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ACUTE MENINGITIS.

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By the term meningitis is understood inflammation of the pia arachnoid, the investing membrane of the brain and spinal cord. Considered as a single membrane, it consists of a serous surface (arachnoid) forming one side of the subdural space and beneath this a loose connective tissue, the pia mater, which carries the blood vessels for the brain and cord. The brain, covered by this membrane, projects into the subdural space as the heart projects into the pericardial cavity. In addition to the vessels, there are numerous lymphatics, which are situated in the adventitial sheaths of the veins and arteries and which are continued with these vessels into the brain. They are true lymphatic vessels with an endothelial lining; they are thin-walled, and, when distended, communicate freely with the tissue spaces. There are no lymphatics in the tissue of the brain itself, nor have lymph spaces, similar to the spaces in other tissues, been demonstrated. The adventitial lymphatics are not continued into the capillary walls. Between the capillaries and the walls of the channels in which they run there are spaces, easily distended, which are in relation with the closely-woven web of the nervous tissue, allowing a free interchange of fluid. Such fluid easily finds its way into the adventitial lymphatics. The relation, by means of blood vessels and lymphatics, between the nervous tissue and the investing membrane is so close that infectious processes in one extend into the other. Strictly speaking, all cases of meningitis deserve the term meningo-encephalitis. The lymphatics of the membrane communicate with the general lymphatic system of the body by means of the lymphatics along the nerves and great vessels.

The pia arachnoid, in the form of the choroid plexus, passes into the ventricles of the brain, and the intraventricular fluid finds its way into the interspaces of the membrane through the foramen of Magendie. The deep cervical lymph nodes belong to the membrane. The pia arachnoid contains the few connective tissue cells of the fibrous tissue, the cells of the blood and lymphatic vessels, and a variable number of lymphoid cells.

There are various means by which infectious agents can gain access to this tissue. They may enter it by means of the blood or by the extension of infectious processes from adjacent regions. The extension may be direct or by means of lymphatics which communicate with those of the membrane.

All inflammatory processes in the pia arachnoid,

however produced, agree more or less in their anatomic features. There are, however, certain minor differences in the anatomic lesions which are sufficient to differentiate certain forms of meningitis from others. In certain cases these differences are more accentuated than they are in others. The same character of exudation may be produced by the *Diplococcus intracellularis meningitidis*, by the pneumococcus, and by the streptococcus. Even cases of tuberculous meningitis may be found in which there may be a fibrino-purulent exudation without the presence of tubercles. The differences lie mainly in the extent and character of the involvement of the brain, and in the degree to which the intima of the veins and arteries is affected. It would be possible anatomically to distinguish cases of acute epidemic cerebrospinal meningitis from other forms, but the differentiation could not be carried further. All cases of meningitis are cerebrospinal, the meninges of the cord being affected as well as those of the brain. In certain forms, the cord lesions are more marked.

Acute meningitis may be produced by a number of bacteria, but chiefly by those belonging to the pyogenic organisms. The three organisms most generally concerned are the *Diplococcus intracellularis meningitidis*, the pneumococcus, and the streptococcus. Of these, the first named deserves the most attention in that it is the cause of the epidemic form of the disease. This organism was first described by Weichselbaum, in 1887, as a specific micrococcus resembling the gonococcus. He found it in six cases of acute cerebrospinal meningitis. The work was confirmed by several investigators, and, in 1895, Jäger found it in a small epidemic which prevailed in the garrison at Stuttgart. To Jäger belongs the credit of first recognizing this organism as the cause of epidemic cerebrospinal meningitis. The description which Jäger gave of the organism differs in minor details from that given by Weichselbaum. Weichselbaum has never regarded it as the sole cause of epidemic meningitis but considers that epidemics also may be caused by the pneumococcus. In the very considerable epidemic which prevailed in Massachusetts in 1897, and which was reported by Councilman, Mallory and Wright, this diplococcus was established as the only cause. It was found in 31 of the 35 cases which came to autopsy. Lumbar puncture was performed in 55 cases, and in 38 of these the same organism was found. It was present in all of the acute cases, but rarely in those which ran a more chronic course. Thus, in lumbar puncture, the average duration from the onset of disease until the puncture was made was seven days in the cases in which the organism was found, and seventeen days in the negative cases.

The organism is one which is cultivated with difficulty. Morphologically, the organisms appear as diplococci occurring as paired hemispheres, separated by

well-marked, unstained intervals, and showing in cultures considerable variation in size. There is a tendency to grouping in fours, or tetrads. In cover-glass preparations from the meningeal exudate, the diplococcus is frequently situated inside leucocytes and sometimes within the nucleus. The appearance is very much like that of gonorrheal pus. The organism is decolorized by the Gram method of staining; in cultures it grows best on blood serum. The colonies are round, colorless, slightly convex or flat, moist and viscid-looking; they may become confluent. The organism has feeble vitality and dies out quickly under cultivation. It has a weak pathogenesis for laboratory animals. The cultures vary in virulence in certain cases, 1 c.c. of a bouillon suspension of a 24-hour blood serum collected and injected intraperitoneally in a guinea-pig will kill the animal in 48 hours.¹

This type of meningitis is constantly present; it exists in the form of epidemics, which are repeated with some regularity. The disease has peculiar interest in Massachusetts from the fact that it was first described here by Danielsen and Mann, in 1806. There have been four epidemics in the state, each of which has been made the subject of a special report. These epidemics occurred in 1809, 1864, 1874 and 1897. There is great difference in the morbidity and mortality of the disease in the different epidemics; Hirsch places the mortality at from 20 to 75 per cent. In the last epidemic, in Boston, the mortality was 65 per cent.; the epidemics are usually of short duration. Between the epidemics, sporadic cases appear, which may be more numerous in some years than in others. Before careful bacteriologic examinations rendered the recognition of the disease certain, the character of the infection in sporadic cases was determined by the clinical history, with or without the reports of autopsies. The disease is sufficiently characteristic to make this method approximately correct. In 1897, from the clinical reports, in some cases with autopsies, it seemed probable that here and in Europe sporadic cases were common. The main clinical features distinguishing sporadic cases of epidemic cerebrospinal meningitis from other forms of meningitis were the low mortality (in 24 cases from the clinic of Prof. Bauer, reported in 1890, there were 8 deaths, and in 17 cases reported from Ziemssen's clinic at the same time there were 3 deaths), its appearance as a primary affection, and the frequency with which it is followed by secondary affections of the eye and ear.

Since our study of the disease in 1897 there have been numerous reports of sporadic cases, in which careful bacteriologic study of the exudation have determined the presence of the *Diplococcus intracellularis meningitidis*, and have confirmed the conclusions which we reached in 1897 of the frequency of sporadic cases. Since 1898 there have been 61 autopsies on meningitis at the Boston City and Massachusetts General Hospitals, with bacteriologic study of the exudation. In 13 of these the *Diplococcus intracellularis meningitidis* was found in culture. In addition to these there were 8 cases which were considered due to the same cause but in which the organism was not obtained in cultures. Of these 5 were chronic, with organization of exudation, the organism having evidently died out, and in 3 the cultures were negative from unknown causes. All of these cases were primary and did not differ from the type of disease which we had studied in the epidemic

in 1897. The absence of bacteria in carefully made cultures of the exudation in acute primary meningitis speaks in favor of this type, for the diplococcus is rather difficult to cultivate, of feeble vitality and can easily die out.

These statistics give no idea of the frequency of the disease. We know that cases do recover, for there are numerous reports of recovery of cases in which the diplococcus has been found in the fluid from spinal puncture. There is great need of more accurate statistics on this subject, and these are to be obtained by careful bacteriologic examination of fluid derived from spinal puncture, in large numbers of cases, including those in which the disease may only be suspected.

Examination of the health statistics in Massachusetts shows a gradual decline in the number of deaths from epidemic cerebrospinal meningitis from 1897 to 1902. In 1897, which was the chief year of the epidemic, there were 355 cases. The deaths were most numerous in April, May and June, which are the months in which the epidemics are most fatal. In 1898 there were 259 cases, the epidemic influence being slightly shown by 91 cases in the same months. In 1899 there were 240 cases, in 1900, 165; in 1901, 176, and in 1902, 165 cases. These cases were scattered over the state without occurring in sufficient numbers in any one place to constitute an epidemic. There is no way of positively determining whether or not they were due to the *Diplococcus intracellularis*. In the Massachusetts reports, other forms of meningitis were placed under the head of cephalitis until 1901, when the term "other forms of meningitis" was used. In 1900 there were 1,205 cases of cerebritis, in 1901, 1,168 cases of other forms of meningitis, and in 1902, 1,200 cases. The cases described as cerebrospinal meningitis are the primary cases, the secondary cases coming under other forms. It is, of course, difficult to determine, without an autopsy account, whether meningitis is or is not primary. All my experience leads me to the belief that, with rare exceptions, cases of primary meningitis are due to the *Diplococcus intracellularis*. In the 35 autopsies made in 1897, all the cases were primary, and the 21 found since were also primary. In the remaining 40 of the 58 cases only 2, in 1 of which the pneumococcus was found and in 1 the streptococcus, were regarded as primary. It can be concluded, both from autopsy evidence and from statistics, that sporadic cases of meningitis due to *Diplococcus intracellularis* are of frequent occurrence, but we have no way of determining how frequent the disease is. Autopsy experience shows that the disease is more frequently not diagnosed when present than the reverse. We have no means of estimating the mortality of meningitis due to the pneumococcus or streptococcus; these cases are usually secondary, and the mortality in secondary meningitis is much higher than in the primary form. Up to 1898 we could not find a case in which the culture of fluid from spinal puncture showed pneumococci or streptococci in which recovery took place. Since 1898 there have been, at the Boston City Hospital, 4 lumbar punctures in which the pneumococcus was found and three in which the streptococcus was found, all of which cases resulted fatally. To a certain extent, we can judge of the frequency of the disease by evidences at autopsies of preceding inflammation of the pia arachnoid, shown by thickening due to connective tissue increase and by lymphocyte infiltration with a corresponding increase in the glia of the cortex, and glia thickening and granulations

1. Mallory and Wright: Pathological Technic, 1904.

on the surface of the ventricles. This condition, which is not uncommon, can be the result of a preceding acute infection, but certainly not all cases are the result of this.

The presence of these sporadic cases is of importance in the occurrence of epidemics. The *Diplococcus intracellularis* is an organism of feeble vitality; it dies out easily on exposure to drying and light and is incapable of a saprophytic existence. In the absence of intervening infections, it would be impossible for the period of epidemics to be bridged over. Not only this, but there is evidence that this organism can produce other infections and may even live as an inhabitant on the normal mucous membrane. There have been a great many cases reported of the presence of the *Diplococcus intracellularis meningitidis* in the nose. In most of these the diagnosis was made on morphologic grounds, and such cases should be thrown out, owing to the probability that the organism was confounded with the micrococcus catarrhalis, which it resembles in morphology and in staining reaction. The differential diagnosis can only be made in cultures. In fifteen cases of meningitis examined in the Boston epidemic, diplococci decolorized by Gram were found in 10. In 12 cases, chosen at random, similar diplococci were found in 2. Attempts were made to cultivate the organisms, but not successfully.

Lord has examined the bacteria of the nose in 21 cases. In the nose of a physician who had been in daily attendance in the throat room and who had a severe rhinitis with congestion of the mucous membrane and profuse muco-purulent discharge, he found diplococci which all tests showed to be the meningitidis. In reviewing the literature, Lord accepts but 3 cases, making, with his own, four, in which the *Diplococcus intracellularis* has certainly been found in the nose. Some of these cases are of considerable interest. Kiefer, after experimenting for some days with the cultivation of the organism with the view of comparing it with the gonococcus, suddenly acquired a severe purulent rhinitis, with headache, nervousness and an uncomfortable sense of contraction of the neck. The temperature remained normal. Examination of the nasal pus by cultures demonstrated the presence of the *Diplococcus intracellularis*, along with other bacteria; the rhinitis lasted 14 days. In this case it seemed probable that there was a primary infection of the nose, with a slight meningitis, resulting from extension of the infection through the lymphatics into the meninges. The case lacks the proof which spinal puncture should have given, both of the meningitis and of the character of the meningeal infection, if present. There can be no doubt that extension may take place from the meninges into the nose, just as it certainly does into the ears and eyes. Rhinitis is not an uncommon condition in acute meningitis, and Albrecht and Ghon found the *Diplococcus intracellularis* by culture from the nose in one of their cases of acute meningitis. The evidence which we have justifies us in the conclusion that there is a form of meningitis produced by the *Diplococcus intracellularis meningitidis*, that the epidemics of acute meningitis are due to this organism, that sporadic cases are not infrequent, that, with rare exceptions, primary cases of meningitis are due to this organism; that recovery takes place much more frequently in this type of disease than when infection is due either to the pneumococcus or the streptococcus, that the disease is more common than is generally supposed, that the organism does not live

as a saprophyte outside the body, that the organism may be found on the mucous membrane of the nose, where it may produce a rhinitis, and that it is probable that infection of the meninges takes place by extension from some of the adjacent mucous membranes by means of the lymphatics. We can only explain the epidemics of the disease by the assumption that at certain times the power of infection is increased either by an increase in the virulence of the diplococcus or by a decrease in the resistance of the tissues. The study of the influenza bacillus in the past years has shown much the same condition. The organism is constantly present, and not only are sporadic infections produced by it frequent, but the bacillus may live as a harmless inhabitant of a mucous surface. The causes underlying the occurrence of epidemics are unknown, and even atmospheric conditions can not be excluded. With regard to the pneumococcus, we know that the organism is associated with acute croupous pneumonia, but we do not know the underlying conditions which enable the pneumococcus to produce this disease.

Of the 61 cases of sporadic meningitis seen since 1897, 18 were found to be due to the pneumococcus. Weichselbaum regards this organism as one of the most frequent exciters of both primary and secondary meningitis, and both he and Netter believe that meningitis due to the pneumococcus may appear in epidemic form. In the report on meningitis in 1898, 10 cases were found to be due to the pneumococcus, and in 2 of these the infection was primary, no other lesions due to the organism having been found. In but one of the recent cases was the infection primary in the meninges, and even here the accompaniment of an acute nephritis suggests a preceding acute infection. In 6 cases the infection was secondary to otitis media and mastoiditis; in 1 case it was secondary to an infection of a tumor of the sphenoid; in 1 case it was associated with the streptococcus, secondary to fracture of skull and operation; in 1 case it was secondary to abscess of the prostate; in 1 case it was secondary to acute infection of ethmoid, "the pores of right cribriform plate contain fibrinous pus in continuity with exudation about right olfactory lobe," in 2 cases it was secondary to acute croupous pneumonia, in 4 cases it was secondary to acute bronchopneumonia and pleurisy, and in 2 cases it was secondary to acute pneumococcus endocarditis.

In but few of these cases did the infection appear to be embolic; in most cases the extension to the meninges was by continuity or by the lymphatics. In its general pathogenic properties, the pneumococcus attacks tissues from mucous surfaces and extends in the body by surfaces. I believe that the frequency of pneumococcus meningitis is greatly overestimated, and especially its frequency secondary to pneumonia.

While vital statistics with regard to the occurrence of disease are not worth much, owing to errors in diagnosis, Chart 1, showing the relative frequency of pneumonia and meningitis in different months, gives some light on the relation between meningitis and pneumonia. The deaths from these diseases in Massachusetts have been taken during a period of five years in order to cover slight inequalities in different years, commencing in 1898, the year following the epidemic of cerebrospinal meningitis. If there is any marked relation between meningitis and pneumonia it should be shown in the inter-occurrence of the diseases. We see from the chart that the greatest number of deaths from what are described as other forms of meningitis occur in

August, when the mortality from pneumonia is lowest. It is very possible that the high number of cases in March, April and May is due to confusion of these cases with primary meningitis due to the *Diplococcus intracellularis*, for these months show the highest mortality in epidemics and in sporadic cases due to this organism. The curve made from the statistics made in New York City, showing the relation between deaths from acute respiratory diseases and cerebrospinal meningitis in five years, shows much the same. It is interesting to see that the apex of the acute respiratory diseases curve in New York is reached in April, while the apex of the pneumonia curve in Massachusetts is reached in March (Chart 2).

There were 18 cases of streptococcus infection, and in 1 the infection was primary. In seven cases it was secondary to fracture or operation wound of the skull;

primary lesion on the face. We have never had any cases due to the typhoid bacilli.

The pathologic process in meningitis due to the *Diplococcus intracellularis* consists in inflammation, with purulent, sero-purulent and fibrino-purulent exudation. The most marked lesions are found at the base of the brain, extending from the optic commissure backward over the crura, the pons and medulla. On the convexity of the brain the exudation is usually most intense on the lateral surface, little or none being found in the meninges of the longitudinal fissure. The meninges of the cerebellum are always involved and often the greatest mass of the exudation is found on the upper surface of this structure. In the most acute cases, those dying a few days after the onset, there may be a little more than intense hyperemia of the vessels of the meninges and cortex. In the more advanced cases, dying

Chart 1.—Deaths from pneumonia, meningitis and epidemic cerebrospinal meningitis in Massachusetts from 1898 to 1902 inclusive. The unbroken line represents pneumonia, the middle line meningitis and the lower line epidemic cerebrospinal meningitis; it is probable that these two forms of meningitis are to some extent intermingled.

in 8 cases it was secondary to otitis media and mastoiditis, in 1 case it was secondary to acute streptococcus endocarditis, and in 1 it was secondary to acute bronchopneumonia and acute cystitis. We see from this analysis that, in the two hospitals mentioned, fatal sporadic cases of meningitis are equally divided between the three organisms which are to be regarded as the main etiologic factors. Of the remaining 4 cases, 2 were produced by the *Staphylococcus pyogenes aureus*, 1 was secondary to trauma with following operation, and 1 was secondary to empyema. In two cases the nature of the infection was not determined. In one of the cases reported in 1898 the meningitis was produced by the anthrax bacillus and was secondary to a

Chart 2.—Acute respiratory diseases and meningitis in New York City from 1898 to 1902 inclusive. The unbroken line represents deaths from acute respiratory diseases. The broken line represents deaths from meningitis. No attempt is made to distinguish between the various forms of meningitis.

from 5 to 12 days after the onset, the amount of exudation is much greater and has a tough, rather gelatinous character. In the chronic cases, in which death has occurred in from 15 to 30 days from the onset, there is edema and general thickening of the meninges, which is most marked at those localities where the acute process is most evident. In one case, the duration of which was apparently over 30 days, the entire medulla was embedded in a dense mass of connective tissue. In the cord the exudation is most marked along the posterior surface and may be found here in large amount, while the anterior surface may show only cloudiness and injection. There is usually more exudation along the dorsal and lumbar cord than along the cervical.

In 8 of 35 cases on which autopsies were made in the epidemic studies, there were definite macroscopic lesions in the brain, consisting in hemorrhages in the white matter. No abscesses were found. The cranial nerves were affected to a greater or less degree in all cases. Those most affected were the second, fifth, seventh and eighth. They were embedded in the exudation which extended along them, and on section they were found to be swollen and reddened. The gasserian ganglia were examined in a number of cases, and in all they were found swollen and softened. The spinal nerves were also affected; the nerve roots were embedded in the exudation and the spinal ganglia were red and swollen. The exudation was also found around the nerves of the cauda equina.

Microscopically, the exudation in the most acute cases was purulent and the leucocytes were exclusively polynuclear. The absence of eosinophile cells was remarkable. In more advanced cases the number of cells in the exudation was greater and the fibrin was abundant. As the process advanced, large endothelial phagocytic cells became increasingly numerous, and in some cases made up a large part of the exudation. They often contained from one to several polynuclear leucocytes enclosed in vacuoles and showing varying degrees of disintegration.

In the chronic cases the exudation was mainly represented by degenerated pus cells. In these chronic cases there were also numbers of plasma and lymphoid cells.

Microscopically, lesions of the tissue of the brain and cord were absent in but few cases. They were most evident in those cases in which from 5 to 10 days elapsed from the onset of the disease until death. The blood vessels of the convexity were injected. The cortex appeared redder and the tissue edematous. In places there was circumscribed infiltration of the tissue with pus cells, which extended downward from the infiltration in the meninges. This infiltration was usually most marked in the outermost layer of the cortex above the ganglion cells, but in some places it extended among the ganglion cells and even into the white matter. Single pus cells were often found in the brain tissue, apparently remote from the areas of infiltration. In 2 cases extensive softening, with purulent infiltration and hemorrhage, was found in the cortex of the cerebellum. These pus cells in the brain were irregularly distributed in the tissue, and were found both in places which appeared to be altered by infiltration of edematous fluid and in those in which the intracellular material seemed to be normal. The pus cells in the tissue were often distorted in shape, sometimes extending in long lines, the shapes resembling those seen in pus cells wandering in the tissue of the cornea. Their situation and shape did not seem to indicate the existence of preformed spaces. They were but rarely found around the ganglion cells.

In certain areas in the cortex, particularly about the vessels, large numbers of large endothelial cells resembling those in the meninges were often found. They were apparently formed by proliferation of the cells in the adventitial tissue. They extended often for some distance in the tissue around the vessels where this showed evidence of disintegration, but they seemed to have little or no power of wandering into tissue which was comparatively normal. The presence of these cells is important in relation to the neuroglia cells. Proliferative changes in the neuroglia were constantly present. In the chronic cases there was a distinct increase

in neuroglia fibrils, together with increase of cells, which was chiefly marked in the tissue of the ventricles and in the outermost layer of the cortex. In several of the more acute cases numerous nuclear figures were found in the cells of the neuroglia. These were particularly marked in one case. The proliferating neuroglia cells somewhat resemble the large endothelial cells. There is an increase of nucleus with the formation of evident protoplasm about it. The nuclear figures are well marked, showing spindles and centrosomes. Often large cells with several nuclei result from such proliferation. In one specimen in which this was most marked, nuclear figures were also found in the so-called Trabant cells adjoining the ganglion cells.

Analogy with other tissues would indicate that such changes in the intercellular tissue consisting of proliferation of fixed tissue elements and exudation of leucocytes would be accompanied by degeneration of the specific cells of the tissue, namely, the ganglion cells. The most evident changes in the ganglion cells were found in those places where disintegration of the tissue was best marked, and consisted in disintegration of the cell protoplasm. It is difficult to distinguish such conditions from artefacts. Degeneration of nerve cells is not of the same character as degeneration of parenchymatous cells in other organs. The state of our knowledge with regard to structure of ganglion cells and arrangement of granules is not sufficiently definite to enable us to determine with certainty their degenerations.

The most marked changes in the nerves were found in the second, fifth and eighth; the lesions of the nerves represent an extension of the inflammatory process from the meninges.

The dural covering of the optic nerve in the orbit showed little change save dilatation of vessels. The subdural space was dilated and the exudation was found in the pia arachnoid of the nerve. From the meninges the infiltration extended more or less into the nerve itself. In both the optic and olfactory nerves, proliferation of the neuroglia cells was shown similar to that in the brain. The exudation may extend along the optic nerve into the eye.

In acute cases, section of the eighth nerve showed it embedded in a mass of pus, its sheaths softened, broken up and in places entirely gone. The nerve was infiltrated with numbers of pus cells, partly in the form of lines running through it, partly in a more diffuse infiltration. The seventh nerve often showed as great a degree of infiltration as the eighth. Longitudinal section of the fifth nerve extending into the gasserian ganglion showed intense neuritis in the nerve on the cerebral side of the ganglion. Similar changes of the nerve roots and ganglion of the spinal cord were found in all cases which were examined. In some of the more chronic cases, lesions of the nerve roots of the spinal cord were more marked than in the acute cases.

In the chronic cases there was marked thickening of the meninges due to connective tissue formation and a marked increase of the neuroglia of the cortex. There was little evident exudation, circumscribed yellowish foci marking the remains of it. The meninges at the base were opaque, and were enormously thickened, and there were bands of organized tissue extending from point to point. In one of the most chronic cases, in which the duration of the disease could not be ascertained with any accuracy, owing to the mental condition of the patient when brought into the hospital, the meningeal changes simulated general paralysis. The only

evidence of exudation was in the ventricles, in which masses of partly organized fibrin were found adherent to the lining. In another case the entire medulla was so embedded in a dense mass of connective tissue that it was difficult to remove it. Chronic hydrocephalus is not uncommon in such cases. It is due to closure of the foramen of Magendie by organization of the exudation about the cerebellum.

There is some difference in the character of the lesions due to pneumococcus and streptococcus, as compared with those due to the *Diplococcus intracellularis*, but no differences between lesions due to the pneumococcus and streptococcus. Endovascular lesions, consisting in cellular infiltration behind the endothelium, were found in both arteries and veins in meningitis due to the pneumococcus and streptococcus. The endothelium was preserved and often formed festoons projecting into the lumen of the vessel, with the cell accumulations behind it. The endothelial cells were swollen, but otherwise unaltered. I do not believe that the large cells arise from proliferation of the endothelium, but they seem to reach their position by emigration from the interior of the vessel. In meningitis due to these organisms there is also less tendency to involvement of the tissue of the brain and cord, nor is the extension along the nerves so marked. The cases of these forms of meningitis have not been so numerous nor has their anatomic study been so thorough as in the cases due to the intracellularis.

THE SURGICAL ASPECTS OF MAJOR NEURALGIA OF THE TRIGEMINAL NERVE.

A REPORT OF TWENTY CASES OF OPERATION ON THE GASSERIAN GANGLION, WITH ANATOMIC AND PHYSIOLOGIC NOTES ON THE CONSEQUENCES OF ITS REMOVAL.

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(Continued from page 929.)

CASE 16.—Mrs. R., aged 55, was referred to me by Dr. Baker of Elmira, N. Y., through Dr. Osler.

History.—She had suffered for fifteen years with a neuralgia which originated in the supraorbital territory. It had become acutely aggravated a few years before her ganglion operation after an exposure to a cold wind. She had taken opiates in large doses during this entire period and, indeed, had been addicted to the habit before the onset of her neuralgia. For the last year the pain had been extreme and almost continuous. A constant attendant was necessary, day and night. All inhibition was lost and she invariably screamed aloud during her paroxysms. She was more or less narcotized most of the time and seemingly was maniacal. The teeth had all been extracted at one sitting two years before. No peripheral neurectomies had been undertaken. The entire territory of the fifth nerve was involved. Pain was in the tongue, in the inside of the ear and nose, as well as in the more commonly described areas. She presented the awful appearance of an extreme case of tic, screaming and clutching at everything during her frequently recurring exacerbations of pain; dirty, with matted white hair, full of sebaceous discharge, her head and face having been unwashed for many months. She looked twenty years more than her actual age.

Examination.—Physical examination discloses a very unpromising condition. An advanced degree of arteriosclerosis was present. The urine had a specific gravity of 1030 and

contained a large amount of sugar. She was unable to speak or to protrude her tongue, and her condition was so serious that most of the usual preliminary examinations were omitted. Owing to the disturbance caused by her frequent cries, she was operated on almost as an emergency a few hours after admission, as it would have been impossible to have kept her over night in the hospital.

Operation.—May 15, 1903; Union Protestant Infirmary; ether. Anesthesia of necessity was administered before any operative preparations could be undertaken. When the side of the head was scrubbed and cleaned, almost the entire epithelium came away, leaving practically a raw surface. Owing to her serious condition, the operative approach was conducted somewhat more hurriedly than should have been done, and by the carelessness of mistaking the ramus of the third for that of the second division, the meningeal artery was torn off at its point of emergence into the cranial cavity at an early stage of the operation. This is the first time that this accident has occurred and it sufficed to show the operator how serious a complication it may be, in delaying and in preventing a subsequent clean neurectomy. The vessel was finally controlled, but the difficulties of the enucleation were such as to preclude the removal of more than the lower two-thirds of the ganglion. It would have been impossible in a case of this kind to have exposed the trigeminal root in order to divide that and thus save the time necessary for the extraction of the ganglion. The wound was sufficiently dry to allow closure without drainage.

Postoperative Notes.—A critical condition, with anuria. Cheynes-Stokes respiration, and a pulse varying between 130 and 160, ensued for twenty-four hours after the operation. It was feared that a condition of diabetic coma was imminent and would lead to her death. Happily, she awakened from her comatose condition, as it were, well on the morning of the third day. The wound healed *per primam*. Her drugs were gradually withdrawn and a fight ensued to keep her from them. The sugar disappeared completely from the urine. An enormous appetite resulted in a very rapid gain of weight. There were no ocular complications. She returned home on the tenth day and reports that she has since remained free from pain. She has, unfortunately, resumed or continued her morphia habit.

This and the case of sinus injury are the only ones in the series which developed any critical postoperative complications.

CASE 17.—Mr. F. T. M., aged 58; a bookkeeper.

History.—He had suffered with a right-sided neuralgia for nine years. The pain originated in the supraorbital region and soon spread to the other divisions. All his teeth had been extracted. In 1898, an infraorbital neurectomy had been done, in Charleston, with a respite of four months. In 1899, other peripheral operations were performed, with little if any relief, and since then the pain has steadily increased despite all forms of treatment. Eating, drinking, almost any movement, in fact, of the palate or tongue, would inaugurate a paroxysm. His weight in consequence had dropped to 102½ pounds. He takes a large amount of morphia daily.

Examination.—Examination showed a greatly emaciated, gray, senile appearing man, with tortuous radials, so ill and suffering so greatly that preliminary observations had to be omitted.

Operation and Result.—July 11, 1903; The Church Home; ether. This proved to be a very easy case without complications, with a total extirpation and closure without drainage. The patient's convalescence and recovery were without incident worthy of mention (Fig. 29). He gained 14½ pounds during the three weeks subsequent to the operation, and his intelligent co-operation enabled me to make many of the observations on the physiology of the fifth nerve which will be subsequently recorded. He has remained well.

CASE 18.—Mr. J. P. B., aged 53; a farmer.

History.—His neuralgia has been of ten years' standing, having originated in the nasolabial region of the right cheek. Even from the onset it has been severe, with flash-like paroxysms, which extended early into the territory of the first di-