The presenters have no conflict of interest to report regarding any commercial product/manufacturer that may be referenced during this presentation.

Objectives

- Recognize mechanisms and presentation of CIPN
- Describe the impact of CIPN on function
- Identify key elements of examination
- Describe selected interventions to maximize outcomes
Peripheral Neuropathy

“A condition arising from damage and dysfunction of the peripheral nerves – the motor, sensory, and autonomic nerves that connect the brain and spinal cord to the rest of the body.”

-Stubblefield et al., 2009; p.51

Cancer-Related Etiology

- Direct effect
  - Infiltration
  - Compression
- Indirect effect
  - Paraneoplastic
  - Nutritional deficiencies
  - Metabolic disturbance
- Iatrogenic effect
  - Radiation
  - Immunosuppression
  - Bone marrow transplantation
  - Chemotherapy

Chemotherapy-Induced Peripheral Neuropathy

“Any injury, inflammation, or degeneration of the peripheral nerves because of the administration of a chemotherapeutic agent”

-Gilchrist 2012; p. 9
Neurotoxic Chemotherapeutics

- Ara-C, Ara-A, Ara-G
- Bortezomib
- Carboplatin
- Cisplatin
- Cytarabine
- Docetaxel
- Epothilones
- Etoposide
- Gemcitabine
- Hexamethylmelamine
- Ifosfamide
- Interferon-alpha
- Misonidazole
- Oxaliplatin
- Paclitaxel
- Procarbazine
- Suramin
- Thalidomide
- Vincristine
- Vinblastine
- Vinorelbine
- Vindesine

Neurotoxic Chemotherapeutics: Classes

Platinum Analogues
- Cisplatin
- Carboplatin
- Oxaliplatin

Vinca Alkaloids
- Vincristine
- Vinblastine
- Vinorelbine
- Vindesine

Taxanes
- Paclitaxel
- Abraxane
- Docetaxel

Neurotoxic Chemotherapeutics: Indications

Platinum Analogues
- Ovarian
- Lung
- Testicular
- Bladder
- Colon
- Colorectal

Vinca Alkaloids
- Lymphoma
- Leukemia
- Multiple Myeloma
- Breast
- Lung

Taxanes
- Ovarian
- Breast
- Lung
- Bladder
- Prostate
Incidence

<table>
<thead>
<tr>
<th>Class</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platinum Analogues</td>
<td>Cisplatin: 28%-100%</td>
</tr>
<tr>
<td></td>
<td>Carboplatin: 6-42%</td>
</tr>
<tr>
<td></td>
<td>Oxaliplatin: acute: 85-95%</td>
</tr>
<tr>
<td>Vinca Alkaloids</td>
<td>30%-47%</td>
</tr>
<tr>
<td>Taxanes</td>
<td>Paclitaxel: 57%-83%</td>
</tr>
<tr>
<td></td>
<td>Abraxane: 73%</td>
</tr>
<tr>
<td></td>
<td>Docetaxel: 11%-64%</td>
</tr>
</tbody>
</table>

Stubblefield et al., 2009

Risk Factors

- Chemotherapeutic profile
  - Type
    - Taxanes: HR=2.22 (95% CI: 1.85-2.66)
    - Combination therapy: HR=3.33 (95% CI 2.05-5.05)
  - Dose
  - Duration
  - Schedule
- PNS integrity
  - Pre-existing dysfunction
  - Neurologic sequelae of cancer treatment

Hausheer et al., 2006; Stubblefield et al., 2009; Nurgalieva et al., 2010

The Big Picture

Health Condition
Chemotherapy-Induced Peripheral Neuropathy

Body Structure Impairments
Body Function Impairments
Limitations & Restrictions

**Mechanism**


**Body Structure Impairments**

- **Peripheral Nervous System**
  - **Sensory**
    - First and most affected
  - **Motor**
    - Less often affected
    - Associated with more severe sensory involvement
    - Potential for regeneration
  - **Autonomic**
    - Rarely affected

Hausheer et al., 2006; Stubblefield et al., 2009

**Body Function Impairments**

- **Sensory**
  - Numbness
  - Paresthesia
  - ↓ Thermal perception
  - ↓ Light touch
  - ↓ Position sense
  - ↓ Vibration
  - Pain

- **Motor**
  - ↓ Strength
  - Cramping
  - Muscle fatigue

- **Autonomic**
  - Orthostasis
  - Arrhythmia
  - Constipation
  - Incontinence

Hausheer et al., 2006; Hile et al., 2010; Stubblefield et al., 2009; Stubblefield et al., 2012
Body Function Impairments

• Neuropathic pain
  – Caused by nervous system lesion / dysfunction
  – No nociceptive stimulation required
  – Disproportionate to the stimulation of receptor

Merskey & Bogduk, 1994; Serra et al., 1999

Positive vs. Negative Symptoms

• Positive Symptoms
  – Pain
    • Allodynia
    • Dysesthesia
    • Hyperesthesia
    • Hyperalgesia
    • Paresthesia

• Negative Symptoms
  – ↓ Strength
  – Sensory Loss
    • Numbness
    • ↓ Light touch
    • ↓ Position sense
    • ↓ Thermal perception
    • ↓ Vibration

Stubblefield et al., 2009; Stubblefield et al., 2012

Presentation: Hallmarks

• Distal
• Symmetric
• Length-dependent
• Stocking-glove distribution
• Sensory > motor
• Onset after chemotherapy
  – Progressive, rapid or coasting
• Dose-dependent

Stubblefield et al., 2009; Keefe et al., 2009; Stubblefield et al., 2009
### Presentation: Platinum Compounds

<table>
<thead>
<tr>
<th>Agent (Dose)</th>
<th>Sensory</th>
<th>Motor</th>
<th>Reflexes</th>
<th>Autonomic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisplatin (500 mg/m²)</td>
<td>Numbness • Tingling • Pain • Paresthesias • Stocking-glove distribution • ↓ Proprioception • Ataxia with impaired gait</td>
<td>WNL</td>
<td>↓ in proportion to sensory impairment</td>
<td>Rare</td>
</tr>
<tr>
<td>Carboplatin (600 mg/m²)</td>
<td>Less severe but similar to Cisplatin</td>
<td>WNL</td>
<td>WNL</td>
<td>Rare</td>
</tr>
</tbody>
</table>

Lee & Wen, 2012; Lee & Wen, 2013; Stubblefield et al., 2009; Wampler, 2006

### Presentation: Platinum Compounds

<table>
<thead>
<tr>
<th>Agent (Dose)</th>
<th>Sensory</th>
<th>Motor</th>
<th>Reflexes</th>
<th>Autonomic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxaliplatin, Acute (Any dose)</td>
<td>Dysesthesia - cold-induced • mouth • throat • ULE's</td>
<td>Cramps • Muscle spasms, throat</td>
<td>WNL</td>
<td>None</td>
</tr>
<tr>
<td>Oxaliplatin, Chronic (750-850 mg/m²)</td>
<td>Similar to Cisplatin</td>
<td>WNL</td>
<td>WNL</td>
<td>Rare</td>
</tr>
</tbody>
</table>

Lee & Wen, 2012; Lee & Wen, 2013; Stubblefield et al., 2009; Wampler, 2006

### Presentation: Vinca Alkaloids

<table>
<thead>
<tr>
<th>Agent (Dose)</th>
<th>Sensory</th>
<th>Motor</th>
<th>Reflexes</th>
<th>Autonomic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vincristine (4-10 mg)</td>
<td>Tingling • distal • symmetric • LE's • UE's rarely affected</td>
<td>Weakness • distal • symmetric • May progress to foot drop • Impaired gait</td>
<td>↓ absent at ankle</td>
<td>Constipation • Orthostatic hypotension</td>
</tr>
<tr>
<td>Vinblastine (4-10 mg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vinorelbine (4-10 mg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vindesine (4-10 mg)</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Lee & Wen, 2012; Lee & Wen, 2013; Stubblefield et al., 2009; Wampler, 2006
Presentation: Taxanes

<table>
<thead>
<tr>
<th>Agent</th>
<th>Sensory</th>
<th>Motor</th>
<th>Reflexes</th>
<th>Autonomic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paclitaxel</td>
<td>• Numbness</td>
<td>• Weakness</td>
<td>• ↓ Ankle</td>
<td>• Rare</td>
</tr>
<tr>
<td>(100-300 mg/m2)</td>
<td>• Pain</td>
<td>• occasional</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Parasthesias</td>
<td>• Impaired gait</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Stocking-glove distribution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Fast &gt; hands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Ataxia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• ↓ Vibration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• ↓ Proprioception</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Docetaxel</td>
<td>• Numbness</td>
<td>• Weakness</td>
<td>• ↓ Ankle</td>
<td>• Rare</td>
</tr>
<tr>
<td>(75-100 mg/m2)</td>
<td>• Pain</td>
<td>• occasional</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Parasthesias</td>
<td>• Impaired gait</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Stocking-glove distribution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Fast &gt; hands</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• ↓ Vibration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• ↓ Proprioception</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Lee & Wen, 2012; Lee & Wen, 2013; Stubblefield et al., 2009; Wampler, 2006

Functional Implications

- ↓ Postural control s/p Taxane therapy
- Impairment associated with high fall risk

- ↓ Balance
- ↓ Falls
- ↓ Mobility
- ↓ ADL
- ↓ QOL

- ↓ Postural control s/p Taxane therapy
- Improvement associated with high fall risk

- ↓ Balance
- ↓ Falls
- ↓ Mobility
- ↓ ADL
- ↓ QOL

Sasane et al., 2010; Hile et al., 2010; Marchese et al., 2011; Ness et al., 2013; Gewandter et al., 2013; Winters-Stone et al., 2011

Functional Implications

• “…worse than alopecia, pancytopenia & fatigue…”
• “least expected… most distressing & disabling…”
• “…made patients feel dependent, disabled & helpless”

—Sasane et al., 2010; p. E16
### Diagnostic Classification

**Common Terminology Criteria for Adverse Events Version 4.03**

<table>
<thead>
<tr>
<th>Toxicity</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
<th>Grade 4</th>
<th>Grade 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Neuropathy</td>
<td>Asymptomatic; clinical or diagnostic observations only</td>
<td>Moderate symptoms; limiting instrumental ADL</td>
<td>Severe symptoms; limiting self-care ADL; assistive device indicated</td>
<td>Life-threatening consequences; urgent intervention indicated</td>
<td>Death</td>
</tr>
<tr>
<td>Sensory Neuropathy</td>
<td>Asymptomatic; Loss of DTR or paresthesia</td>
<td>Moderate symptoms; limiting instrumental ADL</td>
<td>Severe symptoms; limiting self-care ADL</td>
<td>Life-threatening consequences; urgent intervention indicated</td>
<td>Death</td>
</tr>
<tr>
<td>Paresthesias</td>
<td>Mild symptoms</td>
<td>Moderate symptoms; limiting instrumental ADL</td>
<td>Severe symptoms, limiting self-care ADL</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

---

### Prognosis

<table>
<thead>
<tr>
<th>Class</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Platinum Compounds</strong></td>
<td></td>
</tr>
<tr>
<td>Cisplatin &amp; Carboplatin: Partial recovery, possible “coasting”</td>
<td>Partial recovery, possible “coasting”</td>
</tr>
<tr>
<td>Oxaliplatin, acute: &lt;1 week to resolve; Oxaliplatin, chronic: 3 months to resolve, rare long-term persistence</td>
<td>&lt;1 week to resolve; Oxaliplatin, chronic: 3 months to resolve, rare long-term persistence</td>
</tr>
<tr>
<td><strong>Vinca Alkaloids</strong></td>
<td>&lt;3 months to resolve; Vincristine may continue</td>
</tr>
<tr>
<td><strong>Taxanes</strong></td>
<td>&lt;3 months to resolve; May continue</td>
</tr>
</tbody>
</table>

↑ risk of sensory impairment as late effect (OR 1.62, 95% CI: 0.97-2.72)

↑ risk of motor impairment as late effect (OR 1.66, 95% CI: 1.04-2.64)

---

### Management

#### Prophylaxis
- Vitamin E
- Calcium/Magnesium
- Glutamine

#### Negative Symptoms
- Education on safety
- Fall prevention
- Functional training
- Strengthening
- Physical activity

#### Positive Symptoms
- Pharmacologic
  - Anticonvulsants
  - Antidepressants
  - Topical anesthetics
  - Opioids
- Pain procedures
- Neuromuscular stimulation
- Complementary / Alternative medicine

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Rehabilitation Recommendations

Baseline Clinical Evaluation
• History
• Physical Exam

Neuropathic Sx:
• Refer for rehab intervention

Specialized Neuromuscular Assessment
• Consider neurology or physiatry consult.
• Exposure to neurotoxic agents may exacerbate Sx of pre-existing PNS dysfunction.
• Specialist monitors & informs decisions re: management of pain & function.

Assess for emerging or worsening neuropathy / balance
• Every 2-3 wks
• Prior to each cycle

Grade 2-2 neuropathy / worsening balance
• Refer for rehab intervention

Therapists’ Role

• Clinical surveillance
• Therapeutic management

Baseline
• Education
• PNS integrity

Active treatment
• Monitor for developing CIPN
• Intervene as needed

After completion
• Determine prognosis
• Restorative or adaptive interventions as needed
• Periodic monitoring

Examination

Comprehensive History

Self-Report Measures

Functional Performance
• Pain

Impairments
• Sensory
• Motor
• Autonomic

Standardized Measures
• UE Function
• Balance
• Mobility
• Fall Risk

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Subjective: History

- Personal history
- Family history of hereditary neuropathy
- Alcohol use
- Comorbid conditions
  - DM
  - HIV
  - Guillain-Barre
  - CIDP
  - Radiculopathy

Subjective: Neurotoxicity Profile

- Chemotherapeutic regimen
  - Temporal profile
- Symptoms
  - Type
  - Distribution
  - Severity
- Pain
- Time course
- Treatment implications

Subjective: Direct Questioning

Symptoms
- Do you feel:
  - Numbness/tingling in hands/feet?
  - Pain in hands/feet? (rate 0-10)
  - Like having stocking/gloves on?
  - Weakness in arms/legs?
  - These sensations bother you or are getting worse?

Functional Performance
- Do you drop things often?
- Have you fallen recently?
- Do you have difficulty walking?
- Do you have difficulty climbing stairs?
- Do these sensations interfere with your work or daily activities?
Self-Report Measures

**Functional Assessment**
- PNQ (Patient Neurotoxicity Questionnaire)
- FACT (Functional Assessment of Cancer Therapy)
- Taxane
- GOG-Ntx (Gynecologic Oncology Group Neurotoxicity Scale)
- GOG–Oxaliplatin Specific Ntx12

**Pain**
- VAS (Visual analogue scale)
- Brief Pain Inventory
- Neuropathic Pain Score
- LANSS (Leeds Assessment of Neuropathic Symptoms & Signs of Pain Scale)

---

Visual Inspection

- Integument
  - Nail coloration
  - Skin integrity
- Posture
  - COG alignment
- Musculoskeletal abnormalities
  - Foot structure

---

Impairments

**Sensory**
- Pain & temperature
  - Pin-prick sensitivity
- Vibration
  - Biothesiometer
  - 128 Hz tuning fork
- Light touch
  - Semmes-Weinstein Monofilaments
- Proprioception

**Motor**
- Distal muscle strength
  - MMT
  - Dynamometry
- Deep tendon reflexes

**Autonomic**
- Heart rate
- Orthostatic evaluation

---

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**Composite Scales: Total Neuropathy Score (TNS) Scales**

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>TNS</th>
<th>mTNS</th>
<th>cTNS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensory</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Motor</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Autonomic</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exam</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin sensibility</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Vibration</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Strength</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Deep tendon reflexes</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

mTNS: Modified Total Neuropathy Score; cTNS: Clinical Total Neuropathy Score

Cavaletti et al., 2010; Gilchrist et al., 2009; Gilchrist et al., 2012; Marchese et al., 2011; Wampler et al., 2006; Wampler 2006

---

**Composite Scales: Total Neuropathy Score (TNS) Scales**

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<tbody>
<tr>
<td>Sensory</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Motor</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Strength</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DTR</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cavaletti et al., 2010; Gilchrist 2012; Wampler et al., 2006

---

**Functional Task Performance**

- Deficits may be subtle or marked
- Quality is key
- Gait
  - Kinematics
  - Speed
  - Environment
- Name writing
- Buttoning
Standardized Measures: UE Function

- Grooved Peg Board
- Timed Pellet Retrieval

Stubblefield et al., 2009; Wampler et al., 2005; Wampler 2006; Wampler et al., 2007

Standardized Measures: Balance

- Sensory Organization Test (SOT)
  - Postural stability
  - COG alignment
  - Strategy analysis
  - Sensory analysis
  - Correlates with:
    - Fullerton Advanced Balance Scale (FABS)
    - Timed Up & Go (TUG)

Gilchrist et al., 2009; Wampler et al., 2005; Wampler 2006; Wampler et al., 2007

Standardized Measures: Balance

- BESTest
  - Biomechanical constraints
  - Stability limits and verticality
  - Anticipatory postural adjustments, transitions
  - Reactive postural responses
  - Sensory orientation
  - Dynamic balance during gait & cognitive effects

Horak 2009; www.rehabmeasures.org

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**Standardized Measures: Mobility**

- Romberg
- Tandem Romberg
- Single leg stance
- Functional Reach
- Timed “Up & Go”

* Use caution with interpretation of fall risk

- Berg Balance Scale
  - <45/56
- Dynamic Gait Index
  - <19/24
- Fullerton Advanced Balance Scale
  - <25/40
- Short Physical Performance Battery

**Interventions**

- Education
- Symptom management
  - Gait training
  - Balance training
- Sensory re-education
- Therapeutic exercise
- ADL performance

**Education: Signs and Symptoms**

- Recognize signs & symptoms
- Importance of continuous monitoring
- Report to healthcare provider for timely management

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Education: Injury Prevention

- Skin protection
  - Regular self-inspection of hands & feet
    - Proper fit of footwear & orthotics
  - Protect against ischemic injury, thermal stress
    - Set water temperature < 120°F
    - Bath thermometer
    - Gloves with dishwashing
    - Pot holders / mitts with hot & cold items
    - Caution with knives

Stubblefield et al., 2009; Stubblefield et al., 2012; Visovsky et al., 2007

Education: Fall Prevention

- Fall prevention is key
- Visual compensation for somatosensory loss
  - Unfamiliar environments
  - Surface changes
  - Maximize visual contrast
- Proper footwear
  - Closed back and toe
  - No heels
  - Supportive insoles, not too soft
  - Non-skid soles

Stubblefield et al., 2009; Stubblefield et al., 2012; Visovsky et al., 2007

Education: Fall Prevention

- Household modifications
  - Living Area
    - Secure or remove throw rugs
    - Clutter-free floors
    - Secure cords / wires
    - Adequate lighting
    - Nightlights
  - Kitchen
    - Store items within reach
  - Bathroom
    - Bathmat, non-slip surfaces
    - Grab bars
  - Stairs
    - Adequate lighting
    - Handrails
    - Clutter-free

Gillespie et al., 2012; Stubblefield et al., 2009; Stubblefield et al., 2012; Visovsky et al., 2007

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Symptom Management: Pain

- Pain management is key
- Neurostimulation therapies
  - Transcutaneous electrical nerve stimulation (TENS)
  - Electrical Stimulation (ES)
  - High Frequency (HF)
- In diabetic PN:
  - ↓ pain, numbness, tingling
  - ↑ self-reported function
  - No adverse effects
  - Transient benefit

Stubblefield et al., 2009; Stubblefield et al., 2012; Vosecky et al., 2007; Wampler et al., 2005

Symptom Management: Paresthesia

- Cold Sensitivity
  - Room-temperature foods & drinks
  - Avoid iced or frozen food and drinks
  - Gloves to handle refrigerated/frozen item
  - Weather-appropriate protective clothing

Stubblefield et al., 2009; Stubblefield et al., 2012; Vosecky et al., 2007

Symptom Management: Paresthesia

- Massage
- Textures
- Vibration
- Theraputty
- Compression
- Kinesiotape

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### Symptom Management: Autonomic

- **Orthostatic Intolerance**
  - Time to acclimate between positional changes
  - Dangle feet, ankle pumps prior to standing
  - Wait before leaving support surface
  - Compression stockings / abdominal binder
  - Hydration

Stubblefield et al., 2008; Stubblefield et al., 2012; Visovsky et al., 2007

### Sensory Re-education

- Desensitization
- Tactile gnosis
  - Rice
- Graded touch & coordination
  - There’s an app for that!

### Physical Function / ADL Performance

- **Meals**
  - Vegetable chopper
  - Large handled utensils
  - Automatic jar opener

- **Dressing**
  - Velcro closures
  - Button hook

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Physical Function / ADL Performance

- Writing
  - Pen grip
  - Dycem under paper
- Typing
  - Velcro or Dycem on computer keys

Therapeutic Exercise

- Multi-modal exercise
- No studies to date in CIPN
- In PN of varying etiologies:
  - ↑ function, muscle strength, balance, stance, functional reach, NCV
  - ↓ pain, fall risk
  - Reverse muscle loss
  - Potential neuro-protective effects

Therapeutic Exercise

- Strengthening
  - Intrinsics
  - Core
  - Proximal LE
  - Dynamic ankle stabilization
- Aerobic conditioning
- Stretching
  - Wrist/finger flexors
  - Toe flexors
  - Gastroc/soleus
**Balance Training**

- Balance training is key
- Wampler et al., 2005
  - 45-60 min, 2x/week for 4 weeks
  - ↑ self-perceived balance
- Comprehensive training:
  - Static
  - Dynamic
  - Context-Specific
  - Manipulation activities
  - LE strengthening

**Balance Training**

- Additional considerations
  - Postural alignment
  - COG alignment
  - Postural adjustments
  - Movement strategies
  - Sensory strategies
  - Compensations

**Gait Training**

- Mobility training is key
- In diabetic PN:
  - SC, vertical surface, orthotic
  - ↑ gait characteristics (spatial & temporal)
- Quality
- Endurance tasks
- Environment
- Task constraints
- Assistive devices
- Orthotics
Gait Training

- Environment
  - Terrain / obstacles
  - Complexity
- Task constraints
  - Time
  - Physical load
- Assistive devices
  - Cane, walker
  - Somato-sensory input
- Orthotics
  - AFO, dorsiflexion assist, custom
  - Used for foot drop, ankle instability

Richardson et al., 2004; Stubblefield et al., 2009; Stubblefield et al., 2012; Visovsky et al., 2007

The Bottom Line

Health Condition: Chemotherapy-Induced Peripheral Neuropathy

Body Structure Impairments
- Peripheral Nervous System
  - Sensory nerves
  - Motor nerves
  - Autonomic nerves

Body Function Impairments
- Paresthesias
- Pain

Limitations & Restrictions
- Impaired balance
- Gait deviations
  - Wide base of support
  - Foot drop
  - Toe drag
- Mobility limitations
  - Falls
  - Limited ADLs, performance
- Fatigue
- Dressing
- Grooming
- Writing
- Typing
- Driving

Hausheer et al., 2006; Hile et al., 2010; Marchese et al., 2011; Stubblefield et al., 2009; Nurgalieva et al., 2010; Tofthagen et al., 2012; Wampler 2006; Wampler et al., 2007

The Bottom Line

- Clinical surveillance is necessary & on-going
- Key elements of evaluation include:
  - Direct questioning regarding symptoms
  - Impairment-level tests of PNS functions
  - Functional task analysis
  - Standardized measures of fall risk, mobility & balance
- Comprehensive interventions should include:
  - Adaptive and restorativestrategies
  - Fall prevention, pain management, balance & mobility training

Campbell & McNeely 2010; Hile et al., 2011; Marchese et al., 2011; Stubblefield et al., 2009; Stubblefield et al., 2012; Wampler et al., 2005
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