminution of the Cardiac Dullness an Evidence of Lessened Cardiac Output.

Although the amount of recognizable cardiac dullness varies much in patients whose circulation appears to be normal, and although in emphysema it may be absent although the heart be actually enlarged, yet nevertheless a lessening of the cardiac dullness is a valuable sign of lessened cardiac output. This diminution in the area of cardiac dullness may be in part due to the diminution in the size of the heart which accompanies lessened output. Other factors may contribute to this diminution in the cardiac dullness—such as a badly filled aorta or pulmonary artery allowing the heart to fall away somewhat from the anterior chest wall.

A careful study of many cases showing loss of cardiac dullness, however, suggests the probability that the amount of cardiac dullness depends primarily upon the tenseness of the heart and its contained blood, just as is the case with the liver. This may seem theoretically to be altogether improbable, but the clinical evidence in favour of it is very strong. There are certainly clinical grounds for the assertion that valuable information as to the cardiac output can be obtained by observation of the area of the cardiac dullness, and from carefully noting the variations in its size from day to day.

Estimation of the Patient's Vigour as an Indication of the Vigour of the Circulation.

The general practitioner who knows his patient well is able to form a very sound estimate of the cardiac output (when other causes of want of vigour can be excluded) by taking the common-sense view that the vigour of an individual must be proportioned to the effectiveness of the circulation. The same principle of judging the amount of blood the heart is able to circulate without embarrassment finds expression in the exercise tests now so generally adopted for ascertaining the efficiency of the heart. Both these tests, though valuable and reliable up to a certain point, are by their nature only applicable to the less severe degrees of cardiac inefficiency. They give us, moreover, no detailed information regarding the circulation.

Estimation of the Cardiac Output by the Study of the Pulse.

Little information as to the cardiac output can be obtained from the radial pulse (except in the severe degrees of cardiac inefficiency) unless the normal pulse for the individual be well known to the observer. When, however, the normal pulse is well known the radial pulse can give useful information as to the falling output due to cardiac inefficiency.

There are, however, many fallacies which must be guarded against owing to the effect of vasomotor changes upon the peripheral circulation. For instance, in a patient with normally somewhat high blood pressure lessening in the fullness and force of the pulse may only mean that there had been successful elimination of the toxic materials

which were the cause of the high blood pressure; the feeble and more empty radial artery, instead of meaning lessened output, may be accompanied by greater efficiency of the circulation and an increase in the cardiac output.

In the brachial artery, when a sphygmomanometer is used really valuable information as to the cardiac output is obtainable if the range of oscillation of the needle of the aneroid be studied as well as the systolic and diastolic pressures. An abnormally small range of oscillation naturally implies a deficient distension of the arm with blood at each beat of the heart, and therefore presumably a lessened output. It is often possible by the use of the sphygmomanometer alone to diagnose cardiac inefficiency such as that which follows influenza, and to forecast with fair accuracy what other signs of deficient output will be observable in the patient. It must, however, be remembered that in certain conditions small oscillation of the pulse does not imply diminished cardiac output, but only an abnormal state of the peripheral circulation. For instance, a small range of oscillation usually characterizes Graves's disease, Ménière's vertigo, and allied conditions. Information as to the cardiac output can also be gained by noting the nature of the sound heard at the bend of the elbow when using the auscultatory method of reading the blood pressure. A distinctly slapping sound is suggestive of badly filled arteries, due either to failure in cardiac output or to undue relaxation of the arterial system.

When knowledge of the sphygmomanometer has been further increased it is possible that valuable information as to the cardiac output may be given by the relation of the systolic pressure estimated by the finger to that estimated by auscultation, taken in conjunction with the information given by the range of oscillation of the needle of the aneroid.

On comparing the information gained by observation of the size of the lungs, of the physical condition of the liver as judged by percussion, together with the size of the area of cardiac dullness and the results given by the sphygmomanometer, a very trustworthy and exact estimate can be formed as to cardiac output, and the recognition of myocardial weakness will be made more easy, whether toxic in nature or due to atheroma of the coronary arteries. It must, however, be borne in mind that the cardiac output may be lessened by the compensatory diminution in the total volume of blood in circulation which occurs (apart from cardiac weakness) in starvation and certain other pathological conditions.

REFERENCE.

¹ See *The Early Diagnosis of Heart Failure*, Figs. 42 to 45 (pp. 196-199).

URINARY INFECTIONS WITH *B. COLI* AND THE PYOGENIC COCCI:

THEIR PATHOLOGY AND THEIR TREATMENT WITH COLLARGOL.

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A THOUSAND years ago Rhazes¹ described a case of urinary infection in a young man, but it was not until, at the fifteenth French Congress of Surgeons in 1892, Guyon and Reblaub² called attention to the frequent occurrence of spontaneous urinary infections—that is, infections not resulting from trauma or consequent on obstruction—that medical men became alive to their existence. Guyon then expressed the view that the infection was an ascending one from the bladder to the kidney, but ever since there has been a controversy about this question, concerning which there are now two main views.

The first view, the one enunciated by Guyon and vigorously supported by C. R. Box³ among others in this country, maintains that the infection passes from the external surface of the urinary organs along the urethra to the bladder and thence upwards to the kidneys; while according to the second view the infection is haematogenous, and first affects the kidney and its pelvis, whence it passes down into the bladder. Frank Kidd is a firm upholder of

this view, which is accepted by Sir William Hale-White⁴ and probably by the majority of physicians and surgeons. Of course, the fact of the infection being haematogenous would not preclude primary infection of the bladder with ascent to the kidney. The upholders of the ascending view lay stress on the far greater frequency of the complaint in females than in males, while their opponents point out that, although less frequent than in females, cases of urinary infection are quite common in males, in whom the length of the urethra renders the probability slight of an infection spreading from the meatus to the bladder, even if contamination with the most common infecting organism, the *B. coli*, were more frequent than it probably is. Experimental evidence of the effects of the presence or absence of obstruction is adduced in favour of their argument by both sides. Frank Kidd⁵ maintains that "Pure cystitis seldom occurs, but when it does it is never associated with fever. This is because the bladder is designed as a reservoir, is poorly supplied with lymphatics that it shall not absorb water, and therefore equally not poisons."

Now the line of treatment adopted must depend on which of these views is correct. In the end we shall probably find that both views are correct—that is, that in some cases the infection starts in the bladder, in others in the kidney, and that naturally a different line of treatment will be needed for each class of infection. L. S. Dudgeon⁶ and his co-workers showed that in 74 per cent. of *B. coli* infections in females a non-haemolytic bacillus was present, a haemolytic type in 26 per cent., while in males this order of frequency was reversed. This lends some support to the view that the usual progress of the infection differs materially in the two sexes.

The protagonists of both views regard the symptoms of fever, general malaise, and tenderness over one kidney as always evidence of the existence of pyelitis, but I question whether this view is based on indubitable evidence. Cystoscopy combined with ureteral catheterization might give the evidence desired, but in the early stages such examinations are considered inadvisable. However, Frank Kidd has made two or three cystoscopic examinations in the earliest stages, and thus describes what he saw:

"The whole bladder wall was intensely engorged and inflamed, and covered with portions of purulent membrane or fibrinous deposits and the mouths of the ureters buried in the general oedema of the mucous membrane."

I suggest that such oedema produces partial obstruction of the ureteric orifices with consequent distension of the ureter and renal pelvis, accompanied by congestion and tenderness of the kidney. I do not maintain that the pelvis of the kidney is never involved in these cases of urinary infection, but question whether the involvement is as frequent as is usually maintained.

From the successful effects of renal lavage, in which 4 c.cm. of 5 per cent. collargol are injected through a ureteric catheter into the renal pelvis, compared with the unsatisfactory results of ordinary vesical lavage, Frank Kidd considers he has clinched the argument in favour of primary, and persistent infection of the kidney, into which he has found the collargol penetrates. In view of the results I have obtained by injecting 0.5 to 2 per cent. collargol into the bladder, I am led to doubt whether his conclusions are justified. It must be borne in mind that 4 c.cm. of 5 per cent. collargol would make 40 c.cm. or about 1½ oz. of 0.5 per cent., and that the results attributed to renal lavage may possibly be due to the effect of the collargol on the bladder. I must, however, admit that I have obtained no such striking successes as cure after two or three injections. However, in Case 1 of my series the patient, who, previous to receiving the treatment I will describe, suffered from recurring attacks of fever, after treatment had no more of such attacks and has remained cured for over four years. It seems reasonable to conclude either that cystitis alone may produce all the symptoms usually attributed to the presence of pyelitis, or that pyelitis in this case was the result of an ascending infection. The other successful cases of this form of treatment justify the conclusion that, whether the infection ascends or descends, infection of the bladder alone is a very frequent condition in chronic cases, and that, even if the acute cases start in the renal pelvis, the infection there soon disappears, while that in the bladder