ABCs OF PICU NUTRITION

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Nutritional assessment and support

Who needs nutritional support?

Everyone


FEN?
Nutritionist’s input in PICU rounds.

NABH / JCI accreditation requirement
Nutritional goals being met?
Nutritional Assessment

Anthropometry
Height, Weight, Head Circumference

Labs
Albumin, Prealbumin, Urea, Creatinine.
How much Calorie and Proteins intake?

Ideal: Indirect Calorimetry
Theoretical for our scenario

Formula / Tables based requirements
Titrate based on anthropometry/labs
PICU Malnutrition

• Malnutrition:
  • Impairs immune function.
  • Interferes with wound healing.
  • Prolongs hospitalisation.
  • Increases risk of infection and death.
PICU Overfeeding

- Overfeeding:
  - Excess CO2 production & increased minute ventilation
  - Pulmonary oedema & respiratory failure
  - Hyperglycemia, which may increase infection rates
    - Lipogenesis due to increased insulin production
  - Hepatic complications: fatty liver, intrahepatic cholestasis
Balancing Act
## DRI vs. BEE

<table>
<thead>
<tr>
<th>Age</th>
<th>DRI (kcal/kg)</th>
<th>BEE (kcal/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3 months</td>
<td>102</td>
<td>54</td>
</tr>
<tr>
<td>4-6 months</td>
<td>82</td>
<td>54</td>
</tr>
<tr>
<td>7-12 months</td>
<td>80</td>
<td>51</td>
</tr>
<tr>
<td>13-35 months</td>
<td>82</td>
<td>56</td>
</tr>
<tr>
<td>3 years</td>
<td>85</td>
<td>57</td>
</tr>
<tr>
<td>4 years</td>
<td>70</td>
<td>47</td>
</tr>
<tr>
<td>5-6 years</td>
<td>65</td>
<td>47</td>
</tr>
<tr>
<td>7-8 years</td>
<td>60</td>
<td>47</td>
</tr>
</tbody>
</table>
Daily energy & protein requirements

Total Calories : BEE X Stress Factor

Total Proteins : RDA X Stress Factor
**Table 1. Estimate BEE for weight and sex**

<table>
<thead>
<tr>
<th>Age 1 wk to 10 mths</th>
<th>Age 11 to 36 mths</th>
<th>Age 3 to 16 yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt (kg)</td>
<td>MR (kcal/day)</td>
<td>Wt (kg)</td>
</tr>
<tr>
<td>M or F</td>
<td>M</td>
<td>F</td>
</tr>
<tr>
<td>3.5</td>
<td>202</td>
<td>9.0</td>
</tr>
<tr>
<td>4.0</td>
<td>228</td>
<td>9.5</td>
</tr>
<tr>
<td>4.5</td>
<td>252</td>
<td>10.0</td>
</tr>
<tr>
<td>5.0</td>
<td>278</td>
<td>10.5</td>
</tr>
<tr>
<td>5.5</td>
<td>305</td>
<td>11.0</td>
</tr>
<tr>
<td>6.0</td>
<td>331</td>
<td>11.5</td>
</tr>
<tr>
<td>6.5</td>
<td>358</td>
<td>12.0</td>
</tr>
<tr>
<td>7.0</td>
<td>384</td>
<td>12.5</td>
</tr>
<tr>
<td>7.5</td>
<td>410</td>
<td>13.0</td>
</tr>
<tr>
<td>8.0</td>
<td>437</td>
<td>13.5</td>
</tr>
<tr>
<td>8.5</td>
<td>463</td>
<td>14.0</td>
</tr>
<tr>
<td>9.0</td>
<td>490</td>
<td>14.5</td>
</tr>
<tr>
<td>9.5</td>
<td>514</td>
<td>15.0</td>
</tr>
<tr>
<td>10.0</td>
<td>540</td>
<td>15.5</td>
</tr>
<tr>
<td>10.5</td>
<td>566</td>
<td>16.0</td>
</tr>
<tr>
<td>11.0</td>
<td>593</td>
<td>16.5</td>
</tr>
</tbody>
</table>

**Table 2: Determining Stress Factor**

<table>
<thead>
<tr>
<th>Clinical Condition</th>
<th>Stress factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance</td>
<td>1.0</td>
</tr>
<tr>
<td>Fever</td>
<td>12% per degree &gt; 37</td>
</tr>
<tr>
<td>Routine surgery, minor sepsis</td>
<td>1.1</td>
</tr>
<tr>
<td>Cardiac failure</td>
<td>1.25</td>
</tr>
<tr>
<td>Major surgery</td>
<td>1.2</td>
</tr>
<tr>
<td>Sepsis</td>
<td>1.4</td>
</tr>
<tr>
<td>Catch-up grpwhth</td>
<td>1.5</td>
</tr>
<tr>
<td>Trauma (inc TBI)</td>
<td>1.5 – 1.7</td>
</tr>
</tbody>
</table>
Energy Needs: Intubated Infants

Require > BEE
Activity not significant
Calories used predominately for growth

Provide >BEE for infants 0-12 months despite intubation/sedation
(~75-80% of the DRI for age)
0-3 mon (~80kcal/kg)
4-12 mon (~65kcal/kg)
Energy Needs: Intubated Children > 12 months

Goal = BEE

Schofield equation, Harris Benedict equation, ASPEN

3y: ~60kcal/kg
4-8y: ~50kcal/kg

Activity and injury factors not routinely used

BEE x 1.2 for intubated burn pts
Energy Needs: Non-Intubated

Goal = DRIs

Malnourished: Catch up growth needs
(DRI x IBW) ÷ actual wt (kg)

Overweight: BMI for age >85th%ile
(BMI @50th%ile x actual wt) ÷ actual BMI
200 kCal less than average for age
## Protein Requirements

<table>
<thead>
<tr>
<th>Age</th>
<th>DRI (g/kg/day)</th>
<th>PICU (g/kg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6 months</td>
<td>1.52</td>
<td>2-3</td>
</tr>
<tr>
<td>7-12 months</td>
<td>1.20</td>
<td>2-3</td>
</tr>
<tr>
<td>13-23 months</td>
<td>1.05</td>
<td>2-3</td>
</tr>
<tr>
<td>2-3 years</td>
<td>1.05</td>
<td>1.5-2</td>
</tr>
<tr>
<td>4-13 years</td>
<td>0.95</td>
<td>1.5-2</td>
</tr>
<tr>
<td>14-18 years</td>
<td>0.85</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Parenteral Nutrition Calories

- Extubated:
  - provide ~10% < DRIs
  - due to lack of thermogenic effect of food

- Intubated:
  - BEE or
  - ~80% DRI
Continuous Monitoring

Monitor Anthropometry and Labs

Titrate Calories and Proteins
Fluid Requirement

• Holliday-Segar formula
  • 0-10 Kg : 100ml/kg/day
  • 10-20 Kg : 1000 ml + 50 ml for each Kg > 10 Kg
  • > 20 Kg : 1500 ml + 20 ml for each Kg > 20 Kg

• Other fluids and medications
  • Fluid restricted status.
Nutrition: Available Routes

- PPN
- TPN
- Intravenous alimentation
- Nasoduodenal tube
- Nasojejunal tube
- Nasogastric tube
- Gastrostomy tube
- Jejunostomy tube
Parenteral Nutrition
PPN vs. TPN

**PPN**
- Peripheral access
- <900 mOsm/L
- Max D12.5%
- Can go up to D15% with non-central PICC
- Usually requires increased fluid allowance

**TPN**
- Central access
- No osmolarity limitations
- Typical max dextrose usually D25%.
Parenteral Dextrose

- 40-60% of total calories / 60-75% of NP calories
  - Glucose infusion rate (GIR)
    - 3.4 kcal/g dextrose
  - Increased intake: Hyperglycemia, infections, hepatic steatosis, Refeeding syndrome.
# GIR/Dextrose Guidelines

<table>
<thead>
<tr>
<th>Age</th>
<th>Initiate</th>
<th>Advance</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1yr</td>
<td>~6-9mg/kg/min</td>
<td>1-2mg/kg/min</td>
<td>Goal: 10-12mg/kg/min Max: 14mg/kg/min</td>
</tr>
<tr>
<td>1-10yr</td>
<td>1-2mg/kg/min</td>
<td>1-2mg/kg/min</td>
<td>Max: 8-10mg/kg/min</td>
</tr>
<tr>
<td>&gt;10yr (adolescents)</td>
<td>1-2mg/kg/min &gt;IVF GIR</td>
<td>1-2mg/kg/min</td>
<td>Max: 5-6mg/kg/min</td>
</tr>
</tbody>
</table>
Parenteral Lipids

- Initiate @ 1g/kg/day, Advance @ 1g/kg/day
  - Maximum:
    - < 1 yr: 3g/kg/day,
    - 1-10 yr: 2-3g/kg/day,
    - >10 yr: 1-2.5g/kg/day

- Usual 20-50 % of calories.< 60% kcal via lipid (ketosis)

- Maximum lipid clearance 0.15g/kg/hr, TG 100-150 mg/dl

- Carnitine supplements for TPN > 2-4/ 52
  - 10mg/kg/day. May go upto 20mg/kg/day (Carnisure, Torrent)
20% Intralipid

- Essential Fatty Acids (EFA)
  - Omega-6 source,
  - Increased inflammation
  - PNALD/IFALD

- Concentrated source of kcal
  - 2kcal/ml
PNALD/IFALD

Avoid macronutrient overfeeding in general

Decrease lipids to 1 g/kg

Omega 3 FA (Fish oil based)(SMOFLipid20%)

GIR ≤ 12.5mg/kg/min

Initiate EN asap (even trophic feeds)

Strict asepsis protocols
## Parenteral AA Guidelines

<table>
<thead>
<tr>
<th>Age</th>
<th>Initiate</th>
<th>Advance</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1yr</td>
<td>1-2g/kg/day</td>
<td>1g/kg/day</td>
<td>4g/kg/day</td>
</tr>
<tr>
<td>1-10yr</td>
<td>1-2g/kg/day</td>
<td>1g/kg/day</td>
<td>1.5-3g/kg/day</td>
</tr>
<tr>
<td>&gt;10yr (adolescents)</td>
<td>1g/kg/day</td>
<td>1g/kg/day</td>
<td>0.8-2.5g/kg/day</td>
</tr>
</tbody>
</table>

Calorie contribution: 4kcal/g AA
### PN Electrolyte Dosing Guidelines

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Preterm Neonates</th>
<th>Infants/Children</th>
<th>Adolescents/Children &gt;50kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na</td>
<td>2-5meq/kg</td>
<td>2-5meq/kg</td>
<td>1-2meq/kg</td>
</tr>
<tr>
<td>K</td>
<td>2-4meq/kg</td>
<td>2-4meq/kg</td>
<td>1-2meq/kg</td>
</tr>
<tr>
<td>Ca</td>
<td>2-4meq/kg</td>
<td>0.5-4meq/kg</td>
<td>10-20meq/day</td>
</tr>
<tr>
<td>Phos</td>
<td>1-2mmol/kg</td>
<td>0.5-2mmol/kg</td>
<td>10-40mmol/day</td>
</tr>
<tr>
<td>Mg</td>
<td>0.3-0.5meq/kg</td>
<td>0.3-0.5meq/kg</td>
<td>10-30meq/day</td>
</tr>
</tbody>
</table>

IV Phosphate is now available (3mmol/ml Phosphorus +4.5mEq/ml Potassium) Potphos (Neon)
How to order TPN

1. Calculate: Fluid volume available for TPN
2. Calculate: Estimated energy requirement
3. Calculate: Protein Requirement and protein calories
5. Calculate: Carbohydrate Requirement and check GIR
6. Calculate Additives (Electrolytes, Minerals, Vitamins)
7. Calculate Osmolality:
   1. \[ ((\text{g Aminoacid/L} \times 10) + (\text{g Dextrose/L} \times 5) + (\text{Na+K+Ca in mEq/L}) \times 2) \]
15 Kg Child for TPN

3Y/M, 15 Kg, TPN.

Normal labs.

Goal : Age appropriate weight gain.
TPN Calculation

- **Fluid requirement:**
  - Fluid = 1000ml + 50 ml X 5 kg = 1250 ml

- **Estimated energy requirement:**
  - 15 X 85 Kcal/kg = 1275 Kcal

- **Protein requirement:**
  - Protein = 15 X 3g/day = 45 grams
  - Protein calories = 45g x 4 Kcal/g = 180 Kcal.
TPN Calculation

• Lipid Requirement:
  • 15 X 3 g/kg = 45 g
  • Lipid calories:
    • 45 g X 10 Kcal/g = 450 Kcal (35% of EER)

• Carbohydrate calories:
  • EER – (Protein calories + Lipid calories)
    • 1275 – (180+450) = 645 Kcal (51% of EER)
    • Carbohydrate requirement:
      • 645 Kcal / 3.4 Kcal/g = 190 g Carbohydrate
TPN Calculation

- GIR:
  - 190 g = 190,000 mg
  - 190,000 mg/ 15 kg = 12667 mg/kg/day
  - 12667/ 1440 min in a day = 8.8 mg/kg/min

- Final PN solution will contain
  - 45 g AA (14% EER)
  - 45 g IVFE 20% (35 % EER)
  - 190 g Glucose (51% EER)
TPN Calculation

• Total PN volume
  • 45 g from 10% AA → 450 ml 10% AA
  • 45 g from 20% IVFE → 225 ml 20% IVFE
  • 190 g from 50% Glucose → 380 ml 50% D
  • Na= 30 mEq (2 mEq/kg) = 60 ml 3% NaCl
  • K = 30 mEq (2 mEq/kg) = 15 ml KCl (Potclor)
  • Total Volume: 450+225+380 +60+15 = **1130 ml**.

• Still have **120 ml for meds**

• Final Dextrose Concentration = 16.8%(190g/1130 ml)

• Final Osmolality = (450 + 950 + 120) = 1520 mOsm/L

• MVI: 2.5 ml
Enteral Nutrition
Introduction of EN

**Patient considered for Enteral Nutrition?**

**Nil enterally?**
- Discuss with PICU Consultant
- High Risk Abdomen (<48 hours post heart surgery, > 2 inotropes, open chest, central cooling, < 24 hours of cardiac arrest)
- Consider PN
- Reass for EN daily

**Absolute Risk**
- Mechanical Bowel Obstruction
- Current confirmed NEC
- Significant GI bleed
- Ischaemic Bowel

**Relative risk**
- Suspected NEC
- High Risk Abdomen (<48 hours post heart surgery, > 2 inotropes, open chest, central cooling, < 24 hours of cardiac arrest)
- Abdominal distension
- Ileus
- High output stoma
- Complex GI surgery
- Intractable diarrhoea

**Discuss with PICU Consultant --- Decide EN +/- PN**
Commence enteral feed at 0.5-1.0ml/kg/hr. If restarting following a high GRV, recommence at previously tolerated rate. If restarting a feed following a period of fasting, recommence at previously tolerated rate where appropriate.

Feed at this rate for 4 hours

Check for Gastric Residual Volume (GRV). Is it >5ml/kg or 200 ml?

- **No**
  - Replace GRV. Increase feed by 0.5ml/kg/hr & continue at this rate for 4 hrs. Recheck GRV. Is it > 5ml/kg or 200ml.

- **Yes**
  - Replace GRV. Stop feeding for 2 hrs. Recheck GRV. Is it > 5ml/kg or 200ml.
    - **No**
      - Replace GRV. Recheck GRVs every 4 hours and increase at 0.5ml/kg/hr until maximum fluid allowance or target rate of feed reached.
    - **Yes**
      - Treat constipation, hypokalemia. Consider prokinetics, decreasing opiates, Osmolality, decreasing rate. Consider NJ tube/PN.
Thank you