INDIRECT CALORIMETRY: ICU GUIDELINE

1) GENERAL INTRODUCTION: Energy is derived from the oxidation of protein, carbohydrate, and fat. Measurement of the amount and analysis of the concentration of \(O_2\) and \(CO_2\) in the respiratory gases provides information as to the metabolic effects of disease and/or injury on energy requirements and the amount of energy required to maintain, replete, or deplete energy stores. Although indirect calorimetry (IC) can be a precise measure of energy requirements, accuracy requires that a number of parameters be carefully controlled and that the results be interpreted correctly.

2) INDICATIONS: When a predictive equation is considered too inaccurate.
   a) Altered anthropometrics (i.e. limb amputation; BMI < 18 or >30).
   b) High – severe metabolic stress. (i.e. CHI, multiple trauma, burn injury, etc. Refer to document entitled “Rapid Resource 1: Enteral Feeding Facts – Calorie Calculator” for examples of clinical conditions associated with high - severe metabolic stress).
   c) Other (i.e. age <18, pregnancy, weaning difficulty).

3) CONTRAINDICATIONS:
   - ETT or TT leak
   - Circuit leak
   - Bronchopleural fistula
   - \(FiO_2\) > 0.80
   - Hyperventilation
   - Metabolic alkalosis
   - <8 h post-op
   - During dialysis

4) TIMING: 72 hrs following ICU admission. Repeat as indicated.

5) TEAM RESPONSIBILITIES:
   - Respiratory Therapist (RT):
     In collaboration with the RN, ensures that conditions are controlled to support a steady state (i.e. vent settings not changed for 90 minutes before IC measurement).
     Manages all technical aspects (set-up, calibration, maintenance) of the equipment and the performance of the IC testing.
     Completes the RT section of the “IC Request Form”.
   - Registered Nurse (RN):
     Co-ordinates care to ensure that the patient remains unstimulated for 30 minutes prior to IC and during the IC measurement (anxiety and pain free; absence of visitors; etc).
   - Registered Dietitian (RD):
     Maintains file of blank copies of “IC Request Form” (green paper).
     Identifies indications/contraindications to IC assessment.
     Completes RD sections on “IC Request Form” as indicated (i.e. anthropometric data) and inserts “IC Request Form” into RT binder.
     Clips/removes “IC Reminder Notice” onto RN Kardex.
     Collects “IC Request Form” and printed IC results.
     Reviews, interprets, and documents results; communicates results to the ICU team; recommends modifications to the nutrition support as indicated.
     Maintains a paper and electronic database for QI and research purposes (“IC request Form”, printed results, “IC: RD Interpretation Form”).
**Medical Doctor (MD):**
Orders IC assessment.
Reviews results with RD.

5) **TERMINOLOGY AND INTERPRETATION:**
*Energy expenditure (EE):* The amount of energy, expressed as kcal per day, required to maintain body mass and function at rest (euthermic state; fed at goal rate for 12 hrs).

*Total EE (TEE):* The net EE resulting from all metabolic processes during sleep, rest, thermogenesis and activity (see below).

*Steady state:* A steady state has been achieved when the average minute VO₂ and VCO₂ changes by ≤10% (over a 10 minute interval). IC results not consistent with a steady state are not to be used.

*Temperature:* Ideally, the patient should be euthermic at the time of IC measurement. If not, the EE must be modified to account for the increased or decreased energy associated with hyper or hypothermia. As a general rule, for every degree above or below euthermia, the EE is affected by 10%.

*Physical activity:* The EE is to be obtained at rest. To calculate TEE the EE should be modified by an activity factor (AF) where appropriate.

<table>
<thead>
<tr>
<th>Activity</th>
<th>AF</th>
<th>Example</th>
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<tbody>
<tr>
<td>Low</td>
<td>1.0</td>
<td>Heavily sedated, minimal routine nursing/medical care.</td>
</tr>
<tr>
<td>Moderate</td>
<td>1.1</td>
<td>Awake, bedridden, routine nursing/medical care.</td>
</tr>
<tr>
<td>High</td>
<td>1.2</td>
<td>Daily physiotherapy (i.e. active bedside mobilization/walking) and/or repeated extensive nursing/medical/surgical interventions (i.e. burn-injured patient with repeated returns to the OR).</td>
</tr>
</tbody>
</table>

*Respiratory Quotient (RQ):* The ratio of CO₂ produced to O₂ consumed. Results outside of physiologic range (0.67 to 1.3) reflect a flawed measurement and are to be discarded. The clinical value of the measured RQ is limited to that of a marker of test validity and as a measure of tolerance to overfeeding (RQ >1.0) in response to overfeeding.

<table>
<thead>
<tr>
<th>SUBSTRATE</th>
<th>RQ</th>
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<tbody>
<tr>
<td>Fat</td>
<td>.70</td>
</tr>
<tr>
<td>Protein</td>
<td>.82</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>1.0</td>
</tr>
<tr>
<td>Mixed feeding</td>
<td>.85</td>
</tr>
<tr>
<td>Overfeeding</td>
<td>1.1 – 1.2</td>
</tr>
</tbody>
</table>

**ASSOCIATED DOCUMENTS:**
IC Request Form
IC RD Interpretation Form
Rapid Resource 1: Enteral Feeding Facts – Calorie Calculator

**RESOURCES:**
McClave SA, McClain CJ, Snider HL. Should indirect calorimetry be used as part of nutritional assessment? J Clin Gastroenterol 2001;33:14-19

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