Falls and gait disorders in geriatric neurology

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Abstract

Gait disturbances are frequent in older patients and lead to immobility, falls, and increased mortality. In gerontoneurologic patients a higher prevalence of risk factors for gait disturbances and falls has to be attributed due to neurodegenerative diseases, dementia, delirium, or psychotropic medication. The potential of neurological expertise to contribute to the evaluation and treatment of falls and gait disorders in geriatric patients is still not fully exploited. Sometimes a fall can be an index event to the diagnosis of the underlying disorder. This review, therefore, focuses on the relationship between falls, gait, and neurological diagnosis. It helps to find the correct diagnosis of the underlying disease as one major step in the management of gait disorders and fall prevention. From a pragmatic point of view falls can be classified according to loss or preservation of consciousness. Gait disturbances should be differentiated into gait disorders with and without cognitive impairment. Although gait impairments are influenced by multifactorial parameters, this differentiation may help to find a diagnosis and also to initiate an appropriate, disease-specific therapy. In addition, every fall patient has to be analyzed individually according to his individual risk factors, which all can potentially be influenced to improve mobility and to reduce falls.

Keywords: Gait disorders, Falls, Geriatric patient, Neurodegenerative disorders, Cognitive impairment
1. Introduction

Falls and gait disorders are relevant problems in the elderly. While at the age of 60 years still 85% have no gait disorders, the prevalence of gait abnormalities rises up to 82% at the age of 85 and older [1]. In the United States 30% of people over the age of 65 years fall each year and in the group of people older than 80 years this proportion is as high as 50% [2]. 25% of deaths due to falls occur in the 13% of people older than 65 years [3].

The danger of falls in elderly people is due to high susceptibility to injuries caused by prevailing diseases e.g. osteoporosis or reduced protective reflexes. Besides the direct risk of fall-related injuries (e.g. major fractures or head trauma) another important consequence of falls is reduced mobility and loss of self-confidence, which in turn leads, therefore, to a significant reduction of quality of life [4,5]. Recurrent falls often lead to admission of previously independent older people to long-term care institutions with severity of fall-related injuries being a predictor of admission [2,6]. Although not every fall is caused by a specific gait disorder, there are quite a few neurological conditions with abnormalities of gait and stance which predispose to falls. Therefore, these two conditions are obviously strongly associated and it is worthwhile to discuss these two topics together, especially as a fall might be an index event, which draws the attention to abnormalities of gait, or to other underlying pathological and potentially treatable conditions.

Gait disorders are indicators of negative sequelae or even markers for reduced survival [7,8] caused not only by fall-related injuries but also by reduced cardiovascular fitness or death from the underlying disease. Besides, gait disturbances in older people are predictors for the development of dementia [9].

In geriatric neurological patients a higher prevalence of gait disturbance and falls must be considered because neurodegenerative diseases, dementia, delirium, or psychotropic medication are common in the elderly. As population ages, this will place an increasing burden on health care providers and society. This warrants a systematic review to discuss the assessment and timely differential diagnosis of gait disorders and falls of geriatric patients in order to prevent further falls and other deleterious consequences.

Most reviews dealing with falls in the elderly [10,11] focus on interventions which must be multifactorial. However, from a neurological point of view, the significance of gait disorders and falls caused by neurodegenerative diseases is steady increasing as the population ages. A fall can be an index event to the diagnosis of a hitherto unknown underlying disease and hereby help to initiate a timely therapy. Therefore, this review focuses primarily on falls and gait disorders associated to the dysfunction of central nervous system in elderly patients.

2. Assessment of falls and gait

In the elderly population most often causes of falls [3,12] have been attributed to accidental or environmental related factors (31%), gait disorders and weakness (17%), dizziness (13%), drop attack (9%), confusion (5%), postural hypotension (3%), visual disorders (2%), or syncope (0.3%). However, many of the accidental falls may really be attributable to a combination of an “accident” and age or disease-related cofactors. Although not all major factors in fall causation are neurologic in origin, neurological impairments or diseases significantly increase the risk of falls. In addition, mobility limitations, cognitive impairment, history of falls, and use of assistive devices are indicators of increased risk for falls [13–27]. Therefore, a main target to prevent falls is to identify treatable or modifiable risk factors early.

However, risk factors for falls are often multifactorial in origin [10]. These can be classified as intrinsic (e.g. the underlying disease), extrinsic (e.g. polypharmacy) or environmental factors (e.g. lack of safety equipment in the bathroom, poor lighting, etc.). Some of these may be modifiable (e.g. medication, hypotension, muscle weakness, etc.) or not modifiable (e.g. blindness, hemiplegia, etc.) [10].

The first step to assess the risk of falling is a careful history taking of the patient and/or his relatives. Special emphasis has to be put on known gait disorders, medication and especially history of previous falls [28]. Clinical examination is the second step to evaluate gait, balance, and risk of further falls (Table 1). A general medical examination especially evaluating cardio-vascular, visual, and cognitive impairments should be accompanied by a specific neurological examination of stance and gait. Moreover, quantifiable tests and standardized rating scales exist to quantitatively evaluate the risk for falling of the patients (Table 1). In the clinical setting, i.e. on ward rounds, the patients should regularly be instructed to walk whenever possible. Visits of patients lying in bed are not sufficient, especially as information obtained by confused patients as well as by relatives can be misleading. In addition, communication about gait and falls should regularly include relatives and/or nurses. A detailed clinical description of specific gait characteristics helps to identify the cause of gait disturbance from clinical examination. Table 2, therefore, gives an overview about major clinical types of gait disorders.

3. Falls with loss of consciousness

From a pragmatic point of view, the causes for falls can be divided into patients who fall with a loss of consciousness and patients who fall while consciousness is preserved e.g. because they have a disturbance of gait and balance, or because of external reasons. This discrimination, however, may be difficult to make in cognitively impaired elderly patients without an accurate history and/or witness. In case of a self-limiting loss of consciousness with rapid but complete recovery the broad differential diagnosis is usually syncope. Naturally speaking, syncope is a symptom and not a diagnosis as many different mechanisms may lead to the transient cerebral hypoperfusion resulting in loss of awareness and fall. A detailed description of the complete spectrum would be beyond the scope of this review and we will instead focus on the most important facts about syn-
cope and the most common neurological differential diagnosis ‘epilepsy’ [36].

3.1. Syncope

Although not the commonest reason for falls in elderly people, syncope is common with a 10-year cumulative incidence of 11.1% for both genders and 16.9 and 19.5% for men and women, respectively, aged 80 years or older [37]. The incidence and recurrence rate of syncope in institutionalized people is certainly higher reaching 6% per year and 30%, respectively [38]. The clinical hallmark of syncope is a transient loss of consciousness with complete spontaneous recovery and usually with no neurological abnormality detectable in the interval. Sometimes syncope starts with a vague feeling of unsteadiness, sometimes accompanied with visual disturbances. In the elderly it is difficult to pinpoint these precursors. The commonest causes of syncope in elderly patients are orthostatic hypotension, carotid sinus syndrome, a variety of neurally mediated syncope and cardiac arrhythmias [39]. It is important to note, that the different causes of syncope require completely different therapies and, therefore, a thorough investigation is warranted. Orthostatic hypotension can be present in patients with supine hypertension, making treatment a challenge. Furthermore, culprit medication can be the sole or an additional factor predisposing to autonomic dysregulation or hypotension. In case of recurrent falls and suspected but unproven syncope the use of implantable loop-recorders can be helpful [40]. Some neurological disorders have a higher risk of developing autonomic failure. Worth mentioning are primary autonomic failure, secondary autonomic failure (e.g. diabetes induced), Parkinson’s disease or multi system atrophy.

Non-syncopal attacks and falls can go along without loss of consciousness, like cataplexy, drop attacks, psychogenic pseudo-syncope, or transient ischemic attacks of carotid artery origin. Most of the differential diagnoses of syncope with impairment of consciousness tend to subside more gradually and last longer than syncope [36]. Worth mentioning are metabolic disorders (e.g. hypoglycemia and intoxication), and epilepsy. Transient ischemic attacks of vertebro-basilar origin usually go along with additional brainstem signs, which can, however, subside unnoticed.

3.2. Epilepsy

Seizures are common in elderly people, and the etiology, clinical presentation, and prognosis can differ considerably between elderly and younger individuals making the diagnosis more difficult [41]. The highest incidence of unprovoked seizures occurs in the age group older than 65 years of age and this number doubled from 1935 to 1984. This can be explained by better diagnosis of epilepsy in the elderly and by a better prognosis after neurological insults [42]. What we learned from this and several other studies is that older patients do not present with the well-known classical features of complex partial seizures. They less often present with an aura and if so this can be described as dizziness. Besides seizures in the elderly do not tend to generalize and in fact a short or long lasting confusional state can be the sole manifestation of epilepsy in this age group [43]. The low incidence of convulsions and short convulsions which pass unnoticed by witnesses may contribute to an under-identification of epilepsy in the elderly. Therefore, a first fall in this patient group may not be interpreted in connection with epilepsy [41]. Compared to the symptomatology of syncope epileptic falls are followed by a longer time period of confusion and reorientation. Creatine-kinase levels may be elevated and sometimes careful history taking reveals earlier episodes suggestive of seizures. Of note is, that syncope can occur with convolution (i.e. convulsive syncope), and most likely the convolution is mentioned first by any observer, facilitating misdiagnosis.

Treatment of epilepsy in the elderly has to be introduced cautiously. Many of the antiepileptic drugs cause dizziness as the most prominent side effect and can therefore aggravate any tendency to fall. Furthermore, at least the enzyme-inducing antiepileptic drugs have a deleterious effect on bone density, hereby facilitating fall-induced injuries [43,44].

4. Gait disturbances and dementia

A strong relationship between gait and cognition has been demonstrated [45]. The presence of cognitive impairments has a high impact on gait disability and is associated to specific diseases, which are discussed in the following section. Gait involves the integration of attention, planning, memory, and other motor perceptive and cognitive processes [46,47].

Some authors describe a three-level hierarchical model for gait and balance [11,48–50] based on the level of neuronal processing involved. Low level deficits depict gait disorders due to peripheral sensory (peripheral neuropathy, vestibular, or visual dysfunction) or peripheral motor impairment (myopathy, focal muscle weakness e.g. peroneus paresis). Low level impairments can be compensated, if central nervous functions are intact. Thus, intermediate and higher level deficits clearly have higher impact on rehabilitation of gait dysfunction, and therefore will be discussed in more detail in the following sections.

Intermediate level deficits are caused by dysfunction of postural or motor responses, and sensory and motor modulation of gait is defect. Examples for intermediate level gait disorders are spastic hemiplegia, spastic paraplegia, extrapyramidal (e.g. Parkinsonian) gait disorders, and cerebellar movement disorders. Higher level gait disorders are characterized by deficits in planning, intention, and executive functions, as well as gait apraxia. Thus, these gait disturbances are mainly influenced by cognition so that dementia and depression contribute to these dysfunctions of gait [11].
There is a reversed relationship between cognition and gait. Many epidemiological studies describe a negative relationship between physical activity, walking and the risk for cognitive impairment and dementia [51–53]. Verghese et al. [54,55] argued that the presence of neurological gait disorder increases the risk to develop non-Alzheimer dementia. Cognitive impairment in combination with gait slowing is a predictor for the development of dementia and a predictor for death [56]. It has been pointed out that gait and gait-related motor dysfunctions can be found in all subtypes of dementia as well as in early and preclinical stages like mild cognitive impairment [45].

4.1. Motor dysfunction and mild cognitive impairment (MCI)

Mild cognitive impairment (MCI) describes slight cognitive disturbances which do not meet the criteria for dementia. Patients have cognitive impairments beyond that expected for age and education, but that does not interfere severely with daily activities. Indeed, MCI is a syndrome of increased risk for dementia and a significant rate of conversion from MCI to Alzheimer’s disease (AD) or other dementia has been observed [57]. Thus, MCI represents an intermediate condition between age-related changes and fully developed symptoms of dementia. The concept of MCI, therefore, is a hot topic in the current knowledge of dementia with inherent implication for treatment and prognosis.

Recent data have shown that subjects with MCI show an increased risk of falling [58] measured in higher physiological profile assessment scores (PPA) and especially significant increased postural sway in subjects with MCI. Moreover, minimal decrements in mini mental state examination (MMSE) were associated with elevated rate of falls in patients with a history of falls [59]. Furthermore, cognitive impairment in non-demented subjects has been independently associated with falls, hip fracture and polypharmacy [60].

Franssen et al. [61] demonstrated reduced balance and limb coordination in patients with MCI and mild AD. Neurological gait disturbances have been found to be more common in subjects with amnestic MCI than in subjects with non-amnestic MCI and controls [62]. Subjects with amnestic MCI had worse rhythm and variability scores in quantitative gait analysis, and subjects with non-amnestic MCI had worse performance in the pace domain [62]. Moreover, mild Parkinsonian signs, especially rigidity, are associated to MCI [63]. Subjects with MCI showed impaired motor function, and the degree of impairment in lower extremity function was related to the risk of development to AD [64], which is a most important finding in this field.

The association between gait and motor disturbances and MCI suggest that they share a similar pathogenesis [63]. Periventricular leukoaraiosis in MRI was clinically predicted by poorer performance of the ‘up and go test’ (TUG) in patients with MCI [65]. It was, therefore, concluded that vascular extrapyramidal dysfunction may be the cause of mobility dysfunction in MCI [65,66]. However, these parameters only represent MR correlates of vascular pathology, while parameters of subtle cortical dysfunction or atrophy may not be assessable by common MRI routines and may therefore be missed. One study suggested that the increased fall risk of patients with MCI may be attributable more to executive dysfunction than to memory deficits [67].

Gait and motor function has to be seen as a cognitive function besides memory, language, attention, and others. A systematic examination of gait in MCI, therefore, widens the insight into cognitive brain function [62] and might represent an additional assessable risk factor for the conversion from MCI to manifest dementia. Identifying patients earlier in the course of the disease is crucial because these patients may benefit most from intervention strategies [67].

4.2. Alzheimer’s disease (AD)

Alzheimer’s disease is with 60% the most common cause of dementia. In AD gait disorders occur late, while in vascular dementia gait disorders present earlier in the course of disease [68,69]. Patients with AD have a slower walking velocity, a decreased step length, and a greater step-to-step variability [70,71]. Gait disturbances increase with increasing severity of the disease [69] and falls are markedly more frequent in AD in comparison to age-matched controls [72]. The degree of impairment in lower extremity motor function in patients with mild cognitive impairment is related to the risk to develop AD [64].

While positive extra-pyramidal signs in advanced AD do not affect gait modulation [73], executive and neuropsychological deficits are significantly associated with increased gait variability that occur when walking with divided attention [74,75]. Thus, the dominating reason for gait dysfunction in AD is executive dysfunction and loss of attention control [76–78]. This led to the concept of gait apraxia as the cause for walking disturbance in some AD patients [79]. Mayer and Barron [80] introduced the term ‘gait apraxia’ as the loss of ability to properly use the lower limbs in the act of walking, which appears independently from muscle weakness or sensory deficits. Therefore, gait apraxia is an executive dysfunction and is closely related to limb apraxia [79], which is a cortical dysfunction in AD in contrast to predominating subcortical dysfunctions in vascular dementia. The incidence of falls in AD is high and a high grade of periventricular white matter lesions and neuroleptic drug use were significantly associated with an increased risk of falls [81]. Distracting people while walking does increase the risk for falls. Although this has only been studied in AD, it is conceivable that similar effects can be expected with cognitive impairment of other origins [73].

4.3. Vascular dementia (VD)

Microvascular changes in MRI of the brain are closely correlated to gait and balance dysfunction [82,83]. Vascular dementia can follow stroke, lacunar infarctions, and diffuse ischemic lesions [84–86]. Major risk factors for vascular dementia are arterial hypertension and arteriosclerosis [87]. Although a considerable overlap between AD and VD exists, symptoms of VD patients include motor and cognitive dysexecutive slowing, forgetfulness, dysarthria, changes of mood, urinary dysfunctions, and early gait disturbance [88,89]. Gait and balance disturbances are more common in vascular dementia than in AD and abnormalities of gait are early features of vascular dementia [90,91]. The early appearance of gait disturbances makes the diagnosis of Alzheimer’s disease unlikely and helps to distinguish VD from AD patients [92,93]. However, there is no good data on the incidence of falls in VD patients in the literature.

Patients with VD show a variety of gait dysfunctions, i.e. decreased step length, wide-based gait, rigidity, disturbance of postural control, freezing of gait, disturbance in initiation of gait, and also gait apraxia [94,95]. Sometimes the term ‘lower body Parkinsonism’ is used, which is partially misleading as only a minor number of VD patients profit from levodopa therapy [96]. Verghese et al. [54,55] defined a high-risk neurological gait syndrome (based on the presence of hemiparetic, frontal, and unsteady gait) that predicts a higher risk to develop vascular dementia.

4.4. Normal pressure hydrocephalus (NPH)

Normal pressure hydrocephalus is characterized by the clinical triad of gait disturbance, cognitive impairment, and urinary incontinence [97]. The syndrome has been described first by Hakim and Adams in 1965 [98,99]. Disturbances in gait and posture are the
most commonly reported symptoms of NPH, while urinary incontinence is inconsistent and a typically late symptom [97]. Cognitive disturbances are predominantly subcortical in nature with slowing of information processing, psychomotor slowing, and dysfunction of execution without typical cortical dysfunctions. Thus, clinical similarities to vascular dementia exist. Although the syndrome is only in 1–6% the cause of cognitive disorders in older patients [100], the early diagnosis of NPH is crucial because it can successfully be treated. Brain imaging is an important part of the diagnosis of NPH with ventricular enlargement disproportionate to cerebral atrophy. Another diagnostic criterion is the tapping test, i.e. a considerable drainage of CSF by lumbar puncture, which improves cognitive function and gait disturbance. About half of the patients improve after shunt surgery [101]. Signs of frontal dysfunction correlate with poorer prognosis [102] as well as white matter lesion load [103].

Gait in NPH is slow with diminished and highly variable stride length and reduced foot-floor clearance. Specific feature is a broad based gait pattern with outward rotated feet and a diminished height of steps [104]. In contrast to patients with Parkinson’s disease external cues only mildly improve the gait pattern. Although few patients with NPH show hypokinetic motor dysfunctions similar to Parkinson’s disease [105] the major characteristics of gait disturbance in NPH is seen as caused by subcortical frontal lobe dysfunction [106]. Patients with NPH show postural instability with the tendency to fall backwards [107] and falls are frequent [108]. Remarkably after shunt surgery, patients improve more in postural stability than in motor function [107].

4.5. Dementia with Lewy bodies (DLB)

It is still uncertain if dementia with Lewy bodies or vascular dementia represent the second most common type of dementia after AD [109]. About 15–25% of demented patients have Lewy body pathology [110]. Clinical core features of DLB are progressive and fluctuating cognitive impairment, visual hallucinations, and motor Parkinsonism. Supportive features are repeated falls, syncope and transient loss of consciousness, sensitivity to neuroleptics, systematized delusions, and hallucinations in Parkinsonism [110]. Rigidity and bradykinesia spontaneously or as a part of abnormal sensitivity to neuroleptic medication [111] are typical features of the disease and may help to distinguish it from AD besides visual hallucinations. Furthermore, falls are much more common in patients with DLB than AD (10% versus 1%) and this difference is not correlated to the existence of Parkinsonism as none of the DLB patients with falls showed extrapyramidal signs [112]. If dementia occurs within 12 months after the onset of Parkinsonian motor signs, the diagnosis should be dementia with Lewy bodies, otherwise the diagnosis Parkinson disease with dementia should be more appropriate. In comparison to patients with Parkinson’s disease DLB patients show more severe action tremor, body bradykinesia, difficulty arising from a chair, gait, and rigidity symptoms [113]. While one study found that patients with DLB have a significantly worse mobility compared to AD and vascular dementia [114], another study did not find a difference between these groups for any measured gait variables [115]. Medical treatment is characterized by good response to cholinesterase inhibitors [116] in contrast to high sensitivity to neuroleptic drugs [111].

4.6. Frontotemporal dementia (FTD)

Frontotemporal dementia has a relative frequency of about 3–10% of patients with dementia [117]. It represents a heterogeneous group of primary degenerative dementia with frontal and/or temporal lobe dysfunctions [118]. Change of personality, restlessness, disinhibition, and impulsiveness are typical signs of frontal lobe dysfunction, while the temporal variant of FTD will present with language disturbances, i.e. semantic dementia [119] or progressive non-fluent aphasia. Additional neurological signs especially motor neuron signs, Parkinsonism and gait disorders can be found [118]. The onset of symptoms in FTD is most often in the presenile period (45–65 years). In a subgroup of patients, the combination of FTD and Parkinsonism is linked to tau locus on chromosome 17 (FTDP-17) [120].

Although no specific gait pattern is described in FTD, involuntary trunk movements have been found to be the most prominent gait-related motor symptoms in frontotemporal lobe degeneration [121], which may influence gait stability. There is no doubt of an increased risk of falls in FTD but exact figures are lacking [122].

5. Gait disturbances due to other neurodegenerative disorders

Other neurodegenerative diseases represent mainly with extrapyramidal symptoms, which influence gait—not necessarily correlated to cognitive dysfunction. Falls resulting from postural instability lead to considerable morbidity and mortality in patients with Parkinsonism [123,124]. Patients with Parkinson’s disease have a five times higher risk to suffer fall-related injuries (e.g. hip fractures) [125].

5.1. Parkinson’s disease (PD)

Parkinson’s disease is a progressive neurological disorder characterized by various motor and non-motor symptoms. Cardinal features of PD are tremor at rest, rigidity, bradykinesia, and postural instability [126,127]. Associated symptoms such as depression, hallucinations, or dementia may lead patients to psychiatric treatment also.

Gait disturbances are common in PD and most often associated to bradykinesia, rigidity, decrease of step frequency and step length. Patients with Parkinson’s disease have an increased incidence of falls and a five times higher risk to suffer fall-related injuries [125]. This is partly due to freezing, loss or slowing of postural control and reflexes. Rhythmic cues can increase speed and step length. Effects are dependent on cue modality with significant improvements for auditory cues compared to others [128]. In contrast, gait deficits are more severe during the performance of dual tasks [129,130].

However, patients in early stages of PD did not show consistent impairments of kinematic and kinetic patterns during steady-state walking typical for severe PD patients, but presented significant alterations in gait initiation and change of walking condition [131]. This implies the processing of the transition from one condition to another to be impaired. Consequently, PD patients report about turning difficulties in up to 60% of cases, while turning disturbances are not necessarily correlated to basic locomotor deficits, axial rigidity or postural instability [132].

Freezing of gait is a transient block of movement and is a common cause for falls in PD [133]. Freezing of gait significantly impairs initiation of gait, turning, or negotiation of objects [134], and steps prior to freezing show cumulative loss of stride length and accelerated cadence [135].

Postural instability due to loss of postural reflexes generally develops late in the course of disease, but is the most common cause for falls [136]. Postural instability can be tested by the pull test (the patient is quickly pulled forward or backward by the shoulders). If falls due to postural instability occur early in the course of the disease atypical Parkinson disorders have to be taken into account such as MSA or PSP [136,137]. However, it has been found that 46% of PD patients fell at least
once a week [138]. Although PD patients use a lateral stepping strategy in lateral translations, bradykinetic characteristics of the stepping response lead to an increased rate of falls and remarkably no differences have been found in levodopa on and off states [139].

Anti-Parkinson treatment (e.g. dopaminergic medication, deep brain stimulation) is able to improve some axial signs [140] but does not efficiently improve postural stability [141], turning difficulties [132], or freezing of gait [133]. Consequently, physiotherapy is a major additional principle in the therapy of PD. Treadmill training has been shown to improve mobility, reduce postural instability and the fear of falling in patients with [142,143].

In addition, orthostatic hypotension in PD occurs in 20–30% of PD patients and may be another cause of falls [144]. Hypotension is associated with male gender, older age, longer disease duration, and instability of posture and gait [145]. Pronounced vasomotor and cardiac sympathetic dysfunction has been demonstrated to be the major cause of orthostatic hypotension [145]. It must be born in mind, that typical Parkinson medication usually has an additional negative influence on blood pressure.

5.2. Multiple system atrophy—MSA

Multiple system atrophy is clinically characterized as combination of Parkinsonism, autonomic failure, cerebellar dysfunction, or pyramidal signs [146]. MSA is an α-synucleinopathy along with other neurodegenerative diseases. Parkinsonian symptoms (progressive akinesia and rigidity) predominate in 80% of cases (MSA-P subtype), while cerebellar dysfunction (gait ataxia, limb kinetic ataxia, dysarthria, and cerebellar oculomotor disturbances) is the major motor symptom in 20% (MSA-C subtype) [147,148]. Dysautonomia (primarily urogenital and orthostatic dysfunction) is present in both subtypes and develops early in the course of the disease. Freezing of gait has been found to be a common symptom in MSA, both in MSA-P and MSA-C [149].

40–60% of MSA patients with predominant Parkinsonian features may benefit from levodopa therapy and other anti-Parkinson compounds may also have a benefit [150]. In contrast, no effective therapy is known to improve progressive cerebellar dysfunction. Autonomic failure may be influenced by sympathomimetic drug therapy (e.g. midodrine, l-threo-DOPS) or mineralocorticoids (e.g. fludrocortisone). Non-pharmacological options include fluid intake and high salt diet [150].

5.3. Progressive supranuclear palsy—PSP

Progressive supranuclear palsy (Steele–Richardson–Olszewski syndrome) is characterized by early postural instability, supranuclear vertical gaze palsy, levodopa-resistant symmetric Parkinsonism, pseudobulbar palsy and mild dementia [151]. Supranuclear vertical gaze palsy, falls during the first year after symptom onset, and moderate to severe gait impairment are significant indicators to distinguish PSP from non-PSP [152]. Unexpected falls due to postural instability are early and severe events in the course of PSP [153]. PSP patients are not able to counterbalance the fall in the centre of gravity prior to foot-contact. This could reflect the inability to control imbalance induced by the single leg support during the swing phase caused by the absence of a vertical impulse, which could contribute to the postural instability [154].

5.4. Corticobasal degeneration—CBD

Corticobasal degeneration is an atypical Parkinsonian neurodegenerative syndrome. However, no validated criteria for the diagnosis of CBD exist [155]. Like PSP the pathology of CBD is characterized by tau-associated cell changes. CBD is a pathologically and clinically heterogeneous disorder with some overlap to other neurodegenerative disorders [156].

The most commonly reported symptom is asymmetric limb clumsiness with or without rigidity or tremor. Extrapyramidal signs comprise unilateral limb rigidity (79%) or bradykinesia (71%), postural imbalance (45%), unilateral limb dystonia (43%) [157]. Ideomotor apraxia (64%) and cortical dementia (36%) are cognitive symptoms [157]. Unilateral levodopa-resistant Parkinsonism and limb ideomotor apraxia (or alien limb) are clinical hallmarks of CBD.

The onset of the disease is insidious and the rate of progression is slow [158]. First symptoms affect one extremity only with rigidity, slow movement, apraxia, and stimulus-sensitive myoclonus. Fixed dystonic posture of one hand is quite characteristic, while alien limb phenomenon is relatively seldom. In the course of the disease the symptoms also affect the other limbs, gait difficulties and oculomotor disturbances develop [158]. In contrast, cognitive dysfunction is relatively rare.

Pharmacological therapy was largely ineffective in the management of CBD [159]. In a case report of a patient with mixed PSP and CBD features long-term locomotor training appeared to improve balance and to decrease falls [160], but long-time group studies of physical therapy are still missing.

6. Interventions and therapeutical options

Gait, mobility and balance are crucial parameters that affect activities of daily living. A history of falls is a predictor of future falls. A comprehensive neurologic examination is one major tool to assess the risk of fall besides additional screening instruments such as the ‘get up and go’ test, Tinetti mobility index and others.

Neurologists and psychiatrists are often confronted with diseases which increase the risk of falls, e.g. neurodegenerative disorders, dementia, stroke, peripheral neuropathy and others [161,162]. Several therapeutic options exist to improve the symptoms of these diseases. In PD for instance antiparkinson therapy will improve gait difficulties. Shunt surgery in NPH improves postural stability [107]. Therefore, an early and correct diagnosis of the underlying disease is one major step in the management of older patients with gait disturbances and risk of falls.

However, medical treatment of the underlying disease often may improve symptoms and slows the progression of the disease but cannot stop the process in most cases. Moreover, multiple reasons for increased fall-risk can be found which are multifactorial in origin [10]. Therefore, the concept of multifactorial interventions has been developed, which means that the danger for risk for falling has to be assessed, possible risk factors have to be analysed, and identified risk factors—when possible—have to be modified. Single interventions comprise exercise, environmental modification, medication review, assistive devices, behavioural and educational programs, cardiovascular interventions, visual interventions, and footwear interventions [10].

A structured multifactorial intervention reduced the incidence of falls in a hospital ward setting [163]. However, data on fall-intervention programs in residential care is equivocal; Kerse et al. could not demonstrate a reduction of falls or injuries for falls [164]. Interventions in this study included staff education, medication review, environmental assessment, individualized balance training, hip protectors, and postfall conferences. In contrast a similar intervention program with broad dissemination of knowledge of risk-assesment and strategies of fall prevention could demonstrate a reduction in fall-related injuries [16]. In the former study 50% of patients suffered dementia, which is a counterproductive parameter in fall prevention and may explain the discrepancy. A meta-analysis recently found that multifactorial intervention may
moderately reduce rates of falls in hospital settings, while in care homes rates of hip fractures could be reduced using hip protectors [165].

Gait and balance can be improved by physiotherapeutic and exercise training. In a meta-analysis of seven studies that featured exercise as a prominent part of multifactorial interventions, an overall significant reduction in falls among intervention subjects has been demonstrated [166]. Treadmill training has been shown to improve mobility, reduce postural instability, and fear of falling in patients with PD [142,143]. However, patients with dementia often do not per se benefit from physiotherapy if the cognitive deficits are not influenced e.g. by cholinergic therapy or memantine [76]. Therefore, multifactorial intervention has been shown not to be effective in preventing falls in older patients with cognitive impairment and dementia [167].

Physical restraints are a common practice in geriatric psychiatric care [168] and also in a less extent in acute general medical wards [169]. The major intention to use physical restraints is to prevent falls and injuries to patients [170]. However, many problems arise from restraints use caused by deconditioning from mobilization [171]. Patients with severe cognitive impairments have the highest risk for restraints because these have a higher risk to develop delirium characterized by agitation, restlessness, and confusion. However, no significant difference could be demonstrated between the frequency of falls in restrained and unrestrained patients [168]. No evidence-based data support the use of restraints to prevent falls. The reduction of restraint use does not lead to increased fall-related injuries [172,173]. Therefore, the reduction of physical as well as pharmacological restraints – even in demented patients – should be a major goal in geriatric care. Possibilities to reduce restraints are to use the least invasive method to deliver care and environmental changes to ease and comfort the patient (e.g., reduced noise level, appropriate light, provide a sense of familiarity, etc.) [171]. It has been shown in Alzheimer Special Care Units that environmental changes in favor of demented patients reduces the risk of hospitalization and pharmacological and physical restraint use [174].

Adverse effects of medication also have high impact on gait disturbances and falls in elderly people [35,175,176]. A critical review of medication is therefore essential for treatment of elderly people. The underlying pathophysiological mechanism is dependent on the administered drug e.g. sedation (benzodiazepines, neuroleptics, anticonvulsants [177–179]), orthostatic hypotension (antihypertensive medication, anti-arrhythmics [180]), behavioural abnormalities and hallucinations (analectics, anti-Parkinson medication, psychotropic drugs [178]), extrapyramidal side-effects (neuroleptics [178]), or ataxia and dizziness (anticonvulsants [181]). Thus, the use of drugs in the elderly demands to critically balancing possible side-effects against its benefit especially as older patients often will take several drugs. A critical review of medication is therefore essential for treatment of elderly people. Polypharmacy is associated with falls [182], and the reduction of number of drugs in elderly care-home residents reduced falls by 40% [183].

7. Conclusive remarks

In summary, every fall patient has to be analyzed individually according to his specific disease and his individual spectrum of additional risk factors. Neurological expertise helps to make a diagnosis and consequently leads to disease-specific therapy. Sometimes a fall can be an index event to the diagnosis of the underlying neurological disorder and specific characteristics of gait disturbances – although considerable overlap between neurological disorders exists – can contribute to the neurological diagnosis. It is important to further evaluate the relationships between falls, cognitive impairment, and motor symptoms/early Parkinsonian signs in the future as this has turned out to be most relevant for treatment and prognosis. Gait has to be recognized as a cognitive function, and early and detailed analysis of gait disturbances (and other motor functions) after e.g. an index fall, can help to prevent further harmful falls as well as to initiate timely measures against further cognitive deterioration. In addition, many of the risk factors for falls can be influenced positively, some of them in a somewhat counterintuitive way by e.g. reducing medication or the use of restraints. Although evidence based medicine in this field is still scarce, it is worthwhile to invest in further research to alleviate the burden of falls to the patients and to society.

References


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