

including the floor, and the latest date of exposure to infection, and must be followed immediately by a written notice.

Such children will be promptly visited at their homes by a representative of the Department of Health, and instructed as to nature and duration of quarantine. They must not leave the premises until two weeks have elapsed from the date of last exposure to infection.

The premises are not placarded, but the children are visited at regular intervals, and should quarantine be violated the parents or guardians are summoned to Court and fined."

### POLIOMYELITIS: THE PREPARALYTIC STAGE AND DIAGNOSIS.

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To anyone who has passed through one or more epidemics of poliomyelitis, or who has become thoroughly conversant with the disease through reading, the following pages will be of only passing interest; but I am convinced from my association with other physicians, particularly in seeing cases of the disease, that an article dealing with the preparalytic stage, with the findings in the cerebro-spinal fluid, and a few points on the differential diagnosis will be welcomed by many. The old idea of the disease and its clinical paralytic form has become fixed in the minds of the medical profession, so that it will need repeated contributions to eradicate these earlier conceptions of it. I have had, during the past six months, a rather unusual opportunity of seeing a large number of cases, and it was with pleasure that I responded to the invitation of the editor to prepare the following pages.

THE ABORTIVE FORM AND PREPARALYTIC STAGE. Wickman, in his marvelous monograph, divides the abortive cases into four classes:

1. Those with the course of a general infection.
2. Those showing meningeal irritation.
3. Those with marked pains suggesting an influenza.
4. Those with accompanying gastro-intestinal disturbances.

To this one might add a fifth, for the purpose of calling attention to it, of an anginal form, or those beginning with definite sore throat.

It should be borne in mind that poliomyelitis is a disease which, probably in a very large proportion of cases, does not involve the nervous system to such an extent as to cause special symptoms, and the cases characterized as abortive are merely those which go through a preparalytic stage without having any definite paralysis following. If this point is borne in mind it simplifies the conception

and also the description of these cases, for what is true of the abortive cases is equally true of the preparalytic stage of the ordinary form of the disease. Doubtless a great number of the so-called abortive cases have muscular weakness or even paralysis of a very limited amount. It is extremely difficult to detect even marked difference in muscular power in very young infants, so that the lesser degrees of loss of power may easily escape notice even after the most searching and repeated examinations.

The onset of the disease is usually sudden. Occasionally the onset is gradual and it may not be possible to tell exactly when the child was taken ill. The severity of the initial symptoms bears no relation whatever to the subsequent course of the disease, as one sees a very mild onset followed by most extensive paralysis and even death, and other cases coming in a most fulminating manner which subsequently clear up entirely. The first thing observed about the child is that it is ill, and of all the symptoms noted fever is the most constant. There are, perhaps, exceptional cases in which the febrile stage is slight and short and so easily overlooked by ignorant or careless parents; but in cases under careful observation the afebrile attacks are certainly most exceptional. The second most notable symptom is the presence of pain, and in children old enough to locate the pain, headache is, next to fever, the commonest symptom. The pains may be in any part of the body and may be so marked as to overshadow all other features of the disease, or they may be so trifling as to be only elicited by special examination, with all gradations in between. The commonest pain next to headache, and of decidedly more value in diagnosis, is a tenderness and pain along the spine and down the legs reaching to the heels or even the soles of the feet, and another very common and suggestive pain is that in the neck and back of the head. If the head is bent forward this is usually greatly increased, causing the child to cry out and resist very markedly. If there is not much pain present it can usually be elicited by bending the legs up and the head forward, so as to flex the spine. In some children the pain is present only when one attempts to move the arms or legs or various parts of the body; in others it is spontaneous and the child cries most of the time with it; and in still others there is a hyperesthesia, so that the slightest touch without any movement whatever elicits an unusual degree of suffering. In some cases pain is elicited on gently squeezing the muscles. In many cases there is slight stiffness of the neck and the child assumes a very suggestive attitude, lying on one side or the other, but not on the back, so that the head may be thrown slightly backward. The legs are usually drawn up, although not always. The disease may be ushered in with a convulsion, or convulsions may occur in the course of the disease.

The mental condition is extremely interesting. The commonest form of disturbance consists of very marked drowsiness, which is

replaced by a most extraordinary irritability when the child is aroused; but when one ceases to examine him he rolls over into his former position and dozes off again. Other children are extremely restless and irritable and some are wideawake with a hyperacute mentality. With this is a very evident delirium or a tendency to delirium. These cases, in my experience, are of the worst possible type and usually die. In some children there is a very marked delirium—talking, muttering—and this is accompanied by a tendency to move about in the bed and change the position frequently. Often the moving about is exceedingly suggestive, the child tossing from side to side and not lying in any position more than a few moments, sitting up, standing up, and half turning from side to side in a perfectly purposeless way. If the child is watched carefully it will very often be seen to have fibrillary twitching of the muscles; at other times whole muscles will tremble. In rare instances the muscle is more or less spastic and may stiffen when the extremity is taken hold of to relax a few moments later.

The gastro-intestinal symptoms are not uncommon. Anorexia is the rule. Vomiting may be present and may be so marked as to suggest an acidosis. Constipation is rather more common than diarrhea, but the latter is frequently met with. The throat is often reddened; the redness is general and not limited to the tonsils, and in some cases there is a considerable amount of erythema and slight suffusion of the eyes. Another curious feature met with both early and later on in the disease is the tendency to profuse sweating. This may be as marked as the colliquative sweats seen in typhoid. Sometimes the sweating is limited to one part of the body, as to the face or neck, or to one extremity, sometimes to one-half of the face. In some cases there may be retention of the urine, and this should always be looked for.

Usually, as Wickman has suggested, the disease presents certain dominant features. The cases which are like the course of a general infection have nothing to suggest the diagnosis, or they may have some of the things mentioned above, the general history of the attack being that the child is taken ill suddenly with an attack of vomiting followed by a fever of from  $101^{\circ}$  to  $103^{\circ}$  or  $104^{\circ}$ , or sometimes higher, with headache, and feeling very badly, but without any definite symptoms of any kind. This may clear up in twenty-four hours, or it may last two, three, or rarely four days, when the symptoms disappear entirely and the child has nothing whatever to show for it. These cases may be seen in connection with two or three or more cases in a family or group of children, and the diagnosis is made or suspected by the fact that the child was taken ill at the same time with identical symptoms or nearly so, to one or more definite cases of the disease in the immediate surroundings. These cases present the greatest difficulty in diagnosis.

The meningeal form is the most suggestive of all, and one almost

immediately realizes that he has either to do with a beginning poliomyelitis, a meningitis, or a meningismus. In these cases, when the patient is examined, it will be found there is an anterior and posterior stiffness of the neck; Kernig's sign may be present or absent; McEwen's sign elicited by percussing and auscultating the cranium may be present, owing to the distention of the ventricles of the brain with the fluid; and the patient may show a very characteristic sign at this time, or usually a little later, which may be described as follows: If the patient is raised by placing the hands under the shoulders the head will fall back. If the child is told to raise the head when it is sufficiently conscious, it will do so and hold it forward a moment or so and the head will again fall back. This is a sign of very great importance. In some cases there is a curious vasomotor disturbance which is most often seen in the cases of the meningeal form. This consists of an alternate blushing and paling of various areas of the skin. It may be over small spots or over large areas, the part affected being redder than normal, and then after a varying time it may become paler than the surrounding skin or present a normal appearance. Sometimes the flushing is very transient and is only a momentary wavering flooding of the superficial vessels. There is practically never any question in these cases with a meningeal irritability of the advisability of a lumbar puncture, and it should be done as soon as possible, and this usually clears up the diagnosis immediately. The cases with marked pain, resembling influenza, should suggest poliomyelitis. In my own experience I have rarely seen cases of influenza with as much pain, or with the kind of pain, as described above, although they do occur. In these cases a lumbar puncture should be done to settle the question of diagnosis.

The gastro-intestinal cases are more difficult because one does not always have in mind the possibility of a poliomyelitis. The child is taken with a fever with intense vomiting, and if it has had a history of acidosis with vomiting before this the physician may be thrown off his guard. In some of these cases, if the child is carefully observed, some of the special features mentioned above may be elicited, but if they are absent the diagnosis may be impossible. The presence of a very marked diacetic acid reaction in the urine will incline one to believe that the case is one of acidosis, though it must be borne in mind that any febrile condition will show diacetic acid in the urine, although the reaction is not as marked.

The cases with sore throat and coryza are also difficult and practically impossible to tell unless a careful examination elicits some suggestive symptoms or signs. This preparalytic stage, when it does not go on to the development of a paralysis, is what we have called an abortive case, and may subside in twenty-four hours, or it may last two, three, or four days, occasionally five, six, seven, or eight days; in a few instances longer, but rarely. In some of

these cases the convalescence may be slow and the child may suffer with indefinite symptoms for days or even weeks after the attack. These consist chiefly of pain coming on at any time, but more often at night, sometimes waking the child up out of sleep. These pains are usually transient and disappear either spontaneously or after rubbing the affected parts. In some instances the pain is accompanied with cramps in the muscles. The child may tire readily on exertion even though it has shown no paralysis or loss of power, or the tiring may be localized to certain groups of muscles or to one extremity. When this is the case one might assume that the spinal cells supplying this part have been affected. If the child is old enough to make special tests of the power of the muscles according to the method suggested by Lovett the diagnosis may be even more certain.

**THE CEREBROSPINAL FLUID.** The cerebrospinal fluid in practically all cases, certainly in almost all if not all of the cases which show nervous symptoms, is abnormal and may present a number of different changes which, in the main, are constant. The fluid is sterile, usually clear, and sometimes a slight fibrin web forms in it. In exceptional cases the fluid may be cloudy or even bloody. Usually the presence of blood means a faulty technique, the error generally being the use of a needle without a sufficiently close-fitting obturator. The number of cells is definitely increased. The normal fluid contains from five to ten cells per cubic millimeter, while in poliomyelitis the number of cells is increased from sixteen to twenty to one hundred, but in some instances this number is greatly exceeded, as high as five hundred or over being met with. In the early stage of the disease, before the paralysis has made appearance, the chief type of cell found is the polymorphonuclear. Sometimes they form from 80 to 90 per cent. of the cells present. After the appearance of the paralysis the cells found are chiefly lymphocytes, and from 75 to 100 per cent. of the cells present are of the mononuclear type. There is also the presence of large mononuclear cells of an endothelial type which have been regarded by DuBois and Neal as rather characteristic of poliomyelitis. There are also phagocytic cells present. It must be borne in mind that even a slight admixture of blood will account for a certain number of polymorphonuclear cells. The cells rapidly disappear from the cerebrospinal fluid, so that after the first two weeks the count is either normal or nearly so. The fluid is sterile, gives a positive Fehling's reaction like the normal fluid, and usually contains a very definite reaction for globulin, which is, however, not as pronounced as that found in the various forms of meningitis. During the first week the globulin is found in perhaps one-half of the fluids examined. Pandey's test will, as a rule, be found easy and reliable. The globulin increases, as a rule, until about the third week, when it decreases, but a slight increase may be detected even after seven weeks or longer. The

reaction to Fehling's solution is of slight value in diagnosis, inasmuch as in tuberculous meningitis, and sometimes in meningitis due to other organisms, this power to reduce Fehling's solution is absent. If the reaction is present it means nothing, if it is absent it is a point against poliomyelitis.

The fluid in meningismus is increased from 10 to 100 c.c., is sterile, clear, and contains very few cells. Albumin and globulin may be present in very slight traces, or may be absent, the reaction never being anything approaching that seen in poliomyelitis. The Fehling's solution is reduced and animals inoculated with the fluid gave negative results. In tuberculous meningitis, which may resemble poliomyelitis closely, the fluid is usually markedly increased from 30 to 120 c.c. or more, and is usually under decided pressure. On standing a clear fibrin web usually forms, and this is much more marked than the slight web sometimes seen in poliomyelitis; in practically no other fluid is such a dense web seen. This contains a great many cells, and after transfer to a slide and stained, tubercle bacilli may usually be demonstrated if a sufficient amount of time is given to the search. I do not remember a case of tuberculous meningitis which I have seen in recent years in which the tubercle bacillus could not be demonstrated, although sometimes it took a considerable time to do it. The cells present are lymphocytes, which form about 95 per cent. or more of those seen. The reaction for albumin and globulin are more marked, very much more marked than the reaction seen in poliomyelitis. In about 25 per cent. of the cases Fehling's solution is not reduced. Animal inoculations (guinea-pigs) show tuberculosis in about four weeks' time.

In cerebrospinal fever the pressure of the fluid is definitely increased, and the amount very much, as in tuberculous meningitis. The fluid is turbid or cloudy, and stained specimens show the presence of the meningococcus. The cells present are polymorphonuclears up to 98 per cent. The albumin and globulin reactions are as in tuberculous meningitis, and Fehling's solution may or may not be reduced. In meningitis due to other organisms the fluid is increased, is turbid or cloudy, and otherwise resembles that of cerebrospinal fever except that the organism demonstrated in the smears will be found to be a pneumococcus or influenza bacillus or whatever happens to be the cause of the inflammation.

**DIAGNOSIS.** The diagnosis of poliomyelitis presents certain difficulties, the commonest of which are in the cases in the preparalytic stage. If it is borne in mind that the disease may be regarded as a general infection and that various parts of the body may be affected, one understands more readily the rather protean symptomatology of the disease. At the present time the most important thing to confirm the diagnosis is the examination of the cerebrospinal fluid, and abortive cases showing a normal fluid must therefore remain more or less doubtful. The question of whether the child may have

poliomyelitis without having any changes in the cerebrospinal fluid is at present an open one. The general rule is if a case shows a normal spinal fluid that it is not to be regarded as poliomyelitis. Usually when there are any symptoms whatever of involvement of the nervous system the case turns out to be one of poliomyelitis. One sees a patient occasionally, particularly in association with other cases in the same family, in which the cerebrospinal fluid is normal, but in which the patient was strongly suspected of having the disease. This point might possibly be cleared up by a series of observations upon animals.

Another method of diagnosis which has been employed, but which is not suited for ordinary use, is to take the serum from the suspected case, mix it with a fatal dose of the virus, and after incubating it inject it intracerebrally into monkeys. A failure to develop the disease would indicate that the virus had been neutralized, but it must be borne in mind that serum from persons having had the disease recently will also neutralize the fluid, and if the individual had passed through an unrecognized abortive attack the results could well be misleading.

The diagnosis of the paralysis itself is not always easy. In older children it is usually apparent and the child will tell you he cannot make certain movements if asked to do so, unless he is too ill to take notice. In the very sick and the very young the production of pain or tickling must be used and the unparalyzed member will be used to protect the paralyzed one or to brush away the source of the irritation. In young babies picking up the child with the hands under the shoulders and buttocks, leaving the limbs free, will usually make the paralyzed parts plain. The normal infant moves all its members, in the paralyzed the affected part hangs in marked contrast with the moving arms or legs. In very ill children this is not as effective, but still of value.

Before the onset of the paralysis, or when it is unrecognized, the case may be mistaken for almost any acute febrile disturbance, and great care should be taken to elicit changes in the nervous system. In the presence of an epidemic even comparatively slight changes may be sufficient evidence on which to do a lumbar puncture, and most parents will welcome any method which abridges their suspense. The most common sources of error, apart from conditions with nervous symptoms, are as follows:

*Croup or Laryngitis.* With a paralysis of the laryngeal muscles the case may present such dyspnea as to require intubation and the child may be suspected of having croup, laryngitis, or laryngeal diphtheria. Other paralyzes will generally be found on careful examination and the absence of any other evidence of diphtheria will generally make the case clear.

*Bronchopneumonia.* A child with a paralysis of the respiratory muscles may suggest a pneumonia. On careful examination either

the thoracic muscles or the diaphragm will be found paralyzed. The fixed chest wall, either one or both sides with exaggerated abdominal breathing, characterizes the first. When the diaphragm is paralyzed, instead of inspiratory distention of the abdomen there is an inspiratory retraction. With hurried respiration and a little bronchitis or pulmonary edema the physical signs may be misleading unless one is unusually skilled, and even then.

*Nephritis with Uremia.* This may be misleading on account of the convulsions or coma. The edema and urinary findings will be sufficient to clear up the diagnosis, or a lumbar puncture may be done.

*Acidosis. Cyclic Vomiting.* This may be very misleading. The profound languor may suggest a generalized slight loss of power, such as is sometimes seen. There may be twitching of the muscles and other nervous symptoms. The acetone odor of the breath and the marked diacetic reaction in the urine will point the way. The reaction in ordinary febrile disturbances is rarely as pronounced as in acidosis. A lumbar puncture may be needed.

*Diarrhea.* When the symptoms of gastro-intestinal disturbances are very marked the diagnosis may not even be suspected, inasmuch as meningismus and other nervous symptoms are not uncommon in connection with diarrhea. The lumbar puncture will afford a means of settling the question in suspected cases.

One should bear in mind that poliomyelitis may coexist with other diseases and with injuries. A surgeon recently told me of a case occurring in a boy with a broken arm. A couple of weeks after the arm had been put up it became very painful, and there was a slight fever. It turned out to be a poliomyelitis. The disease complicating medical conditions is readily imagined and needs no further detail.

A second class of disease in which there is pseudoparalysis or spasm may also cause difficulty in diagnosis. This includes scurvy, rickets, hysteria, the spasmophilia seen in nutritional disturbances, and tetany.

*Scurvy.* In severe scurvy the child assumes a position which suggests poliomyelitis. The paralysis is only apparent and the child can be made to move the extremities if sufficiently irritated. In the very late cases the muscles will be seen to move if the limbs do not. The reflexes are normal. There are, in addition, the classic signs, the bleeding of the gums, the submucous and subdermal hemorrhages, the periosteal swellings, etc., and symptoms rapidly disappear on the administration of orange juice.

*Rickets.* In acute rickets there is a pseudoparalysis like that described in scurvy, but in place of the scorbutic symptoms there are marked evidences of rickets.

*Tetany.* The characteristic position, the spasm being chiefly in the hands and feet and bilateral, the exaggerated reflexes, the



contraction of the muscles on percussing the nerve, best seen in the facial, and the spasm caused by constricting a limb make the diagnosis easy.

*Spasmophilia.* Apart from tetany a definite tendency to contraction of the muscles exists in certain poorly nourished young infants. The reflexes are increased and the stiffness of the muscles is general.

*Hysteria.* This may present some real difficulties. Fortunately it is rare in older and practically absent in young children. The reflexes are normal and there are sensory disturbances, usually anesthesia of the glove and stocking type. If the condition has existed for some time the absence of marked atrophy is of value.

The third class of cases includes those in which there is some definite disease of the nervous system. To avoid repetition *let me insist upon the necessity of obtaining the history of the attack.* This will save many embarrassments and will also eliminate the congenital conditions. The history may be impossible or difficult to get or may be misleading, but usually it will help tremendously.

In this connection one must bear in mind the possibility of encountering an old poliomyelitis with some intercurrent fever added. We are dealing only with the diagnosis in the acute stage or near it, so that the differential diagnosis between the old nervous lesions will not be touched on.

In the following diseases *the examination of the cerebrospinal fluid is the deciding point.*

*Tuberculous Meningitis.* This may give more difficulty than any other condition. The general appearance, as a rule, is different, but this may not mean much until the child has been seen several times. The cerebrospinal fluid is under greater pressure than in poliomyelitis. Sooner or later there are changes in the eye-grounds. The onset is more slow and more irregular. The dominant symptoms are drowsiness, vomiting, irregular pulse and respiration, convulsions, and rigidity of the muscles. The reflexes are increased. In poliomyelitis the length of time to reach the same stage is much more brief, and while in the incubation stage there may be rigidity or increased reflexes the tendency is to become flaccid and to have a loss of reflexes.

*Cerebrospinal Fever.* At the onset the two diseases may be strikingly alike. The sudden onset with vomiting and high fever, the prostration and rigidity of neck and extremities, the drowsiness with irritability and hyperesthesia, may be simulated by poliomyelitis. The petechial eruption, if present, is a help, and after a few days the marked spasticity and increased reflexes give a picture usually easy to distinguish.

*Other Forms of Meningitis.* Much as above, the diagnosis depending on finding the causal organisms in the cerebrospinal fluid.

*Meningismus.* Meningeal symptoms, drowsiness, retraction of the head, etc., may be seen in connection with inflammatory diseases

of the body elsewhere, as in pneumonia and enterocolitis. This may be intensified by a great loss of fluid from the body, as in the last-named disease. These conditions may tax the diagnostic powers if only the symptoms and physical signs are depended upon. The recognition of the existing disease and the cerebrospinal fluid clear up any doubts.

*Cerebral Thrombosis.* This is seen in connection with inflammatory diseases elsewhere in the body, and the diagnosis may not be suspected. If symptoms are produced that stand out above those of the causative condition they are convulsions and paralysis, either localized or general, strabismus, and coma. When the disease extends from a neighboring inflammation, as in the nose or ear, the symptoms may be more marked, and consist of headache, drowsiness, and if pyemia occurs, chills, sweats, and a high variable temperature. I have seen one instance of a lateral sinus thrombosis in which the drowsiness and irritability were not unsuggestive of poliomyelitis. The localizing symptoms, cyanosis of the face with dilatation of the temporal and frontal veins in thrombosis of the longitudinal sinus, the marked edema of eyelids and face and protrusion of the eye in cavernous thrombosis, and the extension into the neck in lateral sinus trouble soon make the diagnosis plain.

*Mental Deficiency.* When there is some febrile disturbance this has more than once been mistaken for poliomyelitis. The history, if obtainable, and the subsequent history, if not, will generally make the question clear, and one can always resort to a lumbar puncture. I have seen some extraordinary clinical pictures when the two were associated.

*Amaurotic Family Idiocy. Tay-Sachs's Disease.* This, too, can be mistaken if there is an intercurrent fever, as the flaccidity suggests poliomyelitis. The condition affects all the muscles, the blindness is apparent, and there are characteristic changes in the eye-grounds. It occurs in Jews, and the history of gradual onset, beginning between the third and sixth month, is usually obtainable.

*Transverse Myelitis.* This may occur in connection with the acute infectious diseases. The increased reflexes below the lesion and the involvement of bladder and bowels ought to make the diagnosis easy.

*Pott's Disease.* By pressure this may cause a paralysis with increased reflexes. The diagnosis is usually apparent, but cases have been sent to hospitals as poliomyelitis.

*Congenital Spastic Paralysis.* Despite the fact that these do not resemble acute poliomyelitis they have been mistaken for it. The differential diagnosis of late poliomyelitis and these cases is another story.

*Chorea.* This disease has also been mistaken for poliomyelitis, but ordinary careful examination ought to solve the difficulty.

*Facial Paralysis. Bell's Palsy.* In times of epidemic this may give considerable difficulty. In doubtful cases the only way to

clear up the diagnosis is by lumbar puncture, but a facial paralysis coming on after definite exposure to cold and preceded by earache is apt to be called Bell's palsy, and the same is true of cases in which there is marked involvement of the ear. On the other hand, a case coming on with a history similar to poliomyelitis can fairly safely be classed as that disease.

*Peripheral Neuritis.* Cases of this disease may cause very distinct difficulties in diagnosis. In children it usually follows an infectious disease. It is most common after diphtheria, and there is usually a history of throat involvement. The most common forms of paralysis are those of the soft palate and of the eye muscles, particularly of the accommodation. The patient often shows irregular heart action with dilatation of the heart. In poliomyelitis the paralysis comes on within a few days, usually within the first eight days. In diphtheritic paralysis the onset is later. In Rolleston's series, on which I commented in *Progressive Medicine* for March, 1914, the only forms of paralysis which occurred during the first two weeks were those involving the palate and the so-called cardiac paralysis. The ocular paralyses are more apt to occur during the fourth and fifth week, although some occur in the third week, and paralysis involving the lips, pharynx, or diaphragm almost always occurs later than this, that is, during the sixth, seventh, and eighth week. In cases seen early a lumbar puncture will settle the question, but in cases occurring late in which no history can be obtained the difficulties of diagnosis may be almost insurmountable.

## THE CLINICAL ASPECTS AND TREATMENT OF ACUTE POLIOMYELITIS.

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THE epidemic of acute poliomyelitis occurring during 1916 has produced an infinitely larger number of cases than during any preceding epidemic. Up to December 1, 1916, there were 999 cases in Philadelphia, 768 of which were treated at the Philadelphia Hospital for Contagious Diseases, and it is mainly upon the study of these latter that this paper is based.

It has been brought out very forcibly that, while belonging to the acute infectious diseases, it is a general disease in which almost all the organs of the body are involved. This has been proved conclusively by postmortem findings and by experimental work, showing that a solution made from these organs when injected into monkeys has caused typical acute poliomyelitis, which strengthens our belief that the principal mode of entrance in the human being