Home Parenteral Nutrition
Managing Vitamins and Trace Elements

Manpreet S. Mundi, MD

Oley Foundation Annual Conference
Lincolnshire, IL
Disclosures

- Industry support:
  - Research Grants from Fresenius Kabi, Nestle, RealFood Blends
- Off-labeled use: None
2019 Oley/UI Health Combined Conference
The Essentials of Home Parenteral and Enteral Nutrition
What Consumers and Clinicians Need to Know

June 21–24, 2019
Marriott Resort Lincolnshire
10 Marriott Drive
Lincolnshire, IL 60069

Friday, June 21
12:00 pm–5:00 pm
Early Registration
Outside the Grand Marquee Pavilion

1:00 pm–4:00 pm
Ambassador Workshop/Volunteer Info Session
Salon E

4:00 pm–6:00 pm
Panel Discussion (Q&A)
Salon D–E

2:30 pm–3:15 pm
Breakout Sessions (choose one from list below)

- Skin/Wound Care: Problems and Solutions
  Linda Zekas, MSN, APRN, CWON, NP
  Salon H

- Fluid and Electrolyte Management
  Manpreet Mundi, MD
  Salon G

- Minimizing Catheter Complications
  Robert Carroll, MD
  Salon F

- Intestinal Lengthening/Tapering
  Mario Spaggiari, MD
  Salon C

- Discussion of Relationships, Mental Health, and Body Image While Living on HPEN
  Swapna Kakani; John Mahalchak; Emily Parks; and Celia Fairbanks
  Salon B

- Home Blended Enteral Formula: What You’ll Need to Know
  Lisa Epp, RDN, CNSC, LD
  Salon A

Ann Michalek, MD
Salon D–E

AGAF:

8:30 am–8:50 am
Managing Electrolytes, Metals, and Minerals in Parenteral Nutrition
Manpreet Mundi, MD
Salon D–E

8:50 am–9:10 am
Tapering Home Parenteral Nutrition to Never When Possible
Doug Seidner, MD, AGAF, FACG, CNSC
Salon D–E

9:10 am–9:25 am
Panel Discussion (Q&A)
Salon D–E

9:25 am–12:15 pm
Tube Feeding Workshop
Great Lakes IV

- Avoiding Complications
  Cynthia Reddick, RD, CNSC

- Hands-on Demonstrations/Skills Labs
  Manpreet Mundi, MD; Beth Lyman, RN, MSN, CNSC; Cynthia Reddick; RD, CNSC; and more
  * No CE Credit for this session *
  * Overlaps with main session *

9:25 am–10:10 am
Hot Topics: HPN Research Prize Recipient Presentations
Salon D–E

- The Association between a Four-Oil Lipid Emulsion and Parenteral Nutrition Associated Liver Disease–Related Laboratory Values in Adult Patients Receiving Home Parenteral Nutrition
  Heather Stropes, MS, RD, LDN, CNSC

- Safety and Effectiveness of Catheter Repair in Home Parenteral Nutrition
  Sateesh Reddy Velapati, MBBS

- A New Diagnostic Tool for Rapid Detection of Bloodstream Infections Using Droplet Digital Polymerase Chain Reaction in Patients on Home Parenteral Nutrition
  Yannick Woetser, MD
Objectives

At the conclusion of this session the participant should be able to:

• Stay Awake!!!

• Review overall guidelines for daily parenteral recommendations for vitamins and trace elements

• Review in more detail fat soluble vitamins
TPN

<table>
<thead>
<tr>
<th>Institution/Pharmacy Name, Address and Pharmacy Phone number</th>
</tr>
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<tbody>
<tr>
<td>Name</td>
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<tr>
<td>Administration Date/Time</td>
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<table>
<thead>
<tr>
<th>Base Formula</th>
<th>Amount/day</th>
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<tr>
<td>Dextrose</td>
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<tr>
<td>Amino acids</td>
<td>g</td>
<td>(g/L)</td>
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<tr>
<td>IVFE</td>
<td>g</td>
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<td>Sodium acetate</td>
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<td>Sodium phosphate</td>
<td>mmol of P</td>
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<tr>
<td>Potassium chloride</td>
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<tr>
<td>Calcium gluconate</td>
<td>mEq</td>
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<tr>
<td>Magnesium sulfate</td>
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<table>
<thead>
<tr>
<th>Vitamins, trace elements and medications</th>
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</thead>
<tbody>
<tr>
<td>Multiple vitamins a</td>
<td>mL</td>
</tr>
<tr>
<td>Multiple trace elements a</td>
<td>mL</td>
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<table>
<thead>
<tr>
<th>Insulin</th>
<th>Units</th>
<th>Units/L</th>
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<tbody>
<tr>
<td>H2 - antagonists a</td>
<td>mg</td>
<td></td>
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</tbody>
</table>

Rate _____ mL/hour  Volume _____ mL  Infuse over____ hours

Formulation contains_____ mL plus _____ mL overfill
Discard any unused volume after 24 hours

***Central Line Use Only***
Micronutrients
Vitamins and Trace Elements

• In 1941, the US National Academy of Sciences established the Food and Nutrition Board
  • Recommend standard oral daily allowance for each nutrient
  • **Estimated Average Requirement**: average daily intake expected to meet the needs of 50% of healthy individuals
  • **Recommended Dietary Allowance (RDA)**: average daily dietary nutrient intake level sufficient to meet nutrient requirements of nearly all (97-98%) healthy individuals for their age and gender.

Long-term total parenteral nutrition with growth, development, and positive nitrogen balance


Philadelphia, P.A. From the Department of Surgery and the Harrison Department of Surgical Research, School of Medicine, University of Pennsylvania
Can Intravenous Feeding as the Sole Means of Nutrition Support Growth in the Child and Restore Weight Loss in an Adult?

Long-Term Total Parenteral Nutrition

The Concept of an Artificial Gut

Belding H. Scribner, MD; James J. Cole; T. Graham Christopher, MD; Joseph E. Vizzo, Robert C. Atkins, MD; and Christopher R. Blagg, MD

'Suddenly we took something that was 100 percent fatal and overnight turned it into 90 percent survival.'
Micronutrients
Vitamins and Trace Elements

• 1972 FDA noted that current multi-vitamin preparations were inadequate.

• 1975 Nutrition Advisory Group (NAG) and American Medical Association proposed recommendations for:
  • 9 water soluble vitamins (ascorbic acid, thiamine, riboflavin, niacin, pyridoxine, pantothenic acid, folate, cobalamin, and biotin)
  • 4 fat soluble vitamins (A, E, D, K)
• 1979 recommendations about trace elements
<table>
<thead>
<tr>
<th>VITAMIN</th>
<th>A (Units)</th>
<th>D (Units)</th>
<th>E (Units)</th>
<th>K (mcg)</th>
<th>C (mg)</th>
<th>FA (mcg)</th>
<th>B1 (mg)</th>
<th>B2 (mg)</th>
<th>B6 (mg)</th>
<th>Niacin (mg)</th>
<th>B12 (mcg)</th>
<th>PA (mg)</th>
<th>Biotin (mcg)</th>
<th>Fe (mg)</th>
<th>Zn (mg)</th>
<th>Cu (mg)</th>
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<tr>
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<td>600-800</td>
<td>15</td>
<td>120</td>
<td>90</td>
<td>400</td>
<td>1.2</td>
<td>1.3</td>
<td>1.3-1.7</td>
<td>16</td>
<td>2.4</td>
<td>5</td>
<td>30</td>
<td>8</td>
<td>11</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>F (19-70 yr)</td>
<td>2331</td>
<td>600-800</td>
<td>15</td>
<td>90</td>
<td>75</td>
<td>400</td>
<td>1.1</td>
<td>1.1</td>
<td>1.3-1.5</td>
<td>14</td>
<td>2.4</td>
<td>5</td>
<td>30</td>
<td>18-8</td>
<td>8</td>
<td>0.9</td>
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<td><strong>UL</strong></td>
<td>9990</td>
<td>4000</td>
<td>1000</td>
<td>ND</td>
<td>2000</td>
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<td>ND</td>
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<td>ND</td>
<td>ND</td>
<td>45</td>
<td>40</td>
<td>10</td>
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</tbody>
</table>

**Injectables (IV)**

Vitamins Adult (M.V.I. Adult ® or Infuvite Adult ®) (10 mL)

- Multivitamins with Minerals (Cerovite ® Liquid)
  - 1300 | 400 | 30 | -- | 60 | -- | 1.5 | 1.7 | 2 | 20 | 6 | 10 | 300 | 9 | 3 | -- | Mn 2 mg, I 150 mcg, Cr 25 mcg
  - Mo 25 mcg
- **AquADEKs ® (2 mL)**
  - 11502 | 800 | 100 | 800 | 90 | -- | 1.2 | 1.2 | 1.2 | 12 | -- | 6 | 30 | -- | 10 | -- | Se 20 mg, Coenzyme Q10 4 mg, Vit E (other mixed tocoph.) 30 mg

**Capsules/Tablets**

Multivitamins with Minerals (tablet)

- Theragran M ®, Therapeutic-M ®, Thera M Plus ®
  - 5000 | 400 | 60 | 28 | 90 | 400 | 3 | 3.4 | 6 | 20 | 12 | 10 | 30 | 9 | 15 | 2 |
  - I 150 mcg, Mn 2 mg, Cr 50 mcg
  - Se 70 mcg, Mo 75 mcg, Ca 30 mg
  - P 23 mg, Mg 100 mg
- Multivitamins, Therapeutic (Theragran ®, Therapeutic ®, Thera ®)
  - 5000 | 400 | 30 | -- | 60 | 400 | 3 | 3.4 | 3 | 20 | 9 | 10 | 30 | -- | -- | -- | Ca 66 mg
- Multivitamins with minerals, chewable (Flintstones Complete ®, One-A-Day Kids Complete ®)
  - 3000 | 400 | 30 | -- | 60 | 400 | 1.5 | 1.7 | 2 | 20 | 10 | 12 | 10 | 40 | 18 | 12 | 2 |
  - Ca 100 mg, P 100 mg, I 150 mcg
  - Mg 20 mg, Na 10 mg
- **AquADEKs ® (softgel)**
  - 18167 | 800 | 150 | 700 | 75 | 100 | 1.5 | 1.7 | 1.9 | 10 | 12 | 12 | 100 | -- | 10 | -- | Se 75 mcg, Coenzyme Q10 mg, Vit E (other mixed tocoph.) 80 mg
- **AquADEKs ® (chewable tablet)**
  - 9084 | 400 | 50 | 350 | 35 | 100 | 0.75 | 0.85 | 0.95 | 5 | 6 | 6 | 50 | -- | 5 | -- | Se 38 mcg, Coenzyme Q10 5 mg, Vit E (other mixed tocoph.) 15 mg
  - Se 75 mcg, Coenzyme Q10 10 mg, Vit E (other mixed tocoph.) 30 mg
- 1 serving = 2 tablets

**Dialyvite ® (tablet, Rx Only)**

- -- | -- | -- | -- | 100 | 1000 | 1.5 | 1.7 | 10 | 20 | 6 | 10 | 300 | -- | -- | -- | Ca 200 mg, I 150 mcg, Mg 25 mg
- Se 20 mg, Mn 5 mg
  - Cr 25 mcg

**Prenatal Multivitamins with Minerals (tablet)**

- 5000 | 400 | 30 | -- | 120 | 1000 | 3 | 3.4 | 10 | 20 | 12 | 10 | 30 | 27 | 25 | 2 | Ca 200 mg, I 150 mcg, Mg 25 mg
  - Se 20 mg, Mn 5 mg
  - Cr 25 mcg
# Micronutrients

## Fat Soluble Vitamin Parenteral Recommendations

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Oral</th>
<th>Parenteral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>M: 900 mcg or 3000 IU F: 700 mcg or 2333 IU (Preg 770 mcg) (Lactating 1300 mcg)</td>
<td>990 mcg or 3300 IU</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>Age 19-70 y: 15 mcg or 600 IU Age &gt;70 y: 20 mcg or 800 IU</td>
<td>5 mcg or 200 IU</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>15 mg Lactating 19 mg</td>
<td>10 mg or 10 IU</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>M: 120 mcg F: 90 mcg</td>
<td>150 mcg</td>
</tr>
</tbody>
</table>

# Micronutrients

## Water Soluble Vitamin Parenteral Recommendations

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Oral</th>
<th>Parenteral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin B₁ (thiamine)</td>
<td>M: 1.2 mg F: 1.1 mg (preg/lact: 1.4mg)</td>
<td>6 mg</td>
</tr>
<tr>
<td>Vitamin B₂ (riboflavin)</td>
<td>M: 1.3 mg F: 1.1 mg (preg: 1.4 mg) (lact: 1.6 mg)</td>
<td>3.6 mg</td>
</tr>
<tr>
<td>Vitamin B₃ (niacin)</td>
<td>M: 16 mg F: 14 mg (preg: 18 mg) (lact: 17 mg)</td>
<td>40 mg</td>
</tr>
<tr>
<td>Vitamin B₅ (pantothenic acid)</td>
<td>5mg (preg: 6mg) (lact: 7 mg)</td>
<td>15 mg</td>
</tr>
<tr>
<td>Vitamin B₆ (pyridoxine)</td>
<td>Age 19-50: 1.3 mg Age &gt;51: M 1.7 mg F: 1.5 mg (preg: 1.9 mg) (lact: 2.0 mg)</td>
<td>6 mg</td>
</tr>
<tr>
<td>Vitamin B₇ (biotin)</td>
<td>30 mcg (lact: 35 mcg)</td>
<td>60 mcg</td>
</tr>
<tr>
<td>Vitamin B₉ (folate)</td>
<td>400 mcg (preg: 600 mcg) (lact: 500 mcg)</td>
<td>600 mcg</td>
</tr>
<tr>
<td>Vitamin B₁₂ (cyanocobalamin)</td>
<td>2.4 mcg (preg: 2.6 mcg) (lact: 2.8 mcg)</td>
<td>5 mcg</td>
</tr>
<tr>
<td>Vitamin C (ascorbic acid)</td>
<td>M 90 mg F: 75 mg (preg: 85 mg) (lact: 120 mg)</td>
<td>200 mg</td>
</tr>
</tbody>
</table>

## Micronutrients

### Trace Elements Parenteral Recommendations

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Oral</th>
<th>Parenteral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>900 mcg (preg 1000 mcg) (lact 1300 mcg)</td>
<td>300mcg to 500 mcg</td>
</tr>
<tr>
<td>Manganese</td>
<td>M: 2.3 mg F: 1.8 mg (preg: 2.0 mg) (lact: 2.6 mg)</td>
<td>0.06-0.1 mg</td>
</tr>
<tr>
<td>Selenium</td>
<td>55 mcg (preg: 60 mcg) (lact: 70 mcg)</td>
<td>20-60 mcg</td>
</tr>
<tr>
<td>Zinc</td>
<td>M: 11mg, F: 8mg (preg: 11mg) (lact: 12 mg)</td>
<td>2.5-5 mg</td>
</tr>
</tbody>
</table>

Trace elements not routinely added in the US:
- Fluoride
- Iodine
- Iron (given as a separate infusion)
- Molybdenum
Fat Soluble Vitamins
Vitamin A (990 mcg or 3300 IU)

- Ancient writings from Egyptian and Greek physicians noted that liver of ox was cure for night blindness
- The first of vitamins recognized in 1913
  - Can be obtained from pre-formed Vitamin A or provitamin A carotenoids (β-carotene)
  - Retinal combines with opsin to form rhodopsin (Rods)
Fat Soluble Vitamins
Vitamin A Deficiency

- Most Common Symptoms:
  - Earliest → Ocular: *night blindness*, Bitot’s spots, conjunctival xerosis
  - Others: hyperkeratosis, anorexia, phrynoderma (papules around hair follicles) and depressed helper T-cell function

- Pathophysiology
  - Low levels in critical illness associated with decreased hepatic synthesis and release of RBP during inflammation
  - At risk: Liver disease and renal disease

Fat Soluble Vitamins
Vitamin A Toxicity

• Renal disease is main risk factor due to decrease elimination

• Toxicity can occur with as little as 6000 IU/day but most commonly with dose between 10,000-50,000 units/day

• Symptoms:
  • Alopecia, ataxia, myositis, cheilitis, conjunctivitis, headaches, hepatotoxicity, hyperlipidemia, membrane dryness, and vision disorders

• Key: keep closely following levels
Fat Soluble Vitamins
Vitamin D (5 mcg or 200 IU)

- Francis Glisson
  - A treatise of rickets, being a disease common to children

---

"""We affirm therefore, that this disease doth very rarely invade children presently after their birth, or before they are six moneths old; (yea, perhaps before the ninth moneth) but after that time it beginneth by little and little daily to rage more and more to the period of eighteen moneths, then is attaineth its pitch and exaltation, and as it were resteth in it, till the child be two years and six months old: so that the time of the thickest invasion is that whole year, which bears date from the eighteenth month, two years and a half being expired, the disease falleth into its declination, and seldom invadeth the child, for the reasons already allledged."""

Fat Soluble Vitamins
Vitamin D (5 mcg or 200 IU)

• **Schmorl** – noted that in 1909, 96% of infants who died at 18 months or younger had histopathological evidence of rickets.

Fat Soluble Vitamins
Vitamin D (5 mcg or 200 IU)

- Mellanby
  - Raised dogs on rachitic diet
  - Exposed to various foods and noted that cod-liver oil, butter, and whole milk were able to prevent rickets.
  - “It therefore seems probable that the cause of rickets is a diminished intake of an anti-rachitic factor which is either fat-soluble A, or has a somewhat similar distribution to fat-soluble A.”

Vitamin D: History

Rickets

• McCollum
  • Oxidation destroyed Vitamin A
  • Oxidized cod-liver oil had lost its anti-xerophthalmic function, but still retained its calcium-depositing properties.
  • Untreated coconut oil had no anti-xerophthalmic property, but had minimal anti-rachitic function.
  • Anti-rachitic substance was present in certain fats and was distinct from fat-soluble vitamin A

McCollum EV, Simmonds N, Becker JE, Shipley PG. Studies on experimental rickets. XXI. An experimental demonstration of the existence of a vitamin which promotes calcium deposition. J Biol Chem. 1922;53:293–312
Vitamin D: History

UV light

• Theobald Palm
  • Analyzed the geography of Rickets
  • Involved the temperate latitudes of Europe
  • Southern Italy, Southern Spain, Turkey, and Greece “enjoy a notable immunity from it”

**THE GEOGRAPHICAL DISTRIBUTION AND AETIOLOGY OF RICKETS.**

*BY THEOBALD A. PALM, M.A., M.D.*

*Wigton, Cumberland.*
Vitamin D: History

UV light

- Kurt Huldschinsky (Berlin pediatrician)
- Calcium supplementation
- Irradiated with quartz mercury-vapor lamps

Vitamin D: History

UV light

• Kurt Huldschinsky (Berlin pediatrician)
  • Light shined on one arm cured rickets in both arms
  • Chemical synthesized in response to UV light could diffuse throughout the affected child

Vitamin D: History
UV light

• Steenbock and Black
  • Noted that foods could be irradiated to impart antirachitic activity

A Triumph of Public Health Policy and Implementation

Iodine 1920s

Vitamin D 1930s

Vitamin D
Physiology

Skin
7-dehydrocholesterol

290-315 nm UVB

Previtamin D$_3$

Δh

Dietary
Intestinal absorption

Vitamin D$_3$ (or D$_2$)

Vitamin D$_3$
Vitamin D: Photobiology
Latitude, Season, Time of Day

Previtamin D$_3$ formation (%)

Month
Jan, Mar, May, July, Sep, Nov

Hour of day
8:00, 11:00, 12:00, 2:00, 4:00, 6:00
Vitamin D Deficiency Geography
Vitamin D: Deficiency

- PubMed/Medline review of studies addressing vitamin D deficiency worldwide in the last 10 years.
  - 103 articles included
  - Maps of deficiency were created.

Adults

Vitamin D Status
- <30 nmol/l (<12 ng/ml)
- <50 nmol/l (<20 ng/ml)
- <75 nmol/l (<30 ng/ml)

Type of sample
- Representative Sample
- Data from individual studies
- No Data

**Hawaii**

51%
Vitamin D Photobiology

Effect of Sunscreen

Serum concentration of Vitamin D (nmol/L)

Day

Without sunscreen

With sunscreen

Matsuoko: JECM 1987
Vitamin D Photobiology

Effect of Melanin

Vitamin D levels in August in Boston

25(OH)D, ng/mL

White  Hispanic  Black

% Volunteers <20 ng/mL

White  Hispanic  Black

Elderly
Vitamin D Photobiology

Age

Serum concentration of Vitamin D (nmol/L)

Day

Young

Elderly

Holick: Cur Opin in Endo Dia 2002
Vitamin D Physiology

- Skin: 7-dehydrocholesterol is converted to previtamin D₃ (or D₂) by 290-315 nm UVB.
- Dietary: Vitamin D₃ (or D₂) is absorbed into the intestinal tract.
- Liver: 25-hydroxylase converts previtamin D₃ to vitamin D₃ (unregulated, CYP2RI, CYP27A1).
- Kidney: CYP27B1 converts vitamin D₃ to 1,25(OH)₂ vitamin D with the help of PTH.
- Vitamin D: 25(OH) vitamin D is produced by the liver with vitamin D₃ as a precursor.

25(OH) vitamin D is converted to 1,25(OH)₂ vitamin D in the kidney with the help of PTH.
Vitamin D Physiology

Skin
7-dehydrocholesterol

290-315 nm UVB

Previtamin D₃

Δ₈

Dietary
Vitamin D₃ (or D₂)

Intestinal absorption

Vitamin D₃

Liver 25-OHase

1,25 (OH)₂ Vitamin D

Renal CYP27B1

Δ₇

Gut Ca²⁺ Transport

Non-Calcemic Effects

25 (OH) Vitamin D

+ PTH
**Vitamin D: Physiology**

- **Intestine**: Absorption of Vitamin D and calcium.
- **Bone**: Calcium and phosphate metabolism.
- **Liver**: Synthesis of 25 (OH)D.
- **Kidney**: Synthesis of 1,25 (OH)2D.
- **ECF**: Extracellular fluid, where calcium and phosphate are regulated.
- **PTH**: Parathyroid hormone, which regulates calcium and phosphate levels.

Key Points:
- Calcium (Ca)
- Phosphate (PO4)
- Vitamin D: 25 (OH)D, 1,25 (OH)2D
- Positive (+) and negative (-) regulatory effects.
### Vitamin D

**Biochemical Changes Associated with Deficiency**

<table>
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<th>25-OH-D</th>
<th>sCa</th>
<th>sPhos</th>
<th>uCa</th>
<th>PTH</th>
<th>BAP</th>
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<td>N</td>
<td>N</td>
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<td>N</td>
<td>N</td>
<td>↓↓</td>
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</table>
Vitamin D
Fall and Fracture prevention

• 1447 subjects from 6 RCTs

• Inverse relationship b/t 25-OH D and Fall/Fx

1447 individuals from 6 RCTs
Vitamin D
Calcium absorption

• Heaney et
  • Increased in 25-OH Vitamin D level from 20 ng/ml to 32 ng/ml in post-menopausal women
  • Increased efficiency of intestinal calcium absorption by 45-65%

Vitamin D
Bone Health

No defect in mineralization above 30 ng/ml
Vitamin D
Appropriate levels

- Deficiency: <20 ng/ml
- Insufficiency: 21-29 ng/ml
- Sufficiency: 30-100 ng/ml
Fat Soluble Vitamins
Vitamin E (10 mg or 10 IU)

• Eight naturally occurring compounds found to have vitamin E activity:
  • Four tocopherols
  • Four tocotrienols
• First described in 1922 by Evans and Bishop
• Tocopherol – from the Greek words meaning *birth* and *to bear or carry*
Fat Soluble Vitamins
Vitamin E (10 mg or 10 IU)

- **Principle Function:**
  - Maintenance of membrane integrity via action as antioxidant and inhibition of lipid peroxidation
  - Free radical scavenger: requires vitamin C, glutathione, selenium, and NADPH

- **Deficiency:**
  - Major symptom is peripheral neuropathy (degeneration of the large caliber axons in the sensory neurons)
Fat Soluble Vitamins
Vitamin K (150 mcg)

- Vitamin K consists of two natural vitamers
  - Vitamin K$_1$: found in highest amounts in green leafy vegetables
  - Vitamin K$_2$: found in eggs, dairy, and meat
    - Bacteria and animals can convert K$_1$ to K$_2$ and other subtypes
- Plays key role in:
  - Blood coagulation
  - Bone Metabolism
  - Vascular biology
Fat Soluble Vitamins
Vitamin K (150 mcg)

• Deficiency:
  • Is rare from inadequate intake
  • Typically a result of malabsorption, antibiotic therapy, and oral anticoagulants (coumadin)
  • Other causes include impaired lipid absorption (biliary obstruction/short bowel) which can decrease absorption from 80% to 20%

• No storage form
• Most common symptom is bleeding
• Lab test: PT/INR
Vitamins and Trace elements
Drug Shortages

- Drug shortages are not uncommon and most affect IV medications
Vitamins and Trace elements
Drug Shortages

• Etiology
  • Regulatory changes (payment and inspection of plants)
  • Natural disasters
  • Voluntary Recalls
  • Issues with raw materials
  • Loss of manufacturing site
  • Discontinuation
  • Only small number of manufactures produce

• FDA Safety and Innovation Act (FDASIA)
  • Passed in 2011
  • Manufactures collaborate with FDA on impending shortage

https://www.fda.gov/drugs/drugsafety/drugshortages/default.htm
TPN

<table>
<thead>
<tr>
<th>Institution/Pharmacy Name, Address and Pharmacy Phone number</th>
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<tr>
<td><strong>Name</strong></td>
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<td>Administration Date/Time</td>
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<table>
<thead>
<tr>
<th>Base Formula</th>
<th>Amount/day</th>
<th>(Amount/L)</th>
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<tbody>
<tr>
<td>Dextrose</td>
<td>g</td>
<td>(g/L)</td>
</tr>
<tr>
<td>Amino acids*</td>
<td>g</td>
<td>(g/L)</td>
</tr>
<tr>
<td>IVFE*</td>
<td>g</td>
<td>(g/L)</td>
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<table>
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<tr>
<td>Sodium chloride</td>
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<tr>
<td>Sodium acetate</td>
<td>mEq</td>
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<tr>
<td>Sodium phosphate</td>
<td>mmol of P</td>
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<tr>
<td>Potassium chloride</td>
<td>mEq</td>
</tr>
<tr>
<td>Potassium acetate</td>
<td>mEq</td>
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<tr>
<td>Potassium phosphate</td>
<td>mmol of P</td>
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<tr>
<td>Calcium gluconate</td>
<td>mEq</td>
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<tr>
<td>Magnesium sulfate</td>
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<table>
<thead>
<tr>
<th>Vitamins, trace elements and medications</th>
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<tbody>
<tr>
<td>Multiple vitamins*</td>
<td>mL</td>
</tr>
<tr>
<td>Multiple trace elements*</td>
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<tr>
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<tr>
<td><strong>H₂ - antagonists</strong></td>
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<table>
<thead>
<tr>
<th>Rate</th>
<th>Volume</th>
<th>Infuse over</th>
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<tbody>
<tr>
<td>mL/hour</td>
<td>mL</td>
<td>hours</td>
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Formulation contains______mL plus ______mL overfill
Discard any unused volume after 24 hours

***Central Line Use Only***
Pearls
Anemia Due to Nutrient Deficiency

- Macrocytic: Vitamin B$_{12}$ and folate
- Microcytic: iron and copper
- Normocytic: Vitamin K, early iron, or mixed
Pearls
Neurological Abnormalities Due to Nutrient Deficiency

- **Muscle Weakness**: Selenium, Vitamin E, Thiamine (Beri Beri) and hypophosphatemia
- **Dementia**: Niacin and Thiamine (Wernicke’s, Korsakoff)
- **Ataxia**: Vitamin B12, Thiamine (Wernicke’s), Chromium
- **Visual Impairment**: Vitamin A (night blindness) and Thiamine (nystagmus)
Pearls
Rash Due to Nutrient Deficiency

• **Peri-folliculitis**: Vitamin C
• **Dry Skin**: Zinc, Vitamin A, Protein, Essential Fatty Acid
• **Crusting Exudative**: Niacin (pellagra) and Zinc
• **Ecchymoses**: Vitamin K
• **Chelosis**: Riboflavin and B-vitamins
Questions & Discussion

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