### Parenteral Micronutrient Recommendations and Laboratory Monitoring for Infants on Long Term Parenteral Nutrition (PN)

<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>Dosage</th>
<th>Monitor Level</th>
<th>Reference Range</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td><strong>Trace Elements</strong></td>
<td></td>
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</tbody>
</table>
| Chromium⁴     | 0.05-0.3 mcg/kg/day (add only if level low) | After 30 days of PN, then monthly if abnormal or if cholestasis present      | Serum: 0-14 yrs: 0.65-0.88 mcg/L² Term: <1 mo: 0.6-0.8 mcg/L 1-2 mo: 0.5-0.7 mcg/L³ Preterm: <1 mo: 0.8-1 mcg/L 1-2 mo: 0.8-1.2 mcg/L³ | • ASPEN recommends revising to 0.0006 mcg/kg/day for 0-6 mo⁴  
• Routine supplementation may be unnecessary due to contamination in PN solutions⁴  
• Excreted via urine  
• Max dose = 5 mcg/day |
| Copper⁵       | 20 mcg/kg/day   | After 30 days of PN, then monthly (if normal)                                 | Serum: 0-2 mo: 40-140 mcg/dL 3-6 mo: 40-160 mcg/dL >6 mo – 2 yrs: 72-178 mcg/dL⁶ | • Do not adjust dose for cholestasis⁷  
• If abnormal, refer to Appendix A |
| Iodine        | 1 mcg/kg/day    | Not recommended                                                                | -                                                              | • Supplied only in Peditrace® product |
| Manganese     | 1 mcg/kg/day    | After 30 days of PN, then monthly                                            | Whole blood: 4.2-16.5 mcg/L¹¹ | • Excreted via bile; may need to decrease or withhold if cholestasis present  
• Max dose = 50 mcg/day |
| Molybdenium   | 1 mcg/kg/day    | Not recommended                                                                | -                                                              | • None provided in trace element products |
| Selenium      | 2 mcg/kg/day    | Routine monitoring not necessary                                               | Serum: 3-9.4 mcg/dL¹² (30-94 mcg/L)                             | • Dose may need to be reduced with chronic renal failure; consider monitoring levels  
• If abnormal, refer to Appendix B  
• May need to increase dose with high ostomy output  
• Max dose = 5 mg/day |
| Zinc          | 400 mcg/kg/day  | After 30 days of PN, then monthly (if normal)                                 | Serum: 58-144 mcg/dL⁶                                         | • If low, increase dose to 10 mg/kg/day; repeat level in 1 month |
| Carnitine     | 5 mg/kg/day     | After 30 days of PN; repeat only if abnormal                                  | Total carnitine: 1-31 days: 21-83 µmol/L 32 days-12 mo: 38-73 µmol/L | • If low, increase dose to 10 mg/kg/day; repeat level in 1 month |

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Appendix A--Copper

Provide copper at standard dose of 20 mcg/kg/day

Obtain serum copper level after 30 days of PN*

Low

Increase copper by 10 mcg/kg/day in PN (max 40 mcg/kg/day)¹³

Monitor serum copper level in 2 weeks

Low

Normal or trending up

Normal

Maintain current dose of copper in PN

Monitor serum copper level in 2 weeks

Normal or trending up

High

Monitor serum copper level every 4 weeks

Low

Normal or trending up

High

Serum Copper, Reference Values:
0-2 Mo: 40-140 mcg/dL
3-6 Mo: 40-160 mcg/dL
>6 Mo – 2 yrs: 72-178 mcg/dL⁶

High

Decrease copper to 10 mcg/kg/day OR 20 mcg/kg 3 times per week

Monitor serum copper level in 2 weeks

Low

Normal or trending down

High

Increase copper to 20 mcg/kg/day

Maintain current dose of copper in PN

Decrease copper to 20 mcg/kg once weekly

Return to previous dose

"PN = Parenteral Nutrition"
Appendix B--Zinc

Provide zinc at standard dose:
Preterm: 400 mcg/kg/day
Term <3 mo: 250 mcg/kg/day
Term >3 mo: 100 mcg/kg/day

Obtain serum zinc level after 30 days of PN*

Low

Increase zinc by 50 mcg/kg/day in PN (max 500 mcg/kg/day)

Monitor serum zinc level in 2 weeks

Low

Maintain current dose of zinc in PN

Normal

Maintain current dose of zinc in PN

Monitor serum zinc level every 4 weeks

Normal or trending up

High

Decrease zinc by 50 mcg/kg/day

High

Low

Normal or trending down

High

Decrease zinc by 50 mcg/kg/day

Low

Normal or trending up

High

Decrease zinc by 50 mcg/kg/day

Low

Normal or trending down

High

Decrease zinc by 50 mcg/kg/day

Serum zinc, Reference Values:
Term and preterm: 58-144 mcg/dL⁶

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*PN = Parenteral Nutrition
<table>
<thead>
<tr>
<th>Trace Element</th>
<th>Function</th>
<th>Deficiency</th>
<th>Toxicity</th>
</tr>
</thead>
</table>
| Copper        | Cofactor for several key physiologic enzymes, important for:  
  - Connective tissue synthesis  
  - Hematopoiesis  
  - Incorporation of iron into hemoglobin  
  - Formation of melanin  
  - Bone mineralization  
  - Immune and metabolic functions  
| Hypochromic, microcytic anemia  
  - Neutropenia  
  - Osteopenia  
  - Depigmentation of skin and hair  
  - Hypotonia, poor feeding  
| Hepatic necrosis and cirrhosis |
| Chromium      | Enhances ability of insulin to bind to insulin receptors; important for metabolism of carbohydrates, protein, and fat  
| None reported in infants |
| Iodine        | Important component of thyroid hormones; necessary for growth and development  
| Hypothyroidism  
  - Poor growth  
  - Poor neurodevelopment  
  - Cretinism  
  - Goiter  
| Hyperthyroidism  
  - GI irritation  
  - Chronic: hyperthyroidism, goiter |
| Manganese     | Role in enzyme activation (e.g. superoxide dismutase)  
| Nausea  
  - Vomiting  
  - Dermatitis  
  - Hair depigmentation  
  - Growth retardation  
| Cholestasis  
  - Neurotoxicity |
| Molybdenum    | Required for several enzyme involved in DNA metabolism  
| None reported in infants |
| Selenium      | Component of glutathione peroxidase  
  - Plays role in metabolism of thyroid hormone  
| Oxidative diseases (e.g. bronchopulmonary dysplasia, retinopathy of prematurity, myopathy, hypothyroidism)  
| None reported in infants |
| Zinc          | Involved in metabolism of energy, proteins, carbohydrates, lipids  
  - Plays role in immune function  
| Growth retardation  
  - Impaired wound healing and immune function  
  - Diarrhea  
| Nausea and vomiting  
  - Diarrhea  
  - Decreased serum copper levels |
Appendix D

Neonatal and Pediatric Multitrace Element Comparison Table

<table>
<thead>
<tr>
<th>Trace Element</th>
<th>Multitrace 4 Neonatal® (mcg/per mL)</th>
<th>Multitrace 4 Pediatric® (mcg/per mL)</th>
<th>Trace Elements 4 Pediatric® (mcg/per mL)</th>
<th>Peditrace® (mcg/per mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chromium</td>
<td>0.85</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Copper</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td>Fluorine</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Iodine</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Manganese</td>
<td>25</td>
<td>25</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Selenium</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Zinc</td>
<td>1500</td>
<td>1000</td>
<td>500</td>
<td>250</td>
</tr>
</tbody>
</table>

Appendix E

Micronutrient Lab Collection Procedure

<table>
<thead>
<tr>
<th>ARUP Number</th>
<th>Collect</th>
<th>Specimen Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>020096</td>
<td>Royal blue top--red stripe</td>
<td>1 mL</td>
</tr>
<tr>
<td>098830</td>
<td>Royal blue top--red stripe</td>
<td>1 mL</td>
</tr>
<tr>
<td>020097</td>
<td>Royal blue top--red stripe</td>
<td>1 mL</td>
</tr>
<tr>
<td>0099272</td>
<td>Royal blue top--purple stripe (EDTA)</td>
<td>0.5 mL</td>
</tr>
</tbody>
</table>

*Please send copper, chromium and zinc in one royal blue top tube with total of 1 mL; include lab slips for all three with the specimen; Carnitine and manganese should be collected in separate tubes

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## Appendix F

### Standard Micronutrients Added to Parenteral Nutrition--SUMMARY

<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>Dosage at Initiation of PN</th>
<th>Monitor Level</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preterm (mcg/kg/day)</td>
<td>Term (mcg/kg/day)</td>
<td></td>
</tr>
<tr>
<td><strong>Trace Elements</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Chromium      | None                      | None          | • Routine supplementation unnecessary due to contamination in PN solutions  
|               | After 30 days of PN, then monthly if abnormal or if cholestasis present |               |  
|               | • If level low, add 0.2 mcg/kg/day  
|               | • Max dose = 5 mcg/day |               |          |
| Copper        | 20                        | 20            | • Do not adjust dose for cholestasis  
|               | After 30 days of PN, then monthly (if normal) |               |  
|               | • If abnormal, refer to Appendix A |               |          |
| Manganese     | 1                         | 1             | • Excreted via bile; may need to decrease or withhold if cholestasis present  
|               | After 30 days of PN, then monthly |               |  
|               | • Max dose = 50 mcg/day |               |          |
| Selenium      | 2                         | 2             | • Dose may need to be reduced with chronic renal failure; consider monitoring levels  
|               | Routine monitoring not necessary |               |  
| Zinc          | 400                       | <3 Mo: 250  
|               | >3 Mo: 100                | After 30 days of PN, then monthly (if normal) |  
|               | • If abnormal, refer to Appendix B  
|               | • May need to increase dose with high ostomy output  
|               | • Max dose = 5 mg/day |               |          |
| **Carnitine** | 5 mg/kg/day               | 5 mg/kg/day   | • If low, increase dose to 10 mg/kg/day; repeat level in 1 month |
References


