Disorders of gait and balance

clinical assessment and classification

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handout

additional videos and photos will be shown in the presentation
Disorders of gait and balance: basic definitions

Bipedal walking: evolutitional human motor skill, parallels the development of the frontal lobe

- **Balance**: the ability to stand up and remain upright against the force of gravity (equilibrium)
- **Locomotion**: rhythmic stepping movements to advance in space (gait)
- **Adaptability** to the environment

Disorders of gait and balance:

- among the most common problems in neurologic patients
- increasing prevalence with age
- limit QoL, most serious consequence: **Falls**
Disorders of gait and balance: clinical examination

History of gait and balance disorders
- quality of gait, activity levels, walking perimeter
- falls (frequency, circumstances, direction)

Associated symptoms and signs
- dizziness, urinary symptoms
- other neurologic or systemic symptoms
- depression, cognitive dysfunction

Testing of balance and gait
- simple observation
- gait/balance tasks
- questionnaires and scales
- laboratory measurement of gait parameters
# Basic patterns of gait disorders

<table>
<thead>
<tr>
<th>parameter affected</th>
<th>abnormal pattern of gait</th>
</tr>
</thead>
<tbody>
<tr>
<td>muscle strength</td>
<td>↓ weakness: paretic gait</td>
</tr>
<tr>
<td>base width</td>
<td>↑ broad base: ataxic gait</td>
</tr>
<tr>
<td>stride length</td>
<td>↓ stiff gait</td>
</tr>
<tr>
<td>cadence of stepping</td>
<td>↑↑ stiff gait</td>
</tr>
<tr>
<td>fluidity of movement</td>
<td>↓ freezing of gait</td>
</tr>
<tr>
<td>gait initiation and maintenance</td>
<td>↓ „bizarre“ gaits</td>
</tr>
<tr>
<td>unclassifiable</td>
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Classification of gait disorders

phenomenologic (patterns of gait)

- antalgic
- weakness
- ataxic
- stiff
- freezing
- „bizarre“
Classification of gait disorders

- Phenomenologic (patterns of gait):
  - Antalgic
  - Weakness
  - Ataxic
  - Stiff
  - Freezing
  - "Bizarre"

- Anatomic (levels of involvement):
  - Higher
  - Middle
  - Lower

- Disease (etiology):
  - Genetic
  - Autoimmune
  - Degenerative
  - Metabolic
  - Vascular
  - Trauma

Nutt 1993, Verghese 2006, Snijders 2007, Giladi 2013, ...
Classification of gait disorders: anatomic levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Anatomic</th>
<th>Functional subsystem</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Higher</strong></td>
<td><strong>cortex</strong></td>
<td>cognition, attention, insight (conscious)</td>
</tr>
<tr>
<td></td>
<td><strong>subcortical white matter</strong></td>
<td>synergy selection and adaptation to circumstances (unconscious)</td>
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<tr>
<td><strong>Middle</strong></td>
<td><strong>basal ganglia</strong></td>
<td>perception/orientation (body spatial maps)</td>
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<tr>
<td></td>
<td><strong>thalamus</strong></td>
<td>force scaling (modulation of motor patterns)</td>
</tr>
<tr>
<td></td>
<td><strong>cerebellum</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>brainstem</strong></td>
<td></td>
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<tr>
<td></td>
<td><strong>spinal cord tracts</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Lower</strong></td>
<td><strong>periph. sensory nerve</strong></td>
<td>locomotor synergies</td>
</tr>
<tr>
<td></td>
<td><strong>lower motor neuron</strong></td>
<td>primary afferent input</td>
</tr>
<tr>
<td></td>
<td><strong>muscle and nm junction</strong></td>
<td>force production</td>
</tr>
</tbody>
</table>

Nutt 2001, adapted
Anatomo-clinical classification

Lower level disorders of gait

- myopathies
- neuropathies and radiculopathies
- lower motor neuron disease
- sensory disorders
  - visual
  - vestibular
  - proprioceptive

bilateral peroneal neuropathy

distal weakness, foot drop, steppage
Anatomo-clinical classification

Middle level gait disorders

- parkinsonian (hypokinetisch)
  - + PIGD phenotype

- dyskinetic
  - chorea
  - dystonia
  - myoclonus
  - tics

- cerebellar (ataxic)

- corticospinal (spastic)
  - hemiparetic
  - paraparetic
Anatomo-clinical classification
Middle level gait disorders

**Parkinson disease – early onset**

**parkinsonian (hypokinetis)**

- short steps
- shuffling
- festination
- slow turning
- flexed posture
- reduced arm swing

**Ataxia**

- hemiparetic
- paraparetic

**Cerebellar**

- PIGD phenotype
- hyperkinetic
- choreatic
- dystonic
- myoclonic
- tics

**Corticospinal**

- spastic
Anatomo-clinical classification
Middle level gait disorders

parkinsonian (hypokinetisch)

- PIGD phenotype
  - predominant involvement of posture and gait
  - poor response to treatment
  - high risk of dementia
  - frequent falls and injuries

Gait disorders and falls are major problems in late stage PD
- start hesitation in 90%, freezing in 81% patients.
- falls in 81% patients. (mean onset at 11.5 years)

Hely 2005
Anatomo-clinical classification

Middle level gait disorders

Huntington's disease

dyskinetic

- chorea
- dystonia
- myoclonus
- tics

dyskinesia interfering with gait

broad base

variable stride length and cadence
Anatomo-clinical classification

Middle level gait disorders

**BROAD BASED GAIT**

instability
freely-flowing unsteady steps
erratic variance in rhythm and amplitude
action tremor + titubation

cerebellar
(ataxic)

multiple sclerosis
Anatomo-clinical classification
Middle level gait disorders

- **cerebral palsy**
  - corticospinal (spastic)
    - hemiparetic
    - paraparetic

  **STIFF GAIT**
  - spasticity
  - circumduction, scissoring
Anatomo-clinical classification

Higher level gait disorders

1) Freezing of gait (FOG)
   – FOG in PD
   – primary progressive freezing of gait

2) Frontal (apraxia of) gait
   – cautious gait, senile gait, lower body parkinsonism, gait apraxia, ...
   – combining signs of ataxia, parkinsonism, FOG
   – bilateral involvement of frontal lobes = cortical-basal ganglia-thalamo-cortical loops
Higher level gait disorders

FOG in Parkinson disease

FOG leads to falls

FOG + STIFF GAIT
start hesitation
sudden stops
motor blocks
sensory tricks

common cause of falls in PD
Higher level gait disorders

FOG in Parkinson disease

effect of sensory tricks

external pacing cues
  (including emotions)

triggering alternative motor programs

helpful in rehabilitation

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Higher level gait disorders

Primary progressive FOG

FOG more common in APS than in PD: 53% of PSP, 54% MSA, 54% DLB, 25% CBD

50% of vascular parkinsonism cases

FOG is associated with executive dysfunction

Syndromes dominated by FOG: „gait ignition failure, pure akinesia, primary progressive freezing of gait“

Higher level gait disorders

Frontal (appraxia of) gait

1) Freezing of gait (FOG)
   – FOG in PD
   – primary progressive freezing of gait

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Higher level gait disorders

Frontal gait

- increased variability of gait parameters, greatly influenced by the environment and emotion
- narrow or widened base
- stooped or upright posture with flexed hips or knees
- reduced gait speed and stride length
- often associated with FOG, hypokinesia/rigidity, frontal release signs, cognitive deficits - executive dysfunction
- absent or inappropriate rescue reactions, often falls and/or fear of falling
- various etiologies: arteriosclerotic encephalopathy ("vascular parkinsonism"), normal pressure hydrocephalus, etc.
Higher level gait disorders

Frontal gait

FRONTAL GAIT + FOG

- broad base, instability
- fear of falling
- freezing of gait
- hypokinetic gait
- incontinence
- cognitive dysfunction

normal pressure hydrocephalus
Higher level gait disorders

Frontal gait

„VASCULAR PARKINSONISM“

- hypokinetic gait
- FOG
- preserved arm swing
- no hypokinesia of hands and feet
- no effect of L-DOPA

subcortical arteriosclerotic encephalopathy
Falls

• causes and mechanisms (careful history taking!)
  – relative to the primary disease
    • postural instability (e.g. as part of PD symptoms)
    • freezing + (retro)pulsion
    • orthostatic hypotension
  – unspecific causes, comorbidity in the elderly
    • astasia-abasia
    • impairment of vision
    • cardiogenic syncopes

• prevention
  – modifications in the environment and regime
  – physical activity, physiotherapy, mechanical devices
Summary

DISORDERS OF GAIT AND FALLS
• are common in neurologic patients and in the elderly
• substantially limit quality of life

OBSERVATION
• key approach to diagnosis of gait disorders

PHENOMENOLOGIC CLASSIFICATION
• to distinguish basic patterns of abnormal gait
• always consider compensation - fall risk - cognitive dysfunction - continuous vs. episodic disorder

SYSTEM (ANATOMIC) CLASSIFICATION
• lower – middle – higher level gait disorders
• to understand pathophysiology and to recognize etiology
References
Nutt JG, Marsden CD, Thompson PD. Human walking and higher level gait disorders, particularly in the elderly. Neurology 1993;43:268–79.

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