Nutritional management of the burns patient in the ICU

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Mette M Berger

Disclosures

Grants: Baxter, BBraun, Fresenius Kabi

Lecturer: Baxter, BBraun, Fresenius Kabi, Nestlé, Medtronic, Takeda

Advisory board: Baxter, Fresenius Kabi

Bonds ..: none

Member of ICU Guidelines working groups: ESPEN, ESICM
## Summary of statements

<table>
<thead>
<tr>
<th>Indication</th>
<th>Nutritional therapy should be <strong>initiated early within 12 hours of injury</strong>, preferentially by the enteral route.</th>
<th>strong</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route</td>
<td>We recommend to give <strong>priority to the enteral route</strong>, parenteral administration being rarely indicated</td>
<td>strong</td>
<td>C</td>
</tr>
<tr>
<td>Energy requirements &amp; Equations</td>
<td>We recommend considering <strong>indirect calorimetry</strong> as a gold standard to assess energy requirements. If not available or not suitable, we recommend using the Toronto equation for burn adults. For burn children, we suggest to use Schofield formula</td>
<td>weak</td>
<td>D</td>
</tr>
<tr>
<td>Proteins</td>
<td>Protein requirements, are higher than in other categories of patients, and should be set around <strong>1.5 to 2.0 g/kg in adults and 1.5 to 3 g/kg/day in children</strong>. We strongly suggest to consider glutamine supplementation (or ornithine alpha-keto-glutarate) but not arginine supplementation</td>
<td>strong</td>
<td>D</td>
</tr>
<tr>
<td>Glucose and glycemia control</td>
<td>We strongly suggest to limit carbohydrate delivery (prescribed for nutritional and drug dilution purpose to 60% of total energy intake, and not to exceed 5 mg/kg/min in both adults and children. We strongly suggest to keep glucose levels <strong>under 8 mmol/l</strong> (and &gt; 4.5 mmol/l), using continuous intravenous infusion of insulin</td>
<td>strong</td>
<td>E</td>
</tr>
<tr>
<td>Lipids</td>
<td>We suggest to monitor total fat delivery, and to keep <strong>energy from fat &lt;35%</strong> of total energy intake</td>
<td>weak</td>
<td>B</td>
</tr>
<tr>
<td>Micronutrients</td>
<td>We strongly suggest associating, in adults as in children, a <strong>substitution of zinc, copper and selenium</strong>, as well as of vitamin B1, C, D and E.</td>
<td>strong</td>
<td>C</td>
</tr>
<tr>
<td>Metabolic modulation</td>
<td>We strongly recommend using non nutritional strategies to attenuate hypermetabolism and hypercatabolism in both adults and children (warm ambient temperature, early excision surgery, non selective beta-blockers, oxandrolone). Unlike adults, we recommend to administer rhGH to burn children with TBSA &gt;60%</td>
<td>strong</td>
<td>B</td>
</tr>
</tbody>
</table>
10 tips for burn nutrition

• Early enteral feeding < 12hrs
• Trace element repletion from day 1 → 14 d
• Weigh the patients (daily or at least 3 */week)
• Adapt energy target (Toronto)
• Glucose control 6-8 mmol/l (nurse driven)
• High protein
• Low fat
• Glutamine
• Monitor feeding– avoid overfeeding
• Metabolic modulation – β-blockers
Early enteral feeding

Enteral = basic
Parenteral = rescue

Use the gut to prevent loosing it
Intestinal complications in burns life-threatening

**Prevention**

- Abdominal compartment syndrome: ↓ fluids
- Gastro-paresis: EN within 12hrs
- Sub-ileus / ileus: prokinetics
- Constipation: emollients from admission enema
- Upper GI tract bleeding: PPI / anti-H2 (ranitidine)
- Intestinal ischemia: watch perioperative hemodynamics
Early enteral vs parenteral nutrition in severe burns
Chen et al, Burns 2007, 33:708

Patient characteristics

<table>
<thead>
<tr>
<th>Variables</th>
<th>All patients</th>
<th>TEN</th>
<th>TPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients (n)</td>
<td>19</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Age (years ± S.D.)</td>
<td>33.05 ± 9.97</td>
<td>32.40 ± 10.64</td>
<td>33.78 ± 9.77</td>
</tr>
<tr>
<td>Body weight (kg ± S.D.)</td>
<td>61.26 ± 9.25</td>
<td>60.40 ± 6.19</td>
<td>62.22 ± 12.15</td>
</tr>
<tr>
<td>TBSA (% ± S.D.)</td>
<td>44.95 ± 9.91</td>
<td>43.50 ± 11.38</td>
<td>46.56 ± 8.35</td>
</tr>
<tr>
<td>FBSA (% ± S.D.)</td>
<td>29.58 ± 11.87</td>
<td>30.10 ± 10.39</td>
<td>29.00 ± 13.96</td>
</tr>
</tbody>
</table>

Randomised prospective trial

Comparison of TEN and TPN composition

<table>
<thead>
<tr>
<th>Component</th>
<th>TEN [% (kcal)]</th>
<th>TPN [% (kcal)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>63</td>
<td>55</td>
</tr>
<tr>
<td>Protein</td>
<td>25</td>
<td>24</td>
</tr>
<tr>
<td>Fat</td>
<td>12</td>
<td>21</td>
</tr>
<tr>
<td>kcal:N (nitrogen)</td>
<td>100:1</td>
<td>104:1</td>
</tr>
</tbody>
</table>
EN was a more effective to:
• preserve gastrin secretion
• preserve motility of GI tract,
• prevent lower intestinal ischemia and reperfusion injury
• ↓ intestinal permeability,
• ↓ plasma endotoxin and inflammatory mediators
• maintain mucosa barrier function
Whenever GI function permits, EN was superior to PN early after burn.

Early enteral vs parenteral nutrition in severe burns
Chen et al, Burns 2007, 33:708

The changes of %L, %M and U/M in urine

<table>
<thead>
<tr>
<th>Group</th>
<th>PBD1</th>
<th>PBD4</th>
<th>PBD8</th>
<th>PBD14</th>
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</thead>
<tbody>
<tr>
<td>TEN (n = 10)</td>
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<tr>
<td>%L</td>
<td>3.29 ± 0.87</td>
<td>3.26 ± 0.38</td>
<td>2.49 ± 0.77</td>
<td>2.68 ± 0.87</td>
</tr>
<tr>
<td>%M</td>
<td>18.19 ± 6.29</td>
<td>21.11 ± 4.74</td>
<td>14.96 ± 4.32</td>
<td>18.22 ± 4.18</td>
</tr>
<tr>
<td>U/M</td>
<td>0.195 ± 0.048</td>
<td>0.160 ± 0.045</td>
<td>0.169 ± 0.028</td>
<td>0.148 ± 0.034</td>
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<tr>
<td>TPN (n = 9)</td>
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<tr>
<td>%L</td>
<td>3.67 ± 1.08</td>
<td>5.69 ± 1.01a</td>
<td>4.35 ± 2.61</td>
<td>3.55 ± 0.71</td>
</tr>
<tr>
<td>%M</td>
<td>20.35 ± 8.85</td>
<td>21.44 ± 5.41</td>
<td>20.22 ± 10.18</td>
<td>20.41 ± 6.29</td>
</tr>
<tr>
<td>U/M</td>
<td>0.191 ± 0.040</td>
<td>0.274 ± 0.044a</td>
<td>0.213 ± 0.027b</td>
<td>0.183 ± 0.048</td>
</tr>
</tbody>
</table>

\(^a\, p < 0.01\) vs. TEN.
\(^b\, p < 0.05\) vs. TEN.
Early enteral feeding for burned patients—An effective method ... encouraged in developing countries
Lam et al Burns 2008: 34(2):192

• RCT in 82 severe burned patients admitted to National Institute of Burns, Hanoi, Vietnam
• plasma level of IgG, IgM, insulin, cortisol and blood absolute number of TCD4, TCD8.
• Intestinal chyme was drawn: intestinal secreted IgA.
• D7 after burn: both humoral and cellular immunology recovered faster in EEN group compared to TPN ($p < 0.05$).
• EEN: plasma cortisol $\downarrow$ from 599.7 to 437 nmol/l and that of insulin increased from 12.1 to 30.3 µmol/ml. Control group - reverse change ($p < 0.01$).
• Overall complication $\downarrow$ in EEN group compares with TPN group.
• Mortality significantly lower in EEN group versus TPN group (14.7% and 36.6%, respectively).
Early enteral feeding for burned patients-- an effective method which should be encouraged ...
Lam et al, Burns 2008; 34:192

Aim: RCT to investigate impact of early EN on immune, metabolic aspects and outcomes
Patients : 82 severe burned patients
National Institute of Burns, Hanoi, Vietnam from Nov 2003 to Nov 2004

<table>
<thead>
<tr>
<th>Patients characteristics</th>
<th>EN group (mean ± S.E.M.)</th>
<th>TPN group (mean ± S.E.M.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>41</td>
<td>41</td>
</tr>
<tr>
<td>Age (years)</td>
<td>32.0 ± 1.5</td>
<td>33.3 ± 1.9</td>
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<tr>
<td>Burn Surface area (%)</td>
<td>49.8 ± 1.4</td>
<td>48.6 ± 1.3</td>
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<tr>
<td>Full thickness area (%)</td>
<td>15.7 ± 2.3</td>
<td>16.1 ± 1.8</td>
</tr>
<tr>
<td>Admission time postburn (h)</td>
<td>9.7 ± 1.4</td>
<td>10.1 ± 1.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Patients characteristics</th>
<th>EN group (%)</th>
<th>TPN group (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall complication</td>
<td>17/41 (41.5)</td>
<td>27/41 (65.8)</td>
</tr>
<tr>
<td>GI hemorrhage</td>
<td>0/41 (0)</td>
<td>4/41 (9.4)</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>10/41 (24.9)</td>
<td>17/41 (41.5)</td>
</tr>
<tr>
<td>Acute renal failure</td>
<td>2/41 (4.9)</td>
<td>5/41 (12.2)</td>
</tr>
<tr>
<td>Septic shock</td>
<td>10/41 (24.4)</td>
<td>25/41 (60.9)</td>
</tr>
<tr>
<td>Bacteremia</td>
<td>7/41 (17.1)</td>
<td>7/41 (17.1)</td>
</tr>
<tr>
<td>P. aeruginosa bacteremia</td>
<td>2/41 (4.9)</td>
<td>6/41 (14.6)</td>
</tr>
<tr>
<td>Death</td>
<td>6/41 (14.6)</td>
<td>15/41 (36.6)</td>
</tr>
</tbody>
</table>

\[ p < 0.01 \text{ as compared between two groups.} \]

\[ p < 0.05 \text{ as compared between two groups.} \]
Male with burns 55% TBSA – professional injury
PEG a good tool even with a burned abdomen
ENERGY & PROTEINS
Major burns - Energy expenditure

N = 87
565 determinations

% REE

Days post burn
0-3 4.20 21.40 41.60 61.80 >80

30-50 % BSA
51-75 % BSA
76-98 % BSA
Energy requirements in major burns
Burn specific formula

Daily energy requirements =

**Curreri (Cuthbertson) formula**

(J Am Diet Assoc, 1974)

(25 kcal x kg) + (40 kcal x % BSA)

**Toronto** (Allard et al 1990)

*Formula integrating*

Age, Sex, Weight, previous day feed, % BSA, T°C, days after burn

$$TEE= -4.343 + (10.5 \times \% \text{BSA}) + 0.23 \times \text{CI} + 0.84 \times \text{REE H-B}) + (114 \times T°C) – (4.5 \times \text{days})$$
Energy requirements in major burns change over time

REE by indirect calorimetry

GG
15 yrs
55 kg
62 % BSA

REE

Day 5
Day 11
Day 26

REE by indirect calorimetry

40 kcal/kg

Days after burn

Days after burn

REE

40 kcal/kg

REE by indirect calorimetry

REE

REE by indirect calorimetry
Nutritional follow up

male 28 years, admission weight 75 kg, burns 72% TBSA
UNDER feeding is dangerous

OVER feeding is deleterious
What happens backstage?

Shriners
A Aarsland 2003
Fatty infiltration of the liver in burned children

Barret JP et al, J Trauma 51: 736, 2001

Distribution of deaths over time in patients with and without fatty liver. The fatty infiltration of the liver followed a pattern of microvacuolar to macrovacuolar deposition as time passed.
Micronutrients - Trace elements in burns?

<table>
<thead>
<tr>
<th>Periodic Table</th>
<th>Essential for humans</th>
<th>Suggested to be essential for humans</th>
<th>Nonessential for humans</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 H</td>
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<tr>
<td>2 Li</td>
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<td></td>
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<tr>
<td>3 Be</td>
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<tr>
<td>11 Na</td>
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<tr>
<td>12 Mg</td>
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<td>19 K</td>
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<td>20 Ca</td>
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<td>37 Rb</td>
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<td>55 Cs</td>
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<td>87 Fr</td>
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<td>38 Sr</td>
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<td>39 Y</td>
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<td>40 Zr</td>
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<td>41 Nb</td>
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<td>45 Tm</td>
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<td>46 Yt</td>
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<td>47 Lu</td>
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<td>51 Re</td>
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<td>55 Au</td>
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<td>56 Hg</td>
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<td>59 Bi</td>
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<tr>
<td>61 At</td>
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<tr>
<td>62 Rn</td>
<td></td>
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</tbody>
</table>

Circled elements: Cu, Zn, Se.
Burns: Trace element and mineral losses

(N=10, 33% BSA)

Antioxidants in major burns

Accelerated MDA decay with trace elements

Berger & Chiolero, Burns, 21: 507, 1995

Design: PCT
11 patients (5 / 6)
BSA 42 / 43 %
Group control: ø
Group TE: Cu, Se, Zn
Urine: 24 hr coll.
p<0.03
Trace element supplementation after major burns modulates antioxidant status and clinical course by way of increased tissue trace element concentrations\textsuperscript{1–3}

Mette M Berger, Malcolm Baines, Wassim Raffoul, Messod Benathan, René L Chiolero, Chris Reeves, Jean-Pierre Revelly, Marie-Christine Cayeux, Isabelle Sénéchaud, and Alan Shenkin

Mean plasma TE over time

**Copper**

**Zinc**

**Selenium**

**plasma GSHPx**

Am J Clin Nutr 2007; 85: 1293
TE after major burns increase [burned skin] and modulate local protein metabolism


**Graphs:**
- **Zn (nmol/g dry wt):**
  - Vehicle and Trace element graphs showing changes over days.
  - Days after injury from 0 to 20.
  - Significant differences indicated by asterisks.

- **Se (nmol/g dry wt):**
  - Vehicle and Trace element graphs showing changes over days.
  - Days after injury from 0 to 20.
  - Significant differences indicated by asterisks.

- **GSSG reductase, Glutathione, GSHPx:**
  - Graphs showing changes over time with means ± SD.
  - Significant differences indicated by different symbols.
  - Time (days) from 3 to 20.
Trace element (Cu, Se, Zn) substitution in Burns - Nosocomial pneumonia

Berger et al, 2006, Crit Care e-pub

Aggregation of 2 consecutive Randomized Trials → IV
- Cu 3 mg
- Se 300 mcg
- Zn 30 mg

Log Rank p=0.0014
Wilcoxon p=0.0019

65% reduction of pneumonia risk
Weigh your patients
Hyperglycemia and ↑ mortality after major burns
*Gore DC et al, J Trauma, 51:540, 2001*

Retrospective survey 1996-1999 in 58 children with burns > 60% BSA
Glucose control: poor: ≥ 40% of glycemias ≥ 7.8 mmol/l
Adequate: < 40% glycemias ≥ 7.8 mmol/l

→ More infections (Bacteremia & Wounds)
### Graphs by period

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>N patients</td>
<td>20</td>
<td>80</td>
<td>68</td>
<td>61</td>
</tr>
</tbody>
</table>

**Arterial blood glucose (mmol/l)**

- **2000-2001**: Baseline
- **2002-2006**: Tight physician control
- **2007-2010**: Tight nurse control
- **2011-2014**: Moderate nurse control

**Stoecklin et al, Burns 2016**

**Better control of glucose → less infections**
Reversal of catabolism by β-blockade in burns
Herndon DN et al, NEJM, 345:1223, 2001

25 children with burns 50% BSA
PRCT (13/12)
Age 9 ±1 year
TBSA 60 ±3 %
LOS 35 ±4 days
Propranolol for 2 weeks
adjusted to decrease heart rate by 20% from baseline
Reversal of catabolism by $\beta$-blockade in burns

*Herndon DN et al, NEJM, 345:1223, 2001*

Mean (±SE) change from base line in the net balance of muscle-protein synthesis and breakdown during 2 weeks of treatment.

Method: 5-hour kinetic study that used isotopically labeled phenylalanine.

Asterisk = significant difference between groups ($p=0.001$ by t-test) and significant difference between the base-line and value at 2 weeks ($p=0.002$ paired t-test)
Five-Year Outcomes after Oxandrolone administration in Severely Burned Children: A RCT of Safety & Efficacy
Poro et al, J Am Coll Surg 2012;214:489

572 total observations.

(A) total body bone mineral content (B) lean body mass
Monitor nutrition as any ICU therapy

- Energy delivery
- Protein delivery
- Copper (Se, Zn)
# Energy & Substrate requirements

<table>
<thead>
<tr>
<th>Energy</th>
<th>measured EE</th>
<th>Non burn ICU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>minimum 30 kcal/kg/d</td>
<td>measured EE</td>
</tr>
<tr>
<td></td>
<td>20-25 kcal/day</td>
<td>20-25 kcal/day</td>
</tr>
<tr>
<td>CARBS</td>
<td>55-60% total Energy</td>
<td>50%</td>
</tr>
<tr>
<td>Proteins</td>
<td>1.5 – 2.0 g/kg</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>20-25% of total energy</td>
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<tr>
<td></td>
<td>*Includes GLN  30 g/j</td>
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<tr>
<td>Lipids</td>
<td>max 0.5 g/kg</td>
<td>30-35%</td>
</tr>
<tr>
<td></td>
<td>*15% of total energy</td>
<td></td>
</tr>
<tr>
<td>Micronutrients</td>
<td>Trace elements: Cu 3 mg, Se 300-500 µg, Zn 30 mg</td>
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<tr>
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<td>Vitamins: 2-5 times normal normal requirements</td>
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<tr>
<td></td>
<td>Nutrition</td>
<td>Labo</td>
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</table>

**Delivery**
- Target (kcal)
  - % target
  - Energy 24h
  - Energy EN
  - Proteins (g)
  - CarboHyd (g)
  - Lipids (g)
  - Insulin (U/24h)

**Requirements**
- Energy balance
- Weight (kg)
  - Harris&Benedict
  - Calorimetry EE

**Losses**
- Faeces
  - Traces
  - Gaz
  - Diarrhée

**Nutrition in Burn Injury – any recent changes?**
Berger, CO Crit Care, 2016 in press

**Graphs and Data**
- Energy Balance
- Albumin
- Prealbumin
- Urea
- Actual weight
- Glutamine (ml/h)
- Enteral Feed (ml/h)
- Trace elements
- Vitamins
Impact of a computerized information system on quality of nutritional support in the ICU

Effectiveness of caloric value in major burns
Rimdeika el al, Burns 32:83,2006

*Pneumonia
*Pulmonary edema
*Sepsis
Renal insufficiency

Age 42 years
Burn 24% BSA

*difference statistically significant
Weight evolution in major burns $\triangle$ intake

Pantet et al. ClinNutr in press

<table>
<thead>
<tr>
<th>Period</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>33</td>
<td>31</td>
<td>31</td>
<td>28</td>
</tr>
<tr>
<td>E target</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>

$\text{E target} \quad (7) \quad (7) \quad (7) \quad (8) \quad p<0.001$

AUC day 14 to day 21: P1: 601, P2: 616, P3: 605, P4: 603, $p=0.022$. 

Copper

A 33-y-old man was the only survivor of an explosion in a garage. Burn injury 96% BSA, including 85% surgical burns & inhalation injury.
Conclusion: nutrition ICU burn

- Early enteral nutrition
- Early trace elements (Cu, Se, Zn)
- Metabolic Requirements change over time↑:
  energy proteins glucose micronutrients
- Monitor:
  Feed delivery (daily)
  Weights (daily, min 3x/week)
  Blood glucose (daily)
- Nurse handling!
- Modulation of metabolic response with propranolol & oxandrolone