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HOW CAN WE DETECT SLIGHT ENLARGEMENT OF THE HEART?*

BY GEORGE CHEEVER SHATTUCK, M.D., BOSTON.

IF WE are to detect slight cardiac enlargement, by which I mean an increase of two or three centimetres in the transverse diameter of the heart, the first essential is an adequate standard of the normal.

It is generally agreed that the x-ray, when rightly used, is the most reliable means of measuring the heart. By its aid Moritz,¹ Dietlen,² Veith,⁷ Groedel,⁸ and Claytor and Merrill¹⁰ have prepared tables of normal heart-size.

Moritz's work was soon followed by that of Dietlen, his assistant, who amplified it, and prepared new tables based on a larger number of cases. Veith's tables are for children only, and to discuss them here would be to exceed the scope of this paper. These three men worked with their patients in the horizontal position. Groedel subsequently prepared tables from patients sitting. The figures in all of these tables are based on orthodiagraphic tracings.

The patients of Dietlen and of Groedel were divided into four classes, namely, men, youths, women, and girls; and these classes were subdivided into groups based on stature, the difference between each group and that succeeding it being five centimetres. Dietlen's tables show also the average weight and average age of the patients in each group.

All of the tables have been published in full by Albers-Schönberg;¹² and Groedel⁹ published the tables of Veith and of Dietlen but omitted the weights and ages from the latter. An average, a minimal, and a maximal figure is shown for every group in all tables.

A considerable number of heart-measurements are figured in the tables of Dietlen. Groedel tabulated only the four which seemed to him of special value, namely, the greatest distances from the median line to the right horizontally, a similar measurement to the left, the sum of

these which is the transverse diameter, and the length, measured from the apex to the angle formed by the junction of the curve of the great vessels with that of the right border. These four measurements are designated respectively as "MR," "ML," "T," and "L" (Fig. 1.)

FIG. 1.

Orthodiagraph of the heart showing method of measurement. Dietlen: *Verhand. d. Cong. f. inn. Med.*, Vol. 23, p. 268, 1906.
 "Mr" — width to right of median line.
 "ML" — width to left of median line.
 "L" — length.
 — "T" — "Mr" plus "ML".

Groedel's figures are not strictly interchangeable with those of Dietlen as a standard of heart-size because Groedel examined his patients sitting and Dietlen's were horizontal, and it is known that the position of the heart varies with that of the body. Groedel's "MR" in the various classes averages about one centimetre larger, and "ML" about 0.5 centimetre smaller than Dietlen's (Fig. 2). Apparently, in patients

FIG. 2.

AVERAGES FOR GROUPS OF GROEDEL AND DIETLEN.

	MR.		ML.		T.		L.	
	G.	D.	G.	D.	G.	D.	G.	D.
Men	4.6	4.3	8.4	8.9	13.0	13.2	14.0	14.2
Youths	4.1	3.9	7.8	8.0	11.9	11.9	12.7	13.6
Women ...	3.9	3.6	8.0	8.5	11.9	12.1	12.9	13.2
Girls	3.7	3.5	7.2	7.8	10.9	11.3	12.1	12.8
Av. of four groups ..	4.7	3.8	7.8	8.3	11.9	12.1	12.9	13.2

sitting, the heart lies more to the right than when the patient is in the horizontal position.

Albers-Schönberg¹² quotes various authors who found that the heart-measurements in standing were smaller than in lying and attributed this to descent of the apex in standing. No careful comparison has been made of the position of the heart between sitting and standing so far as I know. As a rule, however, the differences between sitting and lying are not great, being, generally less than one centimetre. Drs. Walter J. Dodd and George W. Holmes, however, have found marked differences in the presence of visceral ptosis.

Claytor and Merrill's figures for the erect position are smaller than those of Dietlen or of Groedel (Fig. 3). The differences for "MR,"

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FIG. 3.

CLAYTOR AND MERRILL'S TABLE VII: MEN AND WOMEN.

	MR.		ML.		T.		L.	
	M.	W.	M.	W.	M.	W.	M.	W.
Dietlen ...	4.3	3.6	8.9	8.5	13.2	12.1	14.2	13.2
Groedel ...	4.6	3.9	8.4	8.0	13.0	11.9	14.0	12.9
C. and M. ...	4.0	3.4	8.1	7.8	12.1	11.1	13.7	12.5

for "ML" and for "L" are slight, but "T" for both men and women is about one centimetre smaller. The fact that Claytor and Merrill's tables are based upon weight groups instead of stature groups is no reason why the average figures should differ, and the difference seems most easily explained on the ground of the difference of position of their patients and consequently of shape and measurement of the hearts, which will be further discussed below.

Comparison of average transverse diameter, or "T" for adult men and women (Fig. 3) shows that men's hearts are one centimetre wider. The length, also, averages one centimetre greater in men.

Differences far greater than these are found when the maximal and minimal measurements of a single height-group are compared with each other. Sometimes the average "MR" or "ML" for men of one height group is larger than that for the first, or even for the second, succeeding height-group as may be seen in Groedel's Table (Fig. 4) which is reproduced below. It shows that the maximal and minimal figures for "MR" in man differ by 2.1 centimetres, and those for

"ML" by 3.0 centimetres, and those for "T" by 3.2 centimetres.

Further comparison shows that the minimal "MR" is in the second group and the maximal in the third. Both maximal and minimal figures for "ML" are in the third group and the same is true of "T." Clearly, then, the maximal and minimal figures for these groups do not increase progressively but very irregularly with the stature of the patient. Still more important is the fact that the *average measurements* in the four groups do not increase progressively. The average "MR" in the first group is the same as that in the fourth; and that in the second, which is smaller, equals that in the third. "ML" shows similar discrepancies, and the average figures for "T" in the four groups for men are almost exactly the same.

It seems, therefore, that the tables of Groedel are valuable for providing maximal, minimal, and average figures of normal heart-size, but that the relation of the figures to stature is not clearly apparent. Groedel's other tables are open to similar criticism, and so are the tables of Dietlen.

Groedel⁹ himself criticized the tables on the ground that the material in hand was too small, and he seems to have attributed the discrepancies to this fact.

Dietlen's tables were based on the largest material, comprising 156 men, 31 youths, 58 women, and 17 girls.

It seems to me that Groedel⁹ failed to empha-

FIG. 4.

ORTHODIAGNOSTIC MEASUREMENTS. (GROEDEL.)

For Men Sitting

Height.	Mr.	ML.	T.	L.
I. 145-154 cm.				
Min.	*4.0	*8.0	*12.0	(Min.) *12.0
Av.	†4.7	†8.4	†13.1	12.9
Max.	‡5.2	‡9.2	‡14.4	†14.2
II. 155-164 cm.				
Min.	(Min.) *3.5	*7.4	*12.1	*13.0
Av.	†4.5	†8.7	†13.0	13.9
Max.	‡5.3	‡9.5	‡14.1	†15.0
III. 165-174 cm.				
Min.	*3.7	(Min.) *7.2	(Min.) *11.4	(Min.) *12.0
Av.	†4.5	†8.7	†13.2	14.0
Max.	(Max.) ‡5.6	(Max.) ‡10.2	(Max.) ‡14.6	(Max.) ‡15.3
IV. 175-185 cm.				
Min.	*4.0	*7.3	*12.0	*13.3
Av.	†4.7	†8.5	†13.2	14.2
Max.	‡5.4	‡9.0	‡13.6	†14.7

For Women Sitting.

Height.	Mr.	ML.	T.	L.
I. 145-154 cm.				
Min.	(Min.) *3.0	(Min.) 6.2	(Min.) 10.1	(Min.) 11.0
Av.	†3.8	†8.0	†11.8	†13.0
Max.	‡4.5	9.3	13.1	13.5
II. 155-164 cm.				
Min.	*3.2	6.4	10.4	11.5
Av.	†3.8	†8.0	†11.8	†13.0
Max.	(Max.) ‡5.0	9.5	(Max.) *14.3	(Max.) *14.8
III. 165-174 cm.				
Min.	*3.2	6.5	10.8	12.0
Av.	†4.0	†8.1	†12.1	†13.2
Max.	†4.5	(Max.) 9.8	*14.0	*14.5

* † ‡ Note that most of the minimal and maximal figures are near the middle of the table. Compare figures with others similarly checked in the same column.

size the main fault of the tables, namely, that they should have been based *not on stature, but on weight*.

That weight is the greatest factor in determining heart-size was clearly shown by Dietlen² (Tables 6, 7, 8, and 9). In Tables 10 and 11 he showed that heart-size has no necessary relation to stature, and this is borne out by the discrepancies in Groedel's table mentioned above. Heart-size seems only to follow stature when the body weight is proportional to stature. (Fig. 5). Dietlen² gives further evidence of the importance of weight in determining heart-size by quoting the anatomical work of Thoma and Muller.[†] It seems strange that men who recognized the preponderant effect of body-weight should have arranged their tables by stature-groups instead of by weight-groups (Fig. 5).

FIG. 5.—FROM DIETLEN'S "TABLE 6."

Body-weight Kg.	No of Cases.	Av. Stature	Av. Age.	T.	L.
40-44	7	152	26	11.3	12.1
45-49	5	159	20	11.4	12.9
50-54	27	161	27	12.4	13.5
55-59	39	164	30	12.9	14.0
60-64	54	167	26	13.1	14.1
65-69	24	169	30	13.2	14.5
70-74	18	174	31	13.4	14.8
75-79	5	179	22	14.3	†15.5
80-84	5	185	25	14.4	†15.3

† Note the progressive and gradual increase of size, the only exception being the last two figures in the second column. The number of cases on which these last figures are based, however, is very small.

Dietlen² raises an objection to weight which may be important, namely, that after the age of forty both weight and height diminish in some cases and that nevertheless the heart continues to increase in size. Fig. 6 indicates this, but the number of cases on which the table is based

† Muller: *Massenverhältnisse des Menschlichen Herzens*, 1883.

is too small to allow of safe deductions. If the heart-measurements do really increase after

FIG. 6.

DIETLEN'S TABLE 15.

Ages.	No. of Cases.	Av. Wt.	Av. Size.	Mr.	MI.	T.	L.
15-19	31	54	162	3.9	8.0	11.9	13.6
20-29	33	62	168	4.3	8.6	12.9	14.2
30-39	17	64	169	4.2	8.7	12.9	14.2
40-49	12	61	167	3.9	8.9	12.8	14.1
50-59	13	62	167	4.1	9.1	13.2	14.4
60-69	7	59	167	4.4	9.0	13.4	14.4

Note that with slight differences of weight and of stature there is, on the whole, an increase of heart-size with advance in years, but that it is less pronounced after 40. The number of cases, however, is too small to allow of safe deductions.

forty independently of weight, two factors, or either alone may be causative: first, loss of elasticity in the arteries; second, sinking of the right side of the heart, the apex remaining relatively high, so that the heart assumes a more horizontal position. Such a change of position is common in the elderly, and it increases the transverse diameter of the heart without changing its actual size, but there may be hypertrophy also, and, within limits, this may be considered physiological rather than pathological, just as is the gradual increase of blood-pressure which goes with advancing years.

In summarizing the foregoing it may be said (1) that heart-size is dependent first on body-weight, and second, apparently on age, and that stature *per se* is not important; (2) that tables of heart-size based on stature are unsatisfactory.

The tables of Claytor and Merrill, (Fig. 7), are based on weight as they should be. Their table for men is divided into six groups. The first four groups ascend by ten pounds and the last two by twenty pounds. That for women ascends by ten pounds in six groups, and in the seventh by fifteen pounds. The maximum weight

FIG. 7.

CLAYTOR, MERRILL: ORTHODIAGNAPHY.

Vertical Heart Orthodiagrams. Male (37 Cases.)

Weight. Pounds.	Cases.	Mr. (Min.)	MI. (Min.)	T. (Min.)	L. (Min.)	Min. Av. Max.
120-129	3	3.2 3.7 4.3	7.0 7.2 7.5	10.7 10.9 11.3	11.8 12.6 13.5	Min. Av. Max.
130-139	5	*3.5 3.8 4.2	7.5 †8.0 *8.5	11.0 11.8 12.5	12.0 13.2 14.0	Min. Av. Max.
140-149	9	*3.4 (Min.) †4.0 4.6	7.0 †7.7 *8.4	11.0 11.9 *13.1	12.0 13.4 14.5	Min. Ave. Max.
150-159	8	(Min.) *3.2 †3.9 4.5	7.8 †8.4 *9.0	11.5 12.3 *13.0	12.5 13.5 15.0	Min. Av. Max.
160-179	6	3.7 †4.0 (Max.) 4.8	8.0 †8.2 *9.0	12.0 12.4 (Max.) *13.8	14.0 14.6 (Max.) *15.8	Min. Av. Max.
180-200	6	3.8 (Min.) 4.2 4.5 (Max.)	7.0 8.7 9.7	11.0 12.9 *13.4	14.0 14.7 *15.3	Min. Av. Max.

VERTICAL HEART ORTHODIAGRAMS. FEMALE (54 CASES.)

100-109	2	3.2 †3.3 *3.5	6.7 6.8 7.0	9.9 10.2 10.5	12.0 †12.1 12.3	Min. Av. Max.
110-119	3	3.0 †3.1 *3.2	7.0 †7.6 8.0	10.0 10.7 11.1	11.5 †11.9 12.4	Min. Av. Max.
120-129	14	(Min.) 2.3 †3.5 *4.2	(Min.) 6.4 †7.5 8.6	10.2 11.0 *12.2	(Min.) 10.5 12.2 *13.8	Min. Av. Max.
130-139	19	3.0 †3.4 *4.0	6.4 7.8 *8.8	(Min.) 9.6 †11.2 *12.6	11.2 12.4 *13.3	Min. Av. Max.
140-149	5	2.6 †3.5 *4.1	7.0 †7.6 *8.3	10.0 †11.1 *11.8	12.2 †12.7 *13.2	Min. Av. Max.
150-159	7	3.1 3.6 (Max.) *4.8	7.6 †8.0 (Max.) *9.3	10.9 11.6 (Max.) *12.8	12.3 †12.9 (Max.) *14.2	Min. Av. Max.
160-175	4	3.5 3.8 3.8 *4.1	6.5 †7.9 8.5 *9.0	10.6 11.7 12.3 (Max.) *12.8	11.8 †12.6 13.0 *13.2	Min. Av. Mean Max.

* † || Note the situation of the minimal and maximal figures, and compare figures with others similarly checked in the same column.

for the women is one hundred seventy-five, and for the men, two hundred pounds. Unfortunately, the material of these tables comprises only thirty-seven men and fifty-four women. They show irregularities like those in Groedel's tables but less in degree. Dietlen's weight table (Fig 5) indicates that the irregularities of Claytor and Merrill are to be attributed chiefly to insufficient material. Figures 2, 3, and 4 of Claytor and Merrill's paper show curves indicating the relation of increase of heart-size to body-weight (Fig. 8). For this purpose they used

crease of heart-size in men up to 128 pounds of body weight, and after that the increase is more gradual. In the higher weights the increase is very slight. The increase in women was found to be less marked.

There are still other factors influencing heart-size or heart-measurements which should be mentioned.

Occupation may be important, but its effect probably follows weight in most cases because the well-developed and muscular are heavy, and the sedentary are generally fat, whether they be men or women.

The phase of heart action, according to Groedel,⁹ may cause a difference in extreme cases of 0.5 cm. for both borders. He estimates the normal change at about 1.8 cm., but thinks this figure still too high for most cases. It seems, therefore, that the difference of measurement between systole and diastole is negligible as compared with other variations, and yet, to avoid doubt, orthodiagrams should be made in diastole, and it is probably better to use an exposure of not less than one second for teleoroentgenography than a shorter period, (if plates sufficiently clear for measurement can be so obtained) in order to show the heart outline in diastole.

Posture, already mentioned, seems to be relatively unimportant in its effect on heart-measurement except when there is marked visceral ptosis. It may be said in general that in standing, the heart apex rotates downward around the base as an axis. "MR" is generally about 1 cm. greater, and "ML" about 0.5 cm. smaller in the sitting than in the horizontal position, and the differences between standing and lying are probably similar.

FIG. 8.
Claytor and Merrill's Fig. 4.
(Based on Dietlen's Table 6, see Fig. 5.)

curves of "L" and "T" and of the square area of the orthodiagram. They found that 70% of "T" x "L" gave a close approximation of the square area as obtained by careful measurement. The authors pointed out that there is a rapid in-

The measurement of length, designated "L," is sometimes valuable because it is very little affected by such rotation. As a useful figure for heart-size "L" suffers, however, from the fact that the angle above mentioned may be ill-defined, and that the lowest part of the apex lies below the diaphragm and may be obscured by the shadow of the left lobe of the liver.

The shape of the heart, and consequently its size, is dependent, I believe, to a considerable degree on that of the chest, long narrow hearts being the rule in long narrow chests, and vice versa. The "small heart" in the paralytic thorax has been attributed to tuberculosis, but Wessler¹⁵ pointed out that it was narrow rather than small, and was caused not by tuberculosis but by the narrow chest and low diaphragm.

The position of the diaphragm seems to be the greatest single factor influencing the position of the heart, and therefore, it has an important bearing on shape and measurement. The narrowest hearts are seen with low diaphragm and visceral ptosis, and wide normal hearts with high diaphragm, whether this be due to tight corsets, abdominal distention, or to other causes.

The usual position of the diaphragm in standing, except when temporarily displaced, has a fairly constant relation to the shape of the chest, it being lower in long chests and higher in broad chests. The shape of chest and position of diaphragm generally exert a combined influence on the shape and position of the heart, so that it is difficult to distinguish their efforts separately. Dr. G. W. Holmes recently showed me with the fluoroscope a patient whose heart appeared normal when lying down, but when standing the heart became pear-shaped through ptosis.

The variations of position of the heart between full inspiration and full expiration are important. With expiration the apex is carried upward by the diaphragm and at the same time the right border moves outward a little so that there is a considerable increase in "ML" and a slight increase in "MR." With full inspiration the apex rotates downward and inward and the right border descends causing little change in "MR" but a marked decrease of "ML." During normal breathing the change of position of the heart is slight and the diaphragm moves about equally up and down. When there is marked visceral ptosis, however, the diaphragm remains nearly as low as in full inspiration. On the other hand it ascends much with full expiration, and displaces the heart correspondingly in this phase of respiration.

The relations of the chest-wall, diaphragm, and heart in elderly persons are complex. There is usually more or less visceral ptosis combined with descent of the diaphragm, but there is also sinking of the chest-wall so that the apex generally remains at the level of the fifth interspace. The descent of the diaphragm is more than offset by stretching of the supporting structures at the base of the heart, so that the

right side descends, and instead of a long heart we find a broad heart, the result of rotation. It was mentioned above that the increase of blood-pressure, and arterial changes of old age tend to cause enlargement of the left ventricle, which may be considered physiological when slight, and which tends further to increase "ML."

Three normal types of heart-shape are commonly recognized: (1) the oblique; (2) the relatively perpendicular, and (3) the relatively horizontal. In the first type the heart is ovoid, in the second it is longer and narrower, and in the third it approaches the shape of a boot with heel to right and toe to left. Besides these there is a type associated with visceral ptosis, narrow chest, and low diaphragm. Its location is almost central, and it has been called by the Germans the "drop-shaped heart." It might better be described, I think, as pear-shaped.

The hearts of youths and girls are apt to be relatively oblique, and those of old persons relatively horizontal, or boot-shaped.

Although the heart in young girls is long and like that of young men in relation to the median line, that of grown women is broader, the apex is higher, and a larger proportion of the heart lies to the left of the median line. Dietlen² showed this difference and attributed it to the use of corsets, with resulting higher position of the diaphragm.

Dietlen's article² on the position of the normal heart is classical and should be read by those who want detailed information. In a subsequent article he presents data on the influence of posture on blood-pressure and on heart-size.⁴ Albers-Schönberg¹² and Groedel⁹ review Dietlen's work and discuss that of others bearing on the shape, size, and position of the normal heart.

Among the foregoing facts the following require emphasis. First: the normal heart varies in shape and position. Second: the shape and position in the individual case are probably more dependent on the position of the diaphragm than on any other single factor. Third: the shape of the chest and position of the diaphragm require consideration in the individual case when there is a question about the existence of slight abnormality in size or shape of the heart.

For instance, a broad heart with a low diaphragm is probably enlarged if its measurements exceed the average for normal hearts, but when the diaphragm is unusually high, the transverse diameter of the normal heart may perhaps exceed the maximal tabulated normal figure, as a result of displacement.

When using measurements to determine the presence or absence of cardiac enlargement the weight of the patient, his age, and the position of the diaphragm at the time of examination require careful consideration. Increase of "MR" or of "ML" points to enlargement to right or left, but when one is increased and the

other decreased, "T" remaining normal, we may have to deal with displacement rather than enlargement. In such cases "L" is valuable as a check if it can be measured accurately.

There are other measurements which require brief mention. The breadth of the heart at right angles to the length, and its relation to length were advocated as standards by Otten,¹⁴ and the surface area (measured by laying the orthodiagram over a sheet of paper ruled in square centimetres and counting the squares) by several observers who recognized the insufficiency of other methods. Groedel⁹ objects to both on the ground that the position of the upper border near the base and of much of the lower border is often doubtful even when the orthodiagraph is used. Teleoroentgenography would be still less satisfactory in such cases. Consequently, estimates of breadth or of surface area are of uncertain value.

Giegel¹⁵ proposed a method of comparing surface area with body weight by means of what he called the "reduced heart index." This he obtained by a mathematical formula and compared with a standard area per kilogram of body weight. He admitted that the method was open to objection but thought it the best available. His method seems of doubtful value.

When one considers the many factors influencing heart-size, and the inadequacy of existing tables it seems best for the present to compare heart-measurements with average normal figures for the sexes, and whenever the measurements differ much from the averages, to compare them with maximal or minimal standards, to note the position of the diaphragm, to observe the state of nutrition, and to consider the age of the patient if below twenty or above forty before reaching a conclusion. A table of normal standards from Dietlen, Groedel, and Claytor and Merrill is appended (Fig. 9).

Claytor and Merrill's figures for men show

FIG. 9.

STANDARDS OF NORMAL HEART-SIZE IN CENTIMETRES.

<i>Men—Standing.</i>				
Author; Age; No. of Cases.	Mr.	ML.	T.	L.
Claytor and Merrill; 42 cases	Min. 3.0(3.2) Av. 4.0 Max. 4.8	7.0 8.1 11.0(9.7)	10.7 12.1 14.0(13.8)	11.8 13.7 15.8
<i>Men—Seated.</i>				
Groedel	Min. 3.5 Av. 4.6 Max. 5.0	7.2 8.4 10.2	11.2 13. 14.6	12.0 14. 15.3
<i>Men—Horizontal.</i>				
Dietlen; 156 cases; age 20 or more	Min. 3.1 Av. 4.3 Max. 5.0	7.4 8.9 11.	11.0 13.2 15.3	12.1 14.2 15.9
<i>Women—Standing.</i>				
Claytor and Merrill; 54 cases	Min. 2.3 Av. 3.4 Max. 4.8	6.4 7.8 9.3	9.6 11.1 12.8	10.5 12.5 14.2
<i>Women—Seated.</i>				
Groedel	Min. 3.0 Av. 4.6 Max. 5.0	6.2 8.4 9.8	10.1 11.9 14.3	11.0 12.9 14.8

<i>Women—Horizontal.</i>				
Dietlen: 58 cases; age 17 or more	Min. 2.4 Av. 3.6 Max. 5.2	6.8 8.5 10.3	10.3 12.1 13.7	11.7 13.2 15.0
<i>Youths—Seated.</i>				
Groedel	Min. 3.2 Av. 4.1 Max. 5.2	7.0 7.8 8.5	10.5 11.9 13.5	11.2 12.7 14.3
<i>Youths—Horizontal.</i>				
Dietlen: 31 cases; ages 15-19 years.	Min. 3.0 Av. 3.9 Max. 5.1	6.5 8.0 9.3	10.4 11.9 13.8	11.4 13.6 15.2
<i>Girls—Seated.</i>				
Groedel	Min. 2.5 Av. 3.7 Max. 5.2	6.5 7.2 8.7	9.0 10.9 12.7	10.5 12.1 14.0
<i>Girls—Horizontal.</i>				
Dietlen: 17 cases; ages 15-17 years.	Min. 2.8 Av. 3.5 Max. 4.0	6.5 7.8 8.8	10.3 11.3 12.5	11.9 12.8 14.0

variations of 4.0 centimetres within the normal for "ML;" Groedel found differences of 3.0 centimetres and Dietlen of 3.6 centimetres. The respective variations for "MR" are 1.8 cm., 2.1 cm., and 2.8 cm.; those for "T" are 3.3 cm., 3.2 cm., and 3.3 cm.; and those for "L" are 4.0 cm., 3.3 cm., and 3.8 cm.

Therefore, it appears that a heart, originally small, might become pathologically enlarged by 3 cm. or even more before this enlargement could be detected by measurements alone; but, in such a case, if nutrition, position of diaphragm, and age, when necessary, were considered, it might be possible to discover enlargements of not more than two centimetres. In ordinary cases enlargements of two centimetres in transverse diameter should be demonstrable in this way.

Examination of the tables (Fig. 9) shows that the variations of "MR" and of "ML" are greater than those of "T." This can easily be explained on the ground that the normal position of the heart is not constant but variable, and that sometimes a greater proportion lies to the right or to the left. We know that this is the case when the hearts of men are compared with those of women who wear corsets, and it can scarcely be doubted that other things which influence the position of the diaphragm may influence the location of the heart similarly. We know also that "ML" is considerably diminished at full respiration, and increased at full expiration, and that "MR" is less affected by the phases of respiration than is "ML." "ML" is relatively much smaller in the pear-shaped heart than in other types. Dietlen² prepared tables of the varying average relations of "MR" to "ML" for men, women, and young persons. The average relation of "MR" to "ML" in men he found to be 1.0 to 2.1 and the average for women 1.0 to 2.4, but in a group of women between the ages of twenty and twenty-nine, at which age displacement is most frequent, the relations were 1.0 to 2.6.

These facts assume importance when it is necessary to distinguish slight enlargement

from displacement; for instance, in any case in which the figures for "MR" or for "ML" were disproportionately large, and yet "T" was within normal limits. If the disproportion in such a case could not readily be explained by the position of the diaphragm, or attributed to a normal type of heart-shape, there might be enlargement even though "T" were within normal limits.

Before passing from measurement of x-ray material to other means of detecting abnormality in the heart, let us consider the basis of the statistics of Groedel and of Dietlen.

Dietlen's² material was selected with the greatest care. He excluded all persons having cardiac lesions, severe, or chronic pulmonary diseases, acute infections, nephritis, arteriosclerosis, old syphilis, anemia, cachexia, marked scoliosis or kyphosis, and hard drinkers. Nearly all who complained of cardiac symptoms were excluded, even when clinical signs of disease were not found, and also those in whom the fluoroscope showed aneurism, marked sclerosis of the aorta, or an abnormal position of the heart; and, finally, the rate, rhythm and quality of the pulse were noted. In doubtful cases the blood-pressure was taken. The patients were all ambulatory persons suffering from mild gastric or nervous diseases, muscular rheumatism, gonorrhoea, fresh lues, skin diseases, or slight injuries, and a large number of soldiers were included in the series. The patients of Groedel and of Claytor and Merrill doubtless, were selected with equal care.

It seems pretty certain, therefore, that very few patients with pathologically enlarged hearts were included among the tabulated cases, and yet, I think it possible that some such may have been included, and that, consequently, the maximal figures may be a little too high.

X-ray plates and orthodiagrams may be of great value to show the outline of the heart. The value of such outlines for early diagnosis has been urged by Ottlen,¹⁴ Wessler,¹⁶ Claytor and Merrill,¹¹ and others. The subject deserves much more consideration than it has as yet received. It seems likely that the cardiac outline will often show abnormalities before they can be demonstrated by measurement, and that these changes may be of great value in discovering slight hypertrophies of the right or left ventricle at a stage when there is little or no dilatation and, therefore, little enlargement.

Cardiac enlargement is due mainly to dilatation of the cavities of the heart, and appreciable dilatation is often preceded by hypertrophy with little or no dilatation. We all know how difficult it may be to detect cardiac enlargement in early chronic nephritis and this is because hypertrophy, as such, adds little to the size of the heart. The ventricle may be doubled or trebled in thickness, but, if the cavity be not enlarged, the increase of heart-size is small. In cases of this sort a rounded apex and curved

left side suggests hypertrophy. Wessler,¹⁶ found this sign valuable as an index of the presence of nephritis in children at a stage when the elevation of blood-pressure was slight, and when there was doubt as to the significance of albuminuria.

Finally, fluoroscopic examination of the heart requires consideration. Its advantage lies mainly in the fact that it shows the heart in action, and it is probable that it will be more valued in the future than it has been in the past. Not only can the movements of the heart as a whole be studied in this way, but the pulsation of the different parts can be observed. The method affords also a general view of the heart and surrounding structures, and may suffice in some cases to give the desired information without plates or tracings.

SUMMARY.

Before finishing I want to emphasize the importance of skillful physical examination and careful history as a means of discovering abnormality in the circulatory system and slight signs of enlargement of the heart.

When findings are inconclusive, an examination with the fluoroscope may quickly clear up the diagnosis. In other cases an orthodiagram or a teleoroentgenogram may provide important information by showing slight abnormality in the *outline* or *measurements* of the heart. Even with good technic none of these methods are faultless, and normal heart-size is variable. Therefore, enlargement should be judged, as Groedel⁹ said, not by millimetres, but by centimetres.

By using heart-measurements as described above, it should be possible to detect enlargements of two centimetres in transverse diameter of the heart in most cases, but enlargements of three centimetres may occur without exceeding the maximum figures and in such cases abnormality may be difficult to demonstrate.

Abnormal shape may give the earliest evidence by hypertrophy.

The relative merits of orthodiagraphy and of teleoroentgenography, the technic, and the sources of error have been discussed by Albers-Schönberg,¹² Groedel,⁹ Dietlen⁶ and others. Neither method is satisfactory without proper equipment, nor in the hands of one unfamiliar with its difficulties and possible sources of error.

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