STUDIES OF THE RELATIONSHIP BETWEEN ATMOSPHERIC PHENOMENA AND HUMAN PHYSIOLOGY *

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The question of relationship between solar and atmospheric phenomena and human physiology has always been interesting to the physician and biologist, and has frequently been discussed by them from many angles.

Petersen and Berg [1] and Franke [2] have confirmed the coexistence of the passage of low atmospheric pressure and temporary human leucocytosis. Mills [3] has made an able study of the relationship between the atmosphere and pathology. Haldane, Kellas and Kennaway [4] and Yaglou [5] and Yaglou and Dokoff [6], respectively, have fundamentally studied the skin as a register of atmospheric changes. Eduardo d'Alessandria [7] has made notable observations on the lipopexic and lipodiuretic functions of the lung in relation to low pressure, and Franke [2] has called attention to eosinophilia in conjunction with atmospheric phenomena.

I

RHYTHMIC CHANGES OF BLOOD PRESSURE IN MAN UNDER INFLUENCE OF ATMOSPHERIC PRESSURE.

From October 1931 to September 1932, we studied the semidaily fluctuations of the systolic and diastolic curves of 46 individuals, a sum total of 4,560 readings being made during that time. In some cases the examinations for blood pressure were made twice daily for 6 months, in others for 3 months, and in the remainder for a shorter period. The majority of examinations were made at the same hours daily—at 11 a. m. and at 4 p. m.—but some readings were made four times in the 24 hours.

The results tallied in the following particulars: The systolic blood pressure increased in rhythm and cycle as the

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** In the interim between receiving and publishing this article, further experiments have been carried into 1933.

barometric pressure decreased, and descended markedly on rapid barometric ascent; variations in blood pressure were observed in each individual case, and the difference was found to be more marked during the period of low atmospheric pressure than during that of high. The fact that the semi-daily periodic "highs" and "lows" are followed inversely by the rise and fall of the blood pressure, we believe to be an attribute of the Tropics.

The term "rhythm" refers to the regular daily periods of rise and fall, and "cycle" to those repeated groups of days on which the successive rise and fall take place.

The April and October low pressures exert marked influence on the human blood pressure; October, however, is accompanied by higher temperatures, humidity, and electrical potential, which cause greater variations in blood pressure than will be found in April. Furthermore, should any of the October "lows" be of marked intensity, the blood pressure charts would show still wider fluctuations, an irregularity which might also take place in any of the other hurricane months, i: e: July, August and September.

Low blood pressure in Puerto Rico is always noticeable from the end of November to the beginning of March—being in inverse ratio to the high barometric pressure of these months. We must note, however, that these blood pressures do not vary so much in "lows" during these months as they do in "highs" during the above mentioned days of April and October.

With the approach of a cyclone the blood pressure rises gradually and proportionally to the fall of pressure until the passing of the vortex, at which crisis physical malaise is sometimes felt, such as *tinnitus aurium*, palpitation, etc.

In people who suffer from an obstructive heart lesion, a decompensated condition may occur during high atmospheric pressure, while in those suffering from regurgitant heart pathology, persistent oppression is noted during low atmospheric pressure. Cardiac decompensation is aggravated by heat, damp, and electrically charged atmosphere.

II

RHYTHMIC CHANGES IN THE TOTAL LEUCOCYTE COUNT AND THEIR RELATION TO BAROMETRIC CHANGES.

From the 8th to the 11th of September, 1931, some experiments were made which showed that the nearby passage of

a tropical cyclone, lowering the barometer below 29.90″, caused an increase of white cells in the peripheric circulation. The oscillation of the white blood count so far surpassed the normal limits that the findings were considered of sufficient interest to be published in the local press.

During 1932, and up to the present time in 1933 **, these experiments have been continued in a detailed and careful manner, and the results of the work have agreed with those obtained in 1931, the point at issue being examined not only during "lows", when the barometer stood lower than 29.90″, but also for normal weather.

The results may be summarized thus: The total leucocyte count increases each time the barometric pressure goes lower than 29.90″, the leucocytosis being more marked if conditions are intensified by increased temperature, relative humidity, and electrical potential (See Graphs I and II). This barometrical leucocytosis at times surpasses the maximum limits which leucocytosis naturally reaches when produced by digestion, exercise, baths, etc.

Terror and emotion (stimulants of leucocytosis) contribute to precyclonic reaction—quite naturally, when we realize that the mere official warning of a hurricane augments the white cell count in persons of nervous temperament. However, when people who were unaware of the threatened catastrophe were tested, it was found that their leucocyte count was also relatively high.

During the year 1932, five or six cyclones passed near to Puerto Rico. One of them, on September 26th, struck us with full intensity, but the others only evidenced their existence and proximity by a low barometer. As far as our experiments reach in the present year, 1933 **, we have had nine cyclones, six of which have shown their influence on the subjects of observation, verifying again the accuracy of results already obtained, i:e: that the fall of the barometer below 29.90″ produces an increased leucocytosis in all people in this radius, this increase going no further than a certain limit which nearly always concurs with the minimum reading of that "low".

We can class this "barometric" leucocytosis thus:

1. Oscillating leucocytosis, rhythmic, semi-diurnal, almost imperceptible, concurrent with the rhythm of the semi-diurnal low barometer of 4 a. m. and 4 p. m.

2. Moderate leucocytosis during the normal low pressure of April and October, more noticeable in the daily 4 p. m "lows" than in those of 4 a. m. This, transitory in its nature, keeps a synchronism of hour and cycle, ascending and descending, respectively, which corresponds with the months of the year and the exact relation to the approach, lowest register, and departure of the barometric "low".

3. Marked physical leucocytosis of 12,000 to 14,000 leucocytes, which occurs with the approach of a barometric "low", the count being at its highest during the passing of the vortex, and returning to normal with barometric reestablishment.

III

RHYTHMIC CHANGES IN THE DIFFERENTIAL COUNT OF EOSINOPHILS IN THE HUMAN PERIPHERIC BLOOD AND THEIR RELATION TO ATMOSPHERIC PHENOMENA.

On August 31, 1932, some experiments in the differential count of eosinophils were made during an eclipse of the sun. The results of these experiments were compared with the results obtained on the two ordinary days preceding and following that of the eclipse. It was found that on each day at 4 a. m., irrespective of the eclipse, there was a noticeable increase in the eosinophils. The observations were again made in January, 1933 **, with the purpose of seeing whether or not the results of the previous experiment had been determined by the meteorological phenomena, and the same results were arrived at.

The subjects used for the previous and current years were divided into two distinct groups, and were normal in every way. In both sets of subjects a marked rise in the differential count was noticed each day at 4 a. m., and in nearly all the subjects at 4. p. m.; this phenomenon appears to follow a rhythm and a cycle governed by the hours and days above mentioned. However, the individual percentage of increase was variable; in some cases moderate, in others violent and rapid—in fact, it reached 71 per cent on one occasion. It was observed that the morning ascent was higher and more abrupt than that of the afternoon.

Although the rhythm and cycle seemed to be co-existent, the synchronism did not exist between the cycles of individuals of the same group, sometimes discrepancies of a day being

noted between one person and another. Thus it appears that the motive powers which activate the rhythm may be more stable and insistent than those which activate the cycle. Doubtless there are other contributing causes to this eosinophilic rise and fall, such as difference in individual type, which seems to vary the cycle, although not the rhythm.

The graphs may give more explicit information:

In No. I the ascent in the differential count is observed in four individuals. It can be seen that this occurs in all the cases at 4 a. m.; one case guaranteed free from parasites after repeated tests evidenced as high as a 71 per cent eosinophilia. Case No. 4 is exceptional in that a "low" was registered at 4 a. m. on the 14th of January.

In Graph No. II we can see a study of the differential count made in the blood of two nurses, whose daily work on this occasion took place during the night. For the first two days the rhythm shows lack of equilibrium, doubtless caused by the abrupt change in the hours of work.

In No. III we see the observation made during the day preceding the eclipse of the sun of August 31, 1932, and also during the day itself. In this one may see the rhythm of 4 p. m. in comparison with that of 4 a. m.

In No. IV is shown the proof of the early morning rhythm. Case No. 2 from Graph III has been selected with a special motive, as from it one may gather the visual evidence of this oscillating rhythm.

It is interesting to note that this synchronism of rhythm and cycle, which we have frequently mentioned, does not exist in temperate climates, but falls and rises as irregularly as the barometer in those regions.

Another coincidence of physical and atmospheric action is that the chief eosinophilic rise takes place after hours of accumulated darkness—4 a. m. This being so, it would seem contradictory to expect the lesser rise to take place at 4 p. m. during the intense heat and light of the day—but we have found that most of our subjects of experimentation, and indeed, nearly all inhabitants of the Tropics, either sleep during that hour, or withdraw themselves into darkened rooms, such as one finds in the colonial houses of old San Juan. In our exploration of this phenomenon, we must also take into account the eosinophilia caused by digestion, sleep, and other causes more remote.

Finally we may note one more coincidence: the existence of a semi-daily terrestial magnetic rhythm in the oscillating curve traced by the magnetic needle. These fluctuations follow a descending rhythm which is marked between 8 a. m. and 12 m., and an ascending one from 12 m. to 2 p. m. On the other hand, the maximum in the eosinophilic rhythm which marks the eosinophilic curve at 4 a. m. and 4 p. m. daily, agrees with the average period of "magnetic quietude".

IV

TRANSITORY PHYSIOLOGICAL UNBALANCE CAUSED BY THE SHADOW OF A SOLAR ECLIPSE

On August 31, 1932, we observed in Puerto Rico a partial eclipse of the sun between 4 p. m. and 6 p. m. On the day before, during, and the day after the eclipse, we made the following observations:

The blood pressure fell by degrees, following the course of the eclipsing shadow—not, however, step by step, but lagging a few minutes behind, so that the blood pressure reached its lowest level a few minutes after the maximum shadow, and resumed its normal level a few minutes after the sun became unobscured. The influence of the eclipse was felt in a definite manner, even though at the moment of observation the barometer was low. In the moment when this eclipse was being observed in San Juan, a cyclone was passing about 100 miles to the north, and the barometer was very low—29.75″ without correction—in fact, low enough to have caused the blood pressure to pass the highest limits it may reach under such conditions; yet, as an effect of the simultaneous eclipse, it remained consistently low in each of the 8 persons examined. It would therefore appear that the transitory effect of a solar eclipse exerts a far greater influence on the human blood pressure than the more enduring barometrical "low".

Another curious phenomenon observed in these same 8 individuals under observation, was a leukopenia which descended to its minimum point, following the invading shadow of the moon in direct ratio to the progress of this shadow, and ascending again to a normal level with the passing of the eclipse. The curve, however, lagged 5 minutes behind the shadow.

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Graph No. V shows three interesting things: First, the leukopenia of three of the four cases was well marked towards the period of the maximum shadow of the eclipse, although the low barometer—29.75″ without correction—would at this hour naturally work as an agent of leucocytosis, had it not been for the eclipse; second, the rising leucocyte count in all four cases, in two of them showing a true leucocytosis, a natural thing in the presence of a low barometer, which up to this hour, 5 p. m., on this day worked unhindered by the influence of the eclipse, rising again higher when it passed; third, the leukopenia was noticed at 4 p. m. in all 8 persons examined.

Graph No. VI shows the low blood pressure in those examined at the moment of the eclipse, and the rise after it had passed.

SUMMARY

An account is given of research work on the influence of meteorological phenomena (normal and abnormal barometric fluctuations and an eclipse) on the physiology of humanity, as evidenced by blood pressure readings and the total and differential counts of leucocytes.

From the experiments it would seem that: Blood pressure falls when high atmospheric pressure occurs; blood pressure increases with the advent of a barometric "low", and returns to its initial point with the establishment of normal conditions; the leucocyte count rises gradually on the peripheral circulation during these three barometric lows: The semi-daily of 4 a. m. and 4 p. m., the yearly of April and October, and the abnormal, as in cyclonic weather; there is a daily leukopenia at 4 a. m.; the eosinophilic count rises in accordance with the above mentioned conditions at 4 a. m. and 4 p. m. daily; an eclipse was found to lower the blood pressure and total leucocyte count; when the opposing influences of the eclipse and the abnormal barometric "low" were exerted simultaneously, that of the eclipse was the stronger.