Cardiac Rehabilitation for Intensive Care Patients

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OUTLINE

- Clinical Features of Intensive Care Patients
- Key Issues of Intensive Care Patients
- Early Mobilization in Intensive Care Patients
- Summary
Clinical Features of Intensive Care Patients

• Clinical Features:
  – Instability
  – Airway compromise
  – Multi-organ dysfunction
  – Low survival rate

• With the advancement of intensive care medicine
  – Patients' survival rate↑
  – Mortality after ICU treatment↓
  – Focus shift from short term → long term in ICU survivors

Lee C. M., Fan E. Bmc Medicine. Oct 3 2012;10
Key Issues of Intensive Care Patients

- **Key issues**
  - Respiratory insufficiency
  - Impaired cardiovascular function
  - Musculoskeletal dysfunction
  - Emotional problems

- **Risk factors of activity ability**
  - Medications: sedative drugs, corticosteroids, hyperglycemia
  - Restricted mobility
  - Recumbency

1. Impaired oxygen transport and gas exchange;
2. Reduced cardiopulmonary fitness

Rehabilitation for critically ill patients becomes popular over the world.

Background: Mr E, 56y, severe COPD, admitted to the Johns Hopkins Hospital with ARF, 3 days later, transferred to ICU with acute respiratory failure, requiring MV. Staying in ICU 2 months. Then transferred to an acute rehab facility for ventilator weaning and physical rehab. After 6 weeks rehab, he was discharged home.
Background: Mr E, 56y, severe COPD, admitted to the Johns Hopkins Hospital with ARF, 3 days later, transferred to ICU with acute respiratory failure, requiring MV. Staying in ICU 2 months. Then transferred to an acute rehab facility for ventilator weaning and physical rehab. After 6 weeks rehab, he was discharged home.

Thank you for coming today. Can you tell us about your QOL before hospital admission?

Well, I enjoyed life thoroughly. I went out to dinner with friends, went grocery shopping, and had a wonderful time.

In the ICU, patients frequently receive bed rest. What is that like?

It was unbearable—always being on my back and having the nurses do everything for me. You lose your dignity. I wanted to get out of bed and do something; otherwise, I was laying there saying “Why me?”

I thought it was wonderful. It was nice to get up and walk around. It was not uncomfortable. I enjoyed it. I think it had a very positive effect on me.

What is your QOL like since being discharged home?

Wonderful. I am able to walk around my apartment, make my own food, and bathe myself. I can get outdoors when I want to.

Cont.

I thought it was wonderful.

What did you think when we discussed getting you out of bed while on a ventilator with a breathing tube in your mouth?

I thought it was wonderful. Anything to get me up and moving, and get me out of bed; anything to get me off my back and on my feet—that is what I really wanted.

How did it feel to be awake, with the breathing tube in your mouth, on a ventilator, and walking laps around the medical intensive care unit?
Bed rest

Mobility
History of Early Mobilization in ICU

In 1899
First advocate of early postoperative ambulation in USA.

In 1939
Bed staying for 10 to 14 days after a major operation in USA.

In 1972 and 1975
Early ambulation is clinically useful... Patient acceptance has been excellent, facilitate and hasten weaning, minimize prolonged bed and chair rest.

In 1998
Thomas Petty described: paralyzed, sedated patients, lying without motion, appearing to be dead, except for the monitors that tell me otherwise... This was not the case in past...

During WW2
Early rising in Russia and Germany, shortage of hospital beds → view change → a growing supporters of early post-operative ambulation → most pts. get out of bed by the 3rd or 4th day after operation, or earlier.

In 2016
Early mobility in ICU is clinically feasible, results in improved patient outcomes, and is fiscally sound.

 Benefits of Early Mobilization

- Improve morale, overcome apprehension
- Maintain general health and strength
- Diminish the incidence of complications
- Out of bed earlier (5 vs. 11 days)
- Shorter ICU LOS (5.5 vs. 6.9 days)
- Shorter hospital LOS

Safety of Early Mobilization in ICU

- 0.6% potential safety event (in 4580 patient-days)
  - Arrhythmia (10 occurrences, 0.2%)
  - MAP > 140mmHg (8 occurrences; 0.2%)
  - MAP < 55mmHg (5 occurrences; 0.1%)
  - 4 occurrences (0.1%) required minimal additional treatment or cost, without additional length of staying

Overview of Safety Issues before Mobilizing

MOBILIZING CRITICALLY ILL PATIENTS

REVIEW MEDICAL BACKGROUND

- Past medical history or recent symptoms of cardiovascular/respiratory dysfunction
- Medications which may affect response to mobilisation
- Previous level of mobility and exercise capacity

IS THERE SUFFICIENT CARDIOVASCULAR RESERVE?

- Resting heart rate < 50% age predicted maximal heart rate
- Blood pressure < 20% variability recently
- ECG normal (ie no evidence of MI or arrhythmia)
- Other major cardiac conditions excluded

HR < 40 bpm, > 130 bpm
SBP > 200mmHg, DBP > 110 mmHg

Defer mobilisation or discuss with senior physiotherapist or medical staff

NO

YES

Discuss with senior physiotherapist or medical staff

UNSURE

IS THERE SUFFICIENT RESPIRATORY RESERVE?
- \( \text{PaO}_2/\text{FI}_2 \geq 300, \text{SpO}_2 > 90\% \) and < 4\% recent decrease in \( \text{SpO}_2 \)
- Respiratory pattern satisfactory
- Mechanical ventilation able to be maintained during treatment

- Defer mobilisation or discuss with senior physiotherapist or medical staff
- **NO**
- **YES**
- **UNSURE**
  - Discuss with senior physiotherapist or medical staff

ARE ALL OTHER FACTORS FAVOURABLE?
- Haemoglobin stable and > 7 grams/dL
- Platelet count stable and > 20,000 cells/mm\(^3\)
- White cell count 4,300 – 10,800 cells/mm\(^3\)
- Body temperature < 38°C
- Blood glucose level 3.5-20 mmol/L
- Patient appearance, pain, fatigue, shortness of breath, emotional status acceptable
- Stable conscious state
- No other neurological contraindications
- \( \Delta \text{FiO}_2 \geq 60\%, \text{PEEP} > 10 \text{cmH}_2\text{O} \)
- \( \text{RR} > 40 \text{bpm} \)
- \( \Delta T < 36°C, > 38.5°C \)
- **NO**
- **YES**
- **UNSURE**
  - Discuss with senior physiotherapist or medical staff

SELECT APPROPRIATE MODE AND INTENSITY OF MOBILISATION, MONITORING EQUIPMENT AND PROCEED

Red Flags of Early Mobility

(1) HR < 40 and >130 beats/min
(2) MAP < 60 mmHg and > 110 mmHg
(3) Oxygen Saturation ≤ 90%
(4) FiO₂ ≥ 0.6
(5) PEEP ≥ 10 cmH₂O
(6) RR > 40 breath/min
(7) Consciousness: RASS score: -4, -5, 3, 4
(8) Temperature: ≥ 38.5°C or ≤ 36°C
(9) Doses inotropic: Dopamine ≥ 10 mcg/kg/min
or NE/E ≥ 0.1 mcg/kg/min
(10) PT think it not suitable to do exercise

Relative Contraindications of Early Mobility

(1) Clinical view: decreased consciousness, sweating, abnormal face color, pain and fatigue
(2) Haemoglobin < 7g/dL
(3) Blood glucose < 3.5mmol/L or > 20mmol/L
(4) Unstable fracture
(5) Presence of lines that make mobilization unsafe
(6) Neurological instability: ICP ≥ 20 cmH$_2$O

### "Start to move" – protocol Leuven: step-up approach for progressive mobilization and physical activity program

<table>
<thead>
<tr>
<th>LEVEL 0</th>
<th>LEVEL 1</th>
<th>LEVEL 2</th>
<th>LEVEL 3</th>
<th>LEVEL 4</th>
<th>LEVEL 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NO COOPERATION</strong></td>
<td><strong>NO - LOW COOPERATION</strong></td>
<td><strong>MODERATE COOPERATION</strong></td>
<td><strong>CLOSE TO FULL COOPERATION</strong></td>
<td><strong>FULL COOPERATION</strong></td>
<td><strong>FULL COOPERATION</strong></td>
</tr>
<tr>
<td>$SSQ^1 = 0$</td>
<td>$SSQ^1 &lt; 3$</td>
<td>$SSQ^1 = 3$</td>
<td>$SSQ^1 = 4/5$</td>
<td>$SSQ^1 = 5$</td>
<td>$SSQ^1 = 5$</td>
</tr>
</tbody>
</table>

**FAILS BASIC ASSESSMENT?**

<table>
<thead>
<tr>
<th>BASIC ASSESSMENT =</th>
<th>BODY POSITONING4</th>
<th>PHYSIOTHERAPY4</th>
<th>BODY POSITIONING4</th>
<th>PHYSIOTHERAPY4</th>
</tr>
</thead>
<tbody>
<tr>
<td>✦ Cardiorespiratory unstable: MAP &lt; 60mmHg or $FiO_2 &gt; 60%$ or $PaO_2/FiO_2 &lt; 200$ or RR &gt; 30bpm</td>
<td>✦ 2hr turning</td>
<td>✦ No treatment</td>
<td>✦ 2hr turning</td>
<td>✦ No treatment</td>
</tr>
<tr>
<td>✦ Neurologically unstable</td>
<td>✦ Fowler’s position</td>
<td>✦ Passive ROM 3x/d</td>
<td>✦ Splinting</td>
<td>✦ Passive/Active ROM 3x/d</td>
</tr>
<tr>
<td>✦ Acute surgery</td>
<td>✦ Splinting</td>
<td>✦ Resistance training arms and legs</td>
<td>✦ Upright sitting position in bed 20’ 3x/d</td>
<td>✦ Resistance training arms and legs</td>
</tr>
<tr>
<td>✦ Temp &gt; 40 °C</td>
<td></td>
<td>✦ Passive transfer bed to chair</td>
<td>✦ Passive transfer bed to chair</td>
<td>✦ Passive/Active leg and/or cycling in bed or chair</td>
</tr>
</tbody>
</table>

**PHYSIOTHERAPY**

| MRC: Medical Research Council muscle strength sum scale (0-60); BBS: Berg Balance Score; NMES: Neuromuscular electrical stimulation; ADL: Activities of daily living |
Five Standardized Questions

S5Q: response to 5 standardized questions for cooperation

- Open and close your eyes
- Look at me
- Open your mouth and stick out your tongue
- Shake yes and no (nod your head)
- I will count to 5, frown your eyebrows afterwards

Consciousness: 5 scores
Assessing active muscle strength need 5 scores.

Berg Balance Scale

• Unsupported sitting
  - Sitting with back unsupported but feet supported on floor or on a stool
  - 4 able to sit safely and securely for 2 minutes
  - 3 able to sit 2 minutes under supervision
  - 2 able to sit 30 seconds
  - 1 able to sit 10 seconds
  - 0 unable to sit without support 10 seconds

• Sitting to Standing
  - 4 able to stand without using hands and stabilize independently
  - 3 able to stand independently using hands
  - 2 able to stand using hands after several tries
  - 1 needs minimal aid to stand or stabilize
  - 0 needs moderate or maximal assist to stand

• Unsupported Standing
  - 4 able to stand safely for 2 minutes
  - 3 able to stand 2 minutes with supervision
  - 2 able to stand 30 seconds unsupported
  - 1 needs several tries to stand 30 seconds unsupported
  - 0 unable to stand 30 seconds unsupported

## Medical Research Council Muscle Strength Sum Scale (0-60)

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
<th>Movements Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No visible contraction</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Visible muscle contraction, but no limb movement</td>
<td>Upper extremity</td>
</tr>
<tr>
<td>2</td>
<td>Active movement, but not against gravity</td>
<td>Shoulder abduction</td>
</tr>
<tr>
<td>3</td>
<td>Active movement against gravity</td>
<td>Elbow flexion</td>
</tr>
<tr>
<td>4</td>
<td>Active movement against gravity and resistance</td>
<td>Wrist extension</td>
</tr>
<tr>
<td>5</td>
<td>Active movement against full resistance</td>
<td></td>
</tr>
</tbody>
</table>

Maximum score: 60 (4 limbs; 3 movements per extremity with maximum score of 15 points per limb)
Minimum score: 0 (quadriplegia)

Uncooperative

- Positioning
- Passive stretching
- ROM exercise
- CPM
- Bedside cycle ergometer
- Neuromuscular electrical stimulation

Cooperative

- Transferring in bed
- Sitting over the edge of the bed
- Moving from bed to chair
- Standing
- Stepping
- Walking
- Aerobic training
- Muscle strengthening

Positioning

- **Avoid the adverse effects** of prolonged static positioning on respiratory, cardiac, and circulatory function

- **Prevent soft tissue contracture**, protection of flaccid limbs and lax joints, nerve impingement, and skin breakdown

Every 2 hours

<table>
<thead>
<tr>
<th>Systemic response</th>
<th>Positioning (supine to upright)</th>
<th>Mobilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiopulmonary</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>↑ Total lung capacity</td>
<td>↑ Alveolar ventilation</td>
</tr>
<tr>
<td></td>
<td>↑ Tidal volume</td>
<td>↑ Tidal volume</td>
</tr>
<tr>
<td></td>
<td>↑ Vital capacity</td>
<td>↑ Breathing frequency</td>
</tr>
<tr>
<td></td>
<td>↑ Functioning residual capacity</td>
<td>↑ A–aO₂ gradient</td>
</tr>
<tr>
<td></td>
<td>↑ Residual volume</td>
<td>↑ Pulmonary arteriovenous shunt</td>
</tr>
<tr>
<td></td>
<td>↑ Expiratory reserve volume</td>
<td>↓ V̇ṡ/Q̇ matching</td>
</tr>
<tr>
<td></td>
<td>↑ Forced expiratory volume</td>
<td>↑ Distension and recruitment of lung units with low ventilation and low perfusion</td>
</tr>
<tr>
<td></td>
<td>↑ Forced expiratory flow</td>
<td>↑ Mobilization of secretions</td>
</tr>
<tr>
<td></td>
<td>↑ Lung compliance</td>
<td>↑ Pulmonary lymphatic drainage</td>
</tr>
<tr>
<td></td>
<td>↓ Airway resistance</td>
<td>↑ Surfactant production and distribution</td>
</tr>
<tr>
<td></td>
<td>↓ Airway closure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>↑ PaO₂</td>
<td></td>
</tr>
<tr>
<td></td>
<td>↑ AP diameter of chest</td>
<td></td>
</tr>
<tr>
<td></td>
<td>↓ Lateral diameter of rib cage and abdomen</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Altered pulmonary blood flow distribution</td>
<td></td>
</tr>
<tr>
<td></td>
<td>↓ Work of breathing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>↑ Diaphragmatic excursion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>↑ Mobilization of secretions</td>
<td></td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>↑ Total blood volume</td>
<td>↑ Cardiac output</td>
</tr>
<tr>
<td></td>
<td>↓ Central blood volume</td>
<td>↑ Stroke volume and heart rate</td>
</tr>
<tr>
<td></td>
<td>↓ Central venous pressure</td>
<td>↑ Oxygen binding in blood</td>
</tr>
<tr>
<td></td>
<td>↓ Pulmonary vascular congestion</td>
<td>↑ Oxygen dissociation and extraction at the tissue level</td>
</tr>
<tr>
<td></td>
<td>↑ Lymphatic drainage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>↓ Work of the heart</td>
<td></td>
</tr>
</tbody>
</table>
Passive Stretching/ROM Exercise/CPM/Splinting

- Decrease stiffness and increases extensibility of the muscle
- Prevent contractures
- Reduce fiber atrophy and protein loss (CPM)
- Splinting: pts. without active mobilization, pts. with high risk of soft tissue contracture, such as following severe burns, trauma, and some neurological conditions

Passive Stretching – Upper Extremity

Passive Stretching – Lower Extremity

PROM Training – Upper Extremity

PROM Training – Lower Extremity

Neuromuscular Electrical Stimulation

- Prevent disuse muscle atrophy
- Slower muscle protein catabolism, and increase in total RNA content
- Parameters of NMES: biphasic, symmetric impulses of 45 Hz, 400 μsec pulse duration, 12s on and 6s off, at intensities able to cause visible contractions, 55min in total including 5 min warm up and 5min recovery
- Mean intensities: 38 ± 10 mA for quads, 37 ± 11 mA for peroneous longus

**Bedside Cycle Ergometer**

- Prolonged continuous mobilization with rigorous control of exercise intensity and duration
- Training intensity can be adjusted to the health status and the physiological responses
- Daily bedside (initially passive) leg cycling: functional status↑, muscle function↑ and exercise performance↑ at hospital discharge in critically ill patients than standard physiotherapy without leg cycling

Early Active Mobilization

- Strategies – in order of intensity – include
  - Transferring in bed → sitting over the edge of the bed → moving from bed to chair → standing → stepping in place → walking with or without support
Early Active Mobilization

- Mobilization can elicit acute physiological effects by enhancing
  - Ventilation
  - Central and peripheral perfusion
  - Circulation
  - Muscle metabolism
  - Alertness
- Reduce ICU and hospital stays
- Improved functional status at hospital discharge, shortened duration of delirium and increased ventilator-free days

Aerobic Training and Muscle Strengthening

- Improve walking distance
- Improve limb muscle strength, ventilator-free time and functional outcomes
- Low-resistance multiple repetitions of resistive muscle training can augment muscle mass, force generation, and oxidative enzymes

Resistance Band Used in ICU
Summary

1. Comprehensive cardiac rehabilitation program can be beneficial after balancing the risk and benefit.

2. The immediate goals of rehabilitation are to maximizing oxygen transport, cardiovascular and pulmonary function, musculoskeletal and neurological function.

3. Positioning and early mobilization are two widely used techniques in the rehabilitation among intensive care patients.

Medical staffs, who work on rehabilitation of intensive care patients, should have 4 “hearts”:
Patience, Carefulness, Sympathy, Responsibility.

—— Yafei Wang
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THANK YOU
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