Prevalence of Sarcopenia in ICU Patients and the Role of Nutrition Support in its Development and Treatment

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Assistant Professor
Rush University Medical Center
Chicago, Il
Disclosures

• No commercial relationships to disclose
Learning Objectives

Upon completion of this session, the learner will be able to:

1. Review definitions of muscle wasting (sarcopenia, cachexia and myopenia)
2. Present methods for sarcopenia detection via computed tomography scans
3. Describe the prevalence of sarcopenia among hospitalized patients
4. Summarize how nutrition support may impact the development/prevention of sarcopenia
Outline

I. Definition of sarcopenia
   a) CT-defined sarcopenia

II. Prevalence of sarcopenia
    a) ICU patients
    b) ARDS/ALI patients

III. Agreement between sarcopenia and nutrition assessment

IV. Consequences of sarcopenia

V. Treatment for sarcopenia
Definitions

• **Sarcopenia**: age-related loss of skeletal muscle and strength

• **Cachexia**: a complex metabolic syndrome associated with underlying illness and characterized by loss of muscle mass with or without loss of fat mass. The prominent clinical feature of cachexia is weight loss in adults

• *Throughout presentation the term sarcopenia will be used to describe both age & inflammation related muscle loss*
## Definitions of Sarcopenia

<table>
<thead>
<tr>
<th>Group</th>
<th>Definition</th>
<th>Body Composition Assessment</th>
<th>Functional Status Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>International Working Group on Sarcopenia</strong></td>
<td>Age-associated loss of skeletal muscle and function</td>
<td>Appendicular mass (measured by DXA) relative to height (&lt;7.23 kg/m² in men and &lt;5.67 kg/m² in women)</td>
<td>Gait speed &lt;1 meter per second over 4 meters</td>
</tr>
<tr>
<td><strong>The European Society of Parenteral/Enteral Nutrition</strong></td>
<td>Loss of muscle mass and strength, leading to increased prevalence of falls and dependence</td>
<td>Percentage of muscle mass (measured by BIA) &gt;2 standard deviations below mean for 18–39 year olds from NHANES III</td>
<td>Gait speed &lt;0.8 meters per second over 4 meters or reduced performance in any functional test used for the comprehensive geriatric assessment</td>
</tr>
<tr>
<td><strong>The European Working Group on Sarcopenia in Older People</strong></td>
<td>Syndrome characterized by progressive and generalized loss of skeletal muscle mass and strength with a risk of adverse outcomes such as physical disability, poor quality of life and death</td>
<td>CT, MRI, DXA, BIA or total body potassium</td>
<td>Low muscle strength (measured by grip strength or leg extension) or low physical performance (measured by gait speed)</td>
</tr>
<tr>
<td><strong>Society on Sarcopenia, Cachexia and Wasting Disorders</strong></td>
<td>Sarcopenia defined as reduced muscle mass with limited mobility</td>
<td>CT, MRI, DXA, BIA and US</td>
<td>Low physical performance (measured by gait speed)</td>
</tr>
</tbody>
</table>
CT-Defined Sarcopenia

• Diagnostic abdominal CT scans can be used to assess muscle mass
Review of CT Analysis

• CT imaging provides a series of cross-sectional images
  – Process:
    • An x-ray source rotates around the patient
    • Detectors opposite from the x-ray source measure the strength of the x-rays exiting the section of the patient's body being irradiated
    • The images are reconstructed by a computer
Review of CT Analysis

- The final CT scan consists of multiple cross-sectional images or "slices" of anatomy
Review of CT Analysis

• The 3\textsuperscript{rd} lumbar region is used
  – This region has the highest correlation (compared to all other CT slices) with total skeletal muscle ($r=0.924$, $p<0.001$)
Review of CT Analysis

• Each CT slice is composed of 2-dimensional pixels

• These pixels are assigned a number (Hounsfield unit) that is related to the linear attenuation coefficient (or loss of intensity) of the x-ray beam
Review of CT Analysis

- Pixels within the same HU range (for example, muscle = -29 to +150 HU) are added together to calculate cross-sectional area (cm$^2$)
CT-Defined Sarcopenia

• Establish muscle area associated with mortality
  – Patients with lung and GI cancer from 2004-2007
    • Diagnostic abdominal CT scan completed within 30 days of starting treatment
    • L3 cross-sectional muscle area was calculated (cm²)
    • Skeletal muscle index (SMI) calculated to normalize muscle area
      – divided L3 cross-sectional muscle area by height squared (cm²/m²)
  – Log-rank statistics were utilized to establish L3 SMI gender and BMI-specific cut-offs that were associated with mortality
CT-Defined Sarcopenia

Prado CM, et al.
The lancet oncology. 2008;9:629
- Gender cut-offs associated with mortality among obese (BMI >30):
  - Men
    SMI: ≤52.4 cm²/m²
  - Women
    SMI: ≤38.5 cm²/m²

Martin L, et al.
J Clin Oncol. 2013;31:1539
- Gender and BMI cut-offs associated with mortality:
  - Men & Women with BMI <25
    SMI: ≤43 cm²/m²
  - Men with BMI >25
    SMI: ≤53 cm²/m²
  - Women with BMI > 25
    SMI: ≤41 cm²/m²
Prevalence of Sarcopenia among Chronic Disease

• 30-45% among patients with liver disease

• 15-50% in cancer patients
Prevalence Sarcopenia in General Medical/Surgical Patients

<table>
<thead>
<tr>
<th>Author</th>
<th>Population</th>
<th>Sarcopenia definition: The European Working Group on Sarcopenia in Older People</th>
<th>Sarcopenia prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gariballa S, et al.</td>
<td>432 patients &gt;65 years</td>
<td>MAMC and handgrip</td>
<td>10%</td>
</tr>
<tr>
<td>Sousa AS, et al.</td>
<td>608 patients &gt;18 years</td>
<td>MAMC/BIA (percent skeletal muscle mass &amp; skeletal muscle index) and handgrip</td>
<td>MAMC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Men: 6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Women: 9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Percent skeletal muscle mass</td>
<td>Men: 25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Skeletal muscle index</td>
<td>Women: 22%</td>
</tr>
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</tr>
<tr>
<td>Smoliner C, et al.</td>
<td>198 patients &gt; 65 years</td>
<td>BIA (skeletal muscle index) and handgrip &amp; SPPB</td>
<td>25%</td>
</tr>
<tr>
<td>Rossi AP, et al.</td>
<td>119 patients &gt;65 years</td>
<td>BIA (skeletal muscle index) and handgrip &amp; gait speed</td>
<td>26%</td>
</tr>
</tbody>
</table>
Prevalence Sarcopenia in the ICU

- Current data suggest 60-71% of ICU patients are sarcopenic upon admission
# Prevalence of Sarcopenia in the ICU

<table>
<thead>
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<th>Author</th>
<th>Population</th>
<th>Sarcopenia definition</th>
<th>Sarcopenia prevalence</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisey LL, et al</td>
<td>149 elderly trauma pts</td>
<td>SMI: males &lt; 55.4 cm$^2$/m$^2$ females &lt; 38.9 cm$^2$/m$^2$</td>
<td>71%</td>
<td>Sarcopenic pts had higher mortality, lower vent-free days and ICU free days</td>
</tr>
<tr>
<td>Weijs PJ, et al</td>
<td>240 pts requiring vent support</td>
<td>Skeletal muscle cross-sectional area: males &lt; 170 cm$^2$ females &lt; 110 cm$^2$</td>
<td>67%</td>
<td>Sarcopenic pts had higher mortality</td>
</tr>
<tr>
<td>Sheen PM, et al</td>
<td>56 pts requiring vent support</td>
<td>SMI: males &lt; 52.4 cm$^2$/m$^2$ females &lt; 38.5 cm$^2$/m$^2$</td>
<td>60%</td>
<td></td>
</tr>
</tbody>
</table>
Difficulty Identifying Sarcopenia

• Approximately 40% of sarcopenic patients are not identified with nutrition assessment tools
  – 40% of sarcopenic liver patients incorrectly identified as “normally nourished” by subjective global assessment (SGA) (Tandon P, et al.)
  – General medical/surgical patients
    • ~40% of sarcopenic men and
    • ~45% of sarcopenic women incorrectly identified as “normally nourished” by patient-generated SGA (Sousa AS, et al.)
  – 43% of sarcopenic ICU patients incorrectly identified as “normally nourished” by SGA (Sheean PM, et al.)
**Figure 2** Extensive muscle wasting can be obscured by large fat mass

Fearon, K. *et al.* (2012) Understanding the mechanisms and treatment options in cancer cachexia

Prevalence of Sarcopenia among Patients with ARDS/ALI

Sarcopenia in ALI/ARDS

• Subset of ENP patients with abdominal CT within 4 days of ALI diagnosis
  – n=95
  – Quantified skeletal muscle cross-sectional area (cm2)
    • Slice-O-Matic software v4.3 (Tomovision) with Hounsfield unit range: -29 to 150
    • Determined sarcopenia via skeletal muscle index
      – Men: SMI ≤52.4 cm2/m2
      – Women: SMI ≤38.5 cm2/m2
Sarcopenia: New Skeleton in the Hospital Closet

- 77% of ALI/ARDS patients were sarcopenic (73/95)
## Demographics Characteristics between Sarcopenic & Non-Sarcopenic Patients

<table>
<thead>
<tr>
<th></th>
<th>Sarcopenic (n=73)</th>
<th>Non-Sarcopenic (n=22)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age, years (means ± SD)</strong></td>
<td>62.3 ± 14.0</td>
<td>53.2 ± 17.7</td>
</tr>
<tr>
<td><strong>Female (count (%))</strong></td>
<td>31 (42%)</td>
<td>18 (82%)</td>
</tr>
<tr>
<td><strong>Race/Ethnicity (count (%))</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>14 (23%)</td>
<td>5 (22%)</td>
</tr>
<tr>
<td>African-American</td>
<td>29 (40%)</td>
<td>10 (45%)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>13 (18%)</td>
<td>6 (27%)</td>
</tr>
<tr>
<td>Other</td>
<td>17 (23%)</td>
<td>1 (5%)</td>
</tr>
<tr>
<td><strong>Body mass index (means ± SD)</strong></td>
<td>27.3 ± 8.2</td>
<td>33.4 ± 11.5</td>
</tr>
<tr>
<td><strong>SGA (count (%))</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>33 (45%)</td>
<td>13 (59%)</td>
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<tr>
<td>Mild/Moderate</td>
<td>30 (41%)</td>
<td>8 (36%)</td>
</tr>
<tr>
<td>Severe</td>
<td>10 (14%)</td>
<td>1 (5%)</td>
</tr>
<tr>
<td><strong>APACHE II (means ± SD)</strong></td>
<td>20.2 ± 9.6</td>
<td>22.4 ± 10.7</td>
</tr>
<tr>
<td><strong>Baseline SOFA (means ± SD)</strong></td>
<td>11.6 ± 3.9</td>
<td>11.9 ± 4.2</td>
</tr>
</tbody>
</table>
Sarcopenia: New Skeleton in the Hospital Closet

• Among sarcopenic ALI/ARDS patients – almost half were incorrectly classified as normal nourished by SGA (45%, 33/73)
Agreement between Sarcopenia and SGA

Figure 3. Conceptual model of exclusivity and overlap between body composition using computed tomography and nutrition status classified by subjective global assessment.

## Agreement between Sarcopenia and SGA

<table>
<thead>
<tr>
<th></th>
<th>MISCLASSIFIED Sarcopenic classified as normal nourished (n=33)</th>
<th>CORRECT Non-sarcopenic classified as normal nourished (n=13)</th>
<th>CORRECT Sarcopenic classified as malnourished (n=40)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age, years</strong></td>
<td>62.5 ± 13.2</td>
<td>56.9 ± 18.3</td>
<td>62.2 ± 14.2</td>
</tr>
<tr>
<td><strong>Female</strong></td>
<td>13 (39%)</td>
<td>11 (85%)</td>
<td>18 (45%)</td>
</tr>
<tr>
<td><strong>Race/Ethnicity</strong></td>
<td></td>
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<tr>
<td>Caucasian</td>
<td>10 (30%)</td>
<td>3 (23%)</td>
<td>4 (10%)</td>
</tr>
<tr>
<td>African-American</td>
<td>16 (48%)</td>
<td>6 (46%)</td>
<td>13 (33%)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>4 (12%)</td>
<td>3 (23%)</td>
<td>9 (22%)</td>
</tr>
<tr>
<td>Other</td>
<td>3 (9%)</td>
<td>1 (8%)</td>
<td>14 (5%)</td>
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<tr>
<td><strong>Body mass index</strong></td>
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<td>12.0 ± 3.8</td>
<td>11.2 ± 4.0</td>
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</tr>
</tbody>
</table>
Consequences of Sarcopenia

• Sarcopenia associated with:
  – Decrease in functional status and autonomy
  – Increase in falls
  – Disability
  – Mortality
    • Heitmann BL, et al. *Int J Obes Relat Metab Disord.* 2000;24:33
    • Roubenoff R. *Can J Appl Physiol.* 2001;26:78
Consequences of Sarcopenia

- In the clinical setting, sarcopenia associated with:
  - Infectious complications
  - Prolonged duration of mechanical ventilation
  - Longer hospitalization
  - Readmission to the hospital
  - Greater need for rehabilitation care after hospital discharge
Consequences of Sarcopenia

• Chemotherapy toxicity among sarcopenic patients when body weight/body surface area used a surrogate of lean body mass
Chemotherapy Toxicity among Sarcopenic Patients

• Colon cancer and 5-Fluorouracil
  – 5-Fluorouracil dose varied from 12.8-23 mg/kg lean body mass for men from 12-20.1 mg/kg lean body mass for women.

• Breast cancer and 5-fluorouracil
  – 50% of sarcopenic patients experience toxicity compared to 20% of non-sarcopenic patients (p=0.03).

• Renal cell cancer with Fluoropyrimidine and Sunitinib
  – 41% of sarcopenic patients experience toxicity compared to 13% of non-sarcopenic patients
  – Sarcopenic patients more likely to experience toxicity (OR 4.1 95% CI 1.3-13.3)

• Hepatocellular cancer and Sorafenib
  – 82% of sarcopenic patients experience toxicity compared to 31% of non-sarcopenic patients
Consequences of Sarcopenia

- Similar relationship may exist with estimated calorie requirements for sarcopenic patients

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<td><strong>BMI</strong></td>
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<td><strong>Skeletal muscle index</strong></td>
<td>57.7 cm$^2$/m$^2$</td>
<td>43.4 cm$^2$/m$^2$</td>
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<tr>
<td><strong>Estimated calorie needs</strong></td>
<td>2400 Kcal/day</td>
<td>2400 kcal/day</td>
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Excess Calorie Exposure with Sarcopenia

- Diagnostic abdominal CT scans can estimate lean body mass (ELBM)
  - L3 cross-sectional muscle area is highly correlated with total skeletal muscle volume ($R=0.924$, $p<0.0001$)
  - Developed ELBM (kg) equation:
    0.30 x L3 cross-sectional skeletal muscle (cm²) + 6.06
# ELBM between Sarcopenic & Non-Sarcopenic Patients

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<td>11.6 ± 3.9</td>
<td>11.9 ± 4.2</td>
</tr>
<tr>
<td>ELBM, kg (means ± SD)</td>
<td>35.9±8.9</td>
<td>42.7±10.1</td>
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## Excess Calorie Exposure with Sarcopenia

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</tr>
<tr>
<td><strong>ELBM</strong></td>
<td>57.72 kg</td>
<td>38.34 kg</td>
</tr>
<tr>
<td><strong>Estimated calorie needs</strong></td>
<td>2400 Kcal/day</td>
<td>2400 kcal/day</td>
</tr>
<tr>
<td><strong>Kcal/dosing kg</strong></td>
<td>30 Kcal/dosing kg</td>
<td>30 Kcal/dosing kg</td>
</tr>
<tr>
<td><strong>Kcal/ELBM</strong></td>
<td>~42 Kcal/ELBM</td>
<td>~62 Kcal/ELBM</td>
</tr>
</tbody>
</table>
Excess Calorie Exposure with Sarcopenia

• Examined the relationship between calorie exposure (kcal/ELBM) and:
  • Ventilator days
  • ICU/hospital length of stay
  • Infection
  • Mortality
## Linear Regression: Association between Kcal/ELBM and Mechanical Ventilation

<table>
<thead>
<tr>
<th>Predictors</th>
<th>β</th>
<th>Standard error</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-3.51</td>
<td>3.36</td>
<td>0.30</td>
</tr>
<tr>
<td><strong>Kcal/ELBM</strong></td>
<td><strong>0.32</strong></td>
<td><strong>0.08</strong></td>
<td><strong>&lt;0.0001</strong></td>
</tr>
<tr>
<td>Difference between dosing weight – ELBM</td>
<td>0.15</td>
<td>0.11</td>
<td>0.16</td>
</tr>
<tr>
<td>Received insulin</td>
<td>5.92</td>
<td>2.21</td>
<td>0.0009</td>
</tr>
<tr>
<td>Hypoglycemic event</td>
<td>4.98</td>
<td>0.61</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Model R² = 0.63</strong></td>
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</tr>
</tbody>
</table>
Linear Regression: Association between Kcal/ELBM and ICU Length of Stay

<table>
<thead>
<tr>
<th>Predictors</th>
<th>$\beta$</th>
<th>Standard error</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-1.70</td>
<td>3.64</td>
<td>0.64</td>
</tr>
<tr>
<td>Kcal/ELBM</td>
<td>0.37</td>
<td>0.08</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Difference between dosing weight – ELBM</td>
<td>0.12</td>
<td>0.11</td>
<td>0.30</td>
</tr>
<tr>
<td>Proportion of ICU stay calorie delivery unknown</td>
<td>0.07</td>
<td>0.04</td>
<td>0.09</td>
</tr>
<tr>
<td>Received insulin</td>
<td>6.17</td>
<td>2.28</td>
<td>0.008</td>
</tr>
<tr>
<td>Hyperglycemic event</td>
<td>0.50</td>
<td>0.25</td>
<td>0.04</td>
</tr>
<tr>
<td>Hypoglycemic event</td>
<td>4.19</td>
<td>0.64</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Model $R^2 = 0.63$</td>
<td></td>
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</table>
Linear Regression: Association between Kcal/ELBM and Hospital Length of Stay

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<tr>
<th>Predictors</th>
<th>β</th>
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<th>P-value</th>
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<tbody>
<tr>
<td>Intercept</td>
<td>-4.13</td>
<td>6.65</td>
<td>0.54</td>
</tr>
<tr>
<td><strong>Kcal/ELBM</strong></td>
<td><strong>0.63</strong></td>
<td><strong>0.14</strong></td>
<td><strong>&lt;0.0001</strong></td>
</tr>
<tr>
<td>Difference between dosing weight – ELBM</td>
<td>-0.07</td>
<td>0.18</td>
<td>0.71</td>
</tr>
<tr>
<td>Proportion of hospital stay calorie delivery unknown</td>
<td>0.26</td>
<td>0.07</td>
<td>0.0002</td>
</tr>
<tr>
<td>Hospital days prior to study</td>
<td>0.77</td>
<td>0.10</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Received steroid</td>
<td>7.29</td>
<td>3.54</td>
<td>0.04</td>
</tr>
<tr>
<td>Hypoglycemic event</td>
<td>4.19</td>
<td>1.10</td>
<td>0.0003</td>
</tr>
<tr>
<td>Model $R^2 = 0.67$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Logistic Regression: Association between Kcal/ELBM and Categorical Outcomes

• No relationship observed between Kcal/ELBM Exposure and mortality or infections complications
Muscle Quality

- Average attenuation of L3 cross-sectional area can quantify skeletal muscle quality
  - Hounsfield unit is related to the linear attenuation coefficient (or loss of intensity) of the x-ray beam

- Skeletal muscle Hounsfield unit: -29 to 150
  - Mean attenuation <30 Hounsfield units designated as low-density/low-quality muscle
Muscle Quality

- Each CT slice is composed of 2-dimensional pixels
- These pixels are assigned a number (Hounsfield unit) that is related to the linear attenuation coefficient (or loss of intensity) of the x-ray beam
## Muscle Quality

<table>
<thead>
<tr>
<th></th>
<th>Non-sarcopenic</th>
<th>Sarcopenic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>![Scan Image]</td>
<td>![Scan Image]</td>
</tr>
<tr>
<td><strong>BMI</strong></td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td><strong>Skeletal muscle index</strong></td>
<td>57.7 cm²/m²</td>
<td>43.4 cm²/m²</td>
</tr>
<tr>
<td><strong>ELBM</strong></td>
<td>57.72 kg</td>
<td>38.34 kg</td>
</tr>
<tr>
<td><strong>Muscle quality (average Hounsfield units)</strong></td>
<td>41.2</td>
<td>25.6</td>
</tr>
<tr>
<td><strong>Kcal/dosing kg</strong></td>
<td>30 Kcal/dosing kg</td>
<td>30 Kcal/dosing kg</td>
</tr>
<tr>
<td><strong>Kcal/ELBM</strong></td>
<td>~42 Kcal/ELBM</td>
<td>~62 Kcal/ELBM</td>
</tr>
</tbody>
</table>
Treatment for Sarcopenia

• Available treatments include exercise, medication and diet therapy

• Exercise – gold standard treatment
  – Stimulates non-satellite stem cells in skeletal muscle to release growth factors:
    • aerobic exercise
    • high-intensity resistance training
    • flexibility and balance training
Treatment for Sarcopenia

- Medications:
  - Ghrelin agonists
    - ↓ expression of myostatin and TNF
  - Selective androgen receptor molecules
    - Similar action to anabolic steroids
  - Megestrol acetate
    - progestagen/testosterone/corticosteroid agentactivin receptor antagonists
  - Espindolol (anabolic catabolic transforming agent)
    - β-1 and β-2 adrenergic receptor blocker
  - Fast skeletal muscle troponin inhibitors
    - Amplify the response to motor neuron input
Role of Nutrition Support in its Development and Treatment

• Diet therapy:
  – Consider both the dose and timing of macronutrient delivery
    • Increased provision leucine ↑ muscle synthesis
    • Early calorie exposure in the ICU associated with worse/no difference in outcomes, does not attenuate muscle wasting and may worsen muscle quality
Role of Nutrition Support in its Development and Treatment

• Dose of macronutrients:
  – Protein supplementation: 1-1.5 grams/kg of leucine-enriched, essential amino acids
  – Increased calorie intake
No Benefit to Early Calorie Exposure in the ICU

- Combination of high and early calorie exposure to those with increased severity of illness increased mortality
No Benefit to Early Calorie Exposure in the ICU

• No difference in outcome with increased calorie delivery for first 7 days in ICU
  – Arabi YM, et al. *NEJM*. 201517;373:1175
Preliminary Data: Early Nutrition Support Exposure Unable to Preserve Muscle

• Predictors of percent skeletal muscle cross-sectional area loss:
  - First 7 days in the ICU (n=8):
    • APACHE II score (β: -0.09, p=0.02),
    • BMI (β:-0.07, p=0.01), and
    • Insulin exposure (β: 0.97, p=0.03)
  - Day 8 or more in the ICU (n=9)
    • Calorie delivery (Kcal/kg, β:0.05, p=0.005)
    • Male (β:-0.70, p=0.006)
    • Paralytic exposure (β:-0.85, p=0.003)
    • Admit SOFA (β:-0.07, p=0.01)
Early Nutrition Support Exposure Increased Weakness

• Subanalysis of EPaNIC to determine association between calorie exposure and weakness
    – Patients exposed to late PN had:
      • Lower prevalence of weakness (34% vs 43%, p=0.03)
      • Faster recovery from weakness:
        • Increased autophagy activity:

[Graphs and charts showing recovery and autophagy activity]
Summary

• Sarcopenia occurs frequently in the ICU and is difficult to detect
  – 60-77% of ICU patients sarcopenic
  – SGA does not accurately identify sarcopenia
• Toxic exposure to medication and nutrients may occur with undetected sarcopenia
  – Kcal/ELBM calorie exposure was a stronger predictor of worse outcome
  – More research is needed to determine the influence of decreased muscle mass with poor muscle quality
• Treatment
  – Exercise is currently gold standard
  – Macronutrient exposure
    • Consider both timing and dose
Learning Assessment Questions

1. Which of the following procedures are utilized to identify sarcopenia with diagnostic abdominal computed tomography scans:

   a) Apply gender and BMI cut-offs to skeletal muscle index (skeletal muscle cross-sectional area/height) at the third lumbar region

   b) Apply gender and BMI cut-offs to skeletal muscle index (skeletal muscle cross-sectional area/height) at the first lumbar region

   c) Apply gender and BMI cut-offs to skeletal muscle cross-sectional area at the third lumbar region

   d) Apply gender and BMI cut-offs to skeletal muscle cross-sectional area at the fifth lumbar region
2. Which of the following is an outcome associated with sarcopenia:
   a) Increased falls
   b) Chemotherapy-dosing toxicity
   c) More infectious complications
   d) Higher mortality
Learning Assessment Questions

3. The current gold standard treatment for sarcopenia is:
   a) Ghrelin agonists
   b) Exercise
   c) Selective androgen receptor molecules
   d) Increased leucine dosing