

treatment in the acute stage just as soon as I could have the child brought to the office. I have begun even before the fever had subsided entirely. You commence immediately by treating with applications of heat. I use a five hundred candle-power electric lamp for twenty minutes, and I apply mechanical stimulation by vibration. There is no pain caused by the treatment, and there is entire relief from pain in five minutes after the treatment is started. The relief lasts for a while only; repetition of the treatment, however, makes it permanent. I find that the cases improve faster in that way than when this method is not followed.

In regard to electricity: There are so many ways in which electricity may be applied that it is not fair to say that electricity is of no value without specifying just what method of application is meant, any more than it would be to state that drugs are useless without mentioning which drugs are referred to. The use of electricity is understood by the general practitioner to produce muscle contractions. Personally, I have not done that with it. I think that electricity has a use, but we must decide just what we want to accomplish and then accomplish it. The whole process should be stated in absolutely definite terms.

DR. ROLAND MEISENBACH, Buffalo: I wish to lay stress on the value of apparatus in connection with cases of infantile paralysis, even in the earliest stage. By a careful adjustment of the proper apparatus, one can assist muscles to return to their normal more quickly than without. However, before the apparatus is applied, we must keep in mind the actual condition of the muscle, not only at the time when the apparatus is applied, but in the course of the paralyzed or paretic muscles. The opposite can also be said about apparatus that is applied without any understanding of the muscle action. I have seen an entire quadriceps regenerated in a child, and I know it was due to the fact that a duralumin brace had been applied properly and so regulated from time to time as the muscles became stronger that the opposing group of muscles had no opportunity to check the progress of the quadriceps. Therefore, one should not apply apparatus unless he has a very thorough understanding of the individual muscular action. Dr. Lovett said that operation should be postponed until the third stage. I believe it is true. I think it is wrong to operate in the early stage. The insertion of silk is not the proper method of treating infantile paralysis, for two reasons: First, because it is not permanent; second, because it may check muscle exercise, and therefore prevent regeneration of one or a group of muscles. There is no question that silk resolves. If any one of you has had an opportunity to study cross sections of silk strands embedded in living tissue, you will see that after twenty days there is very little silk left, and in its place is connective tissue. I am taking out many more silk ligaments than I am putting in.

I firmly believe that apparatus, if applied carefully with Dr. Lovett's idea of muscle education in mind, will give better results. Stability is to be desired. You cannot immediately get stability by operative procedure. Where the attack of infantile paralysis is very mild, I have applied rubber muscles, as I chose to call them. These could be adjusted in thickness and width corresponding to the afflicted muscles, whether they were in a state of paresis or total paralysis. These acted as apparatus, and were sometimes combined with apparatus, especially in the early stage of infantile paralysis. The rubber tissue over the involved muscle acted also by causing a hyperemia, and thereby stimulating circulation. I cannot agree with Dr. Lovett in his statement that the pathology of infantile paralysis changes so rapidly for the better. I would like to ask Dr. Lovett whether the afferent and efferent impulses have much to do with the rapid rebound in cases of infantile paralysis, and whether he can tell the percentage of gain in the given paralyzed muscle in, let us say, six months of paralysis.

DR. ROBERT W. LOVETT, Boston: I do not want to go on record as advocating extreme conservatism in the treatment of the disease. If we can avoid operation, so much the better. Dr. Stern's criticism about getting the patients

on their feet is a just one. I intended to protest against allowing children to sit in a chair, month after month, and did not mean to imply that there should not be considerable rest. In many cases, I do not allow walking at all. I am satisfied that the element of fatigue is of great importance in all early cases, and I am getting better results since I have been paying greater attention to it. I did not mean to advocate the insertion of silk ligaments over the other operative measures, but only as one of the operative procedures. I have had failures in cases in which I have used it. I now put in from six to eight strands of No. 12 silk. I do not know how this will work out in the end. I hold no brief for it over astragalectomy. It often has failed, but its results have often been brilliant. The muscle test gives a quantitative test of muscle strength. I believe it to be reliable. I have been able to treat the cases better, because I could take tests of them in that way. I believe that it is the means by which the question of the benefit of electricity can be settled. I am starting on the observation of a set of cases treated with and without electricity in order to compare the two sets by quantitative tests. Nine patients out of ten in my private practice during the last winter have had their muscle training under the mother or an untrained nurse. The results under these circumstances were about one third as good as when given in my office by an expert.

I must differ with Dr. MacAusland about tendon transplantation. I think it is a very good and at times a brilliant operation, although there are failures from its use; but the same may be said of astragalectomy. I think that astragalectomy is suitable for one set of cases, while tendon transplantation is suitable for another set. Tendon transplantation is especially suitable for cases in which you have tested the muscles and know just what you are doing. Of course, if you substitute a very small muscle for one that is strong and heavy there is nothing in it; but if you test out the muscles beforehand, you can avoid this. Therefore, this muscle test is in the line of precision. It has shown me how little I knew about the disease. Dr. Meisenbach's questions I cannot answer. The tendency of my paper is not to advocate any particular method. I merely wished to state my personal experience and to make a plea for a greater precision in the treatment, advocating a plan based on the supposition that there will be two years of nonoperative treatment. What operative treatment we should employ is a separate question.

SPECIFIC TREATMENT OF INFANTILE PARALYSIS

PRELIMINARY NOTE

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Epidemics of infantile paralysis since 1907 have afforded opportunity for careful clinical as well as laboratory study. In the present epidemic of infantile paralysis in New York, large numbers of patients with acute cases have been removed from their homes to the city contagious hospitals. In the Kingston Avenue Hospital at the time of this writing there were over 300 patients.

As a member of the committee in charge of these cases, assigned in charge of the treatment during the acute stages, I had a particularly good opportunity to select different types of the disease at different stages, and to make comparative observations which helped in deciding the value of the different treatments.

It is manifestly difficult to speak with any certainty of the value of any curative treatment in a disease like infantile paralysis in which early diagnosis in the pre-paralytic stage is difficult, often impossible, and in which the mortality is relatively low.

Our active treatment heretofore has been purely symptomatic. Anything based on sound rationale,

which properly used should do no harm, and which should theoretically do good is worth using, at least till we get something better.

The analogy, etiologic, pathologic and epidemiologic, between infantile paralysis and epidemic meningitis is very close. The symptoms of infantile paralysis, as in epidemic meningitis, may be grouped into those caused by (1) hydrocephalus; (2) the inflammatory reaction in the meninges and nerve substance, and (3) paralysis—due to focal involvement of nerve tissue.

The successful treatment of epidemic meningitis depends on the proper relief of hydrocephalus, and the injection into the spinal subarachnoid space of an immune serum which bathes the inflamed parts, produces a local leukocytosis and through its opsonins causes a sharp phagocytosis.

Treatment along similar lines should theoretically be of value in infantile paralysis.

The treatment of infantile paralysis may be divided into: (1) relief of hydrocephalus; (2) intraspinal injection of serum, normal human, normal horse, or convalescent; (3) control of special symptoms, as respiratory paralysis; (4) symptomatic general treatment, and (5) orthopedic treatment.

1. RELIEF OF HYDROCEPHALUS

Hydrocephalus with its pressure symptoms is most pronounced during the acute stage. In most cases it is only moderate, but not infrequently, especially in the cerebral cases, it is quite pronounced. In the latter the patients are often very stuporous, with twitchings, convulsions and respiratory embarrassment. Paralysis of the respiratory center is the usual cause of death in infantile paralysis. Early relief of respiratory embarrassment is therefore important. One lumbar puncture usually suffices, but in some cases it must be done several times till relief is permanent.

The following case history will illustrate:

CASE 1.—A. K., girl, aged 2 years, was admitted to the hospital on the fourth day of an attack of infantile paralysis. Her condition was bad. She was in profound stupor, was cyanosed, and respirations were very irregular, of Biot's type. Macewen's sign of hydrocephalus was marked. There was paralysis of left face and both lower extremities. By lumbar puncture, 60 c.c. of clear fluid under very high pressure were removed; 8 c.c. of normal horse serum were injected. Twelve hours later, the child was much improved but still drowsy, and the respirations were still irregular. Macewen's sign was marked. By lumbar puncture, 50 c.c. of fluid under very high pressure were removed. Two hours later the child was bright, taking the bottle well and breathing well. Convalescence was uninterrupted from that time on.

Relief of hydrocephalus is an important therapeutic measure. In cerebral cases it is often urgently indicated. It is quite safe to remove fluid till the pressure drops to the normal.

2. INTRASPINAL INJECTION OF SERUM, NORMAL HUMAN, NORMAL HORSE OR CONVALESCENT

A highly immune serum for poliomyelitis is what we want. So far such serum has not been produced.

The beneficial results of immune antimeningitis serum therapy have been attributed to a number of factors—the opsonic action of the serum, the stimulation by the serum of a local and general hyperleukocytosis, and the antitoxic, bactericidal and agglutinative action of the serum. Is the hyperleukocytosis, local and general, altogether a specific reaction, produced by the immune serum? I do not believe it is. It is a common

experience to inject patients with meningitis, suspected as being meningococcic (of the epidemic type) with immune antimeningococcic serum. Cases which later proved to be poliomyelitis, tuberculous meningitis, toxic meningismus and syphilitic meningitis have been so treated. A cerebrospinal fluid, obtained twenty-four, or sometimes forty-eight hours after such injection of serum, is often turbid, and shows a marked hyperleukocytosis with relative polynucleosis, a reaction frequently observed in true cases of epidemic meningitis treated with immune serum. The local hyperleukocytosis is, I believe, to a very great extent a nonspecific protein reaction.

We thus have a simple, almost harmless means of producing a hyperleukocytosis in the cerebrospinal fluid. Normal horse serum and normal human serum can be easily procured, and if sterile and properly injected are harmless.

The objection to horse serum would be the sensitization to foreign protein; heretofore, if available, normal human serum would be preferable.

Epidemic infantile paralysis is not a virulent disease, with a tendency to progress unfavorably. It is the very opposite. The febrile and inflammatory stage is a short one, and the lesions usually appear early in the disease and in most instances do not spread further. The mortality is relatively low, averaging during the height of epidemics from 20 to 30 per cent., but usually much lower. It is a disease against which we have very high natural immunity, as evidenced by the very small percentage of all exposed who actually develop the disease.

It has been found that the production of a general hyperleukocytosis is a most important therapeutic measure, as recently pointed out in the treatment of typhoid fever by the intravenous injection of sensitized vaccine and other nonspecific proteins. Similar observations have recently been noted in the treatment of arthritis by the production of a hyperleukocytosis after nonspecific foreign protein injection. The importance of producing a hyperleukocytosis in the cerebrospinal fluid in the treatment of epidemic meningitis has long been known.

The probable value of a hyperleukocytosis in the cerebrospinal fluid in poliomyelitis, a disease produced by an infectious agent of relatively low virulence, should be considerable. In order to be of most help, the serum would have to be used very early in the disease, during the acute inflammatory stage, if possible in the preparalytic stage, especially if prevention of paralysis and abortion of the disease is hoped for. The active, acute inflammatory stage of the disease is so short that it is often impossible to inject more than one dose of serum in the important early stage. Serum injected intraspinally should be injected under the usual precautions of strict asepsis, and control of the dose by coincident blood pressure observations.

In view of my previous experiences with the injection of horse serum in different central nervous system infections, I felt that the measure should certainly be given a thorough trial in the present epidemic. In 1912, I had occasion to use the treatment in two cases, with results which were encouraging.

The present preliminary report is based on only a small series of cases. In view of the harmless nature of the treatment and the general encouraging results, I felt it important to make this a preliminary report at this time.

A series of ten patients were treated with normal horse serum. Unfortunately most of the cases admitted to the hospital were late cases, but a few of the early cases showed interesting results.

The following case histories show the results in different stages and types of the disease:

CASE 2.—G. A., boy, aged 3 years, ill forty-eight hours, was admitted in the early stage with general meningitic symptoms, high fever, 105 F., and a slight facial paresis. Sixty c.c. of cerebrospinal fluid under high pressure were removed by lumbar puncture. Fifteen c.c. of normal horse serum were injected.

Examination of the cerebrospinal fluid gave typical findings. Eighteen hours later the temperature was normal, and the patient much improved in every way but still drowsy. Forty-eight hours later he was still drowsy, and slept most of the time. Macewen's sign was marked. Temperature was 101, and rigidity of the neck was again distinct. By lumbar puncture 30 c.c. of cerebrospinal fluid were removed, and 10 c.c. of horse serum injected. Eighteen hours later the condition was about the same. Thirty-six hours later there was decided improvement. Forty-eight hours later the boy was convalescent, seven days after the acute onset. No paralysis developed.

CASE 3.—Child, aged 3 years (Bridgeport hospital), ill forty-eight hours, was in the acute meningitic stage, with no definite paralysis, but pronounced symptoms of acute meningeal irritation.

Diagnostic puncture of cerebrospinal fluid under high pressure gave typical findings. Two hours later about 15 c.c. of cerebrospinal fluid were removed by lumbar puncture, and 15 c.c. of horse serum injected. Twenty-four hours later the temperature was down and the child much better. Forty-eight hours later the child was convalescent, with no paralysis, and recovery was uninterrupted.

A number of patients under treatment with late cases appeared to show much more improvement than is seen in cases clearing up without any treatment. It should be noted, however, that some cases, even with considerable paralysis of limbs, face or throat, clear up within a period of a few days without treatment of any kind. Judgment of results under curative treatment must therefore be based on comparative results. Results from curative treatment in the late cases could be expected only where there was no destruction of tissue.

CASE 4.—Girl, aged 9 years, ill one week, was still very irritable, and evidence of acute meningitic irritation was still present. There were marked anteroposterior spasm of the neck, and spasm and tenderness of the back. Macewen's sign was marked. Diplegia was complete. Sixty c.c. of clear fluid under high pressure were removed by lumbar puncture, and 15 c.c. of normal horse serum injected.

Twenty-four hours later the patient felt better and was less irritable. Rigidity of the neck and back had improved. She could move with greater ease.

Forty-eight hours: The patient felt good, and could sit up. Opisthotonos was gone.

Seventy-two hours: Rapid improvement continued; some power had returned to both limbs. The patient sat up and moved with freedom.

Five days later the child was convalescent. Diplegia was present, but some power had returned to the limbs, which were growing stronger. There will probably be partial permanent diplegia.

CASE 5.—Child, aged 4 years, with disease of twelve days' duration, had paralysis. There were diplegia and paralysis of the right upper extremity. Evidence of acute meningeal irritation was still present; the patient was very irritable; anteroposterior spasm of the neck and Kernig's sign were marked; respiration showed occasional intermittence. The general condition was only fair. Forty c.c. of clear fluid

under high pressure were removed by lumbar puncture, and 12 c.c. of serum injected.

Eighteen hours later, the child was much brighter, and less irritable. Rigidity of the neck was almost gone. The general condition was better.

Two days later, improvement continued; power was beginning to return to the paralyzed limb.

Four days later, the improvement continued steadily; considerable power had returned to the paralyzed limb.

The immediately favorable response in this case might, to a very great extent, be attributed to the relief of hydrocephalus, but the coincident improvement in the paralyzed limbs suggests favorable action of the serum.

CASE 6.—Child, aged 1 year, was admitted to the hospital on about the fourth day of illness, with right hemiplegia, repeated general convulsions, and continuous clonic convulsion of the paralyzed side. The general condition was bad. Respiration was irregular, of Biot's type. The child was very irritable and stuporous. The fontanel was markedly bulging.

Thirty c.c. of fluid under high pressure were removed by lumbar puncture, and 12 c.c. of serum injected.

Eighteen hours later there was no improvement.

Daily puncture for three successive days was done with injection of horse serum varying from 3 to 12 c.c. There was continuous but slow improvement, and after the fourth treatment the paralysis totally disappeared, the child became bright, took its nourishment well, and made an uninterrupted recovery.

EFFECT OF SERUM INJECTION ON CEREBROSPINAL FLUID

As previously explained, in almost all instances there is a hyperleukocytosis with relative polynucleosis, a change in condition from a moderate number of lymphocytes, within eighteen hours to a very high cell count, almost all being polymorphonuclears. The fluid macroscopically twenty-four hours after serum injection often shows a faint opalescence; occasionally the fluid becomes very turbid, but bacteriologic examination shows a sterile fluid, like that seen in aseptic meningitis. The fluid of the last case treated shows findings typical of all: original fluid on first puncture: clear fluid, moderate pressure, seventy cells per cubic millimeter, all lymphocytes. Globulin positive plus. Fluid eighteen hours after serum injection: 330 cells per cubic millimeter, almost all polymorphonuclears; globulin ++.

The cytologic change following serum injection disappears in a varying length of time, usually about forty-eight hours.

Convalescent Serum.—The use of a blood serum obtained from cases convalescent from infantile paralysis offers the advantage of a human serum plus the presence of immune bodies. That serum obtained from at least recently convalescent cases contains immune bodies has been proved by the neutralization test in the monkey (the neutralization of poliomyelitis virus mixed with the serum, and subsequently injected into the monkey). It has been stated that serum is potent even from those who had had infantile paralysis years previously. The serum used in our series was obtained from two adults three weeks' convalescent. About 10 ounces of blood were removed through a large needle into sterile bottles under strict asepsis. The blood was immediately shaken thoroughly (glass heads in the sterile flasks helps the defibrination). The blood was then thoroughly centrifugated, and the serum aseptically siphoned off. If the serum is to be stored for later use, it is desirable to add a little preservative, as chloroform, and to heat at 56 C. (132.8 F.)

for one hour. The serum should be tested for the Wassermann reaction.

Netter¹ reported the use of convalescent serum in thirty-two cases, with good results. The difficulties of arriving at any decision as to the value of convalescent serum are apparent in attempting an analysis of his figures.

Our first series here reported consist of four cases:

CASE 7.—E. R., aged 4½ years, ill two days, was admitted to the hospital in the preparalytic, meningitic stage. The temperature was 102; there was no paralysis. Forty c.c. of clear fluid under high pressure were removed by lumbar puncture, and 15 c.c. of convalescent serum injected.

Eighteen hours later the child was brighter, not so irritable or drowsy, and there was no paralysis.

Steady improvement continued till the third day, when slight paralysis of the right deltoid appeared.

Sixth day, the patient was well, and there was no paralysis.

This case could well be considered aborted.

CASE 8.—M. C., girl, aged 8 years, ill five days, had complete paralysis of both lower extremities, and partial paralysis of both upper extremities. The patient was very irritable, restless, and noisy, and had considerable respiratory embarrassment. During the first two days in the hospital, general treatment was used, but the condition was unchanged and caused us considerable anxiety on account of the respiratory symptoms. Convalescent serum was then used.

Thirty-five c.c. of clear fluid were removed by lumbar puncture, and 15 c.c. of convalescent serum injected.

The patient on the following day was quieter, looked better and felt better. Her limbs were less painful and tender. Improvement in her general condition continued, but up to the time of this report, six days later, there was no change in the paralytic condition.

CASE 9.—J. A., aged 4 years, was treated on the twelfth day of illness. The general condition was good, but there was phrenic paralysis and persistent cyanosis. Little was to be expected from serum treatment, but it was administered on account of the gravity of the condition. Sixty c.c. of cerebrospinal fluid were removed, and 13 c.c. of convalescent serum injected. Ten days later, there was slight improvement, but it was apparently not due to the serum.

CASE 10.—Child, aged 1½ years, admitted about the sixth day of the disease, with diplegia, was very drowsy, and had marked respiratory irregularity. Macewen's sign was marked.

Forty c.c. of clear fluid were removed by lumbar puncture, and 10 c.c. of convalescent serum injected.

Twenty-four hours later the general condition was much improved, and the child was brighter.

Four days later the child was convalescing, but there were no changes in the paralytic condition.

Results.—The convalescent series was very small, but the results were certainly no better than in the normal horse serum series.

In the normal horse serum series, two cases treated in the preparalytic stage were aborted. One case was aborted under the convalescent serum treatment. Best results were obtained in early cases.

Some of the late cases treated showed more improvement than is generally seen in untreated cases. There was more rapid convalescence and improvement in the paralytic condition.

It is hard to judge as to the saving of life, but the sickest patients, totaling fourteen, were selected for treatment, and there was only one death; that patient was almost moribund at the time of treatment.

Normal Human Serum Treatment.—No observations were made.

Epinephrin Treatment.—Dr. S. J. Meltzer suggested the use of epinephrin intraspinally as an active form of treatment.

The work of Dr. Clark,² done at Dr. Meltzer's suggestion, on the action of subdural injections of epinephrin in experimental poliomyelitis, indicated that for a time at least there was considerable response in the paralyzed animals.

Observations in the hospital were made in only three cases, an insufficient number from which to make any deductions. A boy of 5 with respiration paralysis had three doses at six-hour intervals. There was considerable temporary improvement, but the boy ultimately died. The other two patients each had only one dose with no result except sharp rise in blood pressure. Dr. Meltzer's suggestion, however, was to inject the epinephrin intraspinally at least every six hours in doses of from 0.5 to 1 c.c. for small children.

3. TREATMENT OF RESPIRATORY PARALYSIS

Respiratory paralysis is the most common cause of death in infantile paralysis. It is therefore of prime importance to meet this complication early, so as to tide the patient over the critical period until congestion and inflammation about the center subside. Transient paralysis, which can most logically be explained as being due to relief of congestion, edema and vascular involvement, is one of the regular features of this disease.

Many have noted that patients could be kept alive for hours, in one case three days, under artificial respiration.

In very stuporous, comatose cases with respiratory paralysis, a more active form of artificial respiration is indicated. At my inquiry, Dr. Meltzer suggested his pharyngeal respiratory apparatus for comatose patients; and for conscious patients, if possible early after respiratory difficulty has set in, he suggested the administration of oxygen under pressure by his method. A more detailed discussion of the results and technic will be given in a later paper. The administration of oxygen under pressure kept a number of patients alive for hours. It was used in several cases with slight respiratory embarrassment with benefit, but it was difficult to judge in these whether more serious respiratory paralysis was warded off.

The pharyngeal apparatus was used in several cases without result. As a rule the patient is conscious almost until the end, so that pulmonary edema is far advanced when the patients become unconscious. The method, however, should certainly be given careful trial.

4. GENERAL TREATMENT

At this time attention will be directed only to the importance of general treatment, especially in public wards. We are dealing with helpless children, each of whom requires especial care as to feeding, and care of bladder and bowels. Respiratory embarrassment should be carefully watched for. Turning from side to side is important; in this connection Dr. Meltzer suggested that it might possibly have some influence on the paralysis, owing to shifting of edema.

5. ORTHOPEDIC TREATMENT

This should be begun as early as possible. Patients should be watched from the beginning by the orthopedist.

2. Clark, P. F.: The Action of Subdural Injections of Epinephrin in Experimental Poliomyelitis, *THE JOURNAL A. M. A.*, Aug. 3, 1912, p. 367.

1. Netter: *Arch. de méd. d. enfants*, Jan. 16, 1916.