Risks Associated with Bed Rest and Immobility in ICU

Early Mobility in the Intensive Care Workshop
Mahkota Hotel, Melaka 6-8th Nov 2013
Normal Mobility

On average, a healthy individual will alter his or her posture during sleep every 11.6 minutes.

Immobility

Every organ and body system progressively deteriorates when inactivated

There is a remarkable similarity between physiological effects of ageing and the adverse systemic effect from prolonged immobility

Bortz W. Disuse and Ageing. JAMA 1982; 248: 1203-1208
Organ-systems Affected with Prolonged Bed Rest and Immobility

- Cardiovascular System
- Respiratory System
- Neurological System
- Musculoskeletal System
- Gastrointestinal System
- Genitourinary System
- Psychological Impact
- Skin and Connective Tissue
Impact on Cardiovascular Function

Heart Rate

At rest: HR increased 0.5 bpm/day, maximum 10-15 bpm at 3-4 week

Submaximal exercise: Increased HR 30-40 bpm from baseline. No change in maximum HR

Impact on Cardiovascular Function

Stroke Volume

At rest: Stroke volume decreased 15% at 2 week

Submaximal exercise: Stroke volume decreased 30% after 3-4 weeks with submaximal exercise

Impact on Cardiovascular Function

Cardiac Output

At rest: Cardiac output unchanged or slightly decreased at rest. VO$_2$max unchanged

Submaximal exercise: Cardiac output decreased, maximum VO$_2$max decreased

Impact on Cardiovascular Function

\[ D(a - v)O_2 \]

At rest: \( D(a - v)O_2 \) unchanged or slightly increased

Submaximal exercise: \( D(a - v)O_2 \) increased

Impact on Cardiovascular Function

Orthostatic Intolerance

Occur within 1-2 days with maximum effect at 3 weeks. More rapidly in elderly

Result from baroreceptor dysfunction, decreased autonomic tone and fluid shift

Impact on Respiratory Function

Sputum Clearance

Impaired ability to clear tracheobronchial secretions, dysfunction in normal sputum clearance mechanism in supine position

Atelectasis and pneumonia (hypostatic and aspiration)
Impact on Respiratory Function

Lung Volumes

Potential decreased in lung volumes secondary to muscle weakness, positioning and restriction

Vital capacity, total lung capacity, residual volume, expiratory reserve volume and functional residual capacity
## Impact on Musculoskeletal System

### Muscle Weakness in ICU Patients

<table>
<thead>
<tr>
<th>Skeletal muscle deconditioning</th>
<th>ICU-acquired weakness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common</td>
<td>Also known as ICU neuropathy myopathy</td>
</tr>
<tr>
<td>Mechanical unloading of muscle causes atrophy</td>
<td>Nerve and muscle dysfunction due to:</td>
</tr>
<tr>
<td>Bed rest associated with loss of muscle mass 1-2.5% per day</td>
<td></td>
</tr>
<tr>
<td>Weakness can be demonstrated after 1-2 days of mechanical ventilation</td>
<td>Mechanical unloading</td>
</tr>
<tr>
<td></td>
<td>Inflammation</td>
</tr>
<tr>
<td></td>
<td>Oxidative stress</td>
</tr>
<tr>
<td></td>
<td>Nutritional deficit</td>
</tr>
<tr>
<td></td>
<td>May take months to reverse</td>
</tr>
</tbody>
</table>
Paresis Acquired in the Intensive Care Unit
A Prospective Multicenter Study

Bernard De Jonghe et al.
JAMA Dec 11, 2002 Vol. 288 No. 22 Pages 2859-2867
1246 Patients With Mechanical Ventilation

332 Patients With Mechanical Ventilation > 7 days

206 patients with Mechanical Ventilation > 7 days and had no exclusion criteria

126 excluded
• 15 transfer out from ICU
• 101 had pre-existing neurologic diseases
• 6 had language barrier
• 4 no assessable limbs

111 could not be evaluated
• 85 died before awakening
• 24 discharged before awakening
• 2 omission

95 Evaluable for muscle strength
26 Female and 69 Male

24 Patients With ICU Acquired Paresis

71 Control
# Medical Research Council Neuromuscular Score

<table>
<thead>
<tr>
<th>Movement tested</th>
<th>Upper limb</th>
<th>Lower limb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arm abduction</td>
<td>Hip flexion</td>
</tr>
<tr>
<td></td>
<td>Elbow flexion</td>
<td>Knee extension</td>
</tr>
<tr>
<td></td>
<td>Wrist extension</td>
<td>Ankle dorsiflexion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Score for each movement</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No visible contraction</td>
</tr>
<tr>
<td>1</td>
<td>Visible contraction but no limb movement</td>
</tr>
<tr>
<td>2</td>
<td>Active movement insufficient to overcome gravity</td>
</tr>
<tr>
<td>3</td>
<td>Active movement against gravity</td>
</tr>
<tr>
<td>4</td>
<td>Active movement against gravity and resistance</td>
</tr>
<tr>
<td>5</td>
<td>Normal power</td>
</tr>
</tbody>
</table>
# Medical Research Council Neuromuscular Score

<table>
<thead>
<tr>
<th>Score</th>
<th>Maximum Score</th>
<th>Minimum Score</th>
<th>Significant weakness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>= 60</td>
<td>= 0</td>
<td>≤ 45</td>
</tr>
<tr>
<td>Quadriplegia</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Onset of Muscle Weakness

Risk factors involved in muscle wasting and ICU-AW

Muscle Weakness in the ICU Patients

Drugs Associated with muscle weakness in the ICU

**Peripheral nerve**
- Cancer chemotherapy
- Amiodarone
- Metronidazole

**Neuromuscular junction**
- Non-depolarizing NMBA
- Aminoglycoside, clindamycin, polymyxin-B
- Beta blockers
- Calcium channel blockers
- Procainamide

**Muscle**
- Phenytoin, fosphenytoin
- Hypermagnesaemia
- Corticosteroid
- Colchicine
- Amiodarone
- Procainamide
- Penicillamine
- Cholesterol-lowering agents
- Zidovudine

Upinder K Dhand. Clinical Approach to the Weak Patient in the Intensive Care Unit. Respiratory Care Sep 2006; Vol. 51 No. 9
Critically ill patient at risk for acquired neuromuscular complications
* Multi-system organ failure
* Anticipated prolonged mechanical ventilation

Anticipatory management
(Risk factor modification)

Direct evidence for benefit
Tight glycemic control

Evidence for harm limit use unless evidence-based benefit
Corticosteroids
Neuromuscular blocking agents

Indirect evidence for benefit
Sedation sparing protocol
Early limb mobilization

Theoretical benefit
Careful electrolyte management especially phosphate management
Optimal nutrition
Ventilator weaning protocol

Impact on Musculoskeletal Function

Osteoporosis

Bloomfield noted 6-40% decreased in bone density as a result of bed rest in just 4-6 weeks, affecting mostly weight bearing bones. Trabecular bone is affected more than cortical bone.

Normal

Prolonged bed rest and immobilisation
Impact on Musculoskeletal Function

**Osteoporosis**

Vertebral column can loss up to 50% of bone, which can lead to fracture even with minor trauma.

Immobility hypercalcaemia can occur 2-4 weeks after onset of osteoporosis

Impact on Musculoskeletal Function

Joints

Cartilage degeneration secondary to diminish proteoglycan

Synovial atrophy with underlying bone degeneration

Benign bone effusion may occur spontaneously in spinal cord injury
Impact on Musculoskeletal Function

Contractures

Permanent tightening of non-bony tissues such as muscles, tendons, ligament or skin. The result is a loss of motion in the affected joint.

One of the most function-limiting complication. With immobility, collagen develops cross-link and become less flexible.
Joint Contracture Following Prolonged Stay in the Intensive Care Unit

Research

Heidi Clavet BSc PT et al.

Canadian Medical Association Journal
March 11 2008; 178(6): 691-697
Admitted to Intensive Care Unit, Jan 2003 and March 2005  
\( n = 2360 \)

Survived stay in ICU, with total length of stay >2 weeks and chart reviewed for data on joint contracture before transfer out of ICU  
\( n = 155 \)

Remained in same hospital after transfer out of ICU, and chart reviewed for data on joint contracture before discharged home  
\( n = 147 \)

- Discharged directly to regional hospital, lost to follow-up  
  \( n = 8 \)

- Discharged from rehabilitation unit  
  \( n = 45 \)

- Discharged directly from ICU  
  \( n = 6 \)

- Discharged from hospital ward  
  \( n = 96 \)

Flow diagram of patient recruitment. Discharge home means discharge to patient’s home, a nursing home or a regional hospital.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Adjusted OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age, yr</strong></td>
<td></td>
</tr>
<tr>
<td>&lt; 45</td>
<td>1.00 [ref]</td>
</tr>
<tr>
<td>45-65</td>
<td>0.57 (0.18-1.79)</td>
</tr>
<tr>
<td>&gt; 65</td>
<td>0.70 (0.22-2.23)</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1.00 [ref]</td>
</tr>
<tr>
<td>Female</td>
<td>0.63 (0.28-1.41)</td>
</tr>
<tr>
<td><strong>Admission diagnosis (present v. absent)</strong></td>
<td></td>
</tr>
<tr>
<td>Chronic or acute respiratory disease</td>
<td>1.07 (0.45-2.53)</td>
</tr>
<tr>
<td>Cancer</td>
<td>0.47 (0.17-1.27)</td>
</tr>
<tr>
<td>Neurologic or vascular disease</td>
<td>1.39 (0.49-3.93)</td>
</tr>
<tr>
<td>Sepsis</td>
<td>0.82 (0.25-2.62)</td>
</tr>
<tr>
<td><strong>APACHE II severity score</strong></td>
<td></td>
</tr>
<tr>
<td>&lt; 15</td>
<td>1.00 [ref]</td>
</tr>
<tr>
<td>15-25</td>
<td>1.16 (0.42-3.21)</td>
</tr>
<tr>
<td>&gt; 25</td>
<td>0.79 (0.24-2.55)</td>
</tr>
<tr>
<td><strong>Diabetes (present v. absent)</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.65 (0.27-1.59)</td>
</tr>
<tr>
<td><strong>Length of stay in intensive care unit, wk</strong></td>
<td></td>
</tr>
<tr>
<td>2-2.99</td>
<td>1.00 [ref]</td>
</tr>
<tr>
<td>3-4.99</td>
<td>1.05 (0.37-3.03)</td>
</tr>
<tr>
<td>5-7.99</td>
<td>1.05 (0.26-4.22)</td>
</tr>
<tr>
<td>≥ 8</td>
<td>5.79 (1.08-31.0)</td>
</tr>
<tr>
<td><strong>Duration of invasive mechanical ventilation, d</strong></td>
<td></td>
</tr>
<tr>
<td>&lt; 10</td>
<td>1.00 [ref]</td>
</tr>
<tr>
<td>10-20</td>
<td>1.52 (0.59-3.94)</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>3.24 (0.93-11.3)</td>
</tr>
<tr>
<td><strong>Co-interventions (given v. not given)</strong></td>
<td></td>
</tr>
<tr>
<td>Neuromuscular blockade</td>
<td>1.52 (0.59-3.92)</td>
</tr>
<tr>
<td>Steroids</td>
<td>0.29 (0.12-0.70)</td>
</tr>
<tr>
<td><strong>Length of stay in hospital, wk</strong></td>
<td></td>
</tr>
<tr>
<td>&lt; 4</td>
<td>1.00 [ref]</td>
</tr>
<tr>
<td>4-7.99</td>
<td>0.90 (0.27-2.94)</td>
</tr>
<tr>
<td>≥ 8</td>
<td>0.94 (0.25-3.54)</td>
</tr>
</tbody>
</table>
Venous Thromboembolism

Immobility and VTE

15% of patients on bed rest for < 1 week before death had VTE at autopsy.

Asymptomatic DVT in 60% of paralyzed limbs of stroke patients compared with 7% in the non-paralyzed limbs.

Venous Thromboembolism

Location

Calf vein highest, 20% propagate to popliteal and 50% of popliteal thrombus will emboli
# Pressure Ulcers

<table>
<thead>
<tr>
<th></th>
<th>Condition</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Immobility</td>
<td>87.0%</td>
</tr>
<tr>
<td>2</td>
<td>Fecal incontinence</td>
<td>56.7%</td>
</tr>
<tr>
<td>3</td>
<td>Malnutrition</td>
<td>54.4%</td>
</tr>
<tr>
<td>4</td>
<td>Decreased mental status</td>
<td>50.7%</td>
</tr>
<tr>
<td>5</td>
<td>Peripheral vascular disease</td>
<td>28.1%</td>
</tr>
<tr>
<td>6</td>
<td>Urinary incontinence</td>
<td>27.0%</td>
</tr>
<tr>
<td>7</td>
<td>Diabetes</td>
<td>23.7%</td>
</tr>
</tbody>
</table>
### Pressure Ulcers

**Pressure ulcer prevalence rates at different body sites**

**Percentage of Total Prevalence**

<table>
<thead>
<tr>
<th>Location</th>
<th>Belgium</th>
<th>Italy</th>
<th>Portugal</th>
<th>Sweden</th>
<th>UK</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sacrum</td>
<td>25.6</td>
<td>40.9</td>
<td>26.9</td>
<td>25.3</td>
<td>37.5</td>
<td>532</td>
</tr>
<tr>
<td>Heel</td>
<td>34.9</td>
<td>31.9</td>
<td>33.9</td>
<td>30.0</td>
<td>26.2</td>
<td>484</td>
</tr>
<tr>
<td>Ischium</td>
<td>12.2</td>
<td>7.6</td>
<td>2.7</td>
<td>11.6</td>
<td>13.7</td>
<td>186</td>
</tr>
<tr>
<td>Ankle</td>
<td>3.6</td>
<td>9.1</td>
<td>10.2</td>
<td>24.5</td>
<td>6.4</td>
<td>149</td>
</tr>
<tr>
<td>Elbow</td>
<td>14.3</td>
<td>0.0</td>
<td>6.9</td>
<td>3.0</td>
<td>10.3</td>
<td>143</td>
</tr>
<tr>
<td>Hip</td>
<td>9.3</td>
<td>10.6</td>
<td>19.3</td>
<td>5.6</td>
<td>5.8</td>
<td>136</td>
</tr>
<tr>
<td>Total</td>
<td>301</td>
<td>132</td>
<td>186</td>
<td>233</td>
<td>778</td>
<td>1630</td>
</tr>
</tbody>
</table>

Impact on Gastrointestinal Function

Reduced fluid intake and appetite, increased transition time in esophagus

Decreased small bowel motility secondary to increased adrenergic activity resulting in constipation
Impact on Genitourinary System

Difficult voiding due to positioning, increased risk of urinary tract infection

Calculus formation (10-15%). Hypercalciuria especially in spinal cord injury and fractures (detected within few days after bed rest)
Patient and ICU risk factors for long-term physical complications

Mobility is Life

Early mobility is profoundly beneficial to your patients

Do not be afraid, they do better than you expect

It is a multidisciplinary task

Korupolu R GJ, Needham DM Contemporary Critical Care 2009; 6(9): 1-11
Thank You for Your Attention