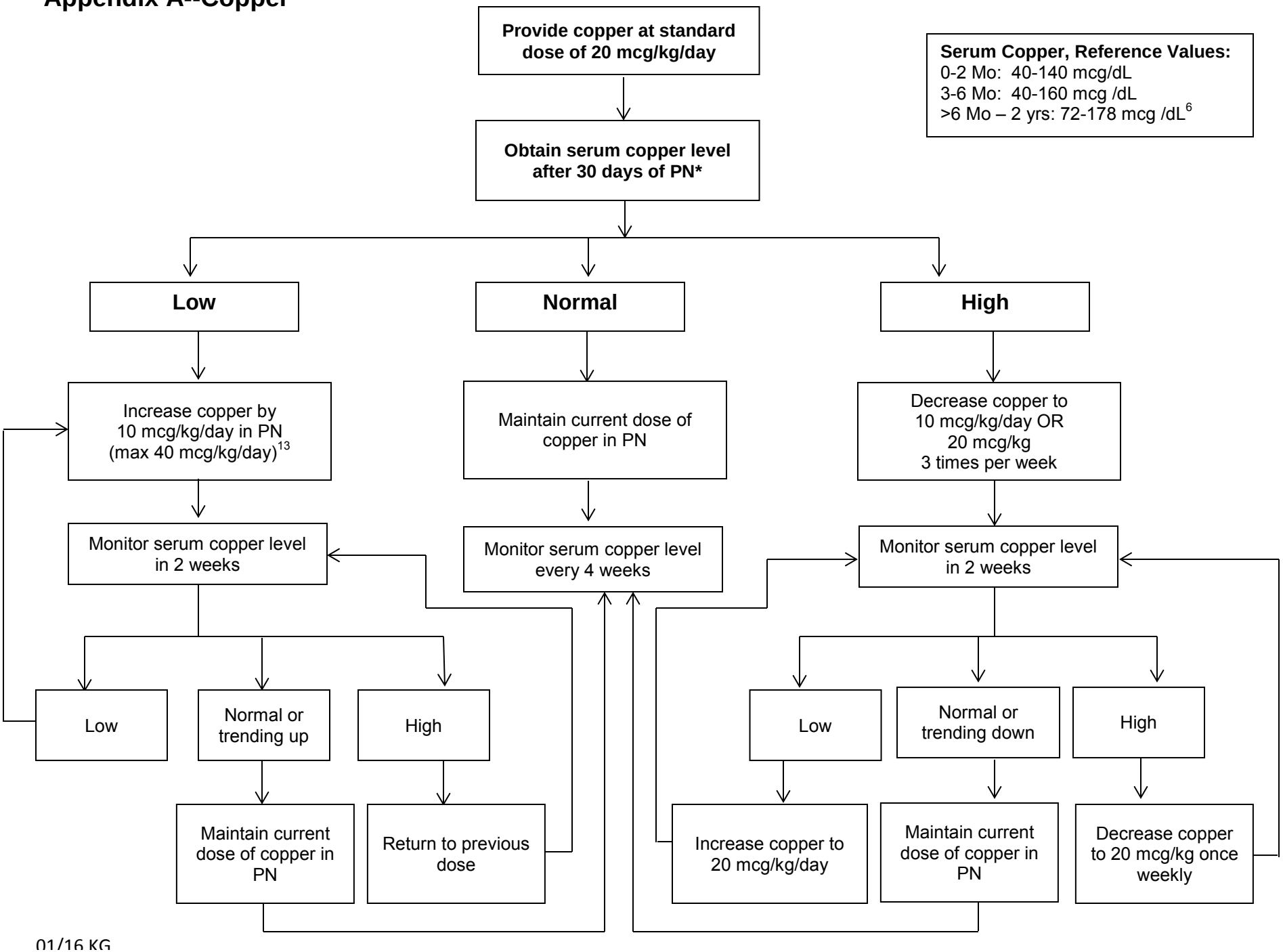
Parenteral Micronutrient Recommendations and Laboratory Monitoring for Infants on Long Term Parenteral Nutrition (PN)

Micronutrient	Dosage		Monitor Level	Reference Range	Comments
	Preterm	Term			
Trace Elements	(mcg/kg/day)	(mcg/kg/day)			
Chromium[1]	0.05-0.3 (add only if level low)	0.2 (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/L[2] Term: <1 mo: 0.6-0.8 mcg/L 1-2 mo: 0.5-0.7 mcg/L[3] Preterm: <1 mo:0.8-1 mcg/L 1-2 mo: 0.8-1.2 mcg/L[3]	• ASPEN recommends revising to 0.0006 mcg/kg/day for 0-6 mo[1] • Routine supplementation may be unnecessary due to contamination in PN solutions[4] • Excreted via urine • Max dose = 5 mcg/day
Copper[5]	20	20	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/dL[6]	• Do **not** adjust dose for cholestasis[7-10] • If abnormal, refer to Appendix A
Iodine	1	1	Not recommended	-	• Supplied only in Peditrace® product
Manganese	1	1	After 30 days of PN, then monthly	Whole blood: 4.2-16.5 mcg/L[11]	• Excreted via bile; may need to decrease or withheld if cholestasis present • Max dose = 50 mcg/day
Molybdenum	1	0.25	Not recommended	-	• None provided in trace element products
Selenium	2	2	Routine monitoring not necessary	Serum: 3-9.4 mcg/dL[12] (30-94 mcg/L)	• Dose may need to be reduced with chronic renal failure; consider monitoring levels
Zinc	400	<3 Mo: 250 >3 Mo: 100	After 30 days of PN, then monthly (if normal)	Serum: 58-144 mcg/dL[6]	• 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	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

Appendix A--Copper



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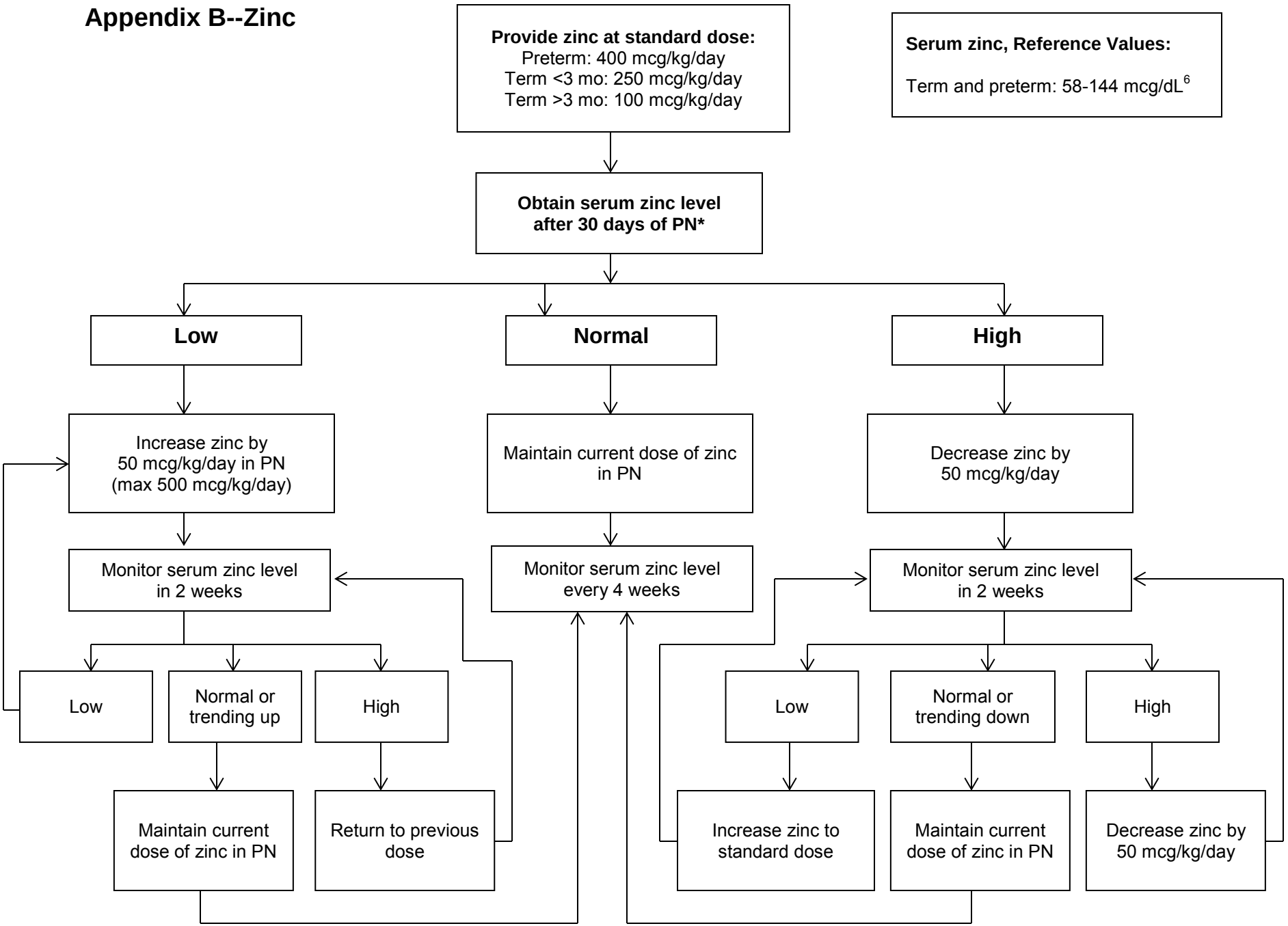
*PN = Parenteral Nutrition

Appendix B--Zinc



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Appendix C

Function, Deficiency, and Toxicity of Trace Elements			
Trace Element	**Function**	**Deficiency**	**Toxicity**
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	• Chronic renal failure
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	• Increases urinary excretion of copper
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				
Trace Element	Multitrace 4 Neonatal® (mcg/per mL)	Multitrace 4 Pediatric® (mcg/per mL)	Trace Elements 4 Pediatric® (mcg/per mL)	Peditrace® (mcg/per mL)
Chromium	0.85	1	1	-
Copper	100	100	100	20
Fluorine	-	-	-	57
Iodine		-	-	1
Manganese	25	25	30	1
Selenium	-	-	-	2
Zinc	1500	1000	500	250

Appendix E

Micronutrient Lab Collection Procedure			
	ARUP Number	**Collect**	**Specimen Minimum**
Copper, serum* Chromium, serum* Zinc, serum*	020096 098830 020097	Royal blue top--red stripe	1 mL
Carnitine, total	080067	Green or red top--frozen	0.5 mL
Manganese, whole blood	0099272	Royal blue top--purple stripe (EDTA)	0.5 mL

*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

Appendix F

Standard Micronutrients Added to Parenteral Nutrition--SUMMARY				
Micronutrient	**Dosage at Initiation of PN**		**Monitor Level**	**Comments**
	Preterm	**Term**		
Trace Elements	(mcg/kg/day)	(mcg/kg/day)		
Chromium	None	None	After 30 days of PN, then monthly if abnormal or if cholestasis present	• Routine supplementation unnecessary due to contamination in PN solutions • If level low, add 0.2 mcg/kg/day • Max dose = 5 mcg/day
Copper	20	20	After 30 days of PN, then monthly (if normal)	• Do **not** adjust dose for cholestasis • If abnormal, refer to Appendix A
Manganese	1	1	After 30 days of PN, then monthly	• Excreted via bile; may need to decrease or withhold if cholestasis present • Max dose = 50 mcg/day
Selenium	2	2	Routine monitoring not necessary	• Dose may need to be reduced with chronic renal failure; consider monitoring levels
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	After 30 days of PN; repeat only if abnormal	• If low, increase dose to 10 mg/kg/day; repeat level in 1 month

References

1. Vanek VW, Borum P, Buchman A, Fessler TA, et al. A.S.P.E.N. Position paper: recommendations for changes in commercially available parenteral multivitamin and multi-trace element products. *Nutr Clin Pract.*2012;27:440-91.
2. Bougle D, Bureau F, Voirin J, et al. Plasma chromium concentrations in infants and cystic fibrosis patients. *Biol Trace Elem Res*.1992;Jan-Mar;32:53-5.
3. Bougle D, Bureau F, Voirin J, et al. Chromium status of full-term and preterm newborns. *Biol Trace Elem Res*.1992;Jan-Mar;32:47-51.
4. Koletzko B, Goulet O, Hunt J, Krohn K, Shamir R. Guidelines on paediatric parenteral nutrition of the European Society of Paediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN) and the European Society for Clinical Nutrition and Metabolism (ESPEN), supported by the European Society of Paediatric Research (ESPR). *J Pediatr Gastroenterol Nutr.*2005;41(suppl 2):S1-S4.
5. Greene HL, Hambidge KM, Schanler R, et al. Guidelines for the use of vitamins, trace elements, calcium, magnesium, and phosphorus in infants and children receiving total parenteral nutrition: report of the Subcommittee on Pediatric Parenteral Nutrient Requirements from the Committee on Clinical Practice Issues of the American Society for Clin Nutr. *Am J Clin Nutr.* 1988; 48:1324–42.
6. Lin C, Wilson A, Church B, et al. Pediatric reference intervals for serum copper and zinc. *Clinica Chimica Acta.* 2012;413:612-15.
7. Sutton AM, Harvie A, Cockburn F, et al. Copper deficiency in the preterm infant of very low birthweight. *Arch Dis Child.* 1985;60:644-51.
8. Frem J, Sarson Y, Sternbern T, Cole CR. Copper supplementation in parenteral nutrition of cholestatic infants. *J Pediatr Gastroenter Nutr.* 2010;50:650-54.
9. Corkins MR, Martin VA, Szeszycki EE. Copper levels in cholestatic infants on parenteral nutrition. *J Parenter Enteral Nut.* 2013;37:92-6.
10. Blackmer A, Bailey E. Management of copper deficiency in cholestatic infants: review of the literature and a case series. *Nutr Clin Pract.* 2013;28:75-86.
11. McMillan NB, Mulroy C, Mackay MW, et al. Correlation of cholestasis with serum copper and whole-blood manganese levels in pediatric patients. *Nutr Clin Pract.*2008;23:161-5.
12. Marriott LD, Foote KD, Kimber AC, et al. Zinc, copper, selenium, and manganese blood levels in preterm infants. *Arch Dis Child Fetal Neonatal Ed.* 2007;92:F494-97.
13. Lockitch G, Godolphin W, Pendray M, et al. Serum zinc, copper, retinol-binding protein, prealbumin, and ceruloplasmin concentrations in infants receiving intravenous zinc and copper supplementation. *J Pediatr.* 1983;102:304-8.