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ON THE
EPIDEMIC MALARIAL FEVER OF ASSAM
OR
KALA-AZAR

BY
LEONARD ROGERS, M.D., M.R.C.P., B.S., F.R.C.S.
INDIAN MEDICAL SERVICE

[From Volume 81 of the 'Medico-Chirurgical Transactions']

LONDON
PUBLISHED BY THE ROYAL MEDICAL AND CHIRURGICAL SOCIETY
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THE disease known in Assam under the name of Kála-azár, or Black Fever, has excited attention in India during the last fifteen years. It was first described in the sanitary report of Assam for the year 1883, when it was mentioned as "a malarial cachexia produced by malarial fever, deriving its peculiar characteristics from the nature of the region where it prevails, and having a singular tendency to run rapidly into the cachexial stage." It was also recorded at this time that according to popular opinion the disease was contagious, and that large tracts of country were being depopulated by it, chiefly in the Terai region at the foot of the Garo Hills. During the next two or three years the disease

spread into the neighbouring district of Goalpara, and then into the Kamrup district still further to the east. Up to this time every medical officer who had seen the disease was of the opinion that it was malarious in its nature, but its steady spread eastward year by year, and its appalling mortality, made some doubt whether there was not some other factor besides malaria in the disease. As anæmia caused by the *Anchylostomum duodenale* had also been recently found to be very prevalent on tea-gardens, more especially in the easterly parts of the Assam valley under the name of beri-beri, Surgeon-Major G. M. Giles, of the Indian Medical Service, was deputed by the Government to investigate and report on both diseases. He began work at about the end of November, 1889, and finding the anchylostomum both in cases of kala-azar and in the so-called beri-beri, while fever was in his experience an inconstant feature of the former disease, he came to the very natural conclusion that both diseases were essentially due to this worm, and only differed in that kala-azar was more frequently complicated by malaria. During the rainy season he worked in Shillong, the hill station of Assam, at the life history of the parasite.

Unfortunately he omitted to examine healthy people for the parasite, and he only worked in the plains during the cold weather season, when, as I shall show presently, such cases of kala-azar as survive the rainy season lose their fever, only too often for it to recur again during the next rainy season, so that he never saw the disease during the season of its greatest activity. Moreover, it was subsequently proved, chiefly by Dr. Dobson, also of the Indian Medical Service, that over 80 per cent. of healthy coolies, imported into Assam from various parts of India, harbour the anchylostoma in numbers varying from units to hundreds. As the disease continued to spread slowly some ten or fifteen miles a year into new districts in a wave of increased fever mortality, it was decided to have the question re-investigated, and I was fortunate enough to be selected for the task, and com-

menced work in the Nowgong district in April, 1896, and presented my report just one year later.

The problem which presented itself for solution was as follows—(1) was the disease anchylostomiasis alone? or (2) was it purely malarial, and if so how was its steady spread to be accounted for? or (3) was it a combination of the two former, the presence of the intestinal worm accounting for the spread of the disease? or (4) was it wholly or in part due to some hitherto undiscovered cause? The third opinion, that it was a mixture of malarial fever and anchylostomiasis, was apparently the view which was most commonly held, at least outside Assam itself.

The first thing to be done was to try to find out what part, if any, the anchylostomum and malaria respectively played in the causation of the disease. It might appear at first sight that the fact which has been already mentioned, namely, that the anchylostoma are found in larger or smaller numbers in a large percentage of healthy natives of Assam and other parts of India, alone throws great doubt on their being the cause of kala-azar in the absence of evidence as to the numbers found in the latter disease; but it was argued by the upholders of the worm theory that even if few or no worms are found in the later stages of, or after death from, kala-azar, yet they may have been present in larger numbers in the earlier stages of the disease; and although it is generally allowed that about 500 of these blood-sucking worms must be present in the small intestine for from six months to a year in order to cause marked anæmia, yet it is very difficult to prove that large numbers of the worms have never been present in given cases of kala-azar, which disease usually lasts from four to nine months, and may occasionally run on for two years. Fortunately a way of overcoming this difficulty was found in an examination of the type of the anæmia in the two diseases. It occurred to me when reading up the literature of the subject that an anæmia

produced by a steady drain of small quantities of blood day by day, such as is produced by the anchylostomum, would differ from that found in chronic malarial fever, in which the red corpuscles are destroyed in the blood by the amœba of Laveran. As I was not able to find any very full account of the quantitative changes in the blood in these two diseases in the scanty literature within my reach, I determined to make an examination for myself with the aid of the hæmocytometer, hæmoglobinometer, and Lloyd Jones' instrument for estimating the specific gravity of the blood, with the result of showing that the anæmia of kala-azar differed so widely from that of anchylostomiasis that, given a drop of blood from typical cases of each disease, a correct diagnosis could be made. The following table shows the differences at a glance, and also the close agreement of the type of anæmia in the cases of kala-azar and that of ordinary malarial cachexia in a district which was not affected by this scourge, all being compared with the blood of healthy natives of Assam, as their standard differs greatly from the European one according to Sir Wm. Gowers' instruments.

The Blood in	Percentage of hæmoglobin.	Red corpuscles per cubic millimetre.	White corpuscles per cubic millimetre.	Ratio of white to red corpuscles.	Specific gravity of blood.	Hæmoglobin in each red corpuscle.
(1) Healthy natives of Assam	62	4,734,000	7,325	1 : 684	1·054	·65
(2) Kala-azar cases... ..	33·45	2,462,000	2,600	1 : 1,170	1·048	·65
(3) Ordinary malarial cachexia	31·6	2,000,000	1,600	1 : 1,400	1·042	·73
(4) Anchylostomiasis	15·2	2,145,000	5,338	1 : 524	1·034	·31
(5) Mixed cases of malaria and anchylostomiasis	27·4	3,120,000	3,200	1 : 975	1·039	·43

In the first line the average blood of healthy Assamese is given, from which it will be seen that although the

red and white corpuscles average about the normal number, yet the percentage of hæmoglobin averages only 62 per cent. of Gowers' standard, and consequently the average amount of hæmoglobin in each red corpuscle or the hæmoglobin value or colour index is only '65. I also ascertained the interesting fact that seven Europeans living in Assam only average 71 per cent. of hæmoglobin during the hot and rainy seasons, but improved by some 10 per cent. during the healthy cold weather.

The second line shows the average blood of a large number of cases of kala-azar, and it will be noticed that there is marked reduction of both the red corpuscles and of the hæmoglobin, but in equal proportions, so that the hæmoglobin value is the same as in healthy Assamese. The specific gravity of the blood averaged 1·048, being somewhat below normal; while the number of the white corpuscles are markedly reduced both absolutely and relatively to the red, so that the average proportion was 1 white to 1170 red.

The third line shows the average condition of the blood in cases of ordinary malarial cachexia in a part of Assam which was unaffected by the epidemic disease, and it will be observed that in all respects it resembles that of the kala-azar cases. The figures given by Cabot in America, and Waddell in India, confirm my results on this head.

The fourth line shows the average blood-state of cases of anchylostomiasis examined by me. It will be seen that the anæmia in these cases was more extreme than in those of kala-azar, but of much greater importance is the marked difference in its type. The differences are, firstly, in the relatively greater decrease of the hæmoglobin as compared with the reduction of the number of the red corpuscles, so that the hæmoglobin value only averages '31 or less than half what it was in kala-azar; secondly, while the white corpuscles are absolutely reduced in numbers, relatively to the red they are increased, being in the proportion of 1 to 524; and thirdly, the

specific gravity of the blood is reduced to the very low average of 1.034, and it may at once be said that these differences are so uniform in different cases that the two diseases can be completely differentiated by their means. Sandwith, of Cairo, also found a very low hæmoglobin value in 173 cases of anchylostomiasis. In the last line is shown the average blood-state of four cases in which kala-azar was complicated by considerable numbers of anchylostoma (from 80 to 120), and it will be seen that the figures are intermediate between those of the two primary diseases.

The differences found are, moreover, just what might have been expected, for in the case of chronic malarial fever the hæmoglobin is not lost to the body, but is stored up in the liver, spleen, &c., in the form of a pigment containing iron, which can be utilised to re-form hæmoglobin to stock the red corpuscles which are being formed in the bone marrow, so that the hæmoglobin value of each corpuscle does not fall. It may be mentioned here that I found the yellow marrow in the shafts of the long bones to be constantly converted into red marrow in fatal cases of kala-azar, just as occurs in pernicious anæmia. The white corpuscles become gradually reduced in the course of their long fight with the malarial parasites, but a temporary relative leucocytosis occurs during actual fever. On the other hand, in anchylostomiasis the constant drain of hæmoglobin from the body, and the great difficulty in replacing it, causes the hæmoglobin value to fall as soon as the reserve iron in the liver becomes much reduced, as is very soon the case. The losses of the red corpuscles, and still more those of the white, are more easily replaced, and their averages remain comparatively high. The constant loss of albuminous and saline substances as well as of the hæmoglobin accounts for the remarkable diminution of the specific gravity of the blood in anchylostomiasis.

The above-described difference of the type of the anæmia found in kala-azar from that which is caused by

anchylostomiasis, together with the facts that in 83 per cent. of kala-azar cases I found less than twenty of the worms present during life—a number which I proved to have no effect on the blood of healthy natives,—and that there were fewer anchylostoma found post mortem in twenty-five fatal cases of kala-azar than were present in those who had died from accidental causes; prove conclusively that anchylostomiasis is not the cause, nor even a contributory cause, of the Assam scourge which is under discussion.

Having thus cleared the ground, it became necessary to determine the part played in the causation of the disease by malaria. I have already shown that the blood-changes are those of ordinary chronic malaria. Moreover I found that during the whole of the hot weather and rainy season, lasting from March to October, fever of an intermittent or remittent nature is present in this disease, with occasional intermissions of from a few days to a few weeks (see temperature chart). Again, the anæmia progressively gets worse during the fever periods, and improves somewhat in the intervals of apyrexia. The cases usually last from four to nine months, and are rarely fatal in less than three months; but with long intervals without fever in the dry cold weather the disease may last two years. Briefly, the disease is characterised by more or less constant intermittent or remittent fever, with marked general wasting of the body, but with great enlargement of the spleen and liver—the former organ averaging over 2 lbs. in weight post mortem,—accompanied in a minority of the cases by œdema of the feet, and always with more or less severe anæmia, great weakness, and often a darkening of the skin, from which the disease probably gets its name of black fever. Death occurs either from exhaustion due to the fever, or from a chronic form of diarrhœa due to atrophy of the mucous membrane of the small intestines and consequent loss of digestive power, or if the patient survives until the onset of the cold weather, pneumonia and other lung

diseases often carry him off. The general condition of the patients is well seen in the photographs which I pass round, and some of which are in my report. The seasonal incidence of the disease is of great importance, as I find that the great majority of patients begin their illness during the rainy season, especially from April to August, and during the dry cold months from November to February very few new cases occur. The season is that of the ordinary malarial fevers of Assam, only it is a somewhat more extended one.

The disease, moreover, is quite indistinguishable in its early stages from the ordinary malarial fever of Assam, and in its later stages it exactly resembles ordinary malarial cachexia. It is, however, characterised by its very great intensity, as shown by the fact that it may produce marked cachexia in as many months as the ordinary malarial fever of unaffected parts of Assam often takes years to produce, while it is very resistant to small doses of quinine, and is of so persistent and virulent a nature that among 200 cases on a tea-garden, where the cases had been treated throughout by an experienced European doctor—Mr. J. Dodds Price, to whom I am greatly indebted for much valuable assistance during the course of my investigation,—the mortality was 96 per cent. The other marked characteristic was the way in which it attacked large numbers of a family, which I can best indicate by the fact that in a series of cases in which I made a note of every member of the patient's near relatives who was alive, and every one who had died of the disease, I found that three quarters of my cases had lost half or more than half of their whole household. I have also seen the last of a family of thirteen, the other twelve having all died of the disease.

But I must pass on to the search for micro-organisms in the disease. Dr. Giles had previously failed to find any organisms which could be cultivated from the blood, or which could be stained in any of the organs after death. I also inoculated blood from the finger-tip and that

drawn from the spleen itself during life on agar-agar with negative results. Moreover, sections of the various organs were stained for bacteria, by various methods, by both Dr. Giles and myself, with negative results.

On the other hand, I examined a large number of cases for the malarial organisms and had no difficulty in finding the amœba of Laveran in all stages of the disease. As I expected to find some differences in those present in this peculiar form of fever from those of ordinary malaria, and hoped to be able to differentiate the two diseases by this means, a careful study of the forms met with was made in early stages of the disease, before marked changes had taken place in the blood. At the same time full notes were taken in shorthand of each case, and temperatures taken four times a day. A series of early cases of fever were thus examined, which could not as yet be said to be typical of kala-azar, but some of whom lived in houses inhabited by typical cases of the epidemic disease. After six or eight weeks they were all re-examined, and by this time many of them had recovered and were apparently only ordinary malarial fever, but others had become typical cases of kala-azar, with constant fever and cachexia. The notes and organisms of the two classes of cases were compared, but no definite differences could be detected. Moreover the organisms found in both groups were the ordinary forms, so well depicted in the plates in the Sydenham Society's translation of Italian works on malaria. They were also similar to those I had previously studied for many months in Bengal.

Again, the post-mortem changes were in all respects those of malarial cachexia, while there is not a symptom or a pathological change that I have found in kala-azar that is not met with elsewhere in malaria,—as, for instance, in the very full description of the disease as seen in Algeria by Kelsch and Kiener. Marked pigmentation of the liver, spleen, kidneys, &c., which is such a characteristic feature of malaria, was constantly found, which

under the microscope showed the same distribution as is figured in the work of the last-named authors, while an analysis of the amount of iron in the liver showed it to be increased. The disease, then, was entirely malarial in its nature, and only differed from ordinary malarial fever in its much greater intensity, its peculiar distribution in families, and its power of spreading.

The next point to be studied was the way in which the disease spreads from village to village and district to district, in order to determine if the disease is a communicable one; and if that proved to be the case, the origin of such a power in a malarial fever remained to be elucidated.

It will be well to say a few words on the ravages of the disease. It has already been mentioned that certain tracts of country have been depopulated by this scourge, but an idea of its ravages can be best conveyed by the figures of the census returns, and by the decrease in the amount of land under cultivation owing to the death of so many workers. Thus between the years 1881 and 1891 there was an increase of 19·36 per cent. in the inhabitants of that portion of the Goalpara district which lies north of the Brahmaputra River, and was very little affected by the epidemic fever; while in the affected southern part there was a decrease of 18·08 per cent. in the same period. In the Kamrup district, which was attacked only during the latter part of this decade, it was calculated that 75,000 persons died of this disease, out of a population of 644,960,—that is, nearly one eighth of the population; and here again the whole of the district was not attacked, and in the southern part there was a decrease of 12 per cent. in the population. In the Nowgong district, which has been attacked during the last decade, just about one fifth of the land which was previously cultivated is now untilled, with a corresponding loss of revenue, and the deserted tumble-down villages and patches of high jungle grass growing in recently cultivated fields testify more eloquently than any words to the terrible nature

of the scourge, which has probably carried off about one fifth of the population of an area extending over some two hundred and fifty miles in length, and varying from twenty to sixty in breadth, in the course of the last fifteen to twenty years. Moreover it is still spreading, with but little abatement of its virulence. It must, however, be mentioned that the disease passes over a district in the course of eight or ten years in a wave of greatly increased death-rate from fever, and then the mortality declines again, and the population of the Garo Hills, which was first attacked, is now once more on the increase.

The general course of the spread of the disease presents some points of interest. Thus it never spreads far up into the hills. The Garo Hills consist for the most part of low hills of from 500 to 1000 feet, with flat alluvial and marshy rice ground between them,—in fact, a typical terai. The higher central range reaches 4000 feet, but the disease affected this part but little. Again, the Kashia Hills, which run up to 6000 feet, were not invaded. The disease was for many years chiefly confined to a narrow tract of country between the hills just mentioned and the Brahmaputra River, and spread slowly eastward along the Grand Trunk road. In places where there was much traffic across the river it spread to the north bank, which with its many sandbanks is often five to ten miles in breadth; but as the more thickly populated parts on the north bank are separated from each other by large rivers and stretches of twenty miles or more of uninhabited jungle, it showed very little tendency to spread eastwards along the north bank of the river. When the disease reached Gauhati, a large town on the south bank of the river in the easterly part of the Kamrup district, with a great deal of traffic and intercommunication with other places east of it, the disease spread in different directions, but always along lines of communication. It now reached the wide district of Nowgong, and here it spread chiefly along the densely populated banks of the Kulung River *right away*

from in under the hills ; yet, although it ceased to be in any way a terai disease, it was none the less virulent. In short the disease has always spread along the lines of human intercourse, and has ceased to spread when a tract of uninhabited jungle obstructed it. Moreover the parts affected all have an alluvial soil, and it fails to get a footing far away from this up in the hills.

Coming now to the way in which it is carried from village to village, I may say as a result of walking several hundred miles, making inquiries in the affected districts, that the disease is carried by one person who has contracted the fever in an infected village, very often while on a visit to a relative, returning to his own previously uninfected village with the fever upon him, with the result that others of his household next are attacked during the ensuing month or two, after which the fever spreads to others in the village during the rainy season. During the next cold weather, when the ground is dried up, and little or no rain falls for three or four months, the cases of fever greatly decrease or disappear, only to break out again in the same villages and houses at the beginning of the next rainy season in March or April, when the ground is once more moist and warm, and so it goes on for from five to seven years until apparently all those who are susceptible have suffered from the disease, and not rarely as many as two thirds of the village have died, including a large proportion of the children. Nothing struck me so much as the way in which the ignorant villagers recognised the first cases of the disease that occurred amongst them as something much more virulent and fatal than the ordinary fever to which they were accustomed, and it became monotonous to hear the head man of a village, who registered the deaths, when asked how the disease began in his village, say, " Oh, such and such a man [naming him] came from such and such a village [which was an infected one] with the fever ; " he was the first, and his wife or one of his children was usually the second to suffer from it. Orphans whose parents had

died of the fever often introduced the infection into houses of relatives who took them in, either in the same or in a different village. Years ago the Garos were known to take a sufferer from the disease out into the jungle, make him comatose with drink, and burn him to death in the hut which they had erected for him, or else place food near him day by day and run away for fear of infection. I have myself seen a victim of the disease turned out from a village by her husband, while her own father was prevented from taking her into his house for fear of infecting the village in which he lived. Once more, I have seen a small village of Brahmins, who could hold no intercourse for caste reasons with those around them, remain free from the disease, although all the villages around them had suffered severely for several years. Again, in other cases I have seen one part of a village badly affected, while another part of the same village two or three hundred yards away, the people of whom had cut off all communication with the affected part, had entirely escaped. Such instances will be found recorded in my book, and they afford ample evidence that the disease is slowly communicable from man to man, either directly through the air, or more frequently, I think, after passage through the soil. But I must pass on to the origin of the epidemic. So far I had come to the conclusion that the disease was purely malarial, while it was certainly very intense and slowly communicable. It remained to be discovered how a malarial fever could have attained to such powers.

While looking up the literature of kala-azar before visiting Assam I was struck by its resemblance in its general features to the famous "Burdwan fever" epidemic of the fifties, sixties, and early seventies. In this case a very fatal form of an admittedly malarial fever spread from one district in Lower Bengal to another over a large tract of country for some twenty years, and carried off half a million of people in the Burdwan subdivision alone. I shall not discuss here the resemblances

of these two epidemics, as I have done so elsewhere ; but its observation made me at one time think that the two phenomena might be connected, and led to a study of the old Bengal reports which revealed the true origin of the mysterious kala-azar. In the first place I found that the so-called Burdwan fever was quite independent of the Assam epidemic, as it died out when it reached rising rocky ground on the west and north-west, and was checked when it encountered dry, porous, laterite soil in the south, and was never able to get any permanent footing away from alluvial soil.

On the other hand, I found there had been an epidemic of malarial fever in the early seventies in the Rungpore district of Bengal, which is only separated from the foot of the Garo Hills by the southward bend of the Brahmaputra River. This district is so very low-lying that it is to a large extent under water during the rainy season from June to September, and at this time the fever is at a minimum. When the country dries up after the rains are over, malarial fevers become very prevalent, and last for about three months. When the rains are steady and last late the autumnal fever has a short duration and low mortality ; but if the rains are short and unevenly distributed, so that the country, which is under water in July, partially dries up, say in August, the fever becomes very prevalent, and its season is much extended, with a resulting heavy mortality. Now between the years 1872 and 1877 there was an extraordinary succession of five out of six years of very deficient and unevenly distributed rainfall, such as has not occurred before or since as far as I have been able to obtain the records ; and this was accompanied by a fever mortality which became increasingly great each successive year, except the one in which the rainfall was normal, in which the fever rate slightly declined. The mortality was so great that there was a decrease in the population of the Rungpore district between the two censuses of 1872 and 1881, just as there was in each district of Assam which

was subsequently invaded. The fever was also recorded as having been more frequently remittent in character, and had a much longer seasonal prevalence, showing an increased intensity of the disease; and in 1875 it was noticed as being especially severe in six areas, all of which were situated on the eastern side of the district, including the low banks and islands of the Brahmaputra River, which takes it up to the foot of the Garo Hills.

Now, before I knew any of the details of the Rungpore outbreak, I visited the Garo Hills, and found from an examination of both the medical and administrative reports that the so-called kala-azar only appeared in an epidemic form, depopulating whole villages, in the year 1875, as evidenced by the fact that this was the first year in which the revenue, which took the form of a house tax, fell below the estimate, owing to the decimation of a group of villages by this disease, but from that date onwards its ravages have been recorded in the revenue reports year by year. Now this group of villages, and also another group fifty miles further north, which was attacked about the same time, are both exactly in the two lines of traffic between Rungpore and the foot of the Garo Hills, and the whole of the Assam epidemic has been traced year by year from this district, as is seen in the map which I show you, the figures in which represent the dates when each place was invaded by the epidemic. It will be noticed that 1875 is the very year in which the Rungpore epidemic fever was so bad on the banks of the Brahmaputra River. The inference obviously is that the epidemic began in Rungpore owing to an intensification of the ordinary malarial fever of that very malarious district, by the extraordinary succession of unhealthy years due to deficiency of the rainfall, until it attained to the power of spreading, and it then crossed the river and invaded the foot of the Garo Hills. Possibly the malarial organisms became intensified by the prolonged fever season allowing of their being rapidly passed through a

series of susceptible persons, but this point cannot be tested until the amœba can be cultivated. The facts, however, remain, and the analogous cases of such diseases as pneumonia and pestis minor, becoming occasionally intensified into epidemic pneumonia and virulent bubonic plague respectively, may be adduced in favour of the view that malaria may become intensified by extraordinary circumstances (as it were in nature's laboratory) until it attains to the power of spreading to other districts in the absence of physical or seasonal changes in those districts to account for its breaking out in them, and only limited by the necessity of a suitable soil, such as an alluvial one. It is very difficult to prove the introduction and spread of an epidemic malarial fever in a district which is already notoriously malarious, but in the case of the outbreak in Mauritius in 1865, in an island hitherto free from malarial fever, the disease appears to have been introduced by coolies from India, and it produced such a fearful epidemic that one third of the population are said to have died in four years, and the disease remains in a milder form to this day. Now it is worthy of note that this occurred during the height of the Burdwan fever epidemic in Bengal, and in the very districts from which coolies are exported from India. Further, it was noted that the form of fever in each instance was very similar. Now there is a good deal of evidence to show that the Burdwan fever was slowly communicable, just as I have shown the Assam malarial fever epidemic to be, so that it appears to be possible that the Mauritius fever was an instance of one of these Indian malarial epidemic fevers being imported into an island previously free from malaria, and spreading with a fearful virulence. Now let it be observed I do not say that all malarial fever is communicable, but only that it may become intensified until it becomes so, as in the case of pneumonia, and as most pathogenic germs which can be cultivated may be artificially intensified. Other epidemics of malarial fever in various countries might be mentioned which were pro-

bably of a similar nature to the Assam epidemic, but space does not permit. As I have been fortunate enough to have had a unique opportunity of investigating such an epidemic malarial fever in the light of recent pathological and bacteriological knowledge, I thought a brief account of my conclusions might not be without interest to this Society.

(For report of the discussion on this paper, see 'Proceedings of the Royal Medical and Chirurgical Society,' Third Series, vol. x, p. 110.)

DESCRIPTION OF PLATE VI.

On the Epidemic Malarial Fever of Assam, or Kala-azar
(LEONARD ROGERS, M.D.).

The numbers refer to the years of prevalence, and the parts
marked red to the distribution of the disease.





