Nutritional assessment of the preterm infants

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Nutrition is key

Improved survival → Better nutrition → Improved survival
Nutritional status = what you are, what you can do, what you eat
1st 1000 days

Critical windows

[Images of various stages of fetal development and a baby being held]
Key points

• Survival is improving
• Nutrition vital to survivors

• Nutritional status: more complex than just intakes

• Why don’t we nourish babies better?
Why are we so bad at pre-discharge nutrition?

- Focus on key morbidities
  - Visual
  - Measurable
Malnutrition is invisible

Birth

48 hours after no protein

Understanding what would have occurred in-utero helps us to know what to give the baby ex-utero
Assessment of respiratory status

Respiratory rate
Cyanosis
Retractions
Auscultation
FiO2 %
Blood gas
Assessment of cardiovascular status

- Heart rate
- Cyanosis
- Precordial heave
- Heart sounds
- Capillary refill
- FiO2 %
- Blood gas
Assessment of nutritional status
<table>
<thead>
<tr>
<th>Test Procedure</th>
<th>Result</th>
<th>Adult Reference Range</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>AST (SGOT)</td>
<td>29</td>
<td>15-66</td>
<td>IU/L</td>
</tr>
<tr>
<td>ALT (SGPT)</td>
<td>31</td>
<td>12-118</td>
<td>IU/L</td>
</tr>
<tr>
<td>T. BILIRUBIN</td>
<td>0.1</td>
<td>0.1-0.3</td>
<td>MG/DL</td>
</tr>
<tr>
<td>ALK PHOS</td>
<td>1410 (H)</td>
<td>5.0-7.4</td>
<td>G/DL</td>
</tr>
<tr>
<td>GGT</td>
<td>7</td>
<td>1-12</td>
<td>IU/L</td>
</tr>
<tr>
<td>TOTAL PROTEIN</td>
<td>7.7 (H)</td>
<td>2.7-4.4</td>
<td>G/DL</td>
</tr>
<tr>
<td>ALBUMIN</td>
<td>3.1</td>
<td>1.6-3.6</td>
<td>G/DL</td>
</tr>
<tr>
<td>GLOBULIN</td>
<td>4.6 (H)</td>
<td>0.8-2.0</td>
<td>G/DL</td>
</tr>
<tr>
<td>A/G RATIO</td>
<td>0.7 (L)</td>
<td>92-324</td>
<td>MG/DL</td>
</tr>
<tr>
<td>CHOLESTEROL</td>
<td>257</td>
<td>6-25</td>
<td>MG/DL</td>
</tr>
<tr>
<td>BUN</td>
<td>9</td>
<td>8.5-1.6</td>
<td>MG/DL</td>
</tr>
<tr>
<td>CREATININE</td>
<td>0.5</td>
<td>4-27</td>
<td>MG/DL</td>
</tr>
<tr>
<td>BUN/CREAT RATIO</td>
<td>18</td>
<td>2.5-6.0</td>
<td>MG/DL</td>
</tr>
<tr>
<td>PHOSPHORUS</td>
<td>6.1 (H)</td>
<td>8.9-11.4</td>
<td>MG/DL</td>
</tr>
<tr>
<td>CALCIUM</td>
<td>8.9</td>
<td>70-138</td>
<td>MG/DL</td>
</tr>
<tr>
<td>GLUCOSE</td>
<td>429 (H)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results have been rechecked and verified.
Why is pre-discharge nutrition so inadequate?

• Focus on key morbidities
  – Visual
  – Measurable

• Nutritional status
  – Poorly defined & difficult to assess
  – Key outcomes of nutritional management often not apparent in short term

Brain matters
The human brain is 10-20 x as large as many other mammals.
Mammalian brain growth spurt

Increase in brain size

Myelination

Synaptogenesis

Apoptosis

Neuronal migration

90% volume

24w 2y
Key points

• Brain is vulnerable

• Malnutrition is *very* common

• How do we assess nutritional status?
What does the fetus receive in-utero?

**Hormonal ‘milieu’**
Active & passive nutrient transport

- Microvillous membrane (MVM)
- Lipases
- Intervillous space
- Amino acid transporters
- Syncytiotrophoblast
- Basal plasma membrane (BM)
- Fetal capillary
- Endothelial cell

**Amino acids**
**Glucose**
**Lipids**

Swallowing amniotic fluid

“Placental insufficiency”
Body composition of reference fetus

24 week infant
90% water

500g baby has just 50g ‘dry’ tissue

No energy ‘stores’

Only tissue available for energy is lean tissue: muscle, liver ....
Preterm infants on NICU

• Limited nutrient stores
• Vulnerable to under-nutrition
• Multiple co-morbidities

How do we assess nutrient requirements
– example of protein
Protein, AA & Nitrogen

- Proteins - 20 amino acids (AA)
- Requirement is for AA
- AA
  - Essential or Non-essential
  - Conditionally essential
- Nitrogen = “exchange currency”
- Nitrogen * 6.25 = Protein
  - (Kjeldahl protein is ~16% nitrogen)
Nitrogen
Oxygen
Argon
Carbon Dioxide
Factorial assessment of protein requirements

Fetus stores approximately **2g/kg/day** of protein
Preterm baby needs more than 2g/kg:
  - Conversion of dietary protein <100% efficient
  - Every day protein (nitrogen) is ‘lost’ in the urine

Obligatory nitrogen losses are very high in preterm infants
Protein synthesis is 5 x protein accretion (highly dynamic)
Nitrogen retention mg/kg/day vs. Protein intake g/kg/day

Protein intake >3g/kg Nitrogen retention ~ fetus

Fetal accretion rate

~Protein intake g/kg/day

Nitrogen retention mg/kg/day

-300 -200 -100 0 100 200 300 400 500

0 0.5 1 1.5 2 2.5 3 3.5 4

Newcastle University

The Newcastle upon Tyne Hospitals
NHS Foundation Trust
Factorial assessment of protein requirements

- Protein accretion
- Dermal, secretions etc.
- Obligatory loss in urine
- ‘Inefficiency’
Factorial assessment of protein requirements

Protein accretion

Obligatory loss in urine

'Inefficiency'

Gestation (weeks)

Protein (g/kg/day)

24 25 26 27 28 29 30 31 32 33 34 35 36
What are preterm babies made of?

- Body composition of reference fetus
- Nutrient stores

Ziegler et al.
Heird et al.
Stored energy

Glycogen
Fat
Protein

Total energy
Stored energy

REE 50-60kcal/kg/day

Total energy ~2000Kcal

Leitch, Denne, Thureen, Heird et al.
Stored energy

26w 1000g
Total energy <500Kcal

32w 1750g
Total energy ~1700Kcal

REE

Days

1 2 3
Baby Smith 24w gestation

- Born at 15.00hrs on Friday 11\textsuperscript{th} October
- Pharmacy is opens Monday 14\textsuperscript{th} October 06.00hrs
- You order PN @3g/kg/d and start Monday 09.00hrs
- 500g

Protein = 50g

\[
\begin{align*}
\text{Friday} & : 1g \\
\text{Saturday} & : 1g \\
\text{Sunday} & : 1g \\
\text{Monday} & : 1g \\
\end{align*}
\]

Protein = 46g
Baby Smith 24w gestation

- Born at 15.00hrs on Friday 11\textsuperscript{th} October
- Pharmacy is opens Monday 14\textsuperscript{th} October 06.00hrs
- You order PN @3g/kg/d and start Monday 09.00hrs
- 500g

Protein = 50g

Monday morning - lean mass only 85\% of fetus

Protein = 55g

Protein = 46g
Key points

- Brain is vulnerable
- Malnutrition is very common
- Malnutrition results in worse outcomes

- Protein accretion 2g/kg/d
- Protein loss 1-1.5g/kg/d
- No ‘energy’ stores
- No ‘protein’ stores
- REE 50-60kcal/kg/d
Assessing nutritional status - direct & indirect

**DIRECT**
- **Anthropometry**
  - Body composition
- **Biochemistry**
- **Clinical assessments**
- **Dietary assessment**
  - Protein & calories
  - Everything else
  - Actual v Rx
  - Excess losses (stoma etc.)

**INDIRECT**
- Policies and guidelines
- Attitudes & beliefs
- Equipment & resource
- Composition of standard PN
- Unit specific data – wt gain etc.
Assessing nutritional status

Anthropometry

- Regular weight & head
- Benefits of length?
- Other measures?
  - Mid-arm
  - Skin folds
  - Knee-heel
  - Lack references
- BMI, ponderal index?

Cheap, specific, sensitive
- Repeatable, safe
- Inter-observer variability?
- Non-invasive...
- Which growth chart?
- Standard v reference
- Interested in GROWTH
  - not size
- SGA is arbitrary cut off
Assessing nutritional status

Body composition
- Primarily research
  - Lean mass
  - Body water → fat mass
  - Bone mineral density
- Methodology
  - Models
  - Assumptions & algorithms
  - Gold standards

• Bio-impedance
  - Cheap, safe, repeatable
  - Validity, fiddly
• DEXA
  - Widely used, easy
  - FM, LM, BMD
  - Validity?
• Isotope dilution
  - Expensive, not clinical
• MRI, Bone USS - SoS
Assessing nutritional status

Biochemistry
• Glucose, electrolytes ✓
• Impossible to quantify macronutrient ‘stores’
• Micronutrient status
  – Complex or prolonged PN ✓
  – Sampling (light etc.)
  – Plasma levels often do not reflect total body stores

Protein
• Total serum protein ✗
• Albumin – long $t_{1/2}$ ✗
• RBP etc. - shorter $t_{1/2}$
  • Research ✓
• Urea – after first week ✓
• PAA profiles ✗
  • Expensive, references
  • Research ✓
Assessing nutritional status

‘Bone’ biochemistry

- Important aspect of nutrition
- Evidence of long-term effects lacking
- XR useless
- DXA impractical
- Alkaline Phosphatase $\times/\checkmark$
  - Frequently measured
  - Rarely changes management

Calcium

- Does not reflect stores $\times$
- Normal despite inadequate intake $\times$

Phosphate

- Reflects recent intake $\checkmark$
- Important acute (PN) $\checkmark$
- Important chronic (EBM) $\checkmark$
- Need it for muscle & cell function and to deposit LM
Assessing nutritional status

**ABCD**
Clinical
- ‘Wasting’
- Vitamins & micronutrients
Assessing nutritional status

Clinical

If you wait until there are clinical signs of poor nutritional status you may cause irreversible damage.
Assessing nutritional status

Direct (AB^CD) and Indirect measures

• Focus on growth (anthropometry) and diet assessment (PN and enteral)
• Discuss on ward rounds
• Document in notes
• Make people THINK NUTRITION
### Assessing nutritional status

#### Quick NDE

<table>
<thead>
<tr>
<th>Growth</th>
<th>Intakes (last 24hrs)</th>
<th>Vol. mls</th>
<th>Daily mls/kg/d</th>
<th>Protein g/kg/d</th>
<th>Calories g/kcal/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current weight (g)</td>
<td>790</td>
<td>Breast milk</td>
<td>80</td>
<td>100</td>
<td>1.4 = 1.4</td>
</tr>
<tr>
<td>Current wt centile</td>
<td>3rd</td>
<td>BM Fortifier</td>
<td>1p</td>
<td></td>
<td>0.6 = 0.6</td>
</tr>
<tr>
<td>Birthweight (g)</td>
<td>650</td>
<td>LBW formula</td>
<td>-</td>
<td></td>
<td>0.24 =</td>
</tr>
<tr>
<td>Birthweight centile</td>
<td>25th</td>
<td>Other formula</td>
<td>-</td>
<td></td>
<td>0.16 =</td>
</tr>
<tr>
<td>Weight gain (g/day)</td>
<td>14</td>
<td>Standard PN</td>
<td>30</td>
<td>35</td>
<td>0.26 = 0.9</td>
</tr>
<tr>
<td>Weight gain (g/day)</td>
<td>10</td>
<td>Special PN</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current OFC (cm)</td>
<td>34</td>
<td>Lipid (SMOF/IL)</td>
<td>3.2</td>
<td>5</td>
<td>1.8 = 9</td>
</tr>
<tr>
<td>OFC centile</td>
<td>25th</td>
<td>10% Dextrose</td>
<td>-</td>
<td></td>
<td>0.4 =</td>
</tr>
<tr>
<td>Probiotic</td>
<td>√</td>
<td>Iron p.o.</td>
<td>X</td>
<td>TOTAL</td>
<td>2.9</td>
</tr>
<tr>
<td>Vitamins p.o.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**Note:** Calculations are approximate and based on standard formulas.