How much is too much?
Calculating nutritional requirements in the septic and obese patient

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Advanced dietetic practitioner - obesity
Aims

• How do we calculate nutritional requirements?
• Look at the evidence behind our estimation equations
• Highlight difficulties of predicting nutritional requirements for obese patients
• Consequences of overfeeding
• Benefits of hypocaloric high protein regimen
Obesity

- Chronic Condition
- Excess Body Fat
- Pro-inflammatory state
- Linked with multiple co-morbidities
  \[\Rightarrow\text{ increased chance of hospital admission}\]
## Obesity - Classification

<table>
<thead>
<tr>
<th>Classification</th>
<th>BMI (kg/m²)</th>
<th>Risk of Co morbidities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Range</td>
<td>18.5-24.5</td>
<td>Average</td>
</tr>
<tr>
<td>Over weight</td>
<td>≥25</td>
<td></td>
</tr>
<tr>
<td>Pre Obese</td>
<td>25-29.9</td>
<td>Increased</td>
</tr>
<tr>
<td>Obese 1</td>
<td>30-34.9</td>
<td>Moderate</td>
</tr>
<tr>
<td>Obese 2</td>
<td>35-39.9</td>
<td>Severe</td>
</tr>
<tr>
<td>Obese 3</td>
<td>≥40</td>
<td>Very Severe</td>
</tr>
</tbody>
</table>

WHO (1998)
Obesity – over nourished?

- 232 Patients pre bariatric surgery
- BMI ≥35kg/m²
- 48.7% showed at least one of the following deficiencies
  1. Vitamin B12
  2. 25-OH Vitamin D3
  3. Zinc

Ernst et al 2009
# Obesity Prevalence 2008

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overweight</td>
<td>66%</td>
<td>57%</td>
<td>61%</td>
</tr>
<tr>
<td>Obese</td>
<td>24%</td>
<td>25%</td>
<td>25%</td>
</tr>
</tbody>
</table>

(Office of Health Economics 2010)

Cost to the NHS = £4.3bn

(Department of Health 2010)
Obesity Prevalence

Fifth highest prevalence of reported developed countries, behind:

1. USA
2. Mexico
3. New Zealand
4. Australia

(Office of Health Economics 2010)
# Obesity Predictions

<table>
<thead>
<tr>
<th>Year</th>
<th>Men (%)</th>
<th>Women (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>2008</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>2015</td>
<td>36</td>
<td>28</td>
</tr>
<tr>
<td>2050</td>
<td>60</td>
<td>50</td>
</tr>
</tbody>
</table>

*(Government Office for Science 2007)*
Obesity - Challenges to HCP’s

More obese people = increased hospital admissions and complex care

- Daily care – changing bed, bathing, toilet, turning
- Equipment – bed, chair, hoist, clothing, stockings
- Mobilising – Aids, manual handling
- Central venous access – markers not easily seen
- Skin care – skin folds, pressure ulcers (infection)
# Case Study

55 year old male  
Height 1.6m  
Weight 100kg  
BMI 39

**PMHx**  
- T2DM  
- Heart Failure  
- Osteoarthritis  
- Gastric Band 15 years ago (failed to achieve weight loss)  
- Gastric Bypass 12 years ago  
- Hernia Repair with Mesh 8 years ago  
- Infected Mesh recently removed

**DHx**  
- Digoxin  
- Diuretic  
- OHA’s  
- NSAID’s
Case Study - Biochemistry

**U+E**
- Na 125mmol/L
- K 5.5mmol/L
- Urea 15.5mmol/L
- Creatinine 250umol/L
- Mg 0.5mmol/L

**LFTs**
- Normal

**Others**
- CRP 250
- random glucose 15mmol/L

**Haematology**
- Hb 9.5g/dl
- WCC 18 x 10⁹ / L
- Plats 150 x 10⁹ / L

**Temperature**
- 38°C
Calculating Requirements - Where do we start? Assessment

Assess patient as a non obese patient
- Previous medical/surgical history
- Co morbidities
- Weight history
- Risk of re feeding syndrome
- Route of feeding
- Anthropometry
Aims of nutrition support

- Prevent Catabolism
- Support wound healing
- Support immune function
- Avoid Over Feeding
- Avoid Fluid over load
Estimating Energy Requirements

Main Components of energy expenditure
- Basal Metabolic Rate (BMR)
- Diet induced thermogenesis
- Level of activity
- Alterations to all above during illness/disease
Indirect Calorimetry

Gold Standard for estimating energy requirements

- As food is oxidised, O_2 is utilised and CO_2 produced
- Measures O_2 uptake and CO_2 released
- Energy expenditure can be calculated
- Unless conditions of BMR met, measures Resting Energy Expenditure
Measuring Basal Metabolic Rate

The patient must be:

- Fasted for 6-12 hours
- lying still at physical and mental rest
- thermo-neutral environment (27 – 29°C)
- no tea/coffee/nicotine in previous 12 hours
- no heavy physical activity previous day
- gases must be calibrated
- establish steady-state (30-40 minutes)
Indirect Calorimetry

• Costly
• Requires Trained Personnel
• Takes time to complete

Many equations that estimate BMR have been published. Few have been validated for use in obese individuals.

(Alves et al 2009)
Estimating BMR
Why is it difficult in the obese?
As weight is gained, both fat mass and fat free mass are gained
• Not in a linear fashion
• As the body gets fatter, more fat mass is gained than fat free mass
• Fat free mass is more metabolically active than fat mass
• Variable presence of chronic disease

(Dickerson 2005)
Adjusted body weight?

Estimate of how much of the extra body weight is lean and thus metabolically active

- 25% adjusted weight
  \[= (\text{actual body weight} \times 0.25) + \text{ideal body weight}\]

- adjusted average weight
  \[= (\text{actual body weight} + \text{ideal body weight}) \times 0.5\]

- Ireton-Jones (1991) = Actual body weight should be used in estimation equations
Schofield (1985) is the most commonly used equation in UK (many others exist)

- meta analysis of 100 studies of 3500 men and 1200 women
- studies conducted between 1914 and 1980
- 2200 (46%) subjects were military Italian adults
- 88 (1.2%) subjects were >60 years
- 4.5% subjects had BMI >30kg/m²
Predictive Equations - Schofield

Horgan and Stubbs (2003) reassessed validity of the Schofield data to predict BMR in the obese, their conclusions were:

• BMR increases more slowly at heavier weights
• to ignore this is to over predict energy requirements
• any general equation for predicting BMR may be biased for some groups or populations
Prediction Equations - Harris-Benedict

Published 1919
Data Collection 1909-1917

136 Men Mean BMI 21.4± 2.8
103 Women Mean BMI 21.5± 4.1

Tends to overestimate in healthy individuals
Prediction Equations - Ireton-Jones

- Developed for specific patient groups
- Critical Illness
- Two IJEE equations (1992 and revised 2002)
  - Spontaneously breathing patients (takes into account obesity)
  - Ventilator dependant patients
Prediction Equations - Obesity

- underestimate the resting energy expenditure of obese individuals when IBW or AjBW is used
- overestimate energy expenditure when actual body weight is used

(Frankenfield 2003, Breen 2004)

- Does your patient fit in with the study used to determine the equations?
## Case Study – BMR

<table>
<thead>
<tr>
<th></th>
<th>Actual Weight (100kg)</th>
<th>Adjusted weight (91kg)</th>
<th>Adjusted average weight (83kg)</th>
<th>Ideal Weight (66kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ireton Jones (1992)</td>
<td>2290</td>
<td>2209</td>
<td>2137</td>
<td>1984</td>
</tr>
<tr>
<td>Schofield (1985)</td>
<td>2023</td>
<td>1920</td>
<td>1828</td>
<td>1632</td>
</tr>
<tr>
<td>Harris Benedict (1919)</td>
<td>1870</td>
<td>1746</td>
<td>1636</td>
<td>1402</td>
</tr>
<tr>
<td>Ireton-Jones and Jones (2002)</td>
<td>1915</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Alves et al 2009 (REE)

Absolute similarity between

- Indirect calorimetry
- Harris Benedict using Actual Body Weight
- Ireton-Jones (1992) using Adjusted Body Weight

Unacceptable variability when matched to REE Values

Indirect calorimetry gold standard
Equations used with caution
SCCM and ASPEN Guidelines 2009

- Energy requirements should be calculated using indirect calorimetry or predictive equations
- Predictive equations should be used with caution
- Predictive equations cause more problems with obese patients
SCCM and ASPEN Guidelines 2009

For those patients with a BMI ≥30kg/m²

• Hypocaloric feeding is recommended
• Aim to achieve 60-70% of (estimated or measured) target
• 11-14kcal/kg actual body weight (1100-1400)
• 22-25kcal/kg ideal body weight (1452-1650)

(Adjusted body weight not recommended)
Diet induced thermogenesis (DIT) and Activity

Energy required to digest and absorb nutrition
- Continuous infusion of parenteral nutrition does not significantly increase REE
- Bolus feeding increases REE by ~ 8-10%
Diet induced thermogenesis (DIT) and Activity

<table>
<thead>
<tr>
<th></th>
<th>Activity Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedbound immobile</td>
<td>10%</td>
</tr>
<tr>
<td>Bedbound mobile/sitting</td>
<td>15-20%</td>
</tr>
<tr>
<td>Mobile on ward</td>
<td>25%</td>
</tr>
<tr>
<td>Community Patient</td>
<td>Physical Activity Level (1.4-1.9)</td>
</tr>
</tbody>
</table>
# Stress Factors

<table>
<thead>
<tr>
<th>Sources of stress</th>
<th>Markers of Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgery</td>
<td>Temperature</td>
</tr>
<tr>
<td>Infection</td>
<td>CRP</td>
</tr>
<tr>
<td>Inflammation</td>
<td>WCC</td>
</tr>
<tr>
<td>Injury</td>
<td>Urea and Albumin</td>
</tr>
</tbody>
</table>
Response to Stress
Carbohydrate Metabolism

Increased Counterregulatory Hormones
Increased inflammatory cytokine release

= gluconeogenesis
lipolysis
insulin resistance

→ Hyperglycemia
Response to Stress
Carbohydrate Metabolism

Obese patients with hyperglycaemia can result in
1. Poorer outcomes (Port 2010)
2. Increased $CO_2$ production $\rightarrow$ difficulty weaning if ventilated
3. Increased lipogenesis $\rightarrow$ fatty liver
Response to Stress
Carbohydrate Metabolism

Obesity related conditions affected by excess CHO
• Diabetes Mellitus, Metabolic Syndrome
• Obstructive Sleep Apnoea, Hypoventilation Syndrome
• Non alcoholic fatty liver disease, non alcoholic steatohepatosis
Benefits of Hypocaloric high protein feeding

- Reduced hyperglycaemia
- Spares lean body mass
- Fat mass loss

Dickerson (2002)

- Reduced ICU stay
- Reduced need for antibiotics
- Fewer days on mechanical ventilation
Nitrogen Requirements

- Hormones
- Immune System
- Transport Proteins
- New Tissue
- Energy

- Large losses in Catabolic Phase
- Large losses in stoma/fistula output
- Increased Requirements during stress and growth
Nitrogen Requirements (g/kg/day)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Requirement</th>
<th>Normal Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>0.17</td>
<td>0.14-0.2</td>
</tr>
<tr>
<td>Depleted</td>
<td>0.3</td>
<td>0.2-0.4</td>
</tr>
<tr>
<td>Hypermetabolic 5-25%</td>
<td>0.2</td>
<td>0.17-0.25</td>
</tr>
<tr>
<td>Hypermetabolic 25-50%</td>
<td>0.25</td>
<td>0.2-0.3</td>
</tr>
<tr>
<td>Hypermetabolic &gt;50%</td>
<td>0.3</td>
<td>0.25-0.35</td>
</tr>
</tbody>
</table>

(Elia 1990)
Nitrogen Requirements

BMI > 30kg/m²
• 75% of value estimated from weight

BMI > 50kg/m²
• 65% of value estimated from weight

(Elia 1990)
Response to Stress
Protein Metabolism

Lean body mass is primary source of energy in the obese during stress especially when protein requirements are not met

Jeevanandam (1991)
Non obese  61% REE from fatty acid oxidation
Obese      39% REE from fatty acid oxidation
Response to Stress
Protein Metabolism

Glucose requirements met by gluconeogenesis
Amino Acid oxidation = ↑Nitrogen loss in urine
Amino Acids also used for synthesis of acute phase proteins
=Breakdown and loss of lean tissue

(Reid and Campbell 2004)

Meet protein requirements first, then carbohydrate and fat

(Elamin 2005)
SCCM and ASPEN Guidelines 2009

For those patients with a BMI 30-40kg/m²
• ≥2.0g protein / kg ideal body weight/day

For those patients with a BMI ≥40kg/m²
• ≥2.5g protein / kg ideal body weight/day
Case Study – Protein

For those patients with a BMI 30-40kg/m²

• ≥2.0g protein / kg ideal body weight/day (ASPEN 2009)
  = 132g protein (21g Nitrogen)

Realistic?

• 0.2g/kg/day = 20g Nitrogen (125g protein)
• 75% = 15g Nitrogen (94g protein)
Effects of Over feeding

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Consequence</th>
<th>Monitor</th>
</tr>
</thead>
</table>
| Carbohydrate | Hyperglycaemia  
Hypertriglyceridemia  
Hepatic Steatosis | BM’s, PCO₂, pH  
Triglycerides  
BM’s, Tg’s |
| Protein    | Azotemia  
Hypertonic Dehydration  
Metabolic Acidosis | Blood urea nitrogen  
Na, hydration  
pH, |
| Fat        | Hypertriglyceridemia  
Fat Over Load Syndrome | Triglycerides  
LFT’s, resp function |
Fluid Requirements

18-60 years old = 35ml/kg/day
>60 years old = 30ml/kg/day

• Temperature; add 2-2.5ml/kg/day for each °C rise above 37 °C
• Replace losses
Case Study – Fluid Requirements

35ml/kg = 3500ml
+ 2ml/kg/day (pyrexial) = 200ml
+ Losses = X

= Potential Fluid Overload

Current Na 125mmol/l ? Overload/loss
Fluid Balance

Fluid restriction may be necessary as obese patients are more at risk of

• Pulmonary Oedema
• Congestive heart failure

(Dickerson 2005)
Electrolyte Requirements

? Use Ideal Body Weight and monitor serum concentration

Sodium  
Potassium  
Calcium  
Magnesium  
Phosphate  

1-1.5mmol/kg plus loss
1-1.5mmol/kg plus losses
0.1-0.15mmol/kg
0.1-0.2mmol/kg
0.5-0.7mmol/kg
Conclusions

• No estimation equation accurately estimates requirements in obese individuals - Indirect Calorimetry remains gold standard
• Estimated Requirements are just a starting point
• Nutritional Monitoring is essential, including blood glucose and respiratory function
Conclusions

• Optimise protein administration followed by Calories
• Nitrogen balance should be monitored, aiming to achieve positive balance
• A large prospective, randomised, double blind controlled trial is warranted to confirm the superiority of Hypocaloric, high protein regimens
References

References