

## XXVI. TUBERCULOSIS.

## I. GENERAL ETIOLOGY AND MORBID ANATOMY.

**Definition.**—An infective disease, caused by the *bacillus tuberculosis*, the lesions of which are characterized by nodular bodies called tubercles or diffuse infiltrations of tuberculous tissue which undergo caseation or sclerosis and may finally ulcerate, or in some situations calcify.

**Etiology.**—1. **Zoölogical Distribution.**—Tuberculosis is one of the most wide-spread of maladies.

In cold-blooded animals it is rare, owing doubtless to temperature conditions unfavorable to the development of the bacillus. Among reptiles in confinement it is, however, occasionally seen (Sibley). In fowls it is an extremely common disease, but recent facts indicate that there are differences in avian tuberculosis sufficient to warrant its separation from the ordinary form.

Among domestic animals tuberculosis is widely but unevenly distributed. Among ruminants, bovines are chiefly affected. The statistics of the Berlin abattoir show that in the years 1887-'88 tuberculosis was found in 4,300 cattle. In this country it is extremely difficult to get satisfactory statistics of the prevalence of the disease. At the meeting of the United States Veterinary Medical Association in 1889, it was stated in a resolution that from ten to fifteen per cent of the dairy stock of the Eastern States was tuberculous.

In Baltimore, A. W. Clement, United States veterinary inspector, informs me that of 5,297 cattle slaughtered in Maryland only 159 were tuberculous.

In sheep the disease is very rare. In pigs it is common, but not so common in this country as in Europe. In the inspection of one thousand hogs, which was made by A. W. Clement and myself in Montreal in 1880, tuberculosis was seen only once or twice. At the Berlin abattoir in 1887-'88 there were 6,393 pigs affected with the disease.

Horses are rarely attacked. Dogs and cats are not prone to the disease, but cases are described in which infection of pet animals has taken place from phthisical masters. Among the semi-domestic animals, such as the rabbit and guinea-pig, the disease under natural conditions is rare, although these animals, particularly the latter, are extremely susceptible to the disease when inoculated. Among apes and monkeys in the wild state, tuberculosis is unknown, but in confinement it is the most formidable disease with which they have to contend.

The important etiological fact in connection with tuberculosis in animals is the wide-spread occurrence of the disease in bovines, from which class we derive nearly all the milk and a very large proportion of the meat used for food.

2. **Geographical Distribution.**—The disease exists in all countries. It

prevails more in the large cities and wherever the population is massed together. Thus, while the general death-rate from it is three per thousand, that of Vienna is 7.7, and of Munich and Glasgow four per thousand. Hirsch, from whose classical work these facts are taken, thinks that geographical position has less influence than has been supposed. Italy and England suffer alike, and the disease is very prevalent in the West Indies and the South Sea islands. Toward the poles it is rare. It is a common disease in Canada, and prevails extensively among the French Canadians and the English. Altitude is a more potent factor than latitude. In the high regions of the Alps and Andes, and in the central plateau of Mexico the disease is very rare. Mountainous countries, such as Switzerland, have a very low death-rate from tuberculosis.

3. **Race.**—No race is immune. The Indians of this continent are very prone to the disease. Matthews, whose experience with the native race is large, states that the disease is on the increase among them. He quotes the ratio from the United States census, 1880, as white 166, negroes 186, Indians 286. The death-rate in the older reservations, as in New York, is three times as great as in Dakota. In the Blood Indian Reserve of the Canadian Northwest Territories, Surgeon Kennedy (N. W. M. P.) has given me the figures for six years. In a population of about 2,000 there were 127 deaths from pulmonary consumption, twenty-three per cent of the total rate. This does not include deaths from "diseases of infancy." This enormous death-rate, it is to be remembered, occurs in a tribe occupying one of the finest climates of the world among the foot-hills of the Rocky Mountains, a region in which consumption is extremely rare among the white population, and in which cases of tuberculosis from the eastern provinces do remarkably well.

The negro race is very susceptible to tuberculosis, more particularly the glandular and osseous forms. Of the 427 cases of pulmonary tuberculosis at the Johns Hopkins Hospital for the two years ending June 1, 1891, there were 41 cases in the colored—i. e., about 1:10. The ratio of colored to white of all patients in the wards has been 1 to 7.

4. **The Bacillus Tuberculosis.**—The history of the discovery of the bacillus presents many points of interest. Confidently expected by such observers as Villemin, Chauveau, Cohnheim, and others, and claimed to have been demonstrated by many, notably by Klebs and Aufrecht, it remained for Koch to demonstrate its existence and its invariable association with the disease. The investigations which he had previously made upon anthrax and experimental traumatic infections, by perfecting the methods of research, paved the way for this brilliant discovery. His preliminary article\* and his more elaborate later work† should be carefully studied by any one who wishes to appreciate the value of scientific methods. It forms

\* Berliner klinische Wochenschrift, 1882.

† Mittheilungen a. d. k. Gesundheitsamte, Bd. 2.



one of the most masterly demonstrations of modern medicine. Its thoroughness appears in the fact that in the nine years which have elapsed since its announcement the innumerable workers at the subject have not, so far as I know, added a solitary essential fact to those presented by Koch.

*Morphological Characters.*—The tubercle bacillus is a short, fine rod, often slightly bent or curved, and has an average length of nearly half the diameter of a red blood-corpuscle (3 to 4  $\mu$ ). When stained it often presents a beaded appearance, which some have attributed to the presence of spores.

With the basic aniline dyes it stains slowly, except at the body temperature, but retains the dye after treatment with acids—a characteristic which separates it from all other known forms of bacteria, with the exception of the bacillus of leprosy.

*Modes of Growth.*—It grows on blood-serum, glycerin-agar, or on potato—most readily on the former. The cultures must be kept at blood-heat. They grow slowly, and do not appear until about the end of the second week. The colonies form thin, grayish-white, dry, scale-like masses on the surface of the culture medium. Successive inoculations may be made from the cultures, and at the end of an indefinite series material from one of them inoculated into a guinea-pig will produce tuberculosis.

*Products of the Growth.*—Little is yet known of the chemical characters of the materials which result from the growth of the tubercle bacilli. Koch's tuberculin is stated to be a glycerin extract of the cultures. Crookshank and Herroun have separated an albumose and a ptomaine.

*Distribution of the Bacilli.*—The bacilli are found in all tuberculous lesions; in some in great abundance, in others sparsely. They are particularly numerous in actively developing tubercles, but in the chronic tuberculous processes of lymph-glands and of the joints they are scanty. When a tuberculous focus communicates with a vein or with lymph-vessels, the bacilli may be spread widely throughout the body. In old lesions they may not be found in the sections, and the demonstration of the true nature may be possible only by culture or inoculation.

*The Bacilli outside the Body.*—Patients with advanced pulmonary tuberculosis throw off in the expectoration countless millions of the bacilli daily. Some idea of the extraordinary numbers may be gained from the studies of Nuttall.\* From a patient in my ward, with moderately advanced disease, the amount of whose expectoration was from seventy to a hundred and thirty cubic centimetres daily, he estimated by his method that there were in sixteen counts, between January 10th and March 1st, from one and a half to four and a third billions of bacilli thrown off in the twenty-four hours. These figures emphasize the danger associated with phthisical sputa unless most carefully dealt with. When expectorated and allowed to dry, the sputum rapidly becomes dust, and is distributed far and wide.

\* Johns Hopkins Hospital Bulletin, May, 1891.

The observations made by Cornet under Koch's supervision are in this connection most instructive. He collected the dust from the walls and bedsteads of various localities, and determined its virulence or innocuousness by inoculation into susceptible animals. Material was gathered from twenty-one wards of seven hospitals, three asylums, two prisons, from the surroundings of sixty-two phthisical patients in private practice, and from twenty-nine other localities in which tuberculous patients were only transient frequenters (out-patient departments, streets, etc.). Of one hundred and eighteen dust samples from hospital wards or the rooms of phthisical patients, forty were infective and produced tuberculosis. Negative results were obtained with the twenty-nine dust samples from the localities occasionally occupied by consumptives. Virulent bacilli were obtained from the dust of the walls of fifteen out of twenty-one medical wards. It is interesting to note that in two wards with many phthisical patients the results were negative, indicating that the dust in such regions is not necessarily infective. The infectiousness of the medical and surgical divisions of a hospital is in the proportion of 76.6 to 12.5. In a room in which a tuberculous woman had lived, the dust from the wall in the neighborhood of the bed was infective six weeks after her death. No bacilli were found in the dust of an inhalation-chamber for consumptives.

The tubercle bacillus is thus a wide-spread organism in regions frequented by phthisical patients.

5. *Modes of Infection.*—(a) *Hereditary Transmission.*—In extremely rare instances the disease is congenital. A few undoubted cases have been reported in man and in the calf. The rarity with which it occurs may be gathered from the fact that of 15,400 calves killed at the Berlin abattoir there were only four instances of tuberculosis. Cases of congenital tuberculosis in man have occasionally been described.

Baumgarten holds that in many cases the virus is transmitted, but the disease does not appear until some time after birth. He bases this opinion upon the following facts:

The great frequency of tuberculosis in sucklings. Thus, in 16,581 autopsies on sucklings, Frobélus found 416 with tuberculous lesions. In 219 cases of tuberculosis in children under two, from Parrot's clinic, there were 23 under three months, and a total of 111 under one year. It seems probable that in many of these cases the virus itself was transmitted.

The common occurrence of tuberculosis in the bones and in the joints of children, regions to which it seems unlikely that the bacilli would be conveyed in accidental infection. To make this objection valid we should require a series of cases of bone tuberculosis in children in which examination showed the lymph portals of the bronchi and the mesentery to be free from disease. He regards the late manifestation as analogous to the *syphilis hereditaria tarda*, and suggests that the growth of the germs is,



as a rule, restrained or held in check by the actively developing tissues of the child.

Tuberculosis unquestionably may be inherited, but in what way and how often are unsettled problems. Congenital disease is extremely rare, but there is no inherent improbability in a prolonged latency of the virus. That it may be present without the existence of actual tubercles is indicated by an experiment of Birch-Hirschfeld, who found that portions of the viscera of a foetus born of a phthisical mother, though not itself tuberculous, were infective to guinea-pigs.

In any series of cases of pulmonary tuberculosis there is a suspicious number in which the ascendants have also been tuberculous. Thus, in 427 cases at the Johns Hopkins Hospital there were 53 in which the mother was affected, 52 in which the father had tuberculosis, and 105 in which brother or sister had had the disease. The estimates by various authors range from 10 per cent (Louis), 25 per cent (Walshe), to even 50 per cent. Fagge very justly remarks that it is impossible to draw a line between hereditary and accidental tuberculosis, and naturally the children of an affected parent are more liable to accidental contamination.

Maternal is very much more common than paternal inheritance. A family tree, such as is here given, of six generations tells its own tale. It is interesting to note the almost constant transmission through the mother.

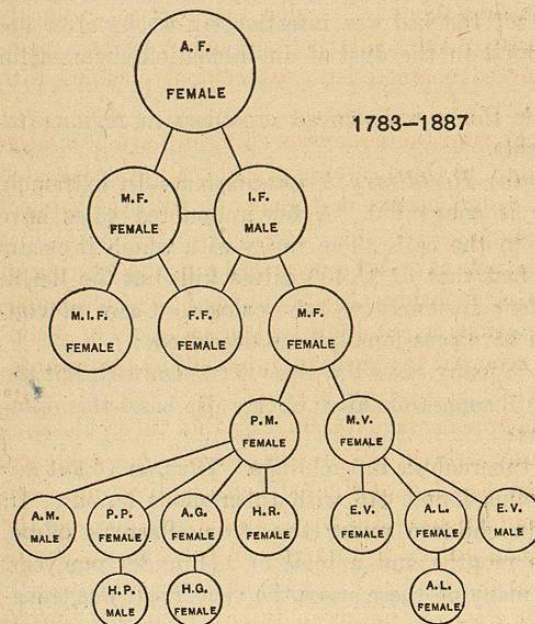


CHART XII.—Heredity in pulmonary tuberculosis.

observations were confirmed by Simon, Andrew Clark, and others, but Burdon Sanderson, Wilson Fox, and others held that the disease could be transmitted by non-tuberculous materials. The beautiful experiments of Cohnheim and Salamonson, who produced tuberculosis in the eyes of guinea-pigs and rabbits by inoculating fresh tubercle into the ante-

rior chamber, confirmed and extended Villemin's original observations and paved the way for the reception of Koch's announcement. It is now universally conceded that *only* tuberculous matter can produce, when inoculated, tuberculosis. In man tuberculosis is not often transmitted by inoculation, and when it does occur the disease usually remains local. This mode of infection is seen in persons whose occupation brings them in contact with dead bodies or animal products. Demonstrators of morbid anatomy, butchers, and handlers of hides are subject to a local tubercle of the skin, which forms a reddened mass of granulation tissue, usually capping the dorsal surfaces of the hands or fingers. This is the so-called post-mortem wart, the *verruca necrogenica* of Wilks. The demonstration of its nature is shown by the presence of tubercle bacilli, and by inoculation experiments in animals.

The statement that Laennec contracted phthisis from this source is probably false, since he did not die until twenty years after the inoculation and in the interval presented no manifestations. The possibility, however, of general infection must be borne in mind. Gerber reports that after accidental inoculation of the hand from a case of phthisis he had for months a "Leichen-tubercle," which was excised. Shortly afterward the lymph-glands of the axilla became enlarged and painful, and when removed showed characteristic tuberculous changes, with bacilli.

In the performance of the rite of circumcision children have been accidentally inoculated. Infection in these cases is probably always associated with disease in the operator, and occurs in connection with the habit of cleansing the wound by suction.

Other means of inoculation have been described: as the wearing of ear-rings, washing the clothes of phthisical patients, the bite of a tuberculous subject, or inoculation from a cut by a broken spit-glass of a consumptive; and Czerny has reported two cases of infection by transplantation of skin.

It has been urged by the opponents of vaccination that tuberculosis, as well as syphilis, may be thus conveyed, but of this there is no evidence, and the lymph from the vesicles of revaccinated consumptives has been shown by many observers to be non-infective. It may be said, on the whole, that inoculation in man plays a trifling rôle in the transmission of tuberculosis.

(c) *Infection through the Air.*—It has been fully proved that the expired air of tuberculous patients is not infective. On the other hand, the virus is contained in enormous amounts in the sputum, which, when dried, is soon widely disseminated in the form of dust, and unless carefully sterilized constitutes a great medium of transmission. A belief in the contagiousness of pulmonary tuberculosis has existed from the days of the early Greek physicians, and has persisted among the Latin races.

The investigations of Cornet afford conclusive proof that the dust of a



room or other locality frequented by patients with pulmonary tuberculosis is infective. The bacilli are attached to fine particles of dust and in this way gain entrance to the system through the lungs. The following are some of the facts in favor of this view:

(1) Primary tuberculous lesions are in a majority of all cases connected with the respiratory system. The frequency with which foci are met with in the lungs and in the bronchial glands is extraordinary, and the statistics of the Paris morgue show that a considerable proportion of all persons dying of accident or by suicide present evidences of the disease in these parts. The post-mortem statistics of hospitals show the same wide-spread prevalence of infection through the air-passages. Biggs reports that more than 60 per cent of his post-mortems showed lesions of pulmonary tuberculosis. In one hundred and twenty-five post-mortems at the Foundling Hospital, New York, the bronchial glands were tuberculous in every case. In adults the bronchial glands may be infected while the individual is in good health. H. P. Loomis found in eight of thirty cases in which there were no signs of old or recent tuberculous lesions that the bronchial glands were infective to rabbits.

(2) The greater prevalence of tuberculosis in institutions in which the residents are confined and restricted in the matter of fresh air and a free open life—conditions which would favor, on the one hand, the presence of the bacilli in the atmosphere, and, on the other, lower the vital resistance of the individual. The investigations of Cornet upon the death-rate from consumption among certain religious orders devoted to nursing give some striking facts in illustration of this. In a review of thirty-eight cloisters, embracing the average number of 4,028 residents, among 2,099 deaths in the course of twenty-five years, 1,320 (62.88 per cent) were from tuberculosis. In some cloisters more than three fourths of the deaths are from this disease, and the mortality in all the residents, up to the fortieth year, is greatly above the average, the increase being due entirely to the prevalence of tuberculosis. It has been stated that nurses are not more prone to the disease than other individuals, but Cornet says that of a hundred nurses deceased, sixty-three died of tuberculosis. The more perfect the prophylaxis and hygienic arrangements of an asylum or institution, the lower the mortality from tuberculosis. The mortality in prisons has been shown by Baer to be four times as great as outside. The death-rate from phthisis is estimated at 15 per cent of the total mortality, while in prisons it constitutes from 40 to 50 per cent, and in some countries, as Austria, over 60 per cent. Flick has studied the distribution of the deaths from tuberculosis in a single city ward in Philadelphia for twenty-five years. His researches go far to show that it is a house disease. About 33 per cent of infected houses have had more than one case. Less than one third of the houses of the ward became infected with tuberculosis during the twenty-five years prior to 1888. Yet more than one half of the deaths from this disease during the year 1888 occurred in those in-

fect houses. There are, however, opposing facts. The statistics of the Brompton Consumption Hospital show that doctors, nurses, and attendants are rarely attacked. Dettweiler claims that no case of tuberculosis has been contracted among his nurses or attendants at Falkenstein. The whole question has recently been thoroughly reviewed by Heron,\* in whose work will also be found a list of cases of infection (prepared by Koch) reported between 1867 and 1889.

(3) Special danger exists when the contact is very intimate, such, for instance, as between man and wife. On this point much difference of opinion exists, but the figures seem to indicate that under these circumstances the husband or wife is much more liable subsequently to die of consumption. Of 427 cases of pulmonary tuberculosis at the Johns Hopkins Hospital, in 25 either husband or wife had been affected with it or had died of tuberculosis. In response to a question as to contagion, asked by the Collective Investigation Committee of the British Medical Association, there were 261 replies in the affirmative, among which were 158 cases of supposed contagion through marriage. Weber's cases are of special interest. One of his patients lost four wives in succession, one lost three, and four lost two each.

(d) *Infection by Milk.*—The milk of an animal suffering from tuberculosis may contain the virus, and is capable of communicating the disease, as shown by Gerlach, Bang, Bollinger, and others. Striking illustrations of this are sometimes afforded in the lower animals. The pigs, for instance, of a tuberculous sow have been shown to present intestinal tuberculosis of the most exquisite form. Of late years the experimental proof has been entirely conclusive. It was formerly thought that the cow must present tuberculous disease of the udder, but Ernst has shown that the bacilli may be present and the milk be infective in a large proportion of cases in which there is no tuberculous mammitis; an observation made also by Hirschberger and others. This author states the interesting fact that an owner of a herd known to be tuberculous withdrew the milk from market and used it without boiling to fatten his pigs, which, almost without exception, became tuberculous, so that the whole stock had to be slaughtered. There is no reason to believe that young children or even adults are less susceptible to the virus than calves or pigs, so that the danger of the disease from this source is real and serious. The great frequency of intestinal and mesenteric tuberculosis in children no doubt finds here its explanation. As noted in Woodhead's analysis of one hundred and twenty-seven cases of fatal tuberculosis in children, the mesenteric glands were involved in one hundred.

(e) *Infection by Meat.*—The meat of tuberculous animals is not necessarily infective. The results of experiments with the flesh of cows are not in accord. This mode of infection probably plays a minor rôle in the

\* Evidences of the Communicability of Consumption, London, 1890.