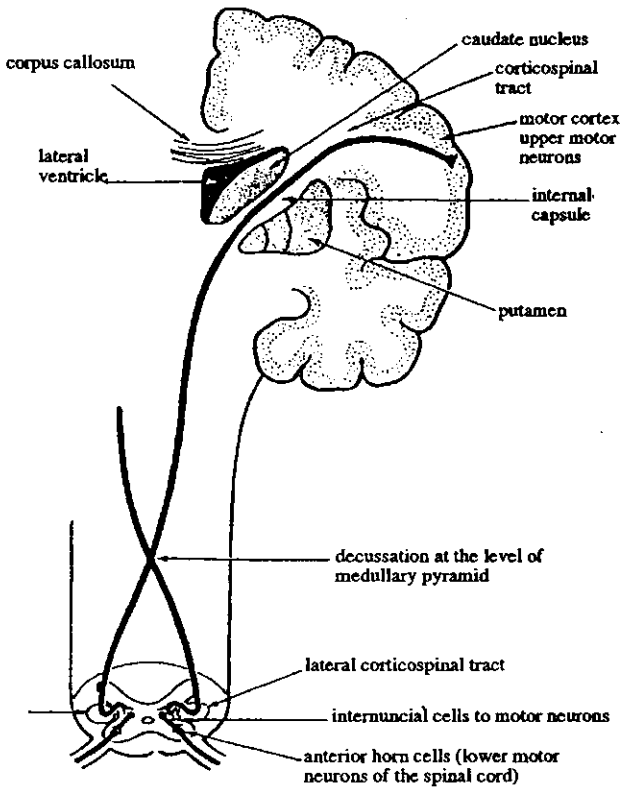


Fig 1. The upper motor system from the motor cortex to the anterior horn motor neuron of the spinal cord.

Axons of the upper motor neurons thus make direct contacts (synapse) with very large neurons of the spinal anterior horn; that is, anterior horn cells (neurons for the second-order motor system or lower motor neurons). The motor commands transmitted from the motor cortex of the contralateral frontal lobe are thus relayed (synapsed) at the level of the anterior motor horn cells and the second-order axons from the anterior horn cells emerge from the anterior surface of the spinal cord to form the spinal ventral roots. The motor axons are in general very large-caliber myelinated (insulated) fibers and thus run with a fast electric conduction velocity. The roots which adjoin with the dorsal roots (spinal sensory roots) form the peripheral nerves that subserve both motor and sensory functions. Also, each peripheral nerve contains very thin autonomic nerve fibers in it. These autonomic (sympathetic) fibers emerge together with the second-order motor fibers from the thoracic spinal cord level but the sympathetic fibers (thinly-myelinated) soon leave the ventral roots to form the sympathetic ganglionic (neuronal) chains along the paravertebral alignment. The extremely thin, unmyelinated sympathetic fibers again merge into the peripheral nerve to supply to the blood vessels, sweat gland and hair follicles. This sympathetic nervous system is important for maintaining blood pressure, controlling body temperature (by sweating and vasodilatation), heart rate and so forth.

Several segmentally emerged peripheral nerves through the intervertebral foramina join, reform, and segregate into multiple branches (the brachial nerve plexus and lumbosacral nerve plexus). In the upper limb and the shoulder girdle, the peripheral nerves include the axillary, suprascapular, radial, musculocutaneous, median and ulnar nerves, to name a few. In the lower limbs, the sciatic nerve and its branches (common peroneal, posterior tibial nerve and so forth), femoral nerve and obturator nerve are responsible for the lower limb function.

The peripheral nerve is divided further into small branches when approached the target muscle and penetrates the fascia to distribute into the belly of muscle fibers. Motor axon then forms a synaptic contact with the muscle, that is, the neuromuscular junction. The chemical mediator (neurotransmitter) is acetylcholine, which is released at presynaptic terminals to postsynaptic (muscular) junctions by the mechanism of exocytosis (shelling). Interruption at any level of the descending motor pathway just described gives rise to

the loss of volitional motor execution, that is, *paralysis*. Paralysis, a loss of muscle power, is caused by diverse reasons that anatomically or functionally interfere with the electric impulse conduction at any level of the motor system. *The upper motor system* consists of the structures connecting axons from the motor cortex to the spinal cord anterior horn. The structures connecting anterior horn motor neurons to skeletal muscles are called *the lower motor system*. Interruption at the lower motor system also gives rise to paralysis but the clinical presentation is different each other.

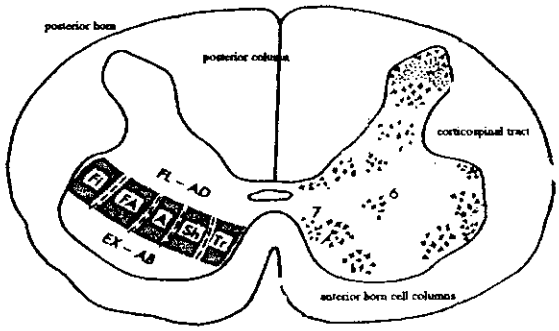


Fig 2 The transverse view of the spinal cord. The anterior horn cells (lower motor neurons) are organized in a topographical manner (FL flexor muscles, EX extensor muscles, AD adductor muscles, AB abductor muscles).

II. Clinical Interpretation and Assessment of Paralysis

1. Understanding the motor function

Functionally, damage to the upper motor system and lower motor system gives the same consequence, that is, *paralysis*. However, the clinical appearance of the paralysis differs significantly between these systems. *Clinical differentiation of paralysis caused by the lesioned upper motor system from the lower is of utmost importance in making a differential diagnosis of paralytic disorders*. This is particularly true when dealing with the AFP (acute flaccid paralysis) cases. The following chart is a simple differential points between these two situations.

A. "Spasticity" and the muscle tone:

When the muscle is passively stretched, there is normally no apparent resistance against the stretch when a person is fully relaxed. However, when the upper motor system is involved, despite paralysis, one shows resistance to passive stretch for a brief period of time (a few hundred milliseconds) and then muscle is relaxed and fully stretched. This phenomenon is called either "spastic catch" or "clasp-knife phenomenon". This is a hallmark of the upper motor involvement and neurophysiologically, the loss of inhibition of spinal anterior motor neurons by an upper motor lesion facilitates the monosynaptic stretch reflex at the spinal segments below the lesion. The spasticity is not always detrimental to human since a totally hemiplegic person due to a cerebral stroke may become able to bear his body weight and to walk as spasticity develops in the paralytic lower extremity. As a rule, the paralysis due to upper motor lesion begins with flaccid paralysis and in a several weeks, the flaccid para-lysis gradually gains the spasticity; thus, even in upper motor system disorders, the initial event may be a flaccid palsy and the distinction between the upper and lower motor system involvement may solely depend on other clinical features during the acute phase of paralysis (Fig.3).

B. *The (muscle) stretch reflex (deep tendon reflex)

This is a phenomenon of spinal monosynaptic relay system at the level of anterior horn cells, afferent signal of which is a burst of impulse from muscle spindles of the extrafusal fibers of the tapped muscle. The efferent arc is the burst of firing of anterior motor neurons, which monosynaptically receive the impulse from the tapped muscle via the dorsal root. When any segment of this reflex arc is interrupted, the stretch reflex goes away or diminishes (Fig 4). If the upper motor system is damaged at any level from the motor cortex down to the corticospinal tract of the spinal cord, the stretch reflexes below that level are exaggerated by the loss of inhibition to anterior motor neurons.

Fig 3 A comparison of the upper versus lower motor syndromes.

	upper motor lesion	lower motor lesion
paralysis	**spastic**	**flaccid**
muscle tone	**increased**	**decreased**
muscle atrophy	**inconspicuous**	**prominent**
stretch reflex	**exaggerated**	**diminished**
Babinski	**extensor**	**flexor**
clonus	**++**	**-**

C. *Babinski sign"

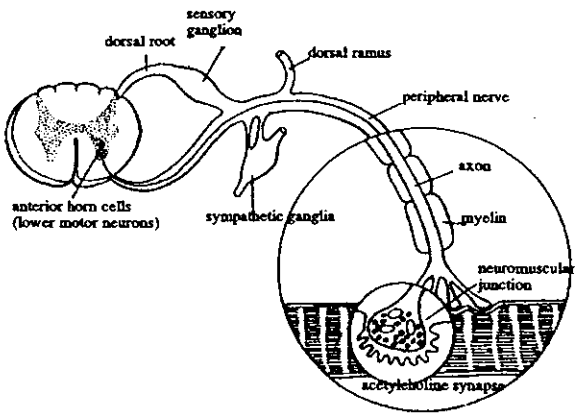


Fig 4 The deep tendon reflex is elicited when the muscle tendon and thus the muscle is abruptly stretched by tapping. The afferent sensory stimuli go from the muscle spindle to the spinal cord anterior horn where the signal is relayed to motor neurons.

This is sometimes replaced by the term "extensor plantar response". The plantar response is elicited by a somewhat uncomfortable sharp scratch to the lateral aspect of the sole from the base way up and around the upper margin of the plantar surface. Normally, such a noxious stimulus to the sole would make the toes to curl down (plantar flexion). However, when an upper motor lesion is present, sometimes (not often), the toes, in particular, the big toe, would show dorsi-flexion (curling up) instead of plantar-flexion (curling down). Neurologists amuse this maneuver very much but the absence of Babinski sign does not exclude the upper motor lesion. It is much more important to rely on the evidence of exaggerated muscle stretch reflex and of spasticity (Fig 3).

Clonus is seen when the stretch reflex is markedly exaggerated and thus the upper motor system is impaired. It is in essence the repetitive ankle or patellar tendon reflex activity, i.e., stretch reflex--contraction--relaxation--stretch reflex--contraction. This is often readily demonstrated when ankle is forcefully stretched or the patella is quickly pushed downwards in order to stretch the quadriceps muscle.

D. *Muscle atrophy (wasting) and weakness (paralysis)

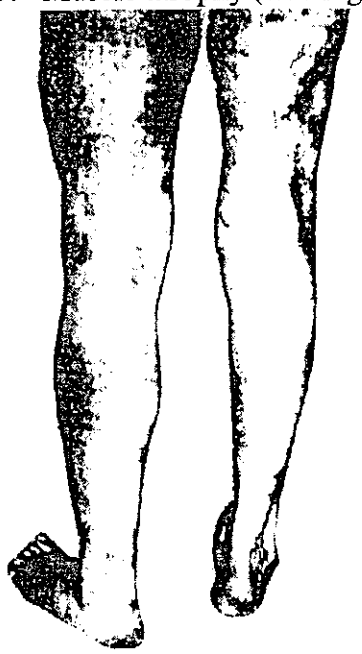


Fig. 5 The right lower extremity is much thinner than the left, as the hamstring muscles (posterior aspect of the thigh and calf muscles is apparently atrophic, due to poliomyelitis.

This rapidly ensues when the lower motor system is involved. When severe paralysis occurs by an upper motor lesion, there may be atrophy of the paralyzed muscles but it is never remarkably wasted. It is important to observe the muscle bulks of four limbs and compare those for the presence of any focal or lateralized prominent wasting (asymmetry). Then, *touch and feel* the muscle bulk carefully. Any difference in the diameter of limb muscles would be felt. In polio the muscle atrophy may be severe enough to be seen by just looking. However, those children who are plump may not show the evidence of muscle atrophy by looking. Then a careful palpation and measurement of the circumference of the limbs are necessary.

The muscle power testing can be performed in a variety of fashion. However, when dealing with an infant, a poor cooperation would make the active power testing impossible. Then, one has to rely on the motor behavior of a child, i.e.; sitting and standing, supporting the body when attempting to stand erect, walking, climbing stairs, standing up from the laying, changing from prone position to supine, holding and handing objects, active head supporting when pulled up and so forth. Depending on the age of a child, one has to estimate the normal motor development and deviation of the child from the normal standard. This sounds somewhat a difficult task but it is essentially a matter of common sense. Quite often, the mother or grandmother may tell you that something is wrong with the child since the time he became sick and more specifically, he or she may describe well how different the child is since his illness. It is important to listen to the parents; they may even imitate the child's' motor behavior for you.

Grading of Manual Muscle Power Testing (MMP test)

Grade	
0.	***No muscle movement at all***
1.	***Only a trace of movements by volitional efforts***
2.	***Can move the muscle when the gravity is canceled***
3.	***Can move the muscle against gravity***
4.	***Weak but can move the muscle actively (may subgrade to 4+ or 4- as grade 4 includes rather wide ranges of weakness)***
5.	*Normal muscle power*

2. Sensory function testing

The sensory system may have to be assessed when seen AFP children. However, it is impossible to be certain as to any sensory deficits in infant, but a withdrawal response or emotional rejection reaction of a child, when given a minor pain stimuli or tickling to the sole or palm, may be observed. The cases of isolated sciatic nerve palsy, occasionally seen as a consequence of incidental injection into the sciatic nerve, may be difficult to distinguish from polio paralysis. The loss of superficial sensation particularly over the small region of the dorsum of the foot (between the 1st and 2nd toes) may be diagnostic.

Deep tendon reflexes (DTRs, muscle stretch reflexes) are indispensable for the assessment of AFP. As described, either the lesion of the lower motor system or the sensory system afferent to the anterior motor neurons may give rise to diminished or abolished DTRs. The upper motor system lesion is indicated when the reflex is exaggerated; the asymmetrical reflex activities (for examples, right Achilles tendon reflex is abolished whereas the left is preserved, or the knee tendon reflex is preserved whereas the ipsilateral ankle jerk is gone) may be an evidence that the nervous system is somehow impaired at some point below the anterior horn cell level).

3. The autonomic function

Bladder function depends largely on the integrity of the sacral autonomic (parasympathetic) nervous system. This is in general not lost by the peripheral nervous disorders or polio. Bladder function may be, however, lost at least for a brief period of time in non-polio myelitis cases. Also, it should be noted that a child may loose his ability to hold urine when confused or in febrile state. The function should return soon when the acute illness is over. The incontinence of urine or difficulty in urination for a child who had been through with bathroom training should raise a high degree of suspicion of myelopathic (spinal cord) diseases. It does not occur in polio, however.

III. Major Categories of Disorders Important for Differentiation from Poliomyelitis

Differentiation of

a. acute paralytic disorders
b. acute meningitic, encephalitic diseases
c. respiratory paralytic and bulbar (important for chewing, swallowing and vocalization) paralytic disorders of acute onset
d. disorders of gait caused by acute painful state of the joint and muscle
e. psychological and malingering (fake) of polio-like disorders

needs to be exercised for AFP in children.

A: Acute paralytic disorders

1. Paralytic poliomyelitis

In general, paralysis in polio appears while the child is febrile or just after the lowering of fever of several days duration. Thus, the paralysis appears in acute "hot" stage. The prodromal symptoms are rather non-specific, that include general malaise, "flu"-like symptoms, headache, and occasionally diarrhea. Then, the body temperature rises up to 40℃ for a few days to 10 days. During the febrile stage, the patient is often obtunded, profusely sweating and may be lethargic. Meningeal irritations in terms of stiff neck and Kernig sign may be demonstrated. The child may complain of soreness or occasionally severe pain in the paralyzed limb.

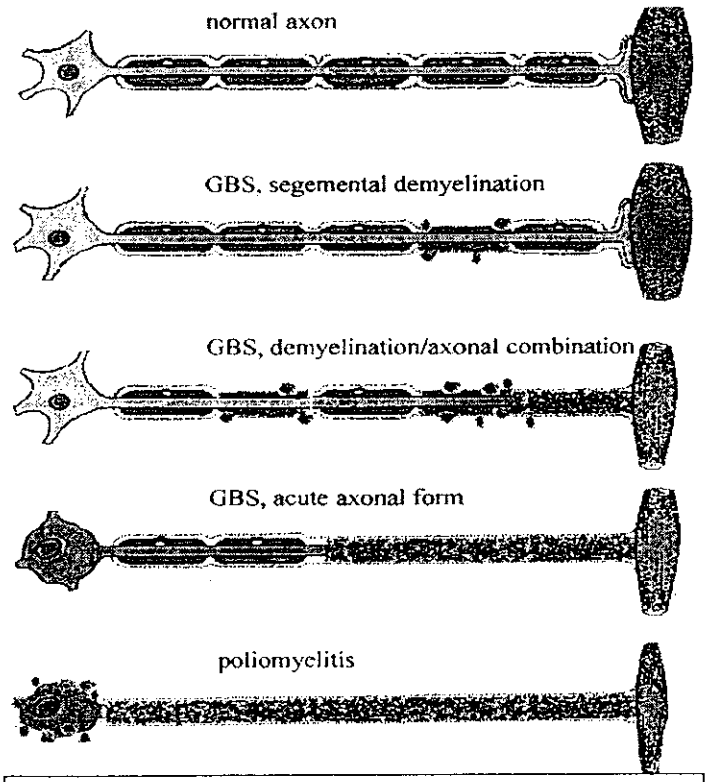


Fig.5 Degrees of muscle atrophy in relation to pathology of lower motor system. In poliomyelitis in which motor neurons are primarily lost, the muscle atrophy becomes most prominent and permanent, while in GBS with demyelination, muscles are not as atrophic since axon-muscle interaction remains intact. Also the recovery is usually favorable when remyelination takes place. In case of acute axonal form exemplified by "Chinese paralysis syndrome", muscle atrophy becomes more prominent and recovery might be delayed, as degenerated axons have to be regenerated in order to restore motor function.

Paralysis is apparent when closely observed during the acute stage but high fever and general obtundation may make the motor system observation difficult for his family and the parents may not find paralysis until the child gets better and ambulatory. When taking history of the child, it is important to be certain when the paralysis had *occurred* or *first found* by the family. The paralysis varies greatly as to the location and severity.

In essence, paralysis may ensue in any part of the body, but from my experience with many Chinese children, the paralysis is localized to the lower extremity in more than 70 percent of the cases. The lower limbs may be unilaterally and occasionally bilaterally involved. The weakness may be more severe in the proximal muscle groups or could be distally dominant. The key issue is the asymmetry of the weakness; e.g., the child may show a severe weakness and muscle atrophy of the left pelvic girdle muscles (gluteus maximum and medius), but only moderate weakness of the quadriceps femoris and anterior tibial component. However, he may have only mild weakness of the right lower extremity with a minimal muscle atrophy of the gastrocnemius muscle. This

degree of marked asymmetry is rather impressive and this observation could almost exclude the possibility of Guillain-Barre syndrome. The shoulder girdle, upper limb, abdominal and paraspinal muscles could be a target as well, but almost always the involvement is asymmetric. In general, the bulbar and respiratory muscles are rarely involved in polio infants and life-threatening situation is thus unusual. However, in those countries, which have poliomyelitis in older children, the danger of life due to respiratory and bulbar paralysis is more commonly encountered.

The weak muscles get atrophic in a few weeks. Careful observation, and "touch and feel" examination would readily disclose wasting of the muscle bulk. Often, the muscle atrophy is so prominent that at a glance one may suspect a diagnosis of polio. Poliomyelitis is a disorder of spinal and sometimes bulbar motor neurons and thus a classical example of the lower-motor neuron disorder. The muscle never gets spastic and remains flaccid throughout the course. Accordingly, the stretch reflexes involving the affected muscles should be hypoactive or abolished. As a rule the muscles, which are not weak or atrophic, remain normoactive by stretch reflex testing.

The paralytic limbs are exposed to extraneous stress as child grows and often shortening of the muscle tendons and overstretching of the joints; e.g.; genu recurvatum (backwardly angulated knee joint), pes equinovarus, and cavus deformities are commonly seen after several months. When the paraspinous muscles and/or pelvic girdle muscles have been affected he may show scoliosis, kyphosis or lordosis deformity. Early medical consultation for rehabilitation is mandatory. There should be neither sensory loss nor autonomic dysfunction in polio.

2. Guillain-Barre syndrome (acute inflammatory demyelinating polyneuropathy, AIDP)

This is an acute paralytic disorder that may affect a person of any age. The cause is autoimmune (allergic) in that the peripheral nerve tissue components become a target of autoimmune attacks. Inflammation of the peripheral nerves and roots with a loss of myelin ensheathing together with electric conduction delay (in nerve conduction velocity) is a hallmark. The allergic response is presumably triggered by a preceded acute infection (flu, enteritis, skin eruption and any non-specific infection). The child develops weakness of the lower and also upper extremities over the period of several days to two weeks one to three weeks after the cessation of acute febrile illness *(cold paralysis* as opposed to *hot paralysis* in polio). It may be associated with tingling sensation or pain in the distal parts of four limbs and when the child is old enough, he may tell the sensory abnormalities he is experiencing. The muscle power is often distally lost but proximal muscle weakness may also be seen. The muscles are flaccid; the reflex is lost or markedly diminished thoroughly.

The objective sensory examination is perhaps difficult when the patient is small. In GBS the sensory involvement is as a rule not prominent. Bladder dysfunction may occur in severe cases in terms of incontinence of urine or inability to void, but it is exceptional. The paralysis may rapidly evolve and in some cases a total paralysis of all four extremities may develop in a several days. In such a case, the impairment of respiratory functions (shallow, rapid respiration and cyanotic finger nails and lips) may warn you that his life is threatening. When severe, he may be unable to move any part of the limbs and neck, and even face and eyes may be paralyzed. The child may require an endotracheal

intubation and artificial respirator to support his breathing, and sometimes a tracheotomy is required.

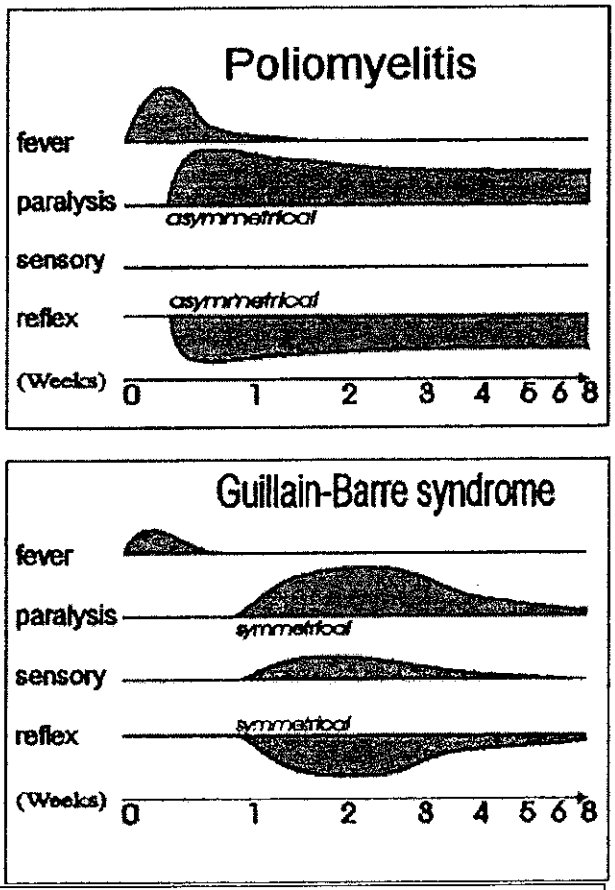


Fig 6. The flow charts of typical poliomyelitis and Guillain-Barre syndrome. Notice the distinct differences of the clinical course between them.

In general, the illness has a peak of evolution in 1-3 weeks after the onset of paralysis and, thereafter, he should improve slowly. According to WHO criteria, GBS improves almost fully in two months. However, our experience with Chinese children differs; often, the child has marked paralysis and muscle atrophy even after two or three months. Clue to the differentiation from polio is that even the recovery is rather slow, he should be steadily improving even after two months while in polio the paralysis improves to a certain degree over a few months but the rate of improvement is far worse and restricted.

The major distinctive point from polio is the long interval from the preceded infection and paralysis occurs over several days when he is way out of febrile stage (paralysis in "cold" stage). The paralysis is rather symmetrical and the stretch reflex is very much depressed or abolished at all segments. The improvement is by far better than polio.

* A form of Guillain-Barre syndrome unique to China that can be called "acute axonal Guillain-Barre syndrome" will be described later.

3. Acute non-polio viral myelitis and acute postinfectious myelitis (so-called transverse myelitis)

Either invasion by a neurotrophic virus or inflammation by the postinfectious autoimmune processes to the spinal cord (myelitis) is two major causes of this disorder. The viruses so far isolated include several enterovirus groups such as Entero 71 and a few Coxsackie's, however; many other viruses could be causative organisms. As one can expect, many enteroviral species, which are capable of causing acute myelitis, are also the causes of enteritis, summer "flu" and cutaneous rash. In this disorder both the spinal white and gray matters are involved to a various extent. Among these lesions, anterior horn cells are target of the disorders; therefore, the pathology of the spinal cord is rather similar to that of poliomyelitis.

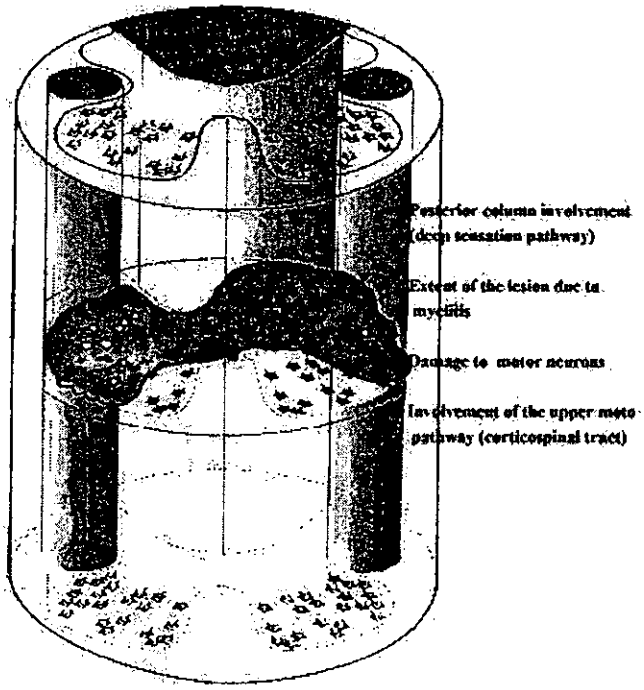


Fig. 7 An example of the extent of lesion following non-polio acute myelitis. The lesion involves not only anterior horn motor neurons but also the upper motor system (corticospinal tract) and the posterior columns subserving deep sensation. Thus the clinical presentation is more complex.

In non-polio myelitis due to some enterovirus, anterior horn cells and surrounding white matter are both affected and thus polio symptoms plus evidence of upper motor neuron signs serve a key to the differential diagnosis. In contrast to the old concept of "transverse" myelitis, that is used by WHO and old textbooks, however, most of the cases encountered during the polio surveillance in Shandong are not transversely affected in the spinal cord and often asymmetrical or patchy lesions, extent of which may be longitudinally large along the spinal cord, are clinically suspected. Thus, this disorder is a major diagnostic challenge for a polio-conscious physician.

Acute myelitis when caused by a certain virus may show a prodromata of febrile episode, diarrhea, or flu-symptomatology and yet in febrile state paralysis may ensue; a similar setting to poliomyelitis. In contrast, postinfectious myelitis, that has a similar autoimmune basis to Guillain-Barre syndrome, may occur in the setting of recurred febrile state after the secession of initial febrile state.

The paralysis that almost always involves the lower extremities may be profound and frequently asymmetrical in magnitude of weakness when both sides are compared each other. The upper extremities are rather infrequently involved; when seen, it is as a rule associated with some degree of spastic paralysis and incontinent of urine for a while and may complain of paresthesia or tingling sensation in the lower extremities. The stretch reflexes that are initially lost or diminished in the weak limbs soon become exaggerated. However, many patients with myelitis develop a focal muscle atrophy in the paralyzed limb and in such a case, one or two segments of stretch reflex involving the muscles that are atrophic may be hypoactive or abolished. In essence, the reflex is not always exaggerated throughout but there are hyperreflexic and hyporeflexic segments by a careful examination.

When the paralyzed limb is pinched, the child may not cry, as the sensation is lost. However, in acute viral non-polio myelitis, the loss of global sensation in the lower extremities is only exceptionally found (not like a typical transverse myelitis). This disorder may be complicated with encephalitis; i.e., acute encephalomyelitis, that is characterized with impaired level of consciousness or drowsiness down to coma, convulsion, and evidence of meningeal irritation signs (stiff neck and Kernig sign). When the acute en-

cephalitic stage is over, the child may be left with myelitic paralysis of the lower extremities.

Major distinction of non-polio acute myelitis from polio resides in demonstration of exaggerated DTR (deep tendon reflex) segments, clonus and/or Babinski signs. Also, the child may walk in spastic leg(s) with circumducting the foot (feet) and when severe, with scissor legs. Also, the patient may show incontinence of urine for a while after the recovery from acute stage. Muscle atrophy is frequently present in myelitis and it should not serve a point of differentiation.

Through my experience, acute non-polio myelitis is the major problem in differentiation from polio, as the clinical course is rather similar.

4. Acute viral myositis and arthritis

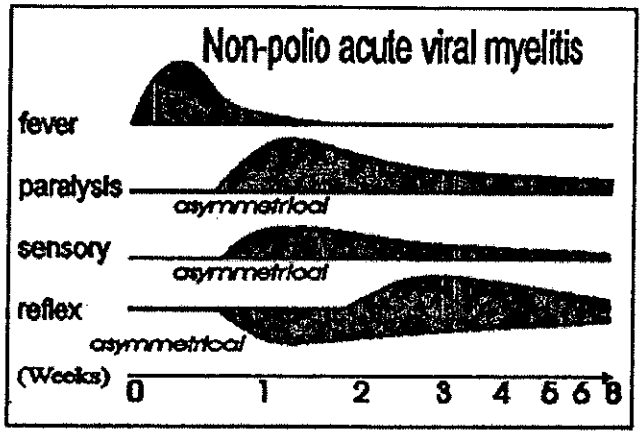
When in "flu" season, some children in febrile illness may develop severe calf or thigh pain and would not move. He may cry out when touched the affected muscle. In several days, however, the pain subsides and he may regain motor function without residuals. This disorder may be mistakenly diagnosed as having polio in epidemic area but this is a benign disease occasionally seen in clusters. Viruses of influenza group and also entero-group may give rise to this disorder. In particular parainfluenza type 3 has been implicated in some cases although the virus has been seldom isolated.

Similarly, the child may rarely develop painful arthritis as a complication of some viral infections such as mumps. Acute, painful mono- or oligo-arthritis affects chiefly in the joints of the lower extremities. Acute arthritis of childhood caused by other viruses or parainfectious process is a poorly defined category but is perhaps is also a rare cause of painful limping in children.

5. Injection palsy

Often, children residing in a rural area are treated with shots of antibiotics and antipyretics. The injection may erroneously hit the peripheral nerve. This is most commonly seen after a shot to the buttock (Fig. 7); the sciatic nerve may destroy the nerve, completely; as the sciatic nerve damage occurs at the level of sciatic notch, the patient shows the paralysis and atrophy of the muscles that are in accord with the innervation of the nerve. The gluteus maximus, the most proximal muscle from the sciatic nerve, gluteus medius, hamstrings, and then the anterior tibial, peroneal and gastrocnemius might be paralyzed to a varying degree.

The key point to differentiation is that even the paralysis is profound, the quadriceps femoris, an extensor of the knee, adductors, the muscles to close the thigh, should be normal as these muscles are innervated by both femoral and obturator nerves but not by the sciatic nerve. The sensory function when tested may be lost over the dorsal surface of the foot (mainly over the surface just proximal to the 1st and 2nd toes)(Fig 8). ***The reflex is lost in the ankle but should be preserved in the knee. The history is of utmost importance: the child might have burst into cry or immediately after the injection, the leg become paralytic and become unable to walk.***



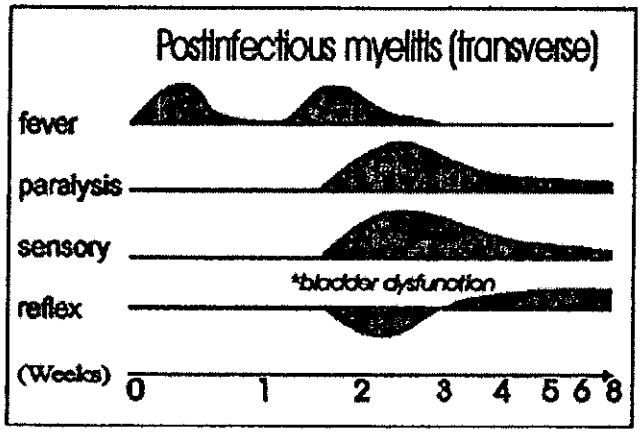


Fig 8 Non-polio acute myelitis may be divided into two forms. One is due to the infection of the spinal cord by non-polio viruses such as entero 70 and other enteroviruses. The postinfectious variety is due to hypersensitivity or autoimmune mechanism by which the spinal cord becomes a target. This sometimes occurs after acute infection of any kind or after the vaccinations such as for rabies and Japanese B encephalitis.

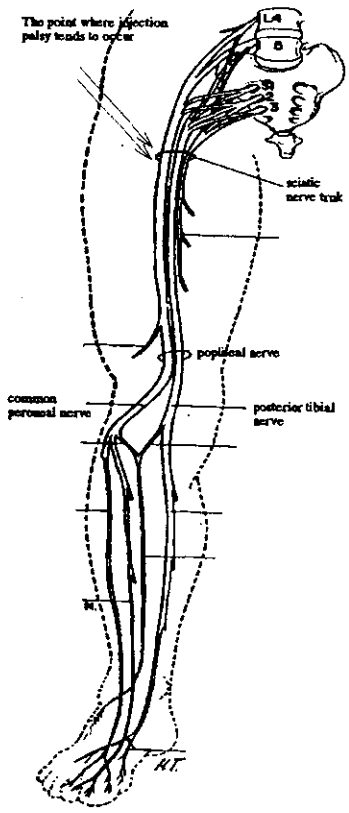


Fig 9. The point of postinjection sciatic nerve palsy by incidental injection.

6. Polio-Panic syndrome

This is not described in any textbook but is an experience of the author. When seen AFP cases chiefly in rural areas of Shandong, there appears to be a group of children and their families stating that the child may have had poliomyelitis. Almost always, there are neighbors whose child had been suffered from polio and they are very much concerned about their children. All of sudden, a child, who had hit his knee on something hard may be dragging his leg due to pain, is believed by the parents to have suffered from polio. Another cases may be a type of compensation wish of parents; in some countries, when a child gets polio, his family is entitled to receive some benefits such as tax exemption or compensation; or the family may be entitled to bear one more child!

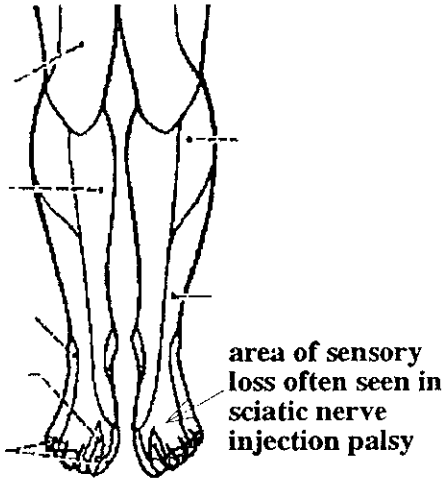


Fig 10. The circumscribed area of sensory loss is usually found over the dorsum of the affected foot between the 1st and 2nd toes. The extent could be larger, involving the dorsum up to the anterior surface of the shin.

7. Other rare illnesses encountered during polio surveillance

a. Postictal paralysis (Todd's paralysis); child who had developed a sudden epileptic convulsion on one side of the limbs may remain paralyzed of the limbs for a few hours to several weeks. The seizure is often associated with febrile illness and thus may be confused with polio.

b. Tuberculosis spondylitis, spinal cord tumor and traumatic myelopathy; these are characterized by slowly evolving pain in the back, spastic paresis of the lower extremities, bladder dysfunction and sometimes muscular atrophy. The signs may be similar to transverse myelitis but one should always examine the spine from the cervical down to the lumbar regions in order to see any deformity, tender spots or abnormal curvature.

c. Werdnig-Hoffmann disease (infantile progressive spinal muscular atrophy); this is not AFP but is a hereditary disorder of rather slow relentless progression in which generalized muscle weakness and atrophy ensue during the first 1-2years of life and in a few years the child becomes totally dependent. There will be respiratory distress and bulbar muscle weakness that are the major causes of death in this particular disease. This is a hereditary, genetically determined fatal motor neuron disease. I have seen several of these cases during the polio surveillance trips to China. The history is never acute in onset.

8. As to "Chinese paralysis syndrome (acute axonal type Guillain-Barre syndrome)"

In 1991, there was a report in Lancet by a group of neurologists of USA and Hubei Province of China, describing a distinctive paralytic disorder endemic to Hubei. The disease appears seasonally in early summer months and children are prone to this illness. The child may develop fever, meningeal signs and then paralysis of the limbs and neck muscles but there is no sensory manifestation. The reflex is generally diminished and in a few weeks severe muscle atrophy is apparent. The recovery is not as good when compared with GBS but appears better than paralytic polio.

Electrophysiological and pathological studies revealed axonal (Wallerian) degeneration of the peripheral motor axons but the spinal cord is unremarkable. From the author's experience of GBS, acute axonal motor neuropathy is not at all unusual here in Japan. In fact, about one-fourth of the GBS patients seen in the hospital ward are that of acute axonal GBS.

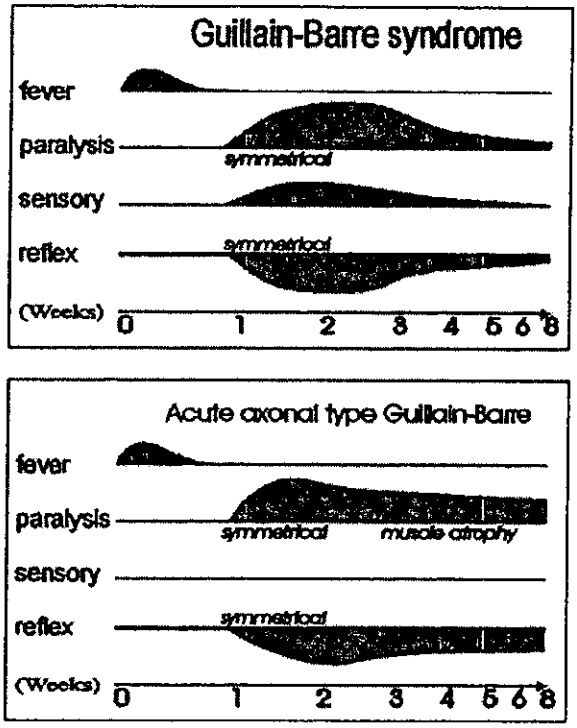


Fig 11. The comparison of typical Guillain-Barre syndrome (demyelinating type) and acute axonal type (Chinese paralysis syndrome). Notice that sensory involvement is not a feature in the latter and the recovery is distinctly delayed. This gives the illness a major differential problem when AFP is concerned.

Currently, the disorder in China is clarified to be a special form of GBS where axonal rather than demyelinating polyneuropathy ensued by the autoimmune inflammation of the axons. The target antigen is presumably GM1 and other gangliosides rich in motor axons. The autoimmune process is likely triggered by infection with ***Campylobacter jejuni,*** a bacteria commonly causing acute enteritis, and chickens in Hubei region are reported to carry the pathogen in rather high incidence. Serologically, Penner 19 subtype of ***Campylobacter jejuni*** is implicated and thus not all Campylo species are the cause of this particular disorder. The seasonal and the endemic occurrence in China are not well explained, however.

I have seen more than several of those axonal cases. The point is that the improvement is rather slow and many recover only incompletely after several months. WHO criteria of Guillain-Barre syndrome that the recovery is a rule in 60 days as opposed to polio cannot be applied to those axonal cases. Thus, as far as China is concerned, the criteria should not be fully applied. It is of interest to see if the same form is prevalent in other southeastern Asian countries.

IV. Clinical Course for Differential Diagnosis as viewed by the symptoms.

A. Fever and prodromal symptoms

In polio, fever and flu-like symptoms and/or diarrhea start 1-5 days before developing paralysis. The fever is in most cases rather high or moderate; afebrile state points against polio. In contrast, prodromal symptoms of "flu" or diarrhea appear 7-21 days preceding the onset of paralysis in Guillain-Barre syndrome and when the paralysis occurs, the body temperature is in most cases normal or only slightly elevated. Thus, ***paralysis in polio is "hot" while in GBS it appears in "cold" child.*** Also in GBS, a history of vaccination or skin eruption suggesting a viral infection may be obtained even though the patient did not have febrile episode. Of course, after ingestion of polio vaccine, one may develop "vaccine-related paralysis", a situation that is neurologically indistinguishable from classical polio. However, vaccine-paralysis is exceedingly rare in inci-

dence (one out of a few million vaccination cases).

Non-polio myelitis ("so-called" transverse myelitis) may take either polio-like or GBS like course, depending on the cause of myelitis; acute viral myelitis related to entero-viruses tends to take polio-like course, whereas in postinfectious myelitis due to a postinfectious hypersensitive or autoimmune reaction, the prodromata is often that of febrile "flu"-like symptoms. The fever subsides soon but in a few days to two weeks, myelitic stage takes place with or without fever. This is a disorder similar to both GBS and poliomyelitis. In acute viral myositis, severe calf or thigh pain occurs immediately following "flu".

B. Paralysis

AFP (acute flaccid paralysis) is a hallmark of polio but it is also a cardinal sign of GBS and non-polio myelitis. The paralysis of polio appears rapidly and is complete in 48 hours. The limbs are rather unequally affected and thus give an impression of asymmetrical paralysis. Rarely, the paralysis may even affect the upper limb and contralateral lower limbs.

In Guillain-Barre syndrome, the paralysis is symmetrical in distribution. When the lower limbs are apparently affected, the upper extremities are always more or less paralyzed as well. In non-polio myelitis, the lower extremities are always paralyzed, although the upper limb involvement is seldom seen. The paralysis may be strikingly asymmetrical in distribution. The paralytic limbs may become spastic in myelitis as a function of time, whereas, in GBS and polio, spasticity is against the diagnosis. The muscle atrophy, which is an important consequence of polio, is also seen in GBS but is in general less prominent. However, in those cases with acute motor axonal polyneuropathy (Chinese paralysis syndrome, a GBS variant) may give rise to severe distal muscle atrophy and also neck muscles are frequently weak and atrophic.

In non-polio myelitis, focal muscle atrophy is often seen and throws a major diagnostic challenge. In my experience, there would be always an evidence of hyperreflexia in some segments. For instance, in one child the quadriceps muscle is rather atrophic and knee tendon reflex is lost, but the ankle jerk may be hyperactive with clonus. Then, the patient should not have had polio but is likely to have suffered from non-polio viral myelitis.

C. Muscle stretch reflexes (deep tendon reflexes, DTRs)

In polio a paralyzed muscle segment is always hypoactive or absent when DTR is attempted. In GBS DTRs are lost in rather early stage of paralysis and in most cases, areflexia is apparent in every segment. In contrary, the reflex may be lost in paralytic muscle segments in non-polio myelitis but sooner, hyperreflexia will be apparent in some segments. If clonus or hyperactive asymmetrical DTR were demonstrated in some muscle segment, one would be certain that he is dealing with upper motor system disorder that is often a case of non-polio myelitis.

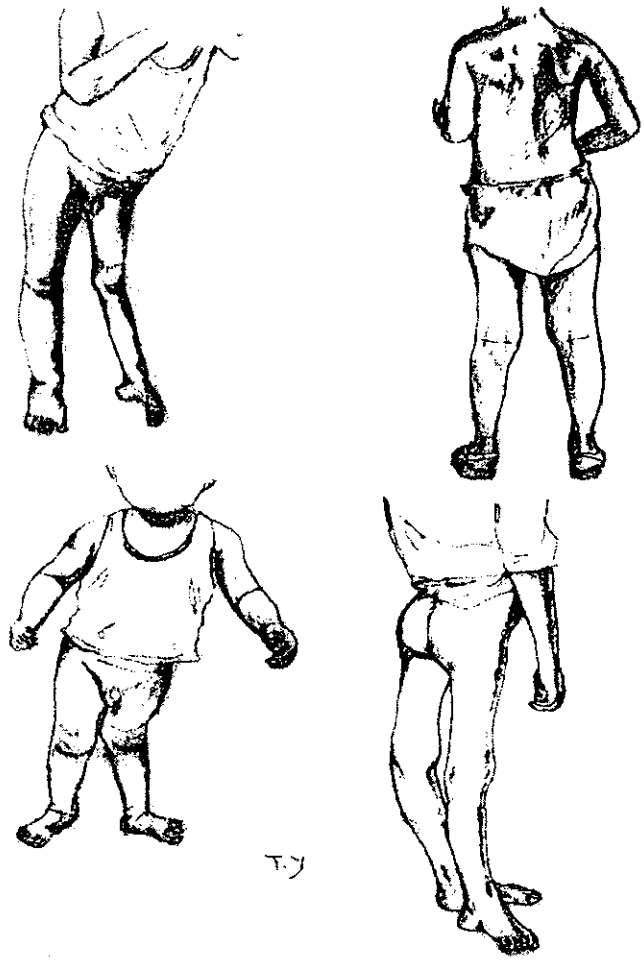


Fig 12. The drawings of the children suffered from paralytic poliomyelitis, as traced from the photographs during the surveillance trips to China. You will be able to find which parts of the body are paralyzed, atrophic and deformed.

D. Sensory deficit

It is the most difficult part of examination when seen small children. Nevertheless, if the sensory deficit is apparent in some parts of the lower extremities, it is important evidence that the child does not have polio, since sensory changes never occur in poliomyelitis. In GBS sensory change is in most cases subtle and difficult to be certain with the child. In non-polio myelitis, there may be sensory loss of either superficial or deep sense below certain somatotome (see the sensory chart for this). But it is yet difficult to assess in small children. In injection palsy, a small spot of anesthesia may be demonstrated over the dorsum of the foot and it should be always unilateral. In Chinese paralysis syndrome (acute axonal Guillain-Barre syndrome) there is no sensory changes although the reflex is lost as a rule.

E. Respiratory paralysis

When paralysis affects respiratory muscles, namely the diaphragm and/or intercostalis muscles of the thorax, respiratory difficulty and cyanosis develop and the child is in danger of life. This occurs both in acute stage of polio and Guillain-Barre but is seldom encounters with non-polio myelitis. In polio the respiratory difficulty is seen when the patient is still febrile but in GBS it is when the child is afebrile, exception being concurrent pneumonia complicated with GBS. The respiratory failure due to paralysis is a rare occurrence in polio when he is a small child below 2 or 3 years. When he is above 4 or 5 years, paralysis tends to be more severe and respiratory crisis may be a major concern.

F. Meningeal irritation signs

Stiff neck and Kernig's sign are the cardinal evidence of meningeal inflammation and thus it becomes positive in meningitis and meningoencephalitis of any sort. However, polio is also an inflammation of the central nervous system and thus in febrile stage, the child may have stiff neck and Kernig's sign. In GBS stiff neck is a rare occurrence but Kernig (Lasegue sign, straight leg rising test) is often positive since inflammation of the lumbar roots gives rise to pain when roots are stretched by the maneuver. This could be mistaken as a meningeal irritation sign.

G. Bladder dysfunction

As a manifestation of autonomic nervous system involvement, incontinence of urine or difficulty in passing urine is occasionally seen in non-polio myelitis but it is not an accompaniment of polio. In GBS, it may occur but is exceptional. In any case, when a child is febrile and somewhat confused, he often looses the learned bathroom habit and temporarily becomes incontinent of urine. Thus, only if the bladder problem is prolonged, it would be suggestive of spinal cord disorder; i.e., non-polio myelitis.

H. Sequelae of polio, GBS and non-polio myelitis

In polio, the muscle weakness and atrophy gradually improve for a few months but almost always, one can detect muscle atrophy by careful observation. Thereafter, it is unlikely that the weakness improves to a noticeable degree. Often, deformities of the joints and spine may develop due to extraneous stress to the joints and imbalance of antagonist/agonist muscles.

In GBS, the recovery is rather favorable in terms of smooth improvement over a few months. In WHO criteria, a crucial differentiation point between polio and GBS is that a full recovery is expected in GBS in 60 days but in polio there should be apparent residual paralysis. My experience in Chinese children differs from WHO view; in some GBS cases, recovery is rather slow and after 2 or 3 months, one may still show significant residual paralysis. It is likely that GBS in Chinese children may predominantly affect axons rather than myelin; the cardinal feature of Chinese paralysis syndrome is axonal degeneration. I have a feeling, however, that pure axonal degeneration form is yet uncommon in Chinese GBS and more commonly demyelination and axonal degeneration are admixed in GBS of Chinese children.

In non-polio myelitis, residual muscle atrophy and/or spastic palsy improves slowly as is the case with polio. The exaggerated DTRs and spasticity appear improved better than focal muscle atrophy.

Postpolio syndrome (postpolio progressive muscular atrophy, PPMA)

This is a progressive muscle-wasting syndrome that occurs in a victim of polio long after the onset. This usually takes more than twenty years for the PPMA to occur. However, this is not like amyotrophic lateral sclerosis, which is ultimately fetal in a few

years. The muscle wasting is rather slow in progression and never to the degree of severity to threat the life. The mechanism is yet unknown but it is likely related to the aging of the motor neurons in the anterior horn; a. e. the function of the muscle is maintained even if the number of motor neurons are decreased to approximately 30-40% of the population. Therefore, it is possible that normal muscles in polio-sufferers might be maintained with only one-thirds of motor neurons. However, when aged, physiological decrease in the number of neurons may influence the already-decreased motor neuronal population and thus the weakness and muscle weakness become manifest. This is, however, incapacitating to the patient who has been already disabled. Often, pain is associated with the progressive weakness. Please remember that this is yet a benign disorder that occurs rarely in a population of polio-sufferers.

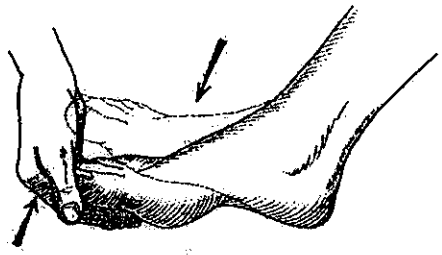
I have currently seen two women of their 50th with this syndrome in Japan who had been suffered from poliomyelitis in infant. Thus, more than 40-50 years after polio they are still suffered from this particular disorder. Poliomyelitis is thus thought to be a life-long illness.

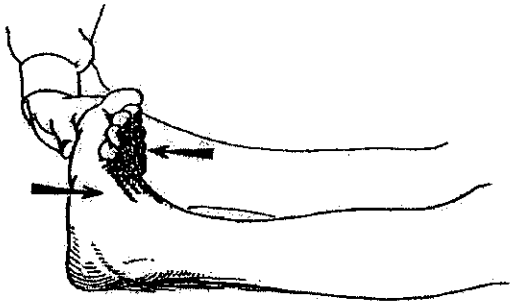
This study was supported in part by the grant-in-aid of Ministry of Health, Japan, for "The strategies of EPI in Developing Countries".

Teiji Yamamoto, MD
Professor and Chairman
Department of Neurology
Fukushima Medical College
Hikarigaoka 1
Fukushima 960-12
Japan

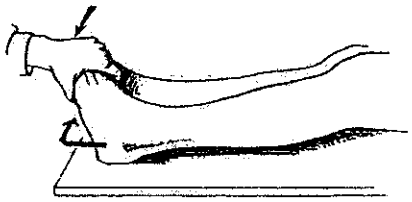
Voice: 81-245-48-2111(ext 2480)
Fax: 81-245-48-3797
E-mail; yamamoto@.fmu.ac.jp

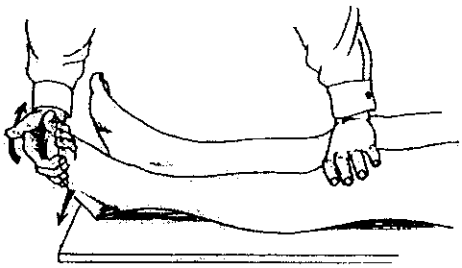
Illustrated examples of manual muscle testing



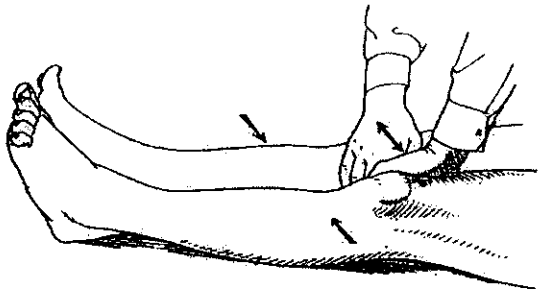


*Anterior tibialis and estensors of the toes (dorsi-flexors of the foot, sciatic nerve)

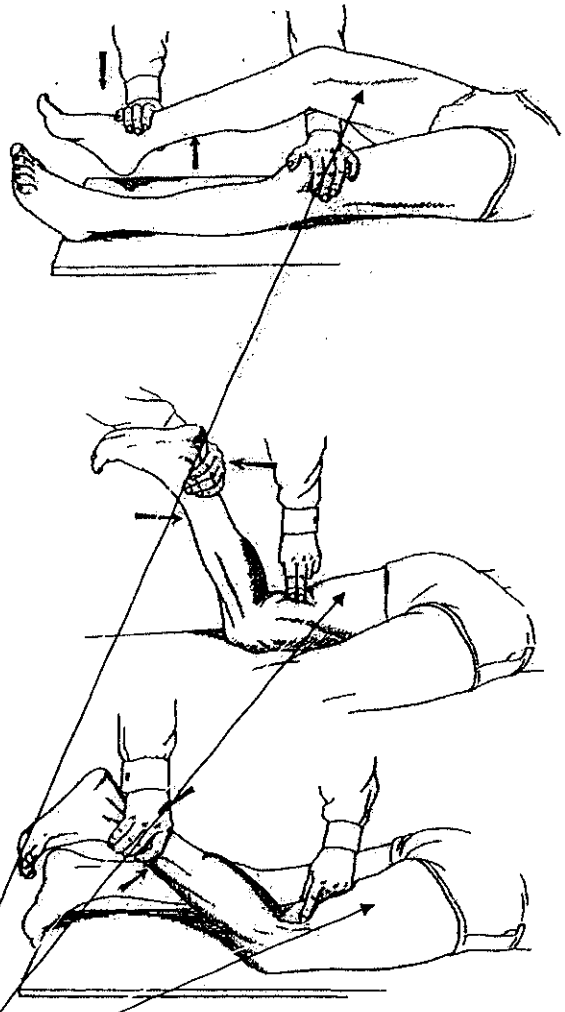




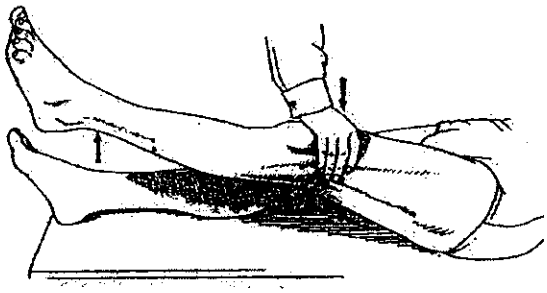
*Gastrocnemius muscle (sciatic nerve foot extensors)
*Tibialis posterior muscle (inversion of the foot, sciatic nerve)
*Peronei muscles (foot eversion, sciatic nerve)



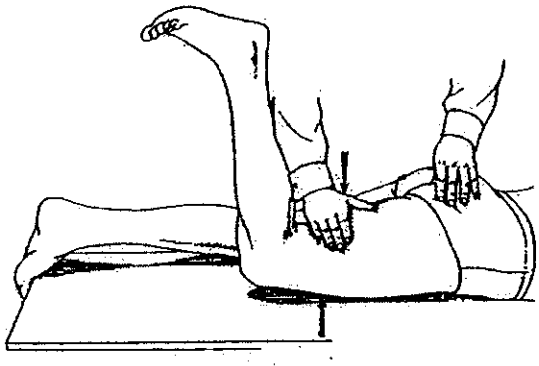
*Adductors of the thigh (obturator nerve)



*Quadriceps muscles, leg extensors (sciatic nerve)
*Hamstrings (leg flexors, sciatic nerve)



*Illiopsoas muscle to flex the thigh (very proximal branch of the femoral nerve)



*Gluteus maximus to dorsiflex the thigh (sciatic nerve)

Annex 2-2

Investigational Record of Patients with Poliomyelitis-like Diseases I

Name of Medical Care Facility _____

Department _____

Name of Physician _____

Tel _____

Patient's Initials _____ (male/female) Date of Birth _____

Address (name of prefecture only) Date of Onset _____

_____ Notification Yes No

Notification of Transference Yes No

History of Vaccination

Number of Vaccinations (inactivated Salk vaccine) Frequency: (times)/Unknown				Number of oral vaccinations (live vaccine) Frequency: (times)/Unknown	
Name of country where vaccination was conducted		Date		Date	

Onset of symptoms within 30 days of being given inactivated Salk vaccine (Yes / No)

Injection site (specify in case of "yes") _____

Onset of symptoms within 90 days of being given the live vaccine (Yes / No)

Interval between administration and onset (specify in case of "yes") _____

Chances of contact with others who have been given the live vaccine for the 90 day period before the onset of symptoms

(Yes / No / Unknown)
Viral type (I · II · III) (in case of "yes")

Family members who have been given the polio vaccine for the 3 month period before the onset of paralysis (Yes / No)

Patient's history of foreign travel for the 3 month period before the onset of paralysis (Yes / No)

Name of country (specify in case of "yes") _____

Family member's history of foreign travel for the 3 month period before the onset of paralysis (Yes / No)

Name of country (specify in case of "yes") _____

History of subcutaneous injections or intramuscular injections for the 3 month period before the onset of paralysis (Yes / No)

(specify in case of "yes")
Date of injection _____
Site of injection _____