Pediatric PN

and what makes it so special

รศ.พญ. นฤมล เด่นทรัพย์สุนทร
นพ. เรืองวิทย์ ตันติแพทยางกูร

1st Introduction

then

The advanced

Introduction


Nutrients
Infection
Gut functions
Estimated requirements
Vascular access
Incompatibility
Growth and development
Liver impairment

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MEDICAL PROGRESS

Intravenous alimentation in pediatric patients

William C. Heird, M.D.,* John M. Driscoll, Jr., M.D., John N. Schullinger, M.D.,
Burton Grebin, M.D.,** and Robert W. Winters, M.D.,*** *New York, N. Y.*

Heird WC, et al (1972)

ND-RT


https://www.flickr.com/photos/hudsonthego/15703326

Pediatric Population

- Diversity
- Growth / development
- Plasticity
- Vulnerability
- Tailor-made nutrition
- Tailor-made preparation

Nutrients are essential in providing energy and substrates for GROWTH AND DEVELOPMENT

Pediatric PN

- To support normal growth and development in case of digestive system malfunction
- Compared to adults
  - Higher probability and more urgency of needing PN
  - Probably longer use of PN
  - More specific in terms of nutrient types and requirements

When to Start

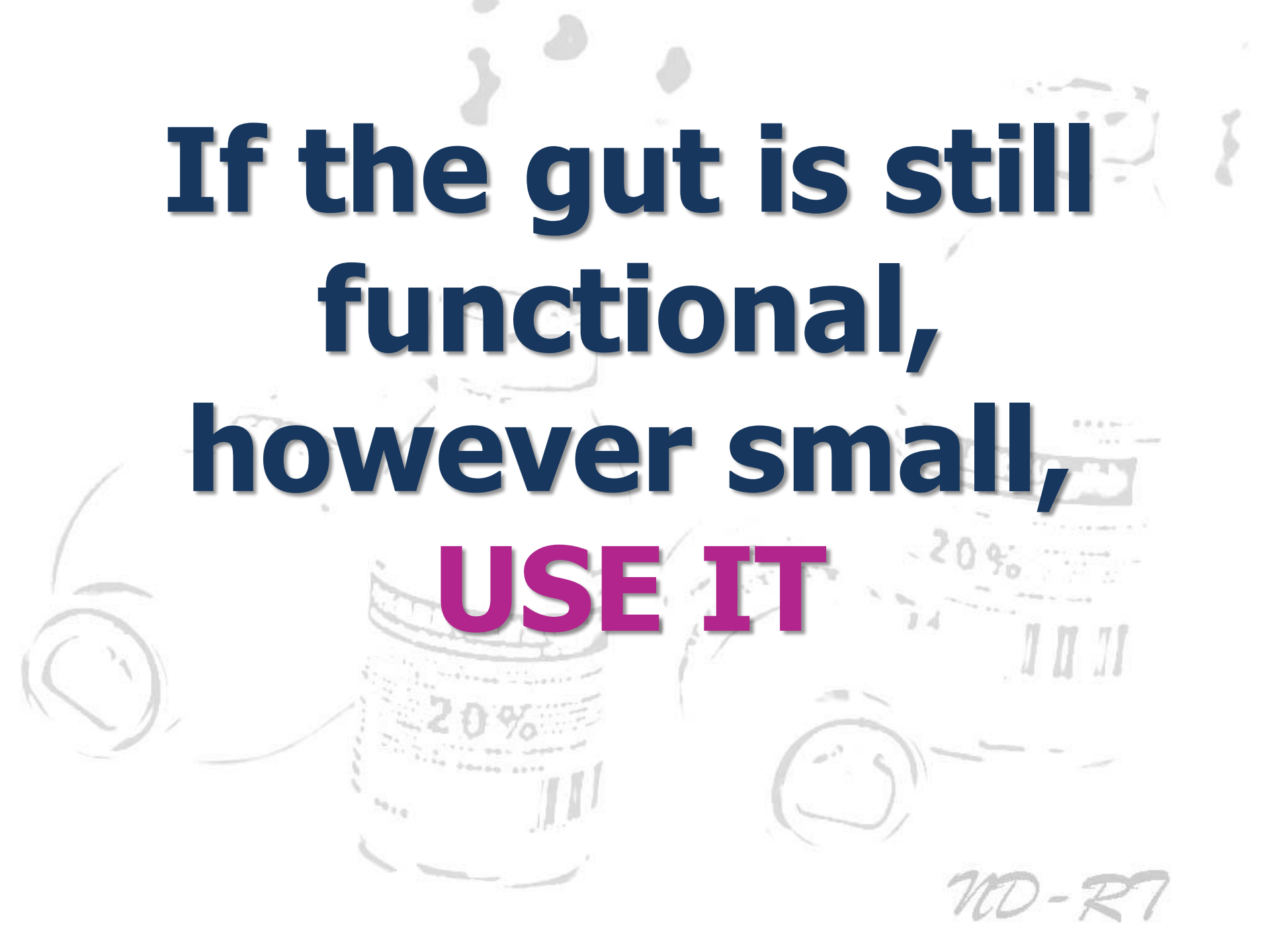
- Whenever
  - A child needs nutritional support

AND

- Oral/enteral feeding cannot fulfill his/her nutritional requirements

When to Start

- Whenever
  - A very low birth weight infant (<1500 g) cannot feed via GI tract in the first day of life
  - An infant cannot adequately feed via GI tract in 1-3 days
  - A small child cannot adequately feed via GI tract in 4-5 days
  - An adolescent cannot adequately feed via GI tract in 7-10 days


If the gut is still functional, however small,
USE IT

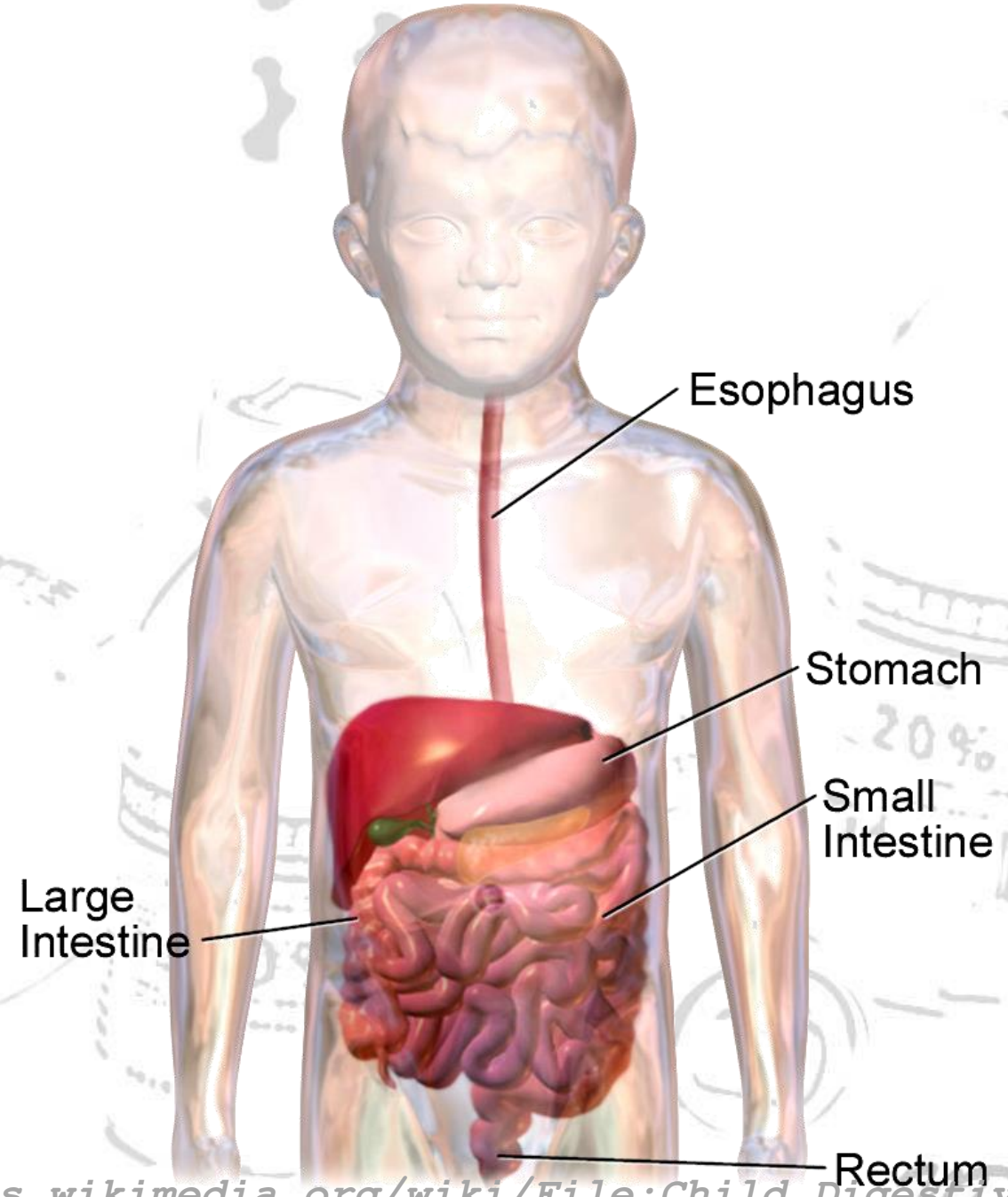
Potential Usage

- Extreme prematurity
- Premature infants
  - Small bowel ischemia, NEC
  - Omphalocele, gastroschisis, GI atresias
- Non-functional GI tract
  - Obstruction, ileus, chronic intractable diarrhea, malabsorption syndrome, short-bowel syndrome
- Severe malnutrition
- Impracticality of enteral feeding
- Vastly increased requirements
  - Burns, multi-organ failure

https://www.uptodate.com/contents/image?imageKey=PEDS%2F90425&topicKey=PEDS%2F15634&source=see_link

Physiology of PN

- Bypass of nutrients through gut and liver
- Absence of direct nutrient for enterocytes
- Deficient and relatively imbalanced nutrients
- Abnormally present nutrients



https://commons.wikimedia.org/wiki/File:Child_Digestive_System.png

Physiologic Effects

- Thinning of GI mucosa and blunting of villi
- Understimulation of gut hormones, bile, and pancreatic secretions
- Undermotility of gut
- Underfeeding or overfeeding of nutrients
- Lack of hunger and eating skills

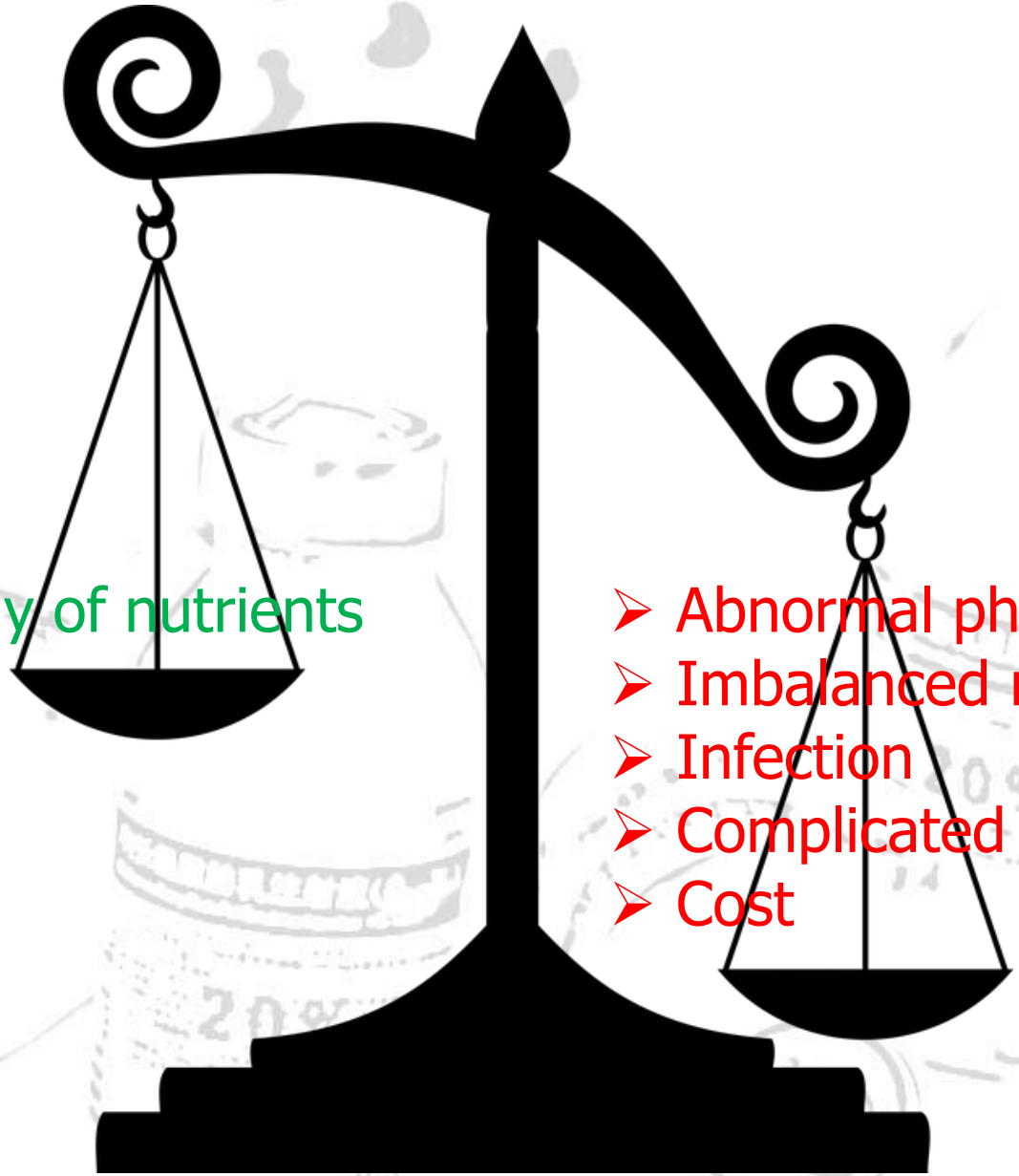
Kudsk KA(2003); Gahagan S (2012); Kaji T, et al (2002)

PN Advantages

- Supply of nutrients without using gut → life saving

PN Disadvantages

- Abnormal physiology
- Risk of imbalanced nutrients
- Risk of infection
- Complicated than enteral feeding → requiring special knowledge of care
- Expensive



Supply of nutrients

- Abnormal physiology
- Imbalanced nutrients
- Infection
- Complicated practicality
- Cost

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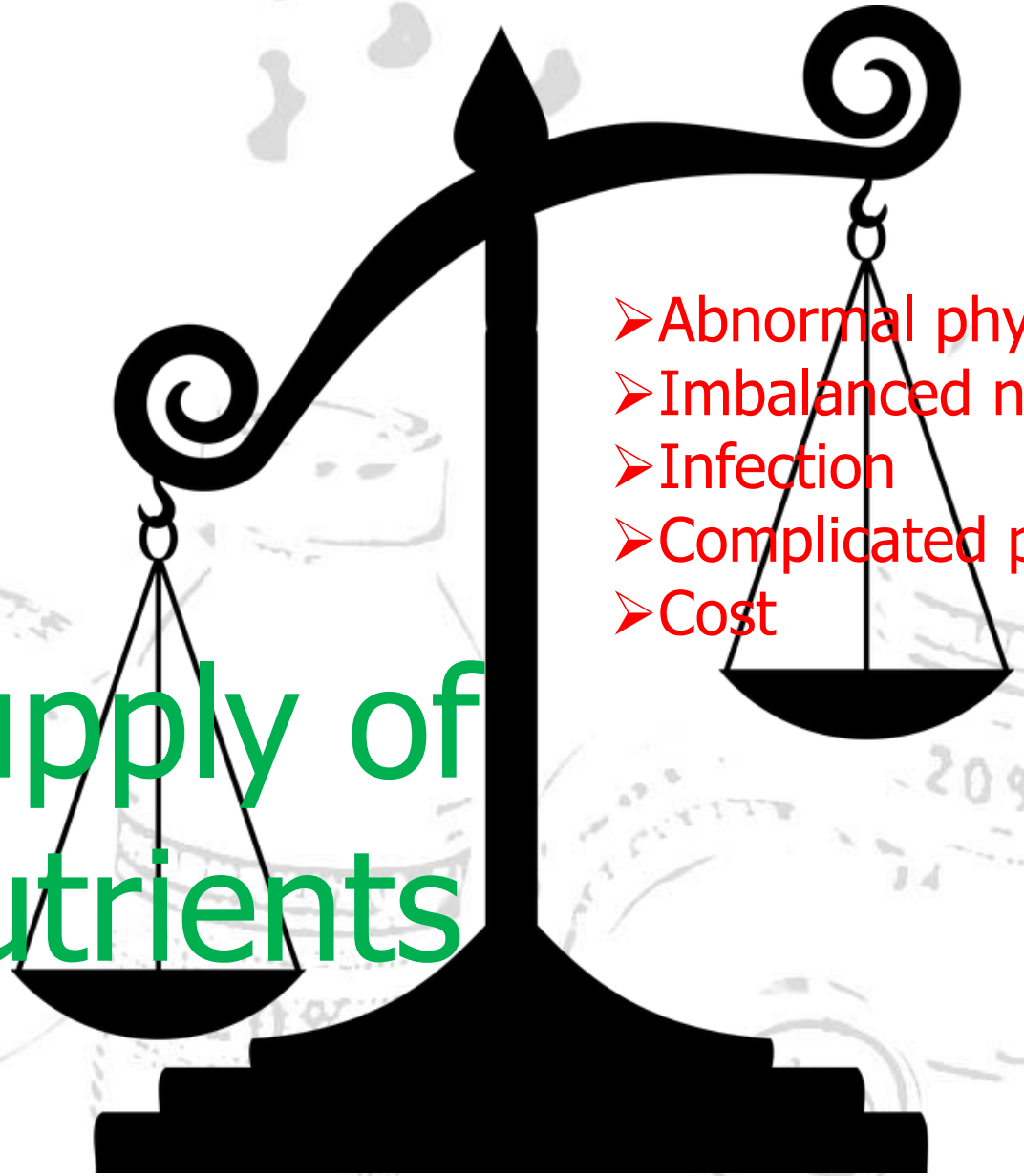

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https://pixabay.com/en/justice-measure-scale-silhouette-1296381/

PN is the LAST RESORT when enteral feeding in not feasible

Specific Considerations

- Patient stability
- Vascular access
- Pediatric nutritional assessment
- Pediatric PN preparations
- Other challenges specific to pediatric patients

Patient Stability

- Hemodynamic stability
  - Nutrients are not properly utilized without stable hemodynamics
- Fluid-electrolyte stability
  - Relatively large amount of fluid is essential for PN
  - Precautions in patients with electrolyte, cardiac, renal, or hepatic compromises

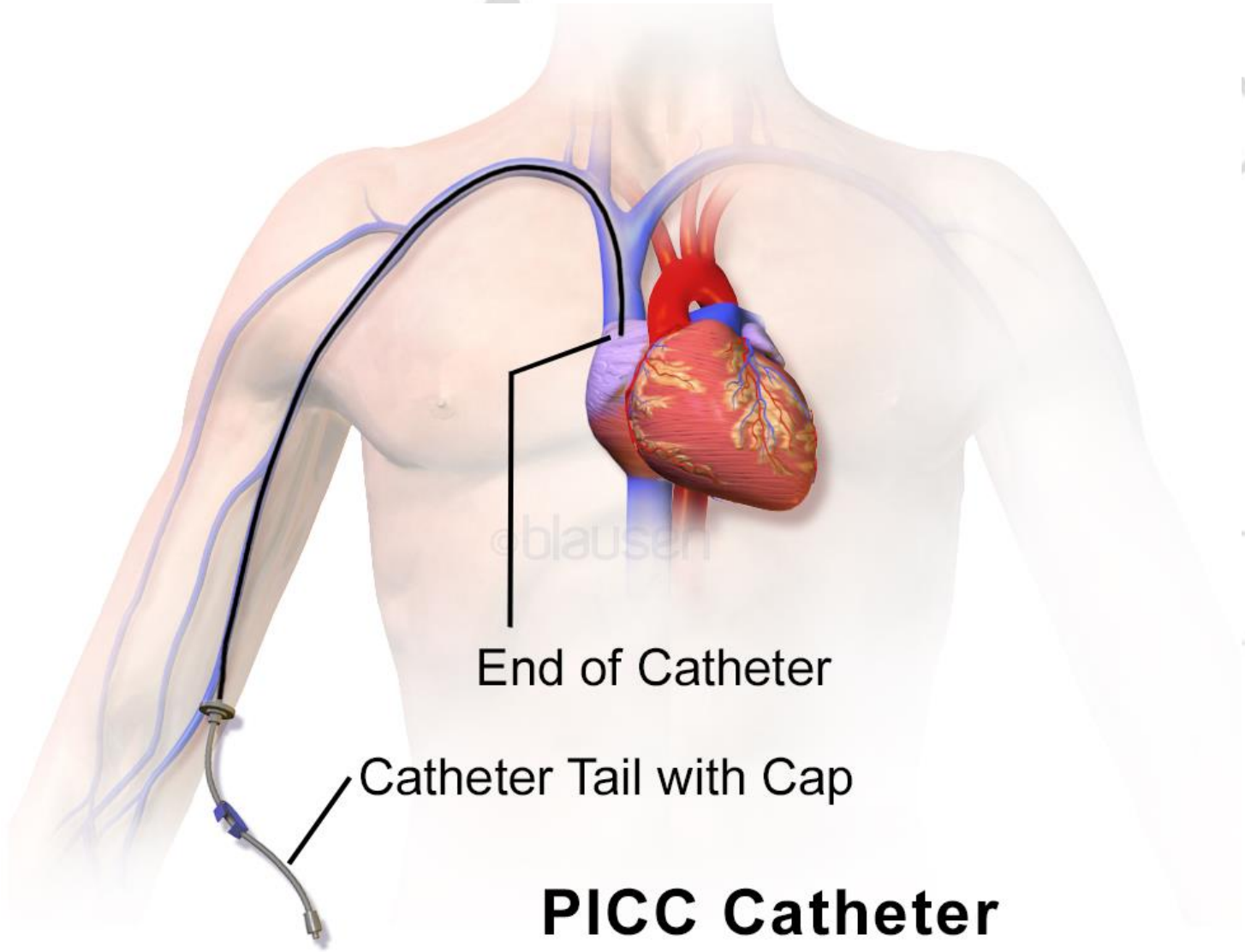
DO NOT start PN if the patient is hemodynamically unstable

DO NOT correct fluid, electrolyte, or metabolic imbalances with PN

Vascular Access

- Peripheral VS central venous access
  - Central lines → distal tip lying in the end of superior vena cava or the right atrium
- Osmolarity of the preparations =
  - (100 x amino acids in g/dL) +
  - (50 x glucose in g/dL) +
  - (2 x NaCl in mEq/L) +
  - (2 x KCl in mEq/L) +
  - (1.4 x Ca-gluconate in mEq/L)
  - In mOsm/L

Krzyuda EA, et al (2007); Baker RD, et al (2001)



https://commons.wikimedia.org/wiki/File:Blausen_0193_Catheter_PICC.png

Osmolarity Estimation

- A one-year-old, 10-kg boy
- Energy requirement 800 kcal, fluid requirement 1000 mL
- GIR 8.5 mg/kg/min (420 kcal), amino acid 20 g/day (80 kcal), lipid 30 g/day (300 kcal), in NSS/4 1000 mL, with 20 mEq of KCl
- = 200 + 612 + 77 + 40 = 929 mOsm/L

Long-term, high-energy TPN **REQUIRES** central vascular access

Nutritional Assessment

- To determine energy and protein requirements
- Measures
  - History and physical examination
  - Anthropometry
  - Disease conditions and complications
  - Laboratory tests
- Tailor-made TPN orders for the patient
- To follow up the results of treatment

Parameter	Suggested frequency	
	Initial/hospitalized	Follow up/home
Growth		
Weight	Daily	Daily to monthly
Height	Weekly	Weekly to monthly
Head circumference	Weekly	Weekly to monthly
Triceps skin fold	Monthly	Monthly to annually
Mid arm muscle circumference	Monthly	Monthly to annually
Serum*		
Electrolytes	Daily to weekly	Weekly to monthly
BUN, creatinine	Weekly	Monthly
Calcium, phosphorus, magnesium	Twice weekly	Weekly to monthly
Acid-base status (venous bicarbonate)	Until stable	Weekly to monthly
Albumin	Weekly	Weekly to monthly
Prealbumin[¶]	Weekly	Monthly
Glucose	Daily to weekly	Weekly to monthly
Triglycerides	Daily while increasing lipid	Weekly to monthly
Liver function tests (AST, ALT, GGTP and alkaline phosphatase)	Weekly	Weekly to monthly
CBC and differential	Weekly	Weekly to monthly
Platelets	Weekly	Weekly to monthly
PT, PTT, INR	Weekly	Weekly to monthly
Iron indices[Δ]	As indicated	Biannually to annually
Trace elements[◊]	As indicated	Biannually to annually
Fat soluble vitamins[§]	As indicated	Biannually to annually
Carnitine	As indicated	As indicated
Ammonia	As indicated	Biannually to annually
Blood culture from central venous catheter	As indicated	Biannually to annually
CRP or ESR	As indicated	As indicated
Urine		
Glucose	2 to 6 times/day	Daily to weekly

Initial PN order is just *initial* ; it needs FOLLOW-UP and ADJUSTMENT

Pediatric Preparations

- Specific nutrient requirements vary from patient to patient, quantitatively and qualitatively
  - Fluid
  - Energy & CHO
  - Protein
  - Micronutrients
- Pediatric PN products must be specifically chosen and prepared
  - Amino acid
  - Lipid
  - Vitamin and trace elements

Amino Acid Solutions

- Extremely high amino acid requirements per kg of body weight in younger children
- Critical period of amino acid delivery
- Conditionally essential amino acids → arginine, cysteine, tyrosine, histidine
- First-pass metabolism at the gut → glutamate

Lipid Emulsions

- Higher percentage of lipid energy
- Essential fatty acid deficiency
- Hyperbilirubinemia
- Lipid intolerance → hypertriglyceridemia
- Fat overload syndrome
- PN-associated liver disease

Ready-to-use PN preparations are NOT APPROPRIATE for use in younger children

Specific Challenges

- Fluid estimation
- Overfeeding
- Calcium & phosphorus precipitation
- Multivitamins
- Trace elements → iron


The advance
20%
VD-R7

What to Be Covered

- Estimation of requirements
- Choosing preparation
- The calcium-phosphorus dilemma
- Trace elements → iron and zinc
- Vitamins
- Pediatric PN tips

Fluid Requirement

- Fluid requirement depends on
  - Hydration status
  - Size
  - Age
  - Environmental factors → radiant warmer, conventional single-walled incubator, and phototherapy, heat shield, thermal blanket, double-walled incubator
  - Underlying diseases

Fluid Requirement

- Excessive fluid may be necessary to provide adequate calorie (a peripheral vein) but care must be given to avoid fluid overload
- Highly concentrated glucose solution and 20% lipid emulsion are used to decrease fluid volume
- PN must NOT be used to replace ongoing loss because the fluid contains not just electrolytes but protein, vitamins, and minerals

Initial volume for patients free of cardiovascular or renal disease	Volume
< 10 kg	100 mL/kg/d
10-30 kg	2,000 mL/m^2/d
30-50 kg	100 mL/h (2.4 L/d)
> 50 kg	124 mL/h (3 L/d)

- Volume can be increased by
  - 10 mL/kg/d in infants until the desired caloric intake is achieved (max. 200 mL/kg/d, if tolerated)
  - > 10 kg: by 10% of initial volume per day until desired caloric intake is achieved (max. 4,000 mL/m2/d, if tolerated)

Energy Requirement

Age(yr)	Parenteral energy (kcal/kg/day)
Preterm	110-120
0-1	90-100
1-7	75-90
7-12	60-75
12-18	30-60

Nonprotein Energy

- Nonprotein calorie (NPC) → combined energy from lipid and carbohydrate
- NPC:N ratios → to describe the balance between energy and protein in specific clinical conditions
- The concept is still debatable, perhaps outdated
- NPC:N = 150:1 – 200:1 kcal/g of N
  → CHO:fat:prot = 45-55:35-40:10-15 (%)
- Basic principles: the balance of macronutrients
  - Minimum and maximum glucose infusion rates
  - Minimum and maximum fat emulsion
  - Adequate amino acids

Shulman RJ, et al (2003); Skipper A, et al (2005); Rugeles SJ, et al (2017)

Carbohydrate

- D-glucose, monohydrate form (dextrose), 3.4 kcal/g
- Most of the osmolality in the PN solution comes from glucose
- Peripheral PN concentration with >10% glucose increases the risk of phlebitis
- Glucose concentration no more than 10-12.5% (wt/vol) can be used for peripheral infusion

Dextrose concentration (%)	Osmolality ($mOsm/kgH_2O$)	Energy (kcal/L)
5	278	170
10	523	340
15	896	510
20	1,250	680
25	1,410	850
30	1,569	1,020

- 20% dextrose solution → 0.68 kcal/mL
- 20% lipid emulsion → 2 kcal/mL

Carbohydrate

- Glucose infusion rate (GIR)
  - Start 5 (or 4-7) mg/kg/min (VLBW 3-5)
  - Advance 2-5 mg/kg/min
  - Maximum
    - Preterm 8 mg/kg/min (11.52 g/kg/day)
    - Term – 2 year 13 mg/kg/min (18.72 g/kg/day)
    - Children 5 mg/kg/min (7.2 g/kg/day)
    - Adult 2 mg/kg/min (2.88 g/kg/day)
    - In cyclical PN 20 mg/kg/min (28.8 g/kg/day)

Carbohydrate

- Initiate in a stepwise fashion to allow appropriate response of endogenous insulin
- A balanced CHO + Lipid as non-nitrogenous calorie may avoid
  - Hepatic fatty infiltration
  - Water retention
  - Higher CO_2 production

Askanazi J (1981)

Carbohydrate

- Glucose infusion rate (GIR) should not exceed endogenous glucose production rate (or glucose oxidation rate) → overfeeding of glucose
- Endogenous glucose production rate is maximum at postnatal age and decreases gradually with age

Carbohydrate

- CHO should provide 45-50% of total energy intake in infants and children
- CHO intake should provide 60-75% of non-protein calorie
- Fat provides energy in order to reduce dextrose infusion to equal or less than maximal rate of glucose oxidation

Koletzko B, et al (2005)

Protein

- Crystalline amino acid (AA) solution
- Lower pH of AA solution allows larger amounts of Ca and P to be added to the PN solution without precipitation
- Growth (weight & height gain and nitrogen retention)
- Taurine
- Cysteine

Fitzgerald KA (1986)

Protein Requirement

Age group	Protein (g/kg/d)
Preterm	2.5-3.5
Full term	
0-6 months	2.5-3.0
6-12 months	2.0-2.5

- Neonates: start AA at 1.5-2.5 g/kg/d and increase to the desired goal

Protein Requirement

Age (yr)	Protein (g/kg/d)
1-6	1-2
7-10	1-2
11-14	1-2
15-18 (boys)	0.9-2
15-18 (girls)	0.8-2

- In older infants and children, AA is started at the goal dose except in hepatic or renal insufficiency or disorders of protein metabolism

Protein in Neonates

- Parenteral protein is usually started on the 1st or 2nd day of life
- Most preterm infants tolerate 1.5-2 g/kg/d of parenteral amino acids in the first day of life
- To achieve intrauterine rate of protein deposit, the upper limits of protein intake is
  - 3 g/kg/d for term infants
  - 4 g/kg/d for preterm infants

Porcelli Jr PJ, et al (2002)

	Aminoven Infant 10%	Aminoven 10%	Aminoplasmal 10%	Aminoplasmal 15%	Amiparen 10%	Aminoleban 8%
EAA (%) (w/w)	56.5	41	44.85	37.7	59	51.6
BCAA (%) (w/w)	30	18.6	20.1	16.3	30	35.5
Na (mmol/L)	-	-	-	-	2	14
K (mmol/L)	-	-	-	-	-	-
Cl (mmol/L)	-	-	-	-	-	94
Mg (mmol/L)	-	-	-	-	-	-
H_2PO_4 (mmol/L)	-	-	-	-	-	-
Acetate (mmol/L)	-	-	28	-	120	-

	Aminoven Infant 10%	Aminoven 10%	Aminoplasmal 10%	Aminoplasmal 15%	Amiparen 10%	Aminoleban 8%
Threonine	0.44	0.44	0.42	0.54	0.57	0.45
Tryptophan	0.20	0.20	0.16	0.21	0.2	0.07
Lysine	0.85	0.66	0.68	0.79	1.05	0.61
Leucine	1.30	0.74	0.89	1.14	1.4	1.1
Valine	0.90	0.62	0.62	0.72	0.8	0.84
Isoleucine	0.80	0.50	0.5	0.58	0.8	0.9
Methionine	0.31	0.43	0.44	0.57	0.39	0.1
Phenylalanine	0.38	0.51	0.47	0.57	0.7	0.1
Histidine	0.48	0.30	0.30	0.52	0.5	0.24

	Aminoven Infant 10%	Aminoven 10%	Aminoplasmal 10%	Aminoplasmal 15%	Amiparen 10%	Aminoleban 8%
Cysteine	0.052	-	-	0.03	0.1	0.03
Arginine	0.75	1.2	-	1.6	1.05	0.6
Taurine	0.04	0.1	-	-	-	-
Tyrosine	0.42	0.04	0.4	0.05	0.05	-
Alanine	0.93	1.4	10.5	2.23	0.8	0.75
Aspartic acid	-	-	5.6	0.79	0.1	-
Glutamic acid	-	-	7.2	1.62	0.1	-
Glycine	0.415	1.1	12	1.92	0.59	0.9
Proline	0.971	1.12	5.5	0.73	0.5	0.8
Serine	0.767	0.65	2.3	0.30	0.3	0.5

Lipid

- Lipid emulsion → oil-in-water emulsion with 10% or 20% TGs
- Different types of TGs (LCT, MCT, SL)
- Different values & ratios of n-3, n-6 and n-9 FAs
- Content of EFAs mostly from soybean oil

Lipid

- Egg yolk PLs as emulsifier
- Osmolality: ~300-400 mOsm/kg H_2O
- Size of lipid droplets similar to size of natural lipid droplets in blood & its mean diameter ~0.3 μm
- High caloric density: 10% ~ 1 kcal/mL, 20% ~ 2 kcal/mL

Lipid

- Soybean oil is the usual source of fatty acids in parenteral fat emulsion
- MCTs have been suggested as an alternative lipid source
  - Cleared faster from plasma
  - Metabolized more rapidly
  - Oxidized mainly independently of carnitine
  - Less reticuloendothelial dysfunction than LCTs

Lipid

- Lipid emulsions are recommended as a supplemental caloric source, for the prevention and treatment of essential fatty acid deficiency (linoleic and α-linolenic acids), and modification of inflammation in patients receiving TPN

Lipid

- To prevent EFA deficiency a minimum linoleic acid intake of
  - 0.25 g/kg/day in preterm infants
  - 0.1 g/kg/day in term infants and older children
- Maximum doses of parenteral lipid
  - Infants: 3–4 g/kg per day
  - Older children: 2–3 g/kg per day

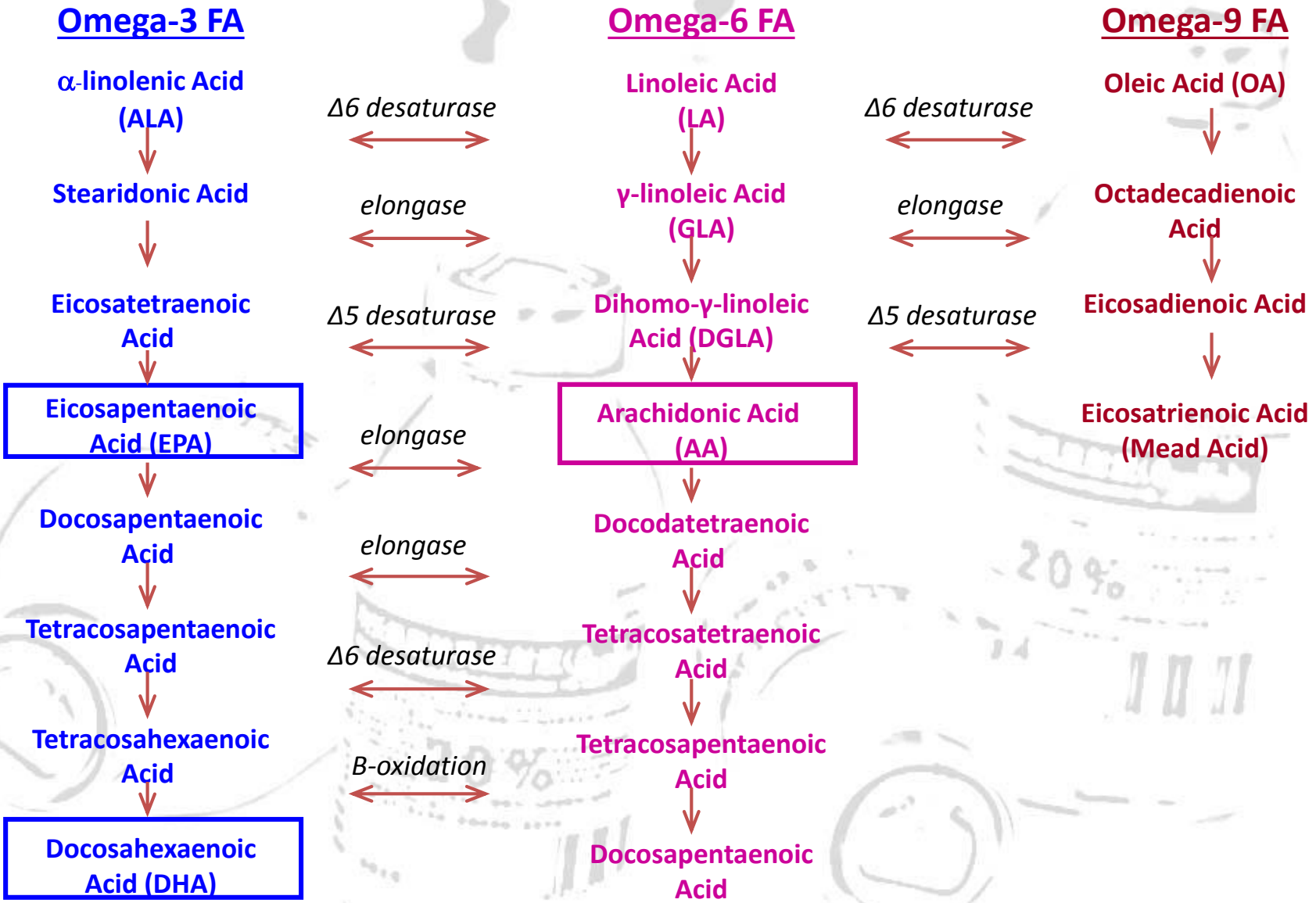
Age	Starting dose (g/kg/day)	Daily dose increase (g/kg/day)	Maximum dose (g/kg/day)
Preterm	0.5-1.0	1.0	3.5
Full term (0-6 mo)	1.0-1.5	1.0-1.5	3.5
Older infants (6-12 mo)	1.0-1.5	1.0-1.5	3.0
Children (1-10 yr)	1.0	1.0-1.5	3.0
Adolescents (11-18 yr)	1.0	1.0	2.0-3.0

Soybean Oil-based IVLE

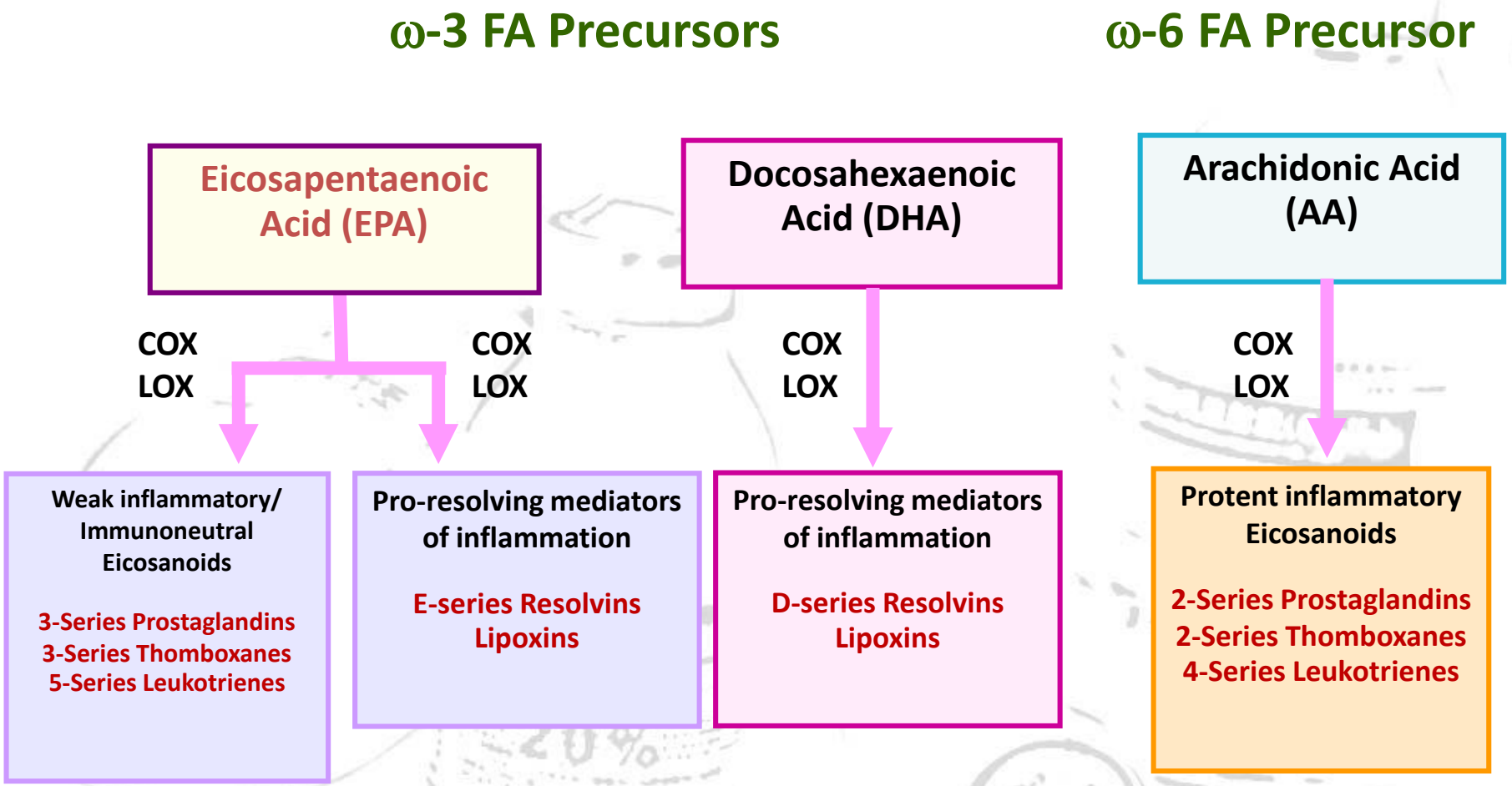
- Proinflammatory cytokines synthesized from the n-6 family member, AA, which may promote liver inflammation

- Arachidonic acid: a precursor of proinflammatory eicosanoids → thromboxane A2, leukotrienes B4 and C4, prostaglandin E2; and can induce production of proinflammatory cytokines (TNF-α, and IL-6)

Tilley SL, et al (2001); Hayashi N, et al (1998); Wachtler P, et al (1997); Deshpande G, et al (2011)



Chang MI, et al (2012)



Chang MI, et al (2012); Adolph M, et al (2009)

SMOFlipid

- A higher n-3/n-6 FA ratio reduces the production of hepatotoxic proinflammatory cytokines

- Reduced amount of soybean oil with decreased phytosterol load

SMOFlipid

- Higher amount of α-tocopherol to counteract free radical generation from the number of double bonds in EPA and DHA → decreased lipoperoxidation

- Increased availability of α-tocopherol in SMOFlipid relative to less antioxidative γ-tocopherol → decreased hepatic lipoperoxidation injury

Product	Intralipid/ Otsulip	ClinOleic	SMOFlipid
Oil Source (g)			
Soy bean	10	2	3
Safflower	0	0	0
MCT	0	0	3
Olive oil	0	8	2.5
Fish oil	0	0	1.5
α-Tocopherol (mg/L)	38	32	200
Phytosterols (mg/L)	348 +/- 33	327 +/- 8	47.6
Fat composition			
Linoleic	5.3	1.9	1.9
α-linolenic	0.8	0.2	0.2
EPA	0	0	0.3
DHA	0	0	0.2
Oleic	2.4	6.2	2.9
Palmitic	1.1	1.2	0.9
Stearic	0.4	0.2	0.3
Arachidonic	0	0.05	0.05

Le HD, et al (2010)

	Soy-based	Olive oil-based	MCT/LCT	Fish oil mixture
Longterm/ home TPN	+	+	+	
Hyper inflammation		+	+	+
Cholestasis		+	+	++
Critically ill disease		+	+	+

Electrolytes and Minerals

Electrolytes & Minerals	Unit	Daily amount
Sodium	mEq/kg	2-4
Potassium	mEq/kg	2-3
Chloride	mEq/kg	2-3
Acetate	mEq/kg	1-4
Calcium gluconate	mg/kg	50-500
Phosphate	mM/kg	0.5-2
Magnesium	mEq/kg	0.25-0.5

Calcium and Phosphate

	Calcium gluconate (mg/kg/d)	Phosphate (mM/kg/d)
Premature infants	300-500	1-1.5
Full term infants	300-400	1-1.5
Older infants & children	100-200	1.0
Adolescents	50-100	0.5-1.0

Duggan C, Nutrition in Pediatrics 4th edition (2008)

The Ca-P Dilemma

- The unique problem of pediatric PN
- Free Ca meets free phosphate, AND THEY DO PRECIPITATE
- Avoid precipitation and you may not get adequate amount of both elements

The Ca-P Dilemma

- Determining factors of solubility / precipitation
  - Types and amounts of calcium and phosphate
  - Mixing order
  - pH of the PN solution

The Ca-P Dilemma

- Determining factors of solubility / precipitation (cont.)
  - Temperature
  - Standing time
  - A presence of lipid emulsion

The Ca-P Dilemma

- Ca gluconate better than other Ca salts
- Mixing phosphate before Ca
- Lower pH → less precipitation
  - Amino acids and dextrose conc.
- Higher temp → more precipitation
- Lipid emulsion (in 3-in-1 prep) → higher pH and less visibility

TPN: Order of mixing

1. Amino acid + Dextrose solution

2. K_2HPO_4

3. KCl/K-acetate

4. NaCl and/or Na-acetate

5. Heparin

6. Trace element

7. $MgSO_4$

8. Calcium gluconate

9. Vision test (black screen)

10. Multivitamin

11. Keep in a refrigerator and use within 24 hr

The Ca-P Dilemma

- Avoiding precipitation
  - Alternate bags → suboptimum retention of both elements
  - Using tools and skills
    - Equations
    - Solubility curves
    - Visual inspection
  - New phosphate preparation

Ca-P Equation

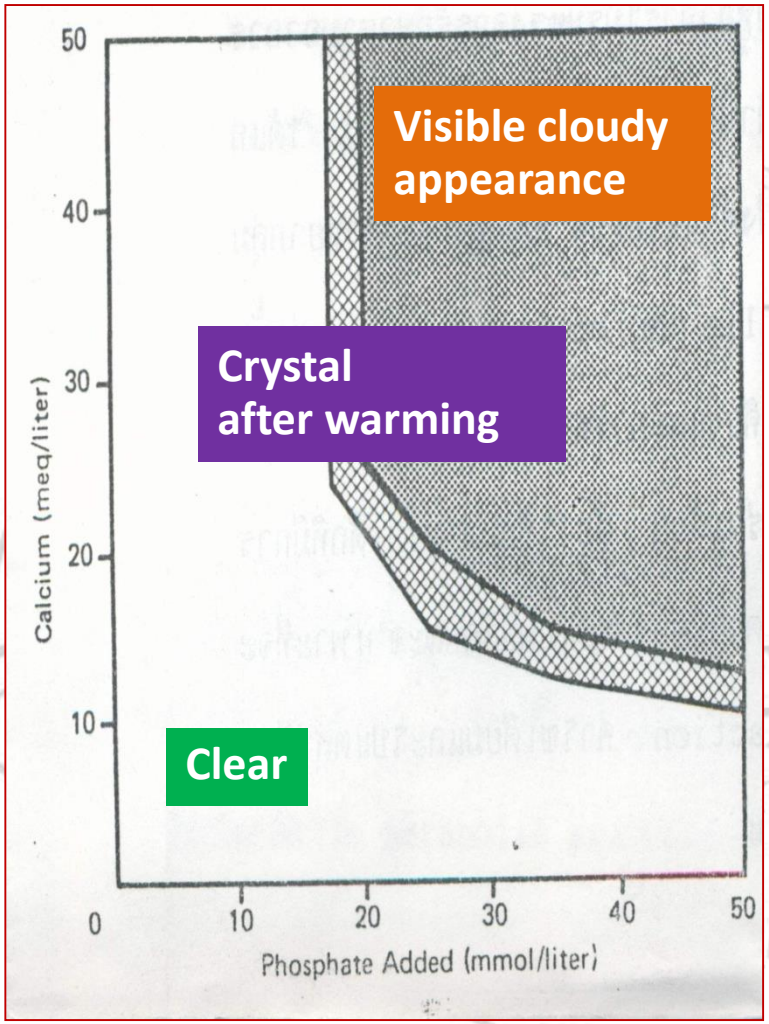
Calcium (mEq/L) * Phosphate (mmol/L) * 1.8 <300

- 10% Calcium gluconate
  - 1 mL = 9 mg elemental Ca = 0.46 mEq Ca = 0.23 mmol Ca
- K_2HPO_4 (1.74 g/20 mL)
  - 1 mL = 15.5 mg elemental phosphorus = phosphate ion 0.5 mmol

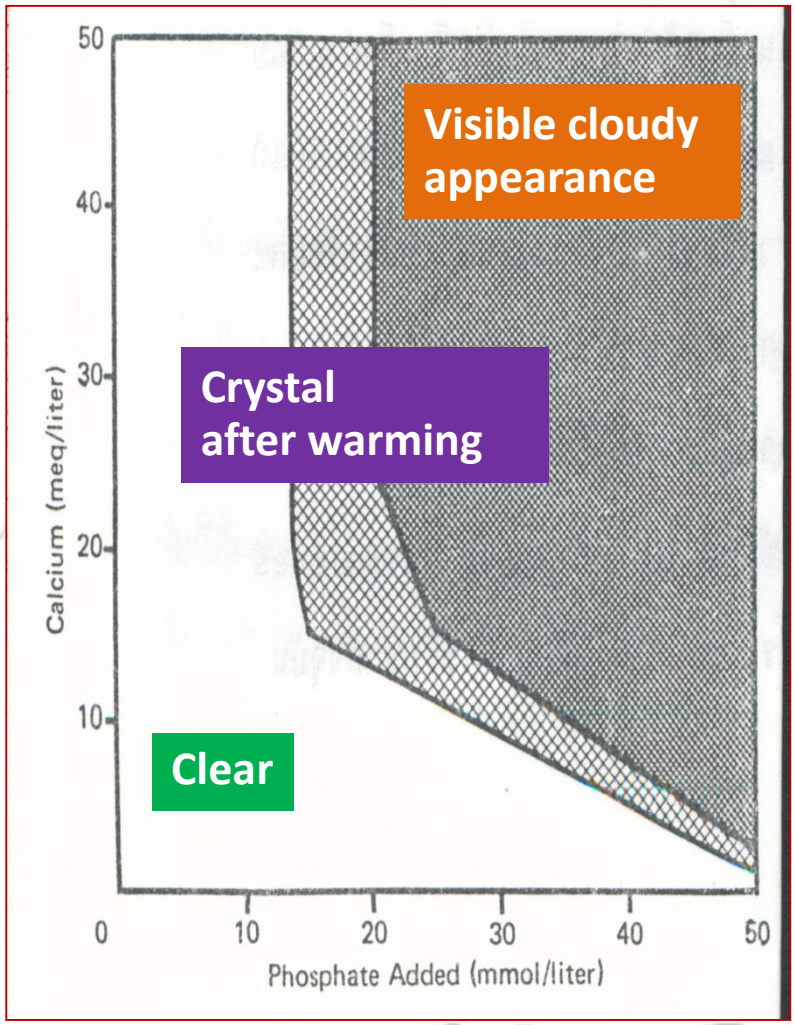
- The safe values serve only as guidelines to what calcium and phosphate concentrations in PN formulas are not associated with precipitation but are not absolute since many factors affect the product

Lebenthal E (1986)

2%Aminosyn, 20%Dextrose, pH 5.1

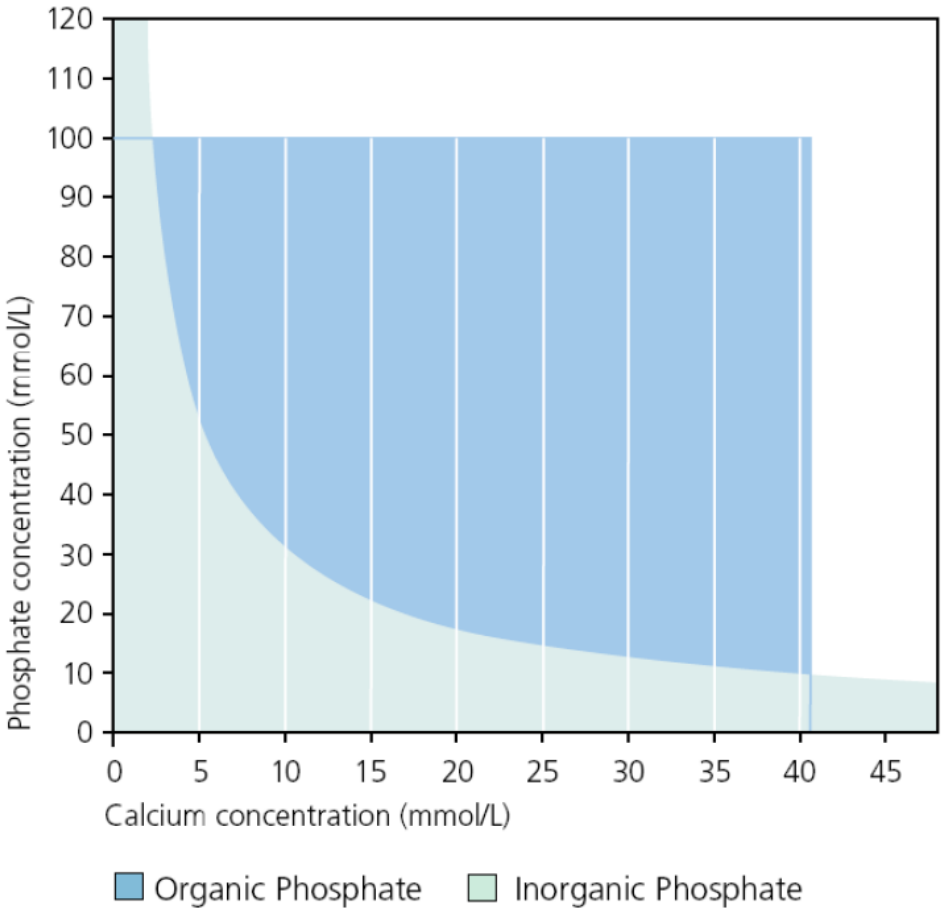


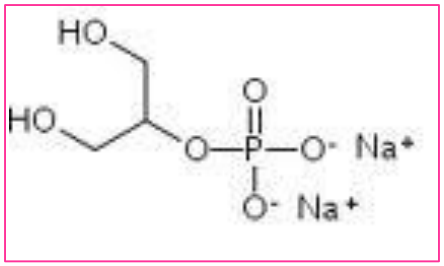
1%Aminosyn, 10%Dextrose, pH 5.4



- White milky solution with fine particulate matter
- Gradually settle to the bottom of the container
- Seen immediately after mixing, or require 12-24 hr for precipitation occurs

Organic Phosphate





- Glycerophosphate is not ionizable, precipitation of Ca-P does not occur
  - Phosphate: 1 mmol/mL
  - Na: 2 mmol/mL
- Higher price than K_2HPO_4
- Dosage:
  - Adults 10-20 mmol/d
  - Infants 1.0-1.5 mmol/kg BW

Rodell O, et al (1989)

Organic Phosphate (Pediatric Ranges)

Admixture	Range	Unit
Amino acid (Aminoven Infant®)	6.5-36.9	g/L
Glucose	40-240	g/L
Sodium	0-100	mmol/L
Potassium	0-100	mmol/L
Magnesium	0-5	mmol/L
Calcium	0-15	mmol/L
Phosphate (Glycophos®Na glycerophosphate)	0-15	mmol/L
Peditrace®	0-15	ml/L
Soluvit N®	0-1	vial

Fresenius Kabi Admixture Guide (2007)

Electrolyte and Mineral Contents in Products

	Contents	
NaCl, 3%	Na 0.513 mEq/mL	Cl 0.513 mEq/mL
Na acetate, 24.6%	Na 3 mEq/mL	
KCl, 15%	K 2 mEq/mL	Cl 2 mEq/mL
K_2HPO_4, 8.71%	K 1 mEq/mL	Phosphate 1.5 mEq/mL Phosphate 0.5 mmol/mL P 15.5 mg/mL
Sodium glycerophosphate	Na 2 mmol/mL	Phosphate 1 mmol/mL
$MgSO_4$, 50%	$MgSO_4$ 500 mg/ml Mg 4 mEq/mL Mg 49.2 mg/mL	
Ca gluconate, 10%		Ca 0.45 mEq/mL Ca 0.23 mmol/mL Ca 9 mg/mL

Trace Elements

	Unit	Preterm	Term newborns	Infants	Children
Iron	mg/kg/d for PN >2 months	0.1-0.2	0.25-0.67	0.05-0.1	0.05-0.1 (max 1 mg/d)
Zinc	mg/kg/d	0.4	0.25	0.25 < 3 months 0.1 > 3 months	0.05 (max 5 mg/d)
Manganese	µg/kg/d	1	1	1	1 (max 50-100 µg/d)
Copper	µg/kg/d	20	20	20	20 (max 500 µg/d)
Chromium	µg/kg/d	0.05-0.2	0.2	0.2	0.2 (max 5-15 µg/d)
Selenium	µg/kg/d	5-7	2	1-3	1-3 (max 30-60 µg/d)
Molybdenum	µg/kg/d	0.25	0.25	0.25 (max 5 µg/d)	0.25 (max 5 µg/d)
Iodine		1 µg/kg/d	0-1 µg/kg/d	0-1 µg/d	1 µg/d

Trace Elements

- Trace elements should be supplemented in long-term PN
- There is no trace element supplement for long-term PN which meets the current recommendations

Iron

- Instability of total nutrient admixtures containing iron has prevented its addition to TE mixtures
- For patients not able take oral iron supplements, addition of iron dextran to fat-free PN or separate infusions of IV iron have been recommended
- Iron is probably not needed in some patients

Zinc

- Zinc is included in all the current parenteral trace element products
- Zinc: not more than 10 mg/L
- Extra supplementation of zinc may be needed in patients with
  - Diarrhea
  - GI fistula
  - Severe burns
  - Preterm infants with NEC esp. in the presence of bowel resection or ileostomy

TE Preparations

	Unit per 1 mL	Addamel	Peditrace	Siriraj
Iron (Fe)	mcg	112	-	-
Zinc (Zn)	mcg	650	250	1000
Manganese (Mn)#	mcg	27	1	-
Copper (Cu)#	mcg	130	20	400
Chromium (Cr)*	mcg	1	-	-
Selenium (Se)*	mcg	3.2	2	-
Molybdenum (Mo)*	mcg	1.9	-	-
Fluoride (F)	mcg	95	57	-
Iodine (I)	mcg	13	1	-
Sorbitol	mg	300	-	-
Volume in vial	mL	10	10	10
Price	Baht	310	235	36
Dosage	mL/kg; maximum	1; 10	1; 15	-

Vitamins

- Soluvit N
  - Infants <10 kg →1/10 vial/kg/day
  - Children ≥10 kg or adults → 1vial/day
  - Solvent: Vitalipid N, lipid emulsion, water, 5-50% glucose solution for infusion
- Vitalipid N
  - BW ≥ 2.5 kg → 4 mL/kg, max 10 mL
- Otsuka MV
  - For adults (AMA: children >11 yr & adults)

Water-soluble vitamins (dry powder, vial)	Otsuka MV No.1 (mg)	Soluvit N (mg)	
Thiamin, B1	3.1	2.5	
Riboflavin, B2	3.6	3.6	
Pyridoxine, B6	4	4	
Cyanocobalamin, B12	0.005	0.005	
Nicotinamide, B3	40	40	
Pantothenic acid, B5	15	15	
Biotin	0.06	0.06	
Folic acid	0.4	0.4	
Ascorbic acid, C	100	100	
Lipid-soluble vitamins (solution)	**Otsuka MV No.2 (4 ml/ampoule)**	**Vitalipid N Infant (10 ml/ampoule)**	**Vitalipid N Adult (10 ml/ampoule)**
Vitamin A	3300 IU	2300 IU	3300 IU
Vitamin D	Cholecalciferol (D3), 200 IU	Ergocalciferol (D2), 400 IU	Ergocalciferol (D2), 200 IU
Tocopherol, E	10 mg	6.4 mg (7 IU)	9.1 mg (10 IU)
Phytomenadione, K1	2 mg	0.2 mg	0.15 mg

Pediatric PN Tips

- In neonatal and pediatric patients, the PN regimen must be tailored to the age of the patient and diagnosis because nutrition needs vary greatly from birth through adolescence

Pediatric PN Tips

- PN in preterms → the earlier, the better
  - Early administration of parenteral amino acids, within hours of birth, has been observed to be safe
  - Data suggest safety and improved nitrogen balance from provision of non-protein energy within the first day
  - Essential fatty acid deficiency develops in as few as 3 days in neonates fed fat-free diets

Pediatric PN Tips

- Shielding PN from light may improve survival rate in premature infants
  - Meta-analysis, 4 trials, 800 newborn premature infants
  - Mortality in the light-protected group was half of that in the light-exposed group and twice as high in males compared with females

- Adequate light protection may not be feasible, depending on the circumstance of whether PN is compounded on-site or at a central location

Chessex P, et al (2002)

Pediatric PN Tips

- PN-associated problems
  - Vascular device-related problems
    - Infection
    - Thrombosis
  - Metabolic bone disease
  - Hepatobiliary disease
  - Micronutrient deficiencies

Pediatric PN Tips

- Modify the PN prescription as indicated per ongoing evaluation of GI function, nutrition status, and growth
- Wean PN when oral intake and/or EN achieves 50-75% of requirements for energy, protein, and micronutrients
- Unless impaired GI function precludes 100% absorption of nutrient needs

Worthington P, et al (2017)


...into
extra time

TPN & FAT Calculator

TPN Unit Call 99809, 99810, 99890

General

ชื่อแพทย์: A

เบอร์ติดต่อกลับ: 1234

หอผู้ป่วย:

วันที่ต้องการสั่ง: 2017-08-02

ชื่อผู้ป่วย: ด.ช.

Body Weight (kg): 6.3

Central Line

Total Parenteral Nutrition Requirements

Total Volume (ไม่เผื่อสาย): 530.2

Drip in (hr): 24

(Drip in 24hr) TPN Rate: 22.1 mL/hr

50% Glucose		20	%	212.08 mL
10% AminoVEN INFANT (Newborn Amino Acid)		1	g/kg	63 mL

สั่ง Phosphate จากแหล่งดังต่อไปนี้

Glycophos (phosphate = 2 mEq/mL, Na = 2 mEq/mL)

ต้องการ Phosphate 2.2 mEq/kg 6.93 mL

Summary

Total Volume	530.20 + 0.106	mL
SWI	200.91	mL
GPR	11.69	mg/kg/min
NPC : N	597 : 1	Kcal/g
K_{total}	2.0	mEq/kg/day
Na_{total}	6.5	mEq/kg/day
K_{rate}	0.08	mEq/kg/hr
$Osmolarity_{TPN}$	1,331.8	mOsm/L
$Osmolarity_{FAT}$	287.1	mOsm/L

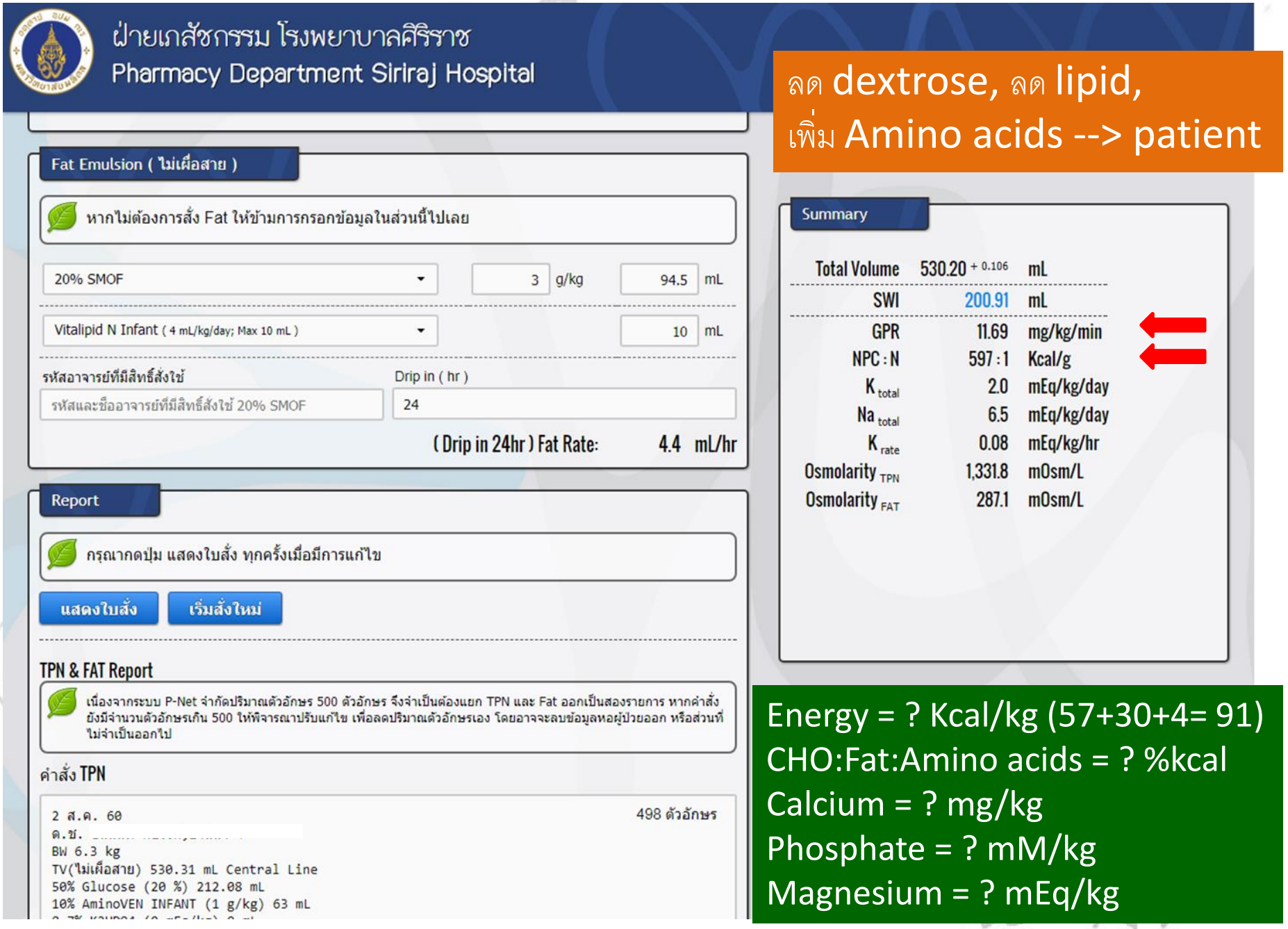
ผู้ป่วยจะได้รับ Na		2.2	mEq/kg	
15% KCl (2 mEq/mL)		2	mEq/kg	6.3 mL
20% NaCl (3.42 mEq/mL)		0.2	mEq/kg	0.368 mL
40.8% Sodium Acetate (3 mEq/mL)		4.1	mEq/kg	8.61 mL
10% Calcium Gluconate (100 mg/mL)		3	mL/kg	18.9 mL
50% $MgSO_4$ (500 mg/mL)		0.08	mL/kg	0.5 mL
☑ Peditrace (1 mL/kg/day; Max 15 mL)				6.3 mL
☑ Soluvit N (1 mL/kg/day; Max 10 mL)				6.3 mL
☑ Heparin (1 U/ 1 mL TPN)				0.106 mL
Other Nutrition ...				mL mL
Other Nutrition (key in)				mL mL
Sterile Water				200.91 mL
Total Volume				530.31 mL

หากตกตะกอน

ติดต่อกลับแพทย์

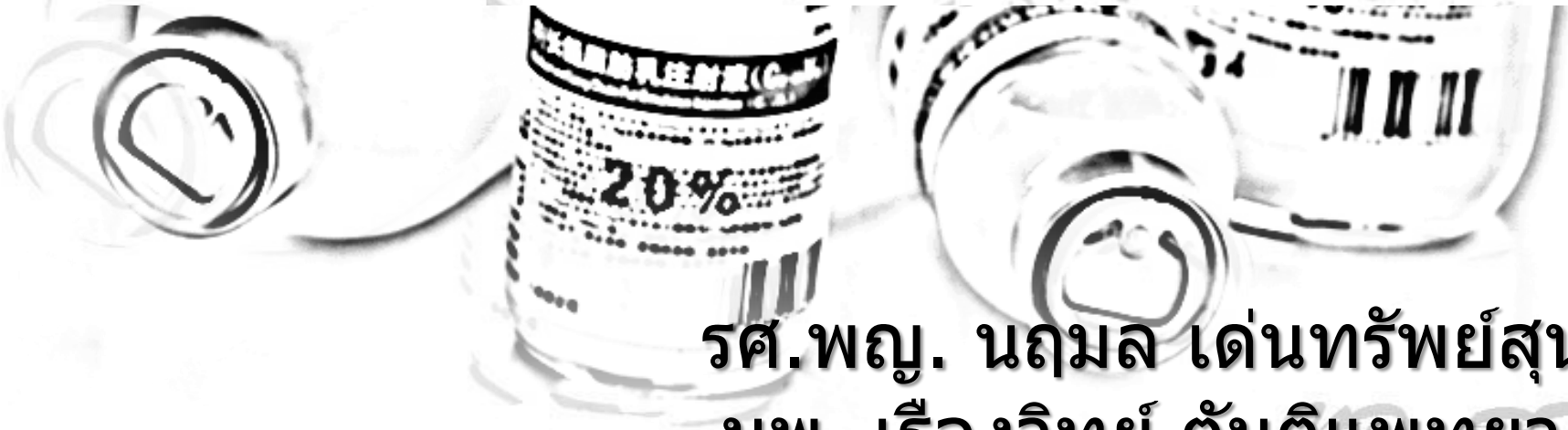
Summary

Total Volume	530.20 + 0.106	mL
SWI	200.91	mL
GPR	11.69	mg/kg/min
NPC : N	597 : 1	Kcal/g
K_{total}	2.0	mEq/kg/day
Na_{total}	6.5	mEq/kg/day
K_{rate}	0.08	mEq/kg/hr
$Osmolarity_{TPN}$	1,331.8	mOsm/L
$Osmolarity_{FAT}$	287.1	mOsm/L


ฝ่ายเภสัชกรรม โรงพยาบาลศิริราช
Pharmacy Department Siriraj Hospital
ลด dextrose, ลด lipid,
เพิ่ม Amino acids --> patient
Fat Emulsion (ไม่เผื่อสาย)
หากไม่ต้องการสั่ง Fat ให้ข้ามการกรอกข้อมูลในส่วนนี้ไปเลย
20% SMOF
3
g/kg
94.5
mL
Vitalipid N Infant (4 mL/kg/day; Max 10 mL)
10
mL
รหัสอาจารย์ที่มีสิทธิ์สั่งใช้
รหัสและชื่ออาจารย์ที่มีสิทธิ์สั่งใช้ 20% SMOF
Drip in (hr)
24
(Drip in 24hr) Fat Rate:
4.4
mL/hr
Report
กรุณากดปุ่ม แสดงใบสั่ง ทุกครั้งเมื่อมีการแก้ไข
แสดงใบสั่ง
เริ่มสั่งใหม่
TPN & FAT Report
เนื่องจากระบบ P-Net จำกัดปริมาณตัวอักษร 500 ตัวอักษร จึงจำเป็นต้องแยก TPN และ Fat ออกเป็นสองรายการ หากคำสั่งยังมีจำนวนตัวอักษรเกิน 500 ให้พิจารณาปรับแก้ไข เพื่อลดปริมาณตัวอักษรเอง โดยอาจจะลบข้อมูลหอผู้ป่วยออก หรือส่วนที่ไม่จำเป็นออกไป
ค่าสั่ง TPN
2 ส.ค. 60
498 ตัวอักษร
ด.ช.
BW 6.3 kg
TV(ไม่เผื่อสาย) 530.31 mL Central Line
50% Glucose (20 %) 212.08 mL
10% AminoVEN INFANT (1 g/kg) 63 mL
Summary
Total Volume 530.20 + 0.106 mL
SWI 200.91 mL
GPR 11.69 mg/kg/min
NPC : N 597 : 1 Kcal/g
K total 2.0 mEq/kg/day
Na total 6.5 mEq/kg/day
K rate 0.08 mEq/kg/hr
Osmolarity TPN 1,331.8 mOsm/L
Osmolarity FAT 287.1 mOsm/L
Energy = ? Kcal/kg (57+30+4= 91)
CHO:Fat:Amino acids = ? %kcal
Calcium = ? mg/kg
Phosphate = ? mM/kg
Magnesium = ? mEq/kg

Pediatric PN

and what makes it so special



รศ.พญ. นฤมล เด่นทรัพย์สุนทร
นพ. เรืองวิทย์ ตันติแพทยางกูร