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Falls in frequent neurological diseases

Prevalence, risk factors and aetiology

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■ **Abstract** The prevalence of falls among neurological patients is unknown, although disturbances of gait and posture are common. Falls may lead to burdens for the patient, the caregivers and the health system. We designed a prospective study and investigated all patients for a history of falls admitted to a neurological hospital during a 100-day period. Clinical investigation was carried out and several disease specific rating scales were applied. A total of 548 patients were investigated. Of all patients 34 % had fallen once or more often during the last twelve months. A disturbance of gait was blamed for the fall in 55 %, epileptic seizures in 12 %, syncope in 10 % and stroke in 7 %. Intrinsic risk factors for falls were high age, disturbed gait, poor

balance and a fear of falling. As extrinsic factors we identified the treatment with antidepressants, neuroleptics and different cardiovascular medications, adverse environmental factors in the patients' home and the use of walking aids. Within the diagnoses, falls were most frequent in Parkinson's disease (62 %), syncope (57 %) and polyneuropathy (48 %). According to these findings falls in neurological in-patients are twice as frequent as in an age-matched population living in the community. Falls in neurological patients are particularly linked to medication and disorders affecting gait and balance.

■ **Key words** falls · prevalence · aetiology · risk factors

Abbreviations

PD	Parkinson's disease
MS	Multiple sclerosis
SAE	Subcortical arteriosclerotic encephalopathy
MND	Motor neuron disease
SD	Spinal disorders
PNP	Polyneuropathy
TIA	transient ischaemic attack
MMSE	Mini mental state examination

Introduction

Falls, especially in the elderly, are a common problem in daily clinical practice and often lead to a loss of mobility and independence [1]. In a community based cross sectional study it has been shown that from one-fourth up to one-third of the persons 65 years or older reported a fall in the previous year [2, 3]. In the elderly, between 10 % and 15 % of the falls result in serious injury and between 5 % and 10 % cause a fracture [4]. Furthermore, falls result in increasing costs for the public health system [5], since the elderly are the fastest growing age group in the western population. Many paroxysmal and acute neurological diseases lead to falls since disturb-

ances of stance and gait are frequent symptoms in neurological patients. However, data concerning prevalence, risk factors and aetiology of falls in neurological in-patients have never been investigated, although in clinical experience falls among neurological patients are frequent. Owing to the typical sequelae of neurological diseases affecting integrative motor functions like balance regulation and gait, a high prevalence of falls in neurological patients is expected, which might be an underestimated problem.

It was the aim of the present study to assess the prevalence of falls in neurological in-patients and to investigate which neurological diseases most frequently lead to a history of falls. Special attention has been paid to the co-morbidity of falls and gait disorders in neurological patients. Therefore, we designed a prospective study over 100 days, collecting data of all in-patients admitted to a neurological hospital. Disease related data and risk factors for falls are analysed in detail.

Methods

■ Epidemiological and environmental bases

Data were collected in the department of neurology in Kiel, which is a university hospital with 64 beds, including 6 on an intensive care unit and 6 on a stroke unit. The department provides neurological health care for about 500,000 people in Schleswig-Holstein, mainly inhabitants of the city of Kiel, but also the surrounding villages. Special research interests of the department are basic and clinical research of movement disorders, pain and cerebro-vascular disorders.

■ Patients and general procedures

During 100 consecutive days all patients admitted to the department of neurology as in-patients (including emergencies) were investigated at the first day of hospital stay for the occurrence of an acute fall or the history of falls. Besides collecting the demographic data, every patient was examined by one of two neurologists who are experienced with postural and gait disorders. If the history of falls was positive (self report), the patients underwent further tests and a special questionnaire. Bedridden and unconscious patients were excluded, since gait and posture could not be investigated in these patients. It was noted whether the patients were admitted to neurology as a cause of a fall. All patients gave their informed consent to participate in the study, which was approved by the ethical committee of the university.

■ Falls

A fall was defined as an unintentional event that results in a person coming to rest on the ground or on another lower level [6]. If a patient had one or more falls during the past 12 months a detailed medical history of the falls and further tests were performed. We checked whether the patient had fallen because of a gait disorder, syncope, seizures, and a sudden stroke, alcohol intoxication or for reasons that remained unclear. A gait disorder was defined as a visible disturbance of gait exceeding a normal slowing of gait velocity and shortening of the steps, as it is normal with ageing [7–8]. After the patients had been discharged, the neurological diagnosis that caused falls and/or a gait disorder was ascertained and for data evaluation the patient was classified in one of 27 common neurological diagnoses (Table 1).

Environmental factors associated with the fall such as wet or slippery surface, obstacles on the ground, dimmed light, barefoot walking or walking with inadequate footwear were noted. The time patients were lying helpless on the ground until they were helped was asked. The use of walking aids and the use of drugs that might be co-factors of falls (alcohol abuse, antidepressants, antihypertensives, barbiturates, benzodiazepines, betablockers, diuretics, digitalis and neuroleptics) were checked. The normal, self-selected walking speed was measured in each patient. Besides the clinical data, the ambulation index [9], balance performance [10], and the mini-mental state examination [11] were carried out. Additionally, a pull-test and standing up from a chair were rated according to the “Unified’s Parkinson’s disease rating scale” (part III) [12]. Rating scales for the consequences of peripheral and head trauma due to the fall were constructed. Peripheral trauma: 0 = no injury; 1 = soft tissue damage; 2 = severe sprain with pain longer than 24 hours, 3 = fracture without surgery; 4 = fracture with surgery and/or prolonged hospitalisation. Head trauma: 0 = no injury; 1 = head trauma (without loss of consciousness); 2 = head trauma with loss of consciousness (without lesion shown on CT or MRI); 3 = contusion of the brain and/or intracerebral bleeding or subdural haemorrhage (without surgery); 4 = severe head trauma with the need for surgery due to contusion and/or intracerebral bleeding or subdural/epidural haemorrhage. The scores for standing balance [10], ambulation index [6] and the mini-mental state examination (MMSE) [11] were carried out in each patient.

■ Statistical analysis

The prevalence of falls was calculated for the whole sample of patients. The prevalence of falls was also calculated for different neurological diagnoses. Further calculations were performed for the 10 neurological disorders with the highest proportion (diagnosis specific prevalence) of falls. Calculations were performed by use of SPSS® statistical software used on an ordinary PC. For numeric values such as the gait velocity and the results of the several rating scales, the mean and standard deviation were calculated. For the identification of risk factors for the occurrence of falls, correlations (Kendall’s τ -B) and logistic regression analyses were computed (α -level of significance $p < 0.05$). Significant differences between demographic data and measurements were calculated by use of the Mann-Whitney U-test (α -level of significance $p < 0.05$).

Results

During 100 consecutive days 548 patients were investigated. 59 patients, mostly from the intensive care unit had to be excluded since they were bedridden or unconscious leaving 489 patients for further analysis. 50.4 % were males, 49.6 % females. The mean age was 58.8 ± 17.2 years.

■ Prevalence and aetiology of falls in neurological patients

The results are summarised in Figs. 1–2 and Tables 1–3. 165 (34 %) of the total of 489 patients experienced one or more falls during the last 12 months. About 16 % of the fallers (or 7 % of all patients) were admitted to the neurology department because of a fall. The mean age of the fallers was higher (62.8 ± 15.5 years) than in the non-fallers (55.3 ± 16.6 ; $p < 0.001$). 52 % were females, 48 %

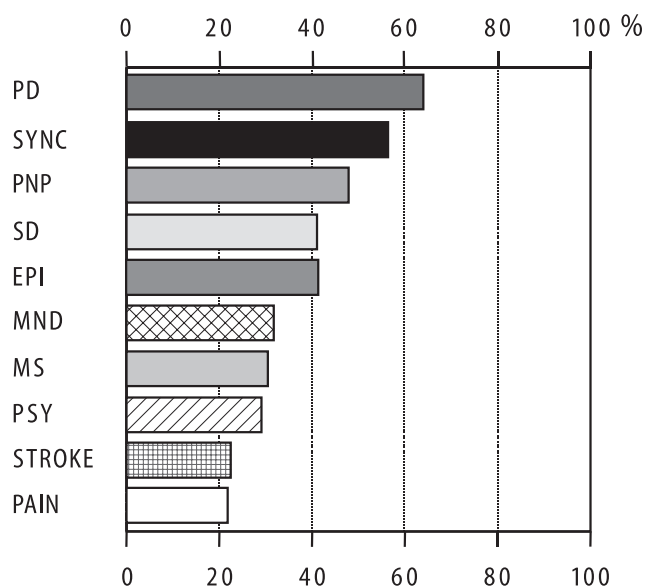


Fig. 1 Displayed are ten neurological diagnoses with the highest frequency of falls (PD Parkinson's disease; SYNC syncope; PNP polyneuropathy; SD spinal disorders; MND motor neuron disease; MS multiple sclerosis; EPI epilepsy; SAE subcortical arteriosclerotic encephalopathy; Pain Pain syndrome)

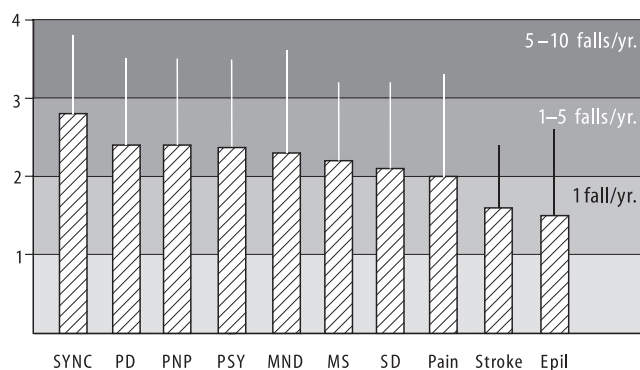


Fig. 2 Frequency of falls in 10 different neurological diseases. 1 = 1 fall in the last twelve months. 2 = 1–5 falls in the last twelve months. 3 = 5–10 falls in the last twelve months. > 4 ≥ 10 falls in the last twelve months

males. 36% of the patients experienced one fall, the other 64% had fallen more frequently (see figure 2). A loss of consciousness was responsible for the fall in 22% (12% epileptic seizures, 10% syncope). In 78% of the fallers no loss of consciousness was found. In most of these patients (55%) an underlying gait disorder was found to be responsible for the falls. A further 7% had fallen due to a sudden stroke and 1% due to acute alcohol intoxication. In 15% the reason of the fall remained unclear to the patient and the investigator (see Table 1).

Table 1 Total number of included patients and number of the patients with falls in specific diagnoses

Diagnoses	n total	n falls
Falls with unconsciousness		
Seizures	32	13
Syncope	7	4
Falls without unconsciousness		
Stroke or TIA	136	30
Idiopathic Parkinson's disease	44	28
Multiple sclerosis	39	12
Pain syndrome	38	8
Polyneuropathy	25	12
Spinal disorders	17	7
Subcortical arteriosclerotic encephalopathy	11	3
Psychogenic disturbances	17	5
Motor neuron disease	12	4
Vertigo	12	3
CNS tumors	11	2
Intracerebral bleeding	10	3
Meningitis/Encephalitis	10	0
Non-idiopathic Parkinson's disease	9	5
Essential tremor	9	2
Polyradiculitis	7	4
Dementia	5	2
Cerebellar disorders	5	3
Myositis/Myopathy	3	0
Hereditary neurodegenerative diseases	2	1
Dystonia	2	1
Subarachnoid haemorrhage	1	0
Chorea Huntington	1	1
Normal pressure hydrocephalus	1	1
Other diagnoses	6	2
Gait disorder without neurological disease	17	9
Total	489	165

General and extrinsic risk factors for falls

Most of the falls occurred inside the home (53%), 14% in other buildings and 33% outside. In the detailed fall history 29% reported that they had fallen because they tripped over an obstacle. 18% said that they found no means of holding on to, for example furniture. 7% made wet ground, 6% poor lighting, 6% inadequate shoes, 5% walking bare foot and 4% a slippery ground responsible for the fall. 51% reported, that they were not able to stand up alone. 68% of the fallers were found by a helping person within the first two minutes, but 7% waited longer than 30 minutes and even 4% more than one hour. 44% of the fallers used a walking aid, which was a stick in 14%, a crutch in 3%, a rollator frame in 14% and 14% were partially wheelchair bound. In 69% the walking aid was judged to be sufficient to improve an underlying disturbance of gait and posture by the investigator. However, in

Table 2 Disease related data of the patients with a history of one or repeated falls. Besides the frequency of falls in the whole sample and disease specific, the number of falls within the last twelve months, balance performance [10] and the results of the trauma score (peripheral and head trauma) are shown (SYNC syncope; PD Parkinson's disease; EPIL epilepsy; PNP polyneuropathy; MS multiple sclerosis; SD spinal disorders; MND motor neuron disease; SAE subcortical arteriosclerotic encephalopathy)

	Percentage of all fallers (n = 165)	Percentage of patients who had fallen within the diagnosis	Fall frequency 1 = 1 fall/year 2 = 1–5 falls/y. 3 = 5–10 falls/y. 4 ≥ 10 falls/y.	Pull-test (0–4)	Standing Balance (0–4) in fallers	Peripheral Trauma Score (0–4)	Head Trauma Score (0–4)	Mini-mental Score (0–30)	Gait velocity (Km/h)	Gait score (0–9)
PD	20%	62%	2.4±1.1	1.1±0.8	3.8±0.7	1.2±0.9	0	24±3	2.5±1.1	3.1±1.2
SYNC	2%	57%	2.8±1.0	1.0±0.7	3.0±1.4	1.0±0.8	0	29±2	2.7±1.7	2.3±2.9
PNP	7%	48%	2.4±1.1	1.6±1.3	2.7±1.5	1.2±0.8	0.2±0.6	27±4	2.8±1.2	3.9±2.4
EPIL	8%	41%	1.5±1.1	2.0±1.4	3.4±1.3	0.7±0.8	0.5±1.2	25±3	4.1±1.5	3.4±4.1
SD	4%	41%	2.1±1.1	0.8±1.2	3.0±1.4	1.0±1.2	0.1±0.4	28±3	2.6±1.7	3.0±2.0
MND	2%	33%	2.3±1.3	2.3±1.3	3.0±2.0	0.8±1.0	0.3±0.5	28±1	2.6±0.9	4.3±3.3
MS	7%	31%	2.2±1.0	2.1±1.7	2.6±1.9	0.8±0.9	0.1±0.3	27±4	3.5±1.4	4.3±3.5
PSY	4%	29%	2.4±1.1	1.4±0.9	3.6±0.9	1.2±1.1	0	24±3	2.0±1.0	3.2±1.6
Stroke	18%	22%	1.6±0.8	1.5±1.4	3.3±1.4	1.0±0.9	0.1±0.3	24±5	2.9±1.5	4.3±3.3
Pain	5%	21%	2.0±1.3	2.3±0.6	3.1±1.4	1.4±1.1	0	27±4	2.6±1.5	1.4±2.0

31 % the walking aid was considered to be insufficient. Interestingly, at the time of discharge the walking aid was changed only in 3 % of the fallers. The number of falls within the past year correlated (Kendall's τ -B) with the use of walking aids (τ -B = 0.15; $p < 0.05$).

Where there was a peripheral trauma due to the fall (68 % of all fallers), 9 % had a fracture and needed to be treated as in-patients, whereas 59 % had a bruise or soft tissue damage. Peripheral traumata due to a fall were most severe in patients with pain syndromes, Parkinson's disease (PD) and polyneuropathy (PNP). Only 5 % (or 9 patients) suffered from head trauma, which was severe in two patients and both underwent surgery. Head trauma was most severe in seizures, which is clearly due to unconsciousness and the lack of any protective reflexes. In patients with a psychogenic disorder, no head trauma was found, and peripheral traumata in these patients were mostly soft tissue damage.

Of the drugs that are known to be risk factors for falls, clear differences were found between fallers and non-fallers. 39 % of the fallers were treated with antihypertensiva (versus 28 % in the non-fallers), 16 % diuretics (versus 6 %), 15 % neuroleptics (versus 6 %), 14 % benzodiazepines (versus 7 %), 14 % betablockers (versus 10 %), 13 % antidepressants (versus 8 %), 7 % digitalis (versus 1 %) and 6 % had an alcohol abuse (versus 2 %). Logistic regression analysis revealed a correlation between the occurrence of falls and medication with digitalis ($r = 0.064$, $p < 0.05$), diuretics ($r = 0.061$, $p < 0.05$) and neuroleptics ($r = 0.062$, $p < 0.05$). The number of falls was correlated (Kendall's τ -B) with antihypertensiva (τ -B = 0.15, $p < 0.05$), benzodiazepines (τ -B = 0.12, $p < 0.05$) and neuroleptics (τ -B = 0.19, $p < 0.05$).

■ Intrinsic and disease related risk factors for falls

There was no significant difference in the mean hospital stay, the duration of the neurological disease, the gait velocity, and the score in the MMSE between fallers and non-fallers. However, the mean MMSE was near the cut-off value (< 24 points) for dementia for the fallers (25.1 ± 4.6 points). Balance performance was correlated with the values of the MMSE ($p < 0.01$). In the pull-test, but not in balance performance [10] the fallers had a significantly (τ -B = 0.13, $p < 0.05$) worse performance than the non-fallers. Falls were correlated with high age (Kendall's τ -B = 0.17, $p < 0.01$), the presence of a gait disorder (τ -B = 0.32, $p < 0.01$), and PD symptoms like freezing episodes (τ -B = 0.14, $p < 0.05$), problems in getting up from a chair (τ -B = 0.14, $p < 0.05$) and problems with turns (τ -B = 0.21, $p < 0.01$). The number of falls was correlated with balance performance (τ -B = -0.27, $p < 0.01$) and the score in the pull-test (τ -B = 0.22, $p < 0.01$). Of all investigated patients 39 % reported a fear of falling, which was present in 57 % of the fallers, but only 24 % of the non-fallers ($p < 0.001$). Fear of falling was correlated with the number of falls in the past year (τ -B = 0.17, $p < 0.05$), female sex (τ -B = 0.21, $p < 0.01$), high age (τ -B = 0.94, $p < 0.05$), the use of walking aids (τ -B = 0.24, $p < 0.001$) and pain during walking (τ -B = 0.17, $p < 0.01$).

In our sample of fallers ($n = 165$), 20 % were PD patients, 18 % stroke patients, 8 % patients with seizures, 7 % patients with polyneuropathy, 7 % multiple sclerosis (MS) patients, 5 % patients with a pain syndrome, 4 % patients with spinal disorders, 2 % syncope, 2 % patients with motor neuron disease (MND) and 2 % patients with subcortical arteriosclerotic encephalopathy (SAE) (see

Table 1 and 2). Within the group of patients who experienced a fall, falls were most frequent in the following 10 diagnoses (see Fig. 2): Parkinson's disease (PD 62%), syncope (57%), polyneuropathy (PNP 48%), epilepsy (41%), spinal disorders (SD 41%), motor neuron disease (MND 33%), multiple sclerosis (MS 31%), psychogenic disorders (29%), stroke (22%) and patients with a pain syndrome (21%). The number of falls was highest in patients with syncope, followed by PD, PNP and MND (see Fig. 2). Interestingly, in psychogenic disorders the number of the reported falls was also very high and the value for the gait velocity was the slowest of all groups. Balance performance and the score in the pull-test were worst in MS, PNP, MND and patients with a pain syndrome. However, the number of patients in the groups syncope and MND was limited (below 5) and therefore data should be interpreted with caution.

Discussion

■ Prevalence and impact of falls

Studies on the prevalence of falls are surprisingly rare, although falls are a frequent cause of disability. Indeed the conclusions of such studies must be interpreted cautiously because the patient selection of the reported studies have defined limits. This is the first study assessing the prevalence of falls in neurological in-patients that is presumably selecting the most severely affected patient group among the diagnoses that have been studied.

Population-based studies found the prevalence of falls between one-third and one-fourth of the persons older than 65 years [2, 13]. In the population of people living in the community aged between 60 and 64 years (comparable to our sample) the prevalence of falls was found to be between 15 and 20% [1, 3]. We have shown that every third in-patient in the neurology department had experienced one or more falls in the past 12 months. Thus, the prevalence of falls is nearly twice as high compared with a community population of similar age [2]. However, the prevalence in our study might even be underestimated, since all unconscious and bedridden patients were excluded.

■ Aetiology and general risk factors for falls

It is self evident that falls have a multi-factorial aetiology [1] and age is an important factor for falls. In our patients, fallers were about 8 years older than the non-fallers. However, in neurological in-patients it is interesting to note that most of the falls (55%) could be directly related to a gait disturbance. Additionally, postural disturbances are strongly correlated with falls. Both are typical findings in neurological patients.

Risk factors for a fall are divided into intrinsic and extrinsic factors. We were able to identify age, disturbed gait, poor balance (pull-test), a fear of falling but not dementia [15] as intrinsic risk factors for falls. Female sex was not found to be a risk factor in our population, but has been previously described [16]. Concerning extrinsic risk factors, e.g. environmental factors, most of the patients reported that they tripped over an obstacle.

Of the drugs that may cause a fall, antidepressants, antihypertensives, diuretics and digitalis were identified as risk factors. We know that drugs are risk factors for falls [17], especially when a "multi-medication" is used, but it is difficult to disentangle how many gait disorders/falls are directly caused by drugs, since gait disorders and falls are often caused by multiple diseases and factors [18]. Nevertheless, the present data show that medications lowering blood pressure have a potential to cause falls irrespective of the neurological diagnosis. This may be an important point for the management of patients with gait disorders. Also the use of walking aids was identified as a risk factor of falls, which is simply reflecting the fact that patients who fell are frequently using walking aids. However, the walking aid that was used by the faller at the time of admittance was rated to be insufficient in a third of the patients and was changed to improve gait less than needed, indicating the need for an optimised walking aid prescription. As most of the falls occurred at home and most falls occur because of tripping over an obstacle it may also be useful to improve the conditions in the houses of handicapped people.

■ Disease related risk factors for falls

As we have demonstrated, most of the falls were linked with a gait disorder as a typical expression of a neurological disease. This underlines the high risk for falls in neurological patients. The largest groups of fallers in our sample of patients were patients with PD and stroke, followed by patients with epileptic seizures and PNP. More important, within the diagnoses, falls were most frequent in patients with PD, syncope, PNP, spinal disorders (SD) and MND. Also every third patient with MS reported one or more falls within the last year. All these groups of neurological diseases have in common a disturbance of the sensory motor system. Since Parkinson's disease is a frequent neurological disorder [19], a high frequency of falls in this group is of outstanding importance for the clinical neurologist. The number of falls was very high and peripheral traumata were among the severest in PD. PD patients who have a high risk for falls were identified to have freezing episodes, difficulties with turns and problems to get up from a chair.

Also the large group of patients with a sensory deficit as a typical symptom of PNP have a high risk for falls, and the number of falls per year was also high. Besides

in syncope, the fall frequency per year was also high in psychogenic disorders. Interestingly, these patients also had the slowest gait velocity, confirming a previous study [20]. However, balance was only mildly affected (see Table 2). The number of falls in patients with epileptic seizures was the lowest, which might be due to the fact that a large proportion of patients are admitted to the department for diagnostics concerning the occurrence of a first seizure.

In conclusion, we have demonstrated, apparently for the first time, that the prevalence of falls among neurological in-patients is very high, bearing burdens for the

caregivers and high costs for the health system. Falls have a multi-factorial aetiology, but the association between falls and disturbances of balance and gait in neurological patients is of outstanding importance. Of special interest for the neurologists are those diagnoses, which most frequently lead to falls (PD, syncope, PNP, SD and epileptic disorders) and of these groups PD patients are particularly in danger of falling. However, further analysis, which should include community based data investigating the correlation of neurological symptoms/diseases and falls are needed to acquire knowledge about this important topic.

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