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THE PULSUS BISFERIENS.

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THE observations upon which this contribution is based were made during and since my term of residence at University College Hospital.

The term "pulsus bisferiens" is now applied to a form of palpably double pulse.* It is described by Broadbent¹ as having two beats, the second of which is really a reinforcement of a prolonged systole. It is the habit of most writers on the subject to define this type of pulse as one which is double to the finger. If this definition is accepted it follows that every individual observer will have a standard of his own, according to the delicacy of his tactile sense. As this definition is followed in this communication it will be of advantage to add that no case is described as pulsus bisferiens in which the apices of the two waves are separated by a time interval of less than $\frac{1}{10}$ th of a second, and in which the second wave is not prominent†². Most of the tracings are from pulses in which the time interval is slightly less than $\frac{1}{10}$ th of a second. It has been stated by one observer³ that the pulsus bisferiens is rare. This is far from being the case. In twenty unselected cases of aortic regurgitation, a double-topped pulse was distinctly appreciable to the finger in thirteen cases.⁶ In three it was an obvious phenomenon, and could be seen as well as felt in the vessels of the arm and neck.

The literature dealing with the pulsus bisferiens from a clinical standpoint is scattered and unconnected. Broadbent¹ associated it with aortic stenosis and with senile degeneration of the arteries. Steell¹¹ found it in connexion with aortic stenosis particularly, but did not consider it pathognomonic of that condition. He stated that a sphygmogram of an ill-developed pulsus bisferiens type is found in aortic incompetence, a conclusion in accord with Mahomed's⁹ work, and in which the present observations fully concur, though they indicate the frequent presence of a well-developed type also in such conditions. Steell¹¹ stated that it is usually accompanied by an ill-developed dicrotic wave, a statement which is by no means free from doubt (cp. Lewis⁶). Both D'Espine⁴ and Mackenzie,⁷ associate the double pulse with aortic conditions. So far the position is clear, and it may be said that almost all writers (cp. Marey,⁸ Galabin,⁵ and others) are agreed that this type of pulse is most frequently associated with disease of the aortic valves. It must be borne in mind that in speaking of the pulsus bisferiens, a character of the pulse rather than its general type is indicated, for there is no distinct dividing line between it and other pulse types; there are all intermediate forms. The transitions to flat-topped, high-tension, and anacrotic types are those most commonly seen. It will simplify matters if only that type having a well-marked bisferient character is discussed.

The opinion was originally expressed in this country by Galabin,⁵ and is still adhered to in some measure by Mackenzie,⁷ that the splitting of the systolic portion of the tracing into two waves is instrumental in origin; it is impossible to accept this position, on account of the palpability of the waves.⁶ Moreover, Galabin,⁵ who originally attempted to explain the deception of the finger in this respect, was eventually convinced of the double nature of the pulse by its visibility in certain cases. Another point of interest—a point which still remains unsettled—is the fact that the double beat is frequently more easily palpable, and gives a more distinctive tracing on one or other side of the body. Taking the experience of all writers, it cannot be said that it is associated with one side of the body more than with the other; its prominence on one side is of little diagnostic importance unless very marked. The view of Walter Broadbent² that

it depends on the arrangement of the aorta and its branches is not tenable, for, if so, it should invariably present more prominence on one side. Steell¹¹ said that he had looked in vain for an anatomical explanation in fatal cases. Morrison¹⁰ was inclined to the view that it is due to varying longitudinal tensions developed in the vessels during the investigation. It is true that it is better shown in tracings taken with the wrist extended, but, as Broadbent¹ has shown, it is better developed by pressure, and extension of the wrist tends to throw pad pressure on to the vascular contents rather than on to overlying tissues.⁶

Moreover, it is frequently more visible on one side of the neck than the other, and there is sometimes a marked difference in tracings from the two superficial temporal arteries, where longitudinal tension can play little or no part (Fig. 1). Again, in cases in which it occurs on one side it is often impossible to obtain it on the other by rearranging the limb. In a previous communication it was pointed out that the height of the second wave of the pulsus bisferiens depends on the degree of arterio-sclerosis present. Differences on the two sides are possibly due to differences in the expansibility of the two vessels. The association of arterio-sclerosis is so close that it is probable that in aortic cases it forms an essential factor to its appearance at the wrist. I venture to place certain cases which will be described later, and which are unassociated with sclerosis, in a different etiological category.

Dealing with the first or generally-recognized type (Figs. 1 to 4), it may be said to occur in those cases in

Fig. 1.—From above down, cardiogram, left and right superficial temporal arteries.

which there is great enlargement of the left heart, associated with or caused by disease of the aortic valves or larger arteries. Attempts have been made to draw conclusions from it as to the relative degree of hypertrophy and dilatation,³ but the relationship appears to be inconstant. Some writers associate it with poor compensation, others with improved compensation. Steell¹¹ noticed its development after the administration of digitalis. In more than one case I have noticed it for a day or two without further change in physical signs. In one case it developed in conjunction with some symptoms of cardiac distress. In the literature three morbid conditions are commonly described in connexion with it: a greatly enlarged heart; pericardial adhesions or excess of fluid, and lastly ballooning of the aorta. It would appear that in aortic cases it is best developed in those cases where with great enlargement of the left heart compensation, though for the moment sufficient, is in a state of instability. In Fig. 1 tracings are shown from the H.A.B. and superficial temporal arteries of a patient aged 30, with free aortic regurgitation, poor compensation, great cardiac enlargement, and a fair degree of arterio sclerosis.

* The association of this pulse with great left cardiac enlargement is suggested by its frequency in aortic disease.

† This statement is based on actual measurements of tracings, in time intervals, employed to check impressions received by palpation.

§ All the cardiograms were taken with the Dudgeon's sphygmograph, that a fairer comparison might be instituted between them and the corresponding sphygmograms.

In Fig. 2 tracings are given from the left radial and left superficial temporal of a patient, aged 35, who died in hospital of aortic disease. The pulsus bisferiens was easily palpable and visible, and the physical signs were those of free regurgitation and great cardiac enlargement. The type of pulse was not so well developed on the right side. *Post mortem* the per-

Fig. 2.—Left radial and left superficial temporal arteries.

cardium contained excess of fluid, and the heart weighed 32 oz., the enlargement being chiefly left-sided. The muscle substance was firm. The aorta was dilated, the valves sclerosed and calcareous, but though regurgitation was free, there was little stenosis. The arteries showed considerable sclerosis. The type of pulse remained practically the same

Fig. 3.—Cardiogram and right radial artery.

during the two months during which the patient was under observation.

Fig. 4 shows a cardiogram and the right radial pulse of a woman admitted for double aortic and double mitral disease. Compensation was poor and the heart greatly enlarged; there was a fair degree of arterial thickening.

Fig. 4.—Cardiogram and right radial artery.

The chief point of note in these tracings, all bisferiens to the finger, is the striking resemblance between cardiogram and pulse tracing. Although in several the second wave of the cardiogram is more prolonged than that of the pulse, yet the general type is the same, and the commencement of the second wave occupies the same time relation to the first in both. This is of considerable importance, for it proves the central origin of the second wave, whether this wave be considered as having its origin in the same manner as the normal "predicrotic" or not. A point which is difficult to settle is whether the second wave has its origin in the ventricle or in the aorta, as Marey⁹ held. In many of these cases there is a visibly double impulse at the apex, notably in the case whose tracings are shown in Fig. 2. This physical sign has apparently been much neglected. Occasionally it is accompanied, as in this case, by reduplicated first sound at the apex, a point of importance in consideration of the views of D'Espine.⁴

Fig. 5 shows a typical pulsus bisferiens from a patient aged 60, in whom there were no signs of aortic valvular disease, but general arterial disease and high blood pressure (160 mm. Hg). The H.A.B. was in the sixth space, 6½ in. from the middle line. There was a past history of syphilis. Fig. 6 shows an aneurysmal, and left radial tracing, from a patient with no signs

Fig. 5.—Right radial artery.

of aortic regurgitation, but an enlarged heart and pointing thoracic aneurysm. The tracing is of interest in connexion with the fact that dilatation of the aorta is commonly asso-

Fig. 6.—Aneurysmal tracing and left radial pulse.

ciated with this type of pulse. There was a fair degree of arterial sclerosis.

Passing to the second type of double pulse, it is illustrated in Figs. 7 and 8.

Fig. 7.—A, Right jugular vein; B, cardiogram; C, right superficial temporal artery; D, right brachial artery; E, right radial artery.

Fig. 8.

A patient, aged 52, suffering from emphysema and general bronchitis, was admitted a few weeks before his death with cyanosis and dropsy. The pulse and H.A.B. were very dis-

tinctly double. The H.A.B. was in the fifth space, 6 in. from the middle line. At the apex the first sound was reduplicated; there were no murmurs. The systolic blood pressure was on an average 170 mm. Hg. *Post mortem* the pericardium was normal, the heart weighed 24 oz., and the muscle substance was firm. The arteries showed little or no degeneration although the left heart was chiefly enlarged; mitral and tricuspid rings were dilated. The tracings from H.A.B. and three arteries show the same time relations throughout. The possibility of the second wave being of dicrotic origin is negatived by this, and by the fact that the second wave reached the superficial temporal artery before the second sound was audible.

The tracing shown in Fig. 7, A, was taken by means of a light straw lever from the jugular vein. It shows the single auricular impulse preceding the double beat of the carotid. The tracing excludes the possibility of a double auricular beat.

Fig. 8 is from a case of severe mitral stenosis of rheumatic origin in a lad, aged 21. He was admitted with marked cyanosis and dropsy, and a large wavy double heart impulse over the fifth to seventh spaces extending 7 in. from the middle line. The blood pressure varied from 90 to 117 mm. for different beats, the pulse being irregular. Originally the pulse was interpreted as dicrotic, but more careful examination proved it to be of the bisferient type, for the second sound was audible an instant later than the upstroke of second wave, also the dicrotic wave is apparent in the last half of each curve.

The type of *pulsus bisferiens* described in the last two cases is uncommon, and is worthy of more attention. No account of it has been found in the literature; possibly it has been mistaken for dicrotism. The type is very different from that depicted in an earlier part of this contribution, and it is notable that in both cases it was unassociated with arterial sclerosis. The cases strongly support the hypothesis of the *deux temps* beat of the ventricle, advocated by D'Espine⁴; it is indeed the only rational interpretation of the tracings. As two cases alone have been met with, it is not possible to draw any further conclusions as to its origin or prognostic significance. Its recognition is of importance in that it is indistinguishable from a dicrotic pulse by palpation.

In conclusion, there appears only one constant relationship with the *pulsus bisferiens*, and that, a greatly dilated and hypertrophied left ventricle; there appear to be two types, the one associated the other unassociated with arterio-sclerosis.

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ON THE PART PLAYED BY THE CALCIUM SALTS IN THE BLOOD AND TISSUES,

WITH SPECIAL REFERENCE TO THEIR INFLUENCE IN REGARD TO THE FEMALE GENITAL FUNCTIONS; TOGETHER WITH A DESCRIPTION OF A SIMPLE METHOD OF QUANTITATIVE ANALYSIS.

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[PRELIMINARY COMMUNICATION.]

A YEAR ago I made a short communication,¹ based entirely on clinical observation, in which I expressed my belief that the uterus took an active part in the genital functions of the female, and was not merely a passive receptacle for the fertilized ovum. I then stated that I looked upon the uterus as an organ whose glands secreted some substance which, for the want of a better or more accurate name, I called "uterin," and which, when in excess, was excreted, producing in some way the menstrual cycle. I further stated that "uterin" circulated in the blood, and produced many of the phenomena common to women, such as the manifestations of the menopause.

Since that time I have been following out the lines of investigation then suggested, and although in this preliminary communication I can only indicate briefly some

of the results obtained, I shall describe fully the method by which I have been able to demonstrate them, and point out in what directions these investigations open up possibilities for further research in branches of medicine other than that in which I am specially interested. Much of this is already in hand, and will I hope be carried out by those who are more competent to deal with it than I am.

It was only after much thought that an explanation of the probable nature of the substance secreted by the uterine glands dawned upon me. Finding no clue from a chemical consideration of the phenomena associated with the function, I turned my thoughts to comparative physiology, and there at once I found the explanation I was seeking—the oviducts of birds secrete calcium salts. Why should not those of the higher animals do likewise?

The more I thought the matter over the more it seemed to fit in with many of the hitherto inexplicable phenomena to be daily observed by any one dealing with women. To take but one example: During lactation, when the woman is giving away to her infant large quantities of lime salts in her milk, the menstrual function is normally in abeyance.

So far I had only the hypothesis, and in my attempt to obtain definite proof I was confronted with a serious obstacle: There was no known method for estimating small quantities of calcium salts in the blood, secretions, and tissues. At least a litre of blood would be necessary for incineration and analysis; even then only a very skilful chemist could be relied upon to give an approximately accurate estimate.

It was necessary, however, to have a method at once simple and accurate that could be used for clinical investigation. I have therefore devised the following, whereby in about half an hour I can calculate the amount of calcium in any solution, in however small a quantity it may be present.

Method as Applied to Blood.

A small capsule (Fig. 1) containing 250 c.mm. of oxalic acid (1 in 30 aqueous solution) sealed at the end of the stem is taken to the bedside of the patient whose blood is to be examined.

N.B.—In Fig. 2 the drawing should show a longer stem between the rubber ball and the largest bulb. This stem should also be marked to indicate the 500 c.mm. level.

When all is ready the stem is broken at the mark A, care having been taken first to shake all the oxalic acid solution into the bulb, and the finger or lobe of the patient's ear pricked; 100 c.mm. of blood are then drawn into a graduated pipette (Fig. 2), and immediately emptied into the oxalic acid by passing the fine stem of the pipette down the neck of the capsule. The stem (or neck) of the capsule is then sealed. The contents on shaking become uniformly chocolate-coloured, and the blood is laked. After ten minutes this mixture is ready for further dilution, but if necessary the final processes may be left over for some hours, although the sooner they are carried