

Post-polio syndrome and total health status in a prospective hospital study

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New loss of function among patients with previous polio is frequently reported and has several causes. All patients referred to the Department of Neurology, Haukeland University Hospital, Bergen, for 13 months during 2000–2001 with diagnosis late effects of polio were examined prospectively to identify their symptoms and loss of function. Eighty-five patients aged 47–91 years with mean of 61 years were included. The most common complaints were pain (44%), muscular weakness (27%), and fatigue (16%). Muscular weakness occurred in lower limbs in 75%, in respiratory muscles in only 5%. Walking in stairs was impaired in 72% and outdoor walking in 65%. Seventeen patients (19%) reported no loss of function. Post-polio syndrome was diagnosed in 26% of the patients. Polio-related loss of function including cervical and lumbosacral radiculopathies, mononeuropathies and degenerative joint disease were found in an additional 53%. Eleven patients (13%) had distinct non-polio-related disorders that caused new loss of function. The remaining 8% had a stable condition. In conclusion, the majority of polio patients who seek hospital, experience a new loss of function because of polio-related disorders. A careful neurological examination is necessary to identify the correct diagnosis and treatment.

Introduction

The large epidemics of acute poliomyelitis (polio) have now been eradicated because of effective vaccination (WHO, 2002). In most cases, the acute illness passes with fever and malaise without any muscle weakness, but in 2–3% of symptomatic patients, virus infects the anterior horn cells of the spinal cord causing muscle weakness (Melnick, 1996). Full motor function is regained when motor cells survive the acute infection. Patients with neuronal cell death can recover because of enlargement of the remaining motor units with axonal sprouting. The clinical end result varies from non-paralytic polio to severe muscle weakness affecting large parts of the body depending on the initial neuronal damage and the recovery phase.

Whereas acute polio represents a diminishing health challenge, there are still millions of patients with polio sequels, most of them experiencing an increasing loss of function and reduced health several years after their acute polio. In 1875, Raymond described a 19-year-old man with previous polio who developed new muscle weakness and atrophy (Raymond, 1875). One hundred years later a new interest in aging polio patients lead to reports of increasing loss of muscle power and atrophy (Mulder *et al.*, 1972; Kayser-Gatchalian, 1973) Symptoms such as fatigue and pain similarly occurred many

years after the acute polio. This led to introduction of the term post-polio syndrome (PPS) (Halstead and Rossi, 1985) to describe new symptoms and function loss that occurred late in polio survivors. Different mechanisms for PPS have been suggested, the most widely accepted pointing to a distal degeneration or dysfunction of enlarged post-polio motor units (Wiechers and Hubbell, 1981; Dalakas, 1995). Immunological explanations have been put forward, but without concluding evidence so far (Sharief *et al.*, 1991; Illa *et al.*, 1995; Trojan *et al.*, 2001; Gonzalez *et al.*, 2002). The criteria for a diagnosis of PPS have been debated. Depending on study population and applied criteria, the prevalence has been estimated to 22–87% (Codd *et al.*, 1985; Halstead and Rossi, 1985). As the polio population gets older, there is an increasing challenge for the medical profession to distinguish between polio-related symptoms and other health problems common in an aging population.

The aim of this study was to define in detail the spectrum of causes for the loss of health and daily functions in patients with previous polio, and hence estimate the incidence of true PPS, unstable polio in a broader view, and loss of function because of polio-unrelated causes. All patients with previous polio admitted to our department were examined prospectively according to an extensive evaluation protocol.

Material and methods

All patients admitted to the Department of Neurology, Haukeland University Hospital with the diagnosis of

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previous polio (both verified and suspected) between June 2000 and June 2001 were examined with a full clinical status according to a protocol. Most patients were admitted from their general practitioners, either for neurorehabilitation or for diagnostic investigations. Both in- and outpatients were included. Eighty-six patients were initially examined, but one was excluded because a diagnosis of previous polio could not be confirmed.

The general physical examination included auscultation of heart and lungs, measure of blood pressure, weight and height, peak expiratory flow (PEF), joint movements, kyphosis and/or scoliosis, deformities of limbs, and a complete neurological examination. Muscle strength was recorded as either normal (MRC 5), mild to moderate weakness (MRC 3–4), or severe weakness/paralysis (MRC < 3). Localization of weakness was grouped as one arm, both arms, neck, one leg, or both legs. Kyphosis and/or scoliosis were diagnosed because of weakness in truncal muscles or compensatory due to anisomelia. Body mass index (BMI) was calculated (weight in kg/square height in meters), and values below 18.5 were defined as underweight, values above 25.0 as overweight, and values above 30.0 as obesity. Year and age at acute polio, localization of muscle weakness in the acute and stable phase, smoking, and non-polio diseases were recorded in detail.

The symptoms that lead to medical consultation were registered: general pain, fatigue, low back pain, breath shortness, sleep disturbances, muscular cramps, muscle weakness, and any other major complaint. Functions of daily life were specified according to the international classification of disability and handicaps (ICIDH-2 beta draft 1999) (WHO, 1999) concerning body movements and positions, moving around with and without transportation, self care, domestic and professional life. Patients were asked if their function had been reduced compared with their previous maximum level. Use of devices were registered. All patients were asked about source of income and employment status.

For each patient a conclusion was drawn: stable function, loss of function because of non-polio causes, polio-related loss of function, or PPS. The definition and criteria for PPS were based on those published by Dalakas (1995);

development of new muscle weakness and fatigue in skeletal or bulbar muscles, unrelated to any known cause, that begin more than 15 years after the acute attack of paralytic poliomyelitis.

This included: (i) history of acute paralytic poliomyelitis; (ii) partial or almost complete recovery and stable neuromuscular function for at least 15 years; (iii) clinical findings in line with lower motor neuron damage, i.e. muscle weakness, atrophy, weak tendon

reflexes, normal sensation; (iv) no other neurological, orthopedic, or medical explanation found.

The diagnosis of previous acute polio was verified by careful history taking and checking old patient files from the acute stage and later stays in the department, when available. Electromyography (EMG) was performed in all patients, either as part of the study or as performed previously (> 10 years after the acute polio). EMG in all included patients were consistent with a diagnosis of previous polio. The excluded patient had no definite history of non-paralytic or paralytic polio, lack of clinical findings and normal EMG in symptomatic muscle. Patients with loss of function because of polio-related disorders, pain and fatigue were defined to have polio-related loss of function. We used the term stable polio when no signs of functional deterioration were present, and the patients' new symptoms were reversible or minor. Patients with medical or neurological disorders not related to their previous polio were defined as non-polio-related.

The two doctors who examined the patients (author 1 and 2) agreed upon the final diagnosis for all patients. Results from supplementing investigations (neurophysiology, imaging, consultations by other specialists) were incorporated in the total evaluation.

Statistical analysis

Cross tables with chi-square or Fisher's test were used when comparing groups. All values reported are two-tailed. Significance level was set at $P = 0.05$.

Results

Acute polio

Thirty-two males and 53 females were examined, with a mean age of 61 years and range 47–91 years. Age at acute polio varied from newborn to 33 years, with a mean of 7 years. Fifty-one patients (60%) had their polio below the age of 7 years, and only four were above 20 years. The oldest patient got acute polio in 1912, the youngest in 1960. Seventy-two patients (85%) were hospitalized during the acute phase. The diagnosis was based on clinical signs of meningitis with or without muscular weakness, CSF pleocytosis, and acute polio in the neighborhood. Acute polio within the family or in the same house was reported by 15 (17%) of the patients. Four patients (5%) who were not hospitalized in the acute phase, had a history appropriate to acute polio and later EMGs with changes in accordance with previous polio. Ten patients (12%) had no confirmed diagnosis in the acute phase or by previous EMG before this study.

Seventy-seven patients (91%) had involvement of more than one extremity in the acute phase, six of them (7%) also with involvement of respiratory muscles, but none had ventilatory assistance. Four patients (5%) had acute non-paralytic polio with no reported muscle weakness. After the primary recovery period, 15 patients (18%) had no detectable persistent muscle weakness, 10 patients (12%) had focal weakness, whereas 60 patients (70%) reported widespread muscle weakness.

Twenty-six patients (31%) were admitted for neurological rehabilitation, 49 (58%) were admitted for a clinical examination and evaluation, and 11 (13%) for both neurorehabilitation and diagnostic evaluation.

Polio-related symptoms

Thirty-three patients (39%) reported muscular pain as their major complaint and the most limiting factor for daily function. New muscular weakness was reported as the major complaint in 23 patients (27%), whereas three patients (4%) reported symptoms apparently unrelated to their previous polio (Table 1).

Pain (84%), muscular weakness (79%), and fatigue (57%) were the most frequent symptoms reported in a yes/no format. Muscular cramps and sleep disorders (insomnia or frequent awakenings) were reported by 37%, and 35% complained of dyspnea. Fatigue was defined as unusual or extensive tiredness, not as of muscular fatigue with decreased endurance. There was a significant association between sleep disorders and fatigue, as 81% of the patients with sleep disorders also reported fatigue ($P = 0.01$). Fatigue was not associated with new muscular weakness.

Women reported articular pain more frequently than men (23 of 53 versus six of 32, $P = 0.024$). Headache was also more common among women (11 of 53 versus two of 32, $P = 0.048$). Two of the patients with headache had non-polio related migraine, one had facial

pain because of sinusitis, and 10 had tension type headache considered as polio related. Women also reported breath shortness more frequently than men (24 of 53 versus six of 32, $P = 0.0016$).

Daily pain was reported by 62 of the patients (72%), nine patients (10%) reported pain 2–3 days/week, four (5%) had pain 2–3 days a month, and 11 (13%) patients reported very infrequent or no pain. The most common pain localization was in clinically non-paralytic muscles (57%), whereas 48% reported pain in paralytic muscles. Low back pain was also common (in 52%), while 39% reported pain in the neck, and 34% felt pain in joints. Ten patients (12%) had tension type headache.

Sixteen patients (19%) experienced no decline in any daily function. The most frequently reduced daily functions were connected to mobility; walking in stairs (reduced in 72%), outdoor walking, running, skiing, and indoor walking (Table 2). In contrast, most patients had no reduction in functions concerning personal care such as hygiene, dressing, preparing meals, and eating. The ability of using public transport and car driving were maintained among 78 and 69% of the patients, respectively. Twelve patients (14%) had started to use a wheelchair either permanent or intermittently. Twenty patients (23%) had changed their apartment, house or moved to facilitate daily life (no stairs, admittance for wheelchair etc.), and 25 patients (29%) had particular utensils (special chairs, can openers) to make household easier. There was no difference between men and women, except for ability of domestic work (household), which was reported to be reduced by more women than men (33 of 42, $P = 0.006$). The patients first noticed their decline at age 26–90 years, mean 53 years.

Table 1 Major complaint reported by 85 polio patients admitted to the Department of Neurology, Haukeland University Hospital, Bergen, June 2000–June 2001

Major complaint	No. of patients (%)
Pain (muscular, articular, headache)	37 (44)
New muscular weakness	23 (27)
Fatigue	14 (16)
Gait disturbance (not related to muscular weakness)	5 (6)
Dyspnea	2 (2)
Sleep disorder	1 (1)
Not polio related (anxiety, tinnitus, depression)	3 (4)

Table 2 Daily skills and functions reported as reduced or not reduced among 85 previous polio patients admitted to the Department of Neurology, Haukeland University Hospital, Bergen, June 2000–June 2001

Daily skills and functions	Reduced no. (%)	Not reduced no. (%)
Keeping posture (longtime standing, sitting)	56 (66)	29 (34)
Changing posture (sitting to standing)	46 (54)	39 (46)
Carrying objects (with hands and arms)	54 (64)	31 (36)
Walking stairs	61 (72)	24 (28)
Outdoor walking, plain ground	55 (65)	30 (35)
Using public transport	19 (22)	66 (78)
Personal hygiene	4 (5)	81 (95)
Domestic work, household	41 (48)	44 (52)
Participation in family life	34 (40)	51 (60)
Hobbies, leisure activities (exclusive sports)	39 (46)	46 (54)

Table 3 Localization and degree of muscle weakness among 85 polio patients admitted to the Department of Neurology, Haukeland University Hospital, Bergen, June 2000–June 2001

Localization		Muscle strength		
		Normal	Mild to moderate weakness	Severe weakness/paralysis
Arms	One	47 (55)	25 (29)	1 (1)
	Both	47 (55)	10 (13)	2 (2)
Legs	One	21 (25)	17 (20)	12 (14)
	Both	21 (25)	22 (26)	13 (15)
Neck		74 (87)	10 (12)	1 (1)
Truncus		60 (71)	24 (28)	1 (1)
Facial and bulbar		83 (98)	2 (2)	0
Respiratory		81 (95)	4 (5)	0

Clinical findings

The most common localization of muscle weakness was the legs; 64 patients (75%) had detectable weakness here (Table 3). Weakness in one or both arms was found in 38 patients (45%). Four patients (5%) had confirmed weakness in respiratory muscles, and one of them needed a respirator intermittently. PEF-values below 80% of predicted age- sex- and height-adjusted value were found in 18 patients (21%), but was not associated with subjective dyspnea.

Kyphosis and/or scoliosis were found in 56 patients (65%), and 24 (28%) had atrophy and weakness of truncal muscles. Distinct atrophy in one or two extremities was found in 68 patients (80%), 21 of them (25%) had atrophy of truncal muscles as well. Three patients had truncal atrophy without involvement of the extremities. Anisomelia (shortened extremity) was found in 43 patients (50%). Pathological joint movements (contractures or hypermobility) were present in 37 patients (43%).

Cervical or lumbosacral radicular neuropathy was found in five patients (6%). Another two patients (2%) had mononeuropathy (carpal tunnel syndrome, ulnar nerve entrapment in the elbow), both with muscle weakness in the neck and upper limbs. Cox- or gonarthrosis verified by x-ray was found in 13 patients (15%), and one patient (1%) had a recent fracture of patella. All these patients had asymmetric muscle weakness in the lower limbs.

Non-polio related illness and life-style factors

The occurrence of non-polio disorders are listed in Table 4. Cardiovascular disease was more common among men (16 of 32) than women (nine of 53) ($P = 0.005$). Although women reported shortness of breath more frequently than men, there was no sex

Table 4 The frequency and percentage of non-polio disorders among 85 polio patients admitted to the Department of Neurology, Haukeland University Hospital, Bergen, June 2000–June 2001

Non-polio disorders	No. of patients (%)
Cardiovascular	27 (32)
Pulmonary	9 (11)
Urinary tract	4 (5)
Gastrointestinal	10 (12)
Diabetes or thyroid	9 (11)
Cancer	2 (2)
Dermatological	5 (6)
Rheumatological	6 (7)
Migraine and other non-tension headache	3 (4)
Psychiatric	9 (11)
CNS	4 (5)

difference for well-defined pulmonary disease (asthma, emphysema, chronic obstructive disease), nor had women with shortness of breath higher BMI. Thirty-six patients (42%) were overweight, three of them obese, and 26 (31%) were daily smokers.

Auscultation of the heart was pathological in five patients, and auscultation of lungs was also pathological in five patients (both 7%).

Cross tables with smokers versus non-smokers regarding coexisting illnesses, symptoms, and findings on clinical examination were performed, and no significant differences were found (data not shown). Patients were divided into two groups with BMI ≤ 25.0 versus BMI > 25.0 and cross tables performed as above. No significant differences were present (data not shown).

Five patients (6%) had rheumatoid arthritis and one patient (1%) had Bechterew's disease.

Classification of present polio disorder

Twenty-two patients (26%) had by definition PPS (Table 5). They had new muscular weakness including objective findings such as weakening of tendon reflexes and new muscle atrophy (compared with previous examinations) in addition to pain or fatigue. Twelve of these patients had either complete muscle power restitution or monoparesis in the stable phase, and there was no association between PPS and severe muscle weakness. Another 45 patients (53%) had polio-related loss of function. The large majority of these had secondary muscle pain related to their previous polio, as muscle weakness led to overload on the healthy limb. Five of them had radiculopathy, two had mononeuropathy, two had severe cox- and gonarthrosis, and one had fracture of patella. Another 11 patients (13%) had non-polio causes for their symptoms and functional loss, including demyelinating and ischemic CNS-lesions, hydrocephalus, depression, rheumatoid arthritis

Table 5 Major cause for symptoms and new loss of function among 85 previous polio patients admitted to Department of Neurology, Haukeland University Hospital, Bergen, June 2000–June 2001

Classification		No. of patients (%)
Post-polio syndrome	Verified polio, increasing muscular weakness, no other explanation found	22 (26)
Polio related loss of function	Verified polio, symptoms and loss of function related to previous polio, but neuromuscular stable function	45 (53)
Loss of function because of non-polio causes	Verified polio, but other causes for symptoms found	11 (13)
Stable polio	Verified polio, no increasing symptoms or new loss of function	7 (8)

and Mb Bechterew. Only eight patients were in a stable condition with no new loss of function.

Discussion

This study shows that patients with previous polio experience increasing symptoms and new loss of function, particularly functions associated with mobility and gait. The prevalence of PPS was 26% in this population of polio patients admitted to a hospital, in line with previous epidemiological reports (Codd *et al.*, 1985; Ramlow *et al.*, 1992). Our material is a selected hospital material, which should not be used to estimate the total prevalence of PPS in polio patients. On the other hand; all our patients had a verified diagnosis of previous polio and they were extensively examined to find the cause for their deterioration, which means they have a confirmed diagnosis of PPS. PPS is a clinical diagnosis without any specific biochemical or physiological marker (Dalakas, 1995). Hence, the diagnosis requires rigid criteria from a systematic clinical examination as most symptoms reported by polio patients are non-specific and common in an aging population. Increasing muscle weakness and/or atrophy were absolute criteria for the consideration of PPS in this study. But muscle weakness may also be a result of pain, low compliance on examination, and orthopedic problems. In the presence of joint inflammation or trauma, there is a reflex inhibition of anterior horn-cell firing (Young, 1993). To confirm increasing atrophy, it is necessary to compare with previous examination results. Inactivity as the cause of new atrophy had to be considered. In the normal population, muscle strength is found to be reduced by 1% every year after the third decade (Borges, 1989), and muscle weakness is therefore a part of the normal aging process. EMG is important to confirm or exclude previous polio damage in the muscle, but also as a tool to sort out disorders such as mono- and polyneuropathies, radiculopathies, motor neuron disease, and myopathies. In patients with minor polio sequels, the prevalence of PPS is expected to be low (Dalakas *et al.*, 1986). The majority of our patients had involvement of several muscle groups, thus they are

prone to develop PPS. In contrast to a previous study we found that more men (41%) than women (11%) had PPS (Ramlow *et al.*, 1992).

Forty-five patients (53%) experienced symptoms and loss of function because of polio related symptoms and illness. Some of these symptoms were caused by definite disorders such as radiculopathies and arthrosis that were considered for surgical treatment. However, the majority had less specific symptoms such as fatigue and pain. The high number of patients with pain and fatigue are in line with earlier studies, and can for a large part be explained by their previous polio with additional problems such as bad-fitting orthoses and crutches, tendinitis, and overuse symptoms in their 'healthy limbs' (Windebank *et al.*, 1991, 1996; Diard *et al.*, 1994; Willen and Grimby, 1998; Aurlieu *et al.*, 1999; Nollet *et al.*, 1999; March of Dimes, 2000; Rekan *et al.*, 2000; Farbu and Gilhus, 2002). However, our patients presented with distinct patterns of pain, mainly intrinsic muscular pain in apparently non-paralytic muscles. None of them had trigger points as in fibromyalgia, which was reported to be frequent in another post-polio study (Trojan and Cashman, 1995). Inactivity may be an explanation for the commonly reported articular pain in women. Pain in general did not differ between men and women.

The prevalence of arthrosis and orthopedic disorders were lower in our study than reported by Kidd *et al.* (1997), where orthopedic disorders were found as a major cause for loss of function. Kidd *et al.* reported from a multidisciplinary unit including orthopedic surgery. Thus the referral pattern is probably different. The prevalence of PPS, which was the cause for loss of function in 26% of our patients, was not estimated in that study.

Cervical radiculopathies because of acquired foraminal stenosis develop with increased frequency where muscle imbalance causes overload on one side, and is described in previous polio patients (Drapkin and Rose, 1995; Kidd *et al.*, 1997). All the patients with radicular and mononeuropathies in our study had muscular weakness that lead to muscle imbalance, and it was reckoned as a late effect of polio.

The prevalence of polio-related and non-polio-related pulmonary disorders were low, although scoliosis, kyphosis and atrophy of truncal muscles were common. In addition to the muscular weakness, chest deformities are known to predispose for respiratory insufficiency and failure in polio patients (Howard *et al.*, 1988). Some patients with respiratory symptoms may have been admitted directly to the chest medicine unit. Surprisingly, more women than men reported shortness of breath, although cardiovascular disease was more common among men, and there was no difference between the genders in frequency of pulmonary diseases. 'Shortness of breath' is a common complaint in polio patients (Halstead *et al.*, 1985). Reduced cardiopulmonary fitness rather than pulmonary disease is the cause for this symptom in polio patients admitted for rehabilitation (Stanghelle *et al.*, 1993). It is likely that the women who experienced breath shortness when performing daily life activities had reduced physical fitness because of inactivity. We used PEF as a measure of respiratory function in addition to the general physical examination. However, PEF was not a complete tool when examining respiratory function, and in the cases where pulmonary dysfunction was suspected, the patients were submitted to spirometry and examination by a pulmonologist.

We found that sleep disorders were associated with fatigue, and frequent awakenings because of pain and insomnia are probably the most contributing factor for fatigue, not new neuromuscular weakness.

Nine patients had a non-polio-related disorder that explained their symptoms. This was lower than in a cohort-based population where 40% had another explanation for their symptoms (Windebank *et al.*, 1996), and in a patient population from a multidisciplinary unit (Kidd *et al.*, 1997). The difference can be explained by the different populations examined in the studies. In our study, all patients were specifically admitted to a neurological department with a well-known interest in polio. Several of these nine patients had disorders that were treated specifically and with good results. This emphasizes the need for a careful history taking and medical investigation in previous polio patients.

Outdoor walking and walking in stairs were the most common reduced activities, in accordance with previous studies (Diard *et al.*, 1994; Nollet *et al.*, 1999). This was predictable as most patients have weakness in their lower limbs (Ivanyi *et al.*, 1999). In contrast, self-care such as personal hygiene, family life, and preparing meals were abilities that did not change. None of the examined patients needed to move into institutions. The number of patients employed were lower than in a previous cohort-based study, and also in a hospital-

based polio population in Bergen (Farbu and Gilhus, 1997, 2002). The patients' experience of increasing symptoms and functional decline explain this; they seek medical examination and treatment when the symptoms and reduced function limit their daily life and participation in professional life. In addition, mean age was higher for the present patients. However, except for ability keeping posture and stair walking, there were no significant differences in daily functions between the patients taking part in professional life versus patients with a disability pension. Muscle weakness and coexisting illnesses (except for arthrosis) did not differ. Hence participation in professional life is not measure of physical status and performance of daily life functions.

In conclusion, the majority of previous polio patients experience increased or new symptoms and a functional decline. PPS was found in 26% of the patients seeking a hospital-based polio clinic. Among the patients with new neuromuscular symptoms, additional neurological conditions were common, many of them related to the previous polio.

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