Assessment and monitoring of nutritional status. Principles of nutritional support, enteral and parenteral nutrition. Dietary constituents providing a sufficient energy intake.

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EVALUATION OF NUTRITIONAL STATUS

- Long-term state of nutrition
- Actual (contemporary) state of nutrition

  - Data to assess: antropometric
    laboratory: biochemical
    hematological
    imunological
  - indirect calorimetry

Antropometric data

	Normal values
weight w, height h	
BMI	18.5 – 24.9 kg/m^2
Broca index	h (cm) – 100 = w (kg)
Arm muscles circumference (arm circumference – π . triceps skinfold /cm/)	≥ 25 cm, ≥ 20 cm
triceps skinfold	12.5 mm, 16.5 mm
body composition	

What are your values?

Laboratory data

- Total protein/S
- Albumin /S ($t_{1/2}$ = 21 days)
- Prealbumin /S ($t_{1/2}$ = 2 - 3 days)
- Transferrin /S ($t_{1/2}$ = 7 days)
- RBP ($t_{1/2}$ = 0.5 day)
- CRP /S
- Zn /S (binds to alb)
- Chol (long-term indicator)
- Blood count
- Total lymphocytes number, number of CD4, CD8
- Ig /S
- Delayed skin reaction

Energy balance

- Energy ingested = energy expended

- Resting metabolic rate RMR (kJ/day) = 100 . w (kg) = 4.2 . S (m^2)
- reserves formation
- heat production
  - rise in body temperature by 1°C → + 15 % RMR
- activity
  - activity factor: bedridden → 1.2 RMR
    not - bedridden → 1.3
    (heavy physical activity → 2)
- stress
  - trauma factor: small surgery → 1.2
    severe surgery → 1.35
    sepsis → 1.6
    severe burns → 2.1

What is your RMR (in kJ, kcal)?

1 kcal = 4.19 kJ

Energy balance

- Harris-Benedikt equation for RMR assesment

- Male
- BM (kcal/24 h) = 13.7516 · w (kg) + 5.0033 · h (cm) – 6.755 · age (years) + 66.473
- Female
- BM (kcal/24 h) = 9.5634 · w (kg) + 1.8496 · h (cm) – 4.6756 · age (years) + 655.0955

INDIRECT CALORIMETRY

- Weir equation for energy expenditure
- EE (kcal/ 24 h) = 3.95 · V (O_2) + 1.11 · V (CO_2)
- Computational relations for estimation of substrate oxidation
- Saccharides, lipids mg/min from V(O_2), V(CO_2)
- Proteins g/24 h = 6.25 · nitrogen output/24 h

$$N_{out}\ (g) = c_{urea/U} \cdot V_u \cdot 100/84 \cdot 0.028 + \text{other (faeces, skin)}$$

1 kcal = 4,185 kJ

DISORDERS OF NUTRITION - MALNUTRITION

- State of nutrition linked to deficiency, dysbalance or rebundance of energy, proteins and other nutrients

Undernutrition

Simple undernutrition, simple cachexy, marasmus
Energy malnutrition

Stress undernutrition, kwashiorkor, kwashiorkor-like undernutrition
Protein malnutrition

Obesity

BMI > 30 kg/m^2
Waist circumference ≥ 94 cm , ≥ 80 cm

METABOLISM LEADING TO OBESITY

INSULIN

- Glc entering the cells (GLUT-4)
- Glykolysis
- Synthesis of glykogen
- LPL activity
- **Synthesis of fatty acids → triacylglycerols → VLDL**
- Proteosynthesis

METABOLISM IN OBESITY

INSULIN RESISTANCE + RELEASE OF ADIPOKINES produced by adipose tissue (leptin, resistin, angiotensinogen, adipsin, ACE, CETP, TNFα, IL-6 et al.)

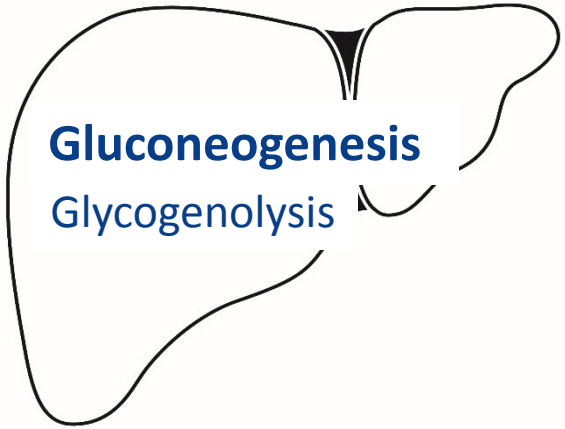
GLUCAGON

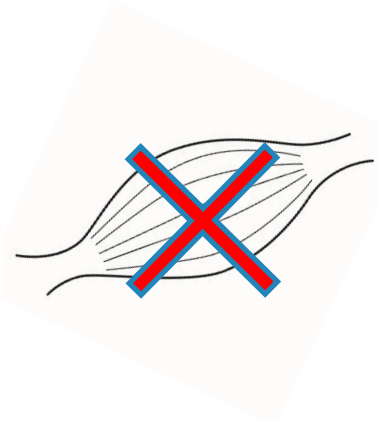
- ↑ lipolysis in adipose tissue → ↑ FA in blood
- Excess FA to liver → formation of VLDL → ↑ TAG and chol in blood
  → ectopic accumulation of lipids
- ↓ activity of LPL → ↑ TAG in blood + stopped liponeogenesis
- ↓ utilization of glc in muscles and adipose (GLUT-4) → hyperglycemia
- ↑ accumulation of liver glycogen

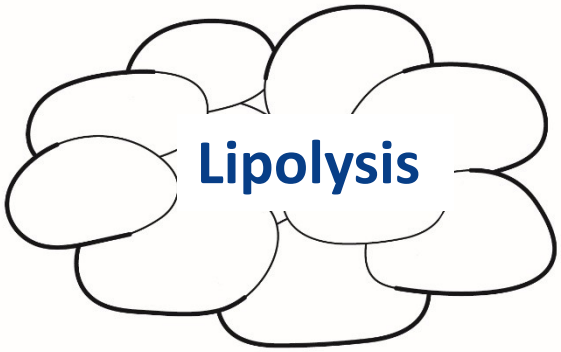
SIMPLE UNDERNUTRITION

- = energy malnutrition
- Insufficient intake of carbohydrates, lipids and proteins
- Progressive symmetric weight loss leading to cachexy in otherwise healthy individuals with limited food intake

GLUCAGON







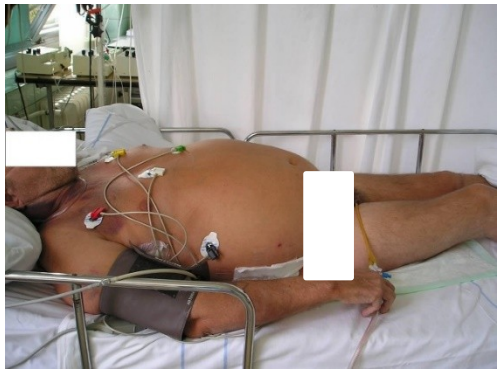
SIMPLE UNDERNUTRITION

- atrophy of GIT → restoration of nutrition p.o. is not possible!!

- Sources of energy: **lipolysis in adipose tissue** → glycerol + acetyl-CoA →
  - gluconeogenesis → glc
  - Krebs cycle → reduced cofactors → RC → ATP
  - synthesis of ketone bodies – en. substrate for CNS, myocardium, muscles

proteolysis in striated muscles → AA for synthesis of plasma proteins

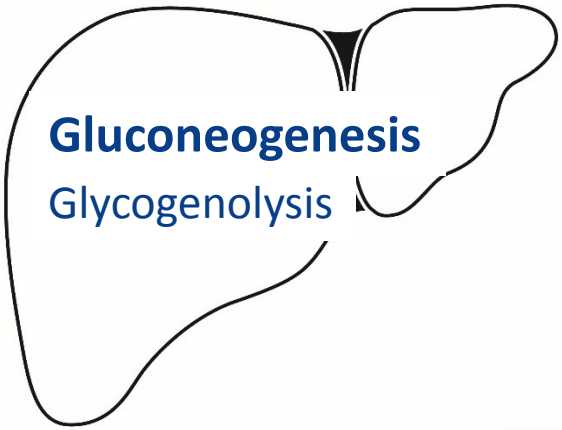
STRESS UNDERNUTRITION

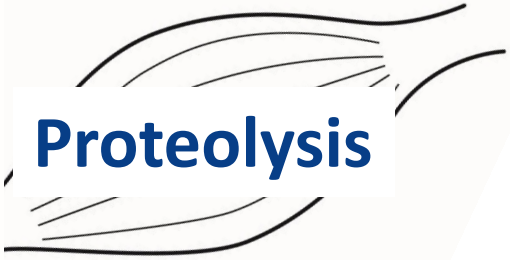


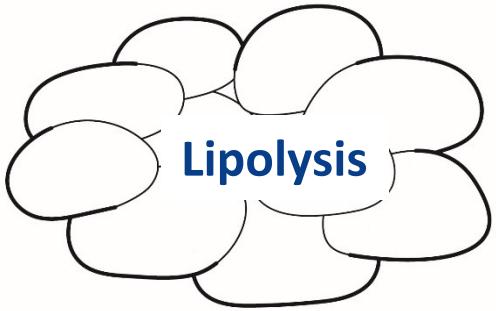
- = protein malnutrition
- Insufficient protein intake + fast proteolysis

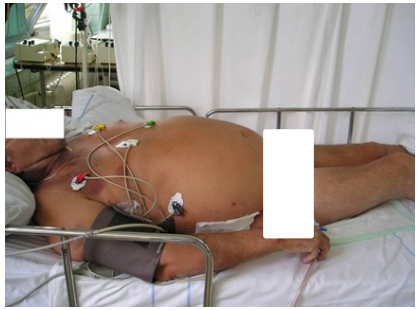
Causes: ↓ intake, ↑ loss, ↑ needs, ↑ breakdown (catabolism), ↓ synthesis (liver) = STRESS

GLUCAGON
+
STRESS HORMONES









STRESS UNDERNUTRITION

- Presence of systemic inflammation with ↓ insulin and ↑ stress hormones, STH and proinflammatory cytokines
- Sources of energy: **proteolysis in muscles and albumin** → AA for gluconeogenesis, proteosynthesis (AFP, wound healing…)

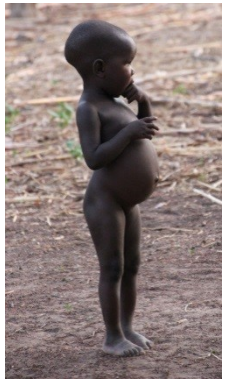
lipolysis in adipose tissue

- Water retention, ascites and edemas at the same or increasing weight

Comparison of simple and stress undernutrition

	Simple undernutrition	Stress undernutrition
Origination	weeks - months	days
Inflammation	no	present
Weight	↓	normal - ↑
Muscle mass	slightly ↓	extremely ↓
Fat mass	↓	↓, normal or ↑
Content of water and Na^+	↓	↑
Serum proteins, albumin	normal	extremely ↓
Acute phase proteins (AFP)	normal	↑
Example	geriatric cachexy, mental anorexia, m. Crohn, chronic pancreatitis	sepsis, trauma, surgery, burns, acute pancreatitis

Which of the findings in the child shown at right would support a diagnosis of kwashiorkor?



A. Shows increased serum albumin.
B. Shows a good appetite.
C. Appears plump due to increased adipose tissue.
D. Has markedly decreased weight for height.
E. Displays abdominal and peripheral edema.

Which of the findings in the child shown at right would support a diagnosis of kwashiorkor?

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C. Appears plump due to increased adipose tissue.
D. Has markedly decreased weight for height.
E. Displays abdominal and peripheral edema.

Kwashiorkor is caused by inadequate protein intake in the presence of fair to good energy intake. Typical findings include abdominal and peripheral edema caused largely by a decreased serum albumin concentration. Anorexia is almost always present. Weight is often normal due to edema. Treatment includes a diet adequate in energy and high-quality protein.

THE DAILY REQUIREMENTS OF BASIC NUTRIENTS

- Energy

Reccomended (reference) daily intake

- Carbohydrates — 45 – 60 % (2 (4) - 6 g glc /kg/day)
- Proteins — 0.83 g/kg/day (0.8 – 1.6 g/kg/day)
- Lipids — 20 - 35 % (1 – 1.5 g/kg/day), min. 15 - 20 %

Why?

UNDERNUTRITION

Carbohydrates	Proteins (AA)	Lipids
Anabolic ratio of nutrients		
6 g/kg	1 g/kg	1 – 1.5 g/kg
Stress ratio of nutrients		
2 - 3 g/kg	1.5 - 2 g/kg	0.7 g/kg

CARBOHYDRATES

- RDA = 2 – 6 g glc /kg / day ≈ 45 – 60% of energy supply

Enteral nutrition:
Starch, oligosaccharides (maltodextrin), sugars

Parenteral nutrition:
Glc: isoosmolar – 5% (50 g/l = 278 mmol/l), low energy content
10% (100 g/l = 556 mmol/l), 15% (150 g/l = 833 mmol/l)
– peripheral or central vein
20% (200 g/l = 1111 mmol/l) and more – only central vein

OSMOLALITY OF GLC SOLUTIONS

- **G5** = 5% Glc = 5 g Glc / 100 g of solution

  50 g Glc / 1000 g

  ≈ 50 g Glc / 1 L

$M_{r(Glc)}$ = 180

osmolarity = 50 : 180 = 0.278 mol / 1 L

= 278 mmol / 1 L

- normal osmolality of blood plasma = 275 - 300 mmol / kg H_2O
- The infusion of 5 % glc is isotonic with blood plasma.

OSMOLALITY OF GLC SOLUTIONS

- **G15** = 15% Glc = 15 g Glc / 100 g of solution

  150 g Glc / 1000 g

  ≈ 150 g Glc / 1 L

$M_{r(Glc)}$ = 180

osmolarity = 150 : 180 = 0.833 mol / 1 L

= 833 mmol / 1 L

- The highest osmolality for infusion into a peripheral vein is 850 mmol/kg

  = 15% glc solution - without any additives !!!

REM. – DIETARY FIBER

- *Biological definition:* Carbohydrates which are not lysed enzymatically in the small intestine and thus are passed into the large intestine.
- *Chemical definition:* Non-starch polysacharides and lignin.

Water-insoluble:
celulose, hemicelulose, lignin; psyllium

Water-soluble:
pectin, inulin, gums, mucilage and storage polysaccharides (guar gum)

- Adequate intake = 25 g /day - adults

  ≈ age + 5 g – teens 11 – 20 years

Function of insoluble fiber

- Acceleration of intestinal passage, ↑ stool weight and volume
- ↓ resorption of bile acids, ↓ chol /S
- ↓ resorption of sugars
- ↓ resorption of lipids
- ↓ resorption of minerals and microelements

What is happening with soluble fiber in the colon?

- Fermented by bacteria
- Products: acetic, propionic, butyric acids
- These acids are utilised by enterocytes – 70% of energy
- Significance : to maintain the intestinal barrier
- ↑ resorption of Na^+ and water

Need of proteins

Reference daily intake of proteins* in g / kg / day	
Infants (1 year)	1.14
Toddlers (2years)	0.97
Children, adolescents	≈ 0,9
Adults	0.83
Pregnant and breastfeeding women	≈ 1.1 (0.83 g/kg/day + 1-28 g/day according to trimester)
Sportmens	1.3 – 2.0
Parenteral nutrition (AA) or other nutritional support	1.0 – 1.5
Minimal intake	0.4 – 0.5

*valid in case of sufficient intake of non-protein energy

Why?

Correct protein dosing – influencing morbidity and mortality

- critically ill patients have higher levels of protein in parenteral nutrition – daily dose > 1.2 g / kg / day (ESPEN), up to 2 – 3.5 g / kg / day

Compare with stress ratio of nutrients.

ASPEN (2016):
BMI < 30 kg/m^2 … 1,2-2,0 g/kg actual weight /day
BMI > 30 kg/m^2 … 2,0 g/ kg ideal weight / day

- Ensure the adequacy of total energy intake.
- Excessive energy intake is a burden on many organs and leads to the storage of fats in patients' liver (overfeeding).

Aminoacids (AA)

Essential

- Val
- Leu
- Ile
- Met
- Phe
- Thr
- Trp
- Lys
- His

Semiessential

- Arg
- Gln
- (Glu)
- Cys
- Tyr

Specific pharmacologic effects and indications of selected Essential AA

Val, Leu, Ile

- favour muscle proteosynthesis (especially in DM)
- inhibit sarcopenia

Why?

Increased needs of Semiessential AA

Arg

- growth
- sepsis, injuries, post-operative period (resource of optimal immunological defence mechanisms)
- immunity stimulation
- NO synthesis

Tyr + Cys

- infants
- lack of Phe and Met
- liver insufficiency

Increased needs of Semiessential AA

Gln

- stress situations – *energy substrate* for immune system cells (lymphocytes, macrofages, fibroblasts), enterocytes, kidneys
- *metabolic substrate* for NA bases synthesis (cell division - mucosis, bone marrow)
- important source of nitrogen, the main AA of plasma
- maintaining the intestinal barrier (toxins, starvation, radiation, inflammation)

Unstable in parenteral nutrition solutions!

Select correct answers: With regard to protein in the diet:

A. It may contribute to the supply of energy.

B. Supplies only seven of the essential amino acids.

C. Is a source of ammonia which is detoxified through urea production.

D. Must include an animal source to provide all essential amino acids in the diet.

Select correct answers: With regard to protein in the diet:

A. It may contribute to the supply of energy.

The carbon skeleton of amino acids can contribute to energy supply.

B. Supplies only seven of the essential amino acids.

All essential amino acids can be provided through dietary protein.

C. Is a source of ammonia which is detoxified through urea production.

Ammonia is a toxic end product of amino acid metabolism that is converted to urea in the liver and then excreted through the kidneys.

D. Must include an animal source to provide all essential amino acids in the diet.

Using a variety of vegetable sources it is quite possible to provide all essential amino acids.

LIPIDS

- RDI = 0.5 – 1.5 g /kg/ day ≈ 20 – 35% of energy supply

Enteral nutrition:
vegetable oils (rapeseed, sunflower, soya, coconut)

Parenteral nutrition:
10-20% lipid emulsions (of olive, soybean oil
+ event. fish, coconut)

- source of essencial FA, fat-soluble vitamins

Give names
of essential FA.

Significance of fatty acids according to their chain lenght

- **2 - 4 C:** resorption to portal vein, probably inhibit chol synthesis in the liver
  energy for enterocytes (70% of en., intestinal barrier)

- **6 - 10 C:** fast energy: resorption to portal vein, β-oxidation without carnitine; component of MCT

- **≥ 12 C:** resorption to thoracic duct (as CM), carnitine needed for their transoprt to mtch matrix; component of LCT
- 12 – 16 C: energy, atherogenic
- ≥ 18 C: energy, structure of PL, TAG
- 20 C (DHGLA, AA, EPA): synthesis of eicosanoids

SATURATED FATTY ACIDS WITH 12C – 16C CHAIN

- Highly atherogenic, increase total cholesterol

> **↑ synthesis of chol de novo**
> **↓ affinity of LDL-receptors to LDL** (only C14:0 and C16:0?)

- lauric 12:0 – increases total and HDL cholesterol
- myristic 14:0 (Myristica fragrans) – 4x more efective than 16:0
- palmitic 16:0

SATURATED FATTY ACIDS WITH 12C – 16C CHAIN SOURCES

Fatty acid (% of total FA)	Coconut fat	Palm fat	Palm kernel fat	Milk fat	Lard	Olive oil	Rapeseed oil	Sunflower oil
Butyric 4:0	x	x	x	3.6	x	x	x	x
Capronic 6:0	0.5	x	0.3	2.2	x	x	x	x
Caprylic 8:0	7.8	x	4.4	1.2	x	x	x	x
Caprinic 10:0	6.7	x	3.7	2.5	x	x	x	x
Lauric 12:0	**47.5**	**0.2**	**48.3**	**4.5**	**x**	**x**	**x**	**x**
Myristic 14:0	**18.1**	**1.1**	**15.6**	**14.6**	**1.7**	**x**	**x**	**x**
Palmitic 16:0	**8.8**	**44.0**	**7.8**	**30.2**	**25.0**	**8.4**	**3.6**	**6.3**
Stearic 18:0	2.6	2.0		10.5	15.0	2.5	1.5	4.6
Palmitooleic 16:1 (9)	X	X	x	5.7	3.0	0.7	x	X
Oleic 18:1 (9)	6.2	39.2	15.1	16.7	45.0	78.0	61.6	26.7
Linoleic 18:2 (9, 12)	1.6	10.1	2.7	2.4	8.0	8.3	21.7	61.2
α-linolenic 18:3 (9, 12, 15)	x	0.4	x	x	x	0.8	9.6	x

Pánek J.: Odborné výživové hodnocení palmového a palmojádrového tuku 2015

LIPIDS – PREFERABLE RQ

- $RQ = \frac{CO_2}{O_2}$

- glc: $C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$

$RQ = 6 / 6 = 1.0$

- palmitic a.: $C_{16}H_{32}O_2 + 23\ O_2 \rightarrow 16\ CO_2 + 16\ H_2O$

$RQ = 16 / 23 = 0.7$

- Lower CO_2 production during oxidation of FA – important source of energy in ventilatory problems.

Daily requirement for basic nutrients

Water	30 – 40 ml /kg ≈ 2( )-2.5( ) l/d
Energy	25 – 30 kcal = 105 – 126 kJ /kg
Glc	2 – 6 g /kg
Lipids	1 – 1.5 g /kg
AA	0.8 – 1.6 g /kg
Sodium	1 – 2.5 mmol /kg
Potassium	1 – 2.5 mmol /kg
Calcium	0.05 – 0.1 mmol /kg
Magnesium	0.1 – 0.2 mmol /kg
Phosphorus	0.4 mmol /kg

Vitamins
Trace elements

1 kcal = 4.19 kJ

Select correct answers: In the provision of dietary energy:

A. Carbohydrates are preferred as they do not contribute to increasing body fat stores.

B. Fats are not required as all energy and essential nutrition requirements can be met from other sources.

C. The calorific value of lipids exceeds that of carbohydrate.

D. Stored carbohydrate in the liver (as glycogen) is depleted after 18–24 h starvation.

SELECT CORRECT ANSWERS: IN THE PROVISION OF DIETARY ENERGY:

A. Carbohydrates are preferred as they do not contribute to increasing body fat stores.

Excess carbohydrate in the diet can be converted to fat and stored as fat in adipose tissue

B. Fats are not required as all energy and essential nutrition requirements can be met from other sources.

A source of fat is required to provide the essential fatty acids, linoleic and α-linolenic acids, in the diet.

C. The calorific value of lipids exceeds that of carbohydrate.

The calorific value of lipids is 38 kJ/g compared to 17 kJ/g for carbohydrates.

D. Stored carbohydrate in the liver (as glycogen) is depleted after 18–24 h starvation.

The reserves of glycogen in the liver are relatively small and comparatively quickly depleted.

MICRONUTRIENTS

- = vitamins + microelements

- from day one until the and of hospitalization
- Adapt RDI to individual needs (especially for microelements)
- Monitoring of levels - always necessary after dose adjustment, liver and renal disease ; repeated checks recommended (ESPEN)
- Causes of deficiency: insufficient or inappropriate administration, increased or changed needs for nutrients, increased losses

MICRONUTRIENTS

In critically ill patients are often present deficiencies of zinc, iron, selenium,
vitamins A, B and C.

However, decreased serum levels may not correspond to the current deficiency, but only to redistribution (sequestration in the liver and RES).

Thoughts on the composition of trace element mixes have recently shifted towards a minimum of manganese, iron, copper and a higher supply of selenium and zinc.

BASIC CONCEPT OF CLINICAL NUTRITION

- **Normal food** (made at home, in restaurants, hospitals; including gluten- or lactose- free diet, food alergies)

- **Diet**

- **Nutritional support**
  - **Fortified diet (oral nutrition support)**
  - **Enteral tube feeding**
  - **Parenteral nutrition**

DIET SYSTEM IN CR – BASIC DIETS

No.	Name	Energy value kJ	Specification
0	fluid	6 000 – 12 000	
1	pappy	9 500	
2	GIT- saving	9 500	Fried food – free. Proteins 80 g, lipids 70 g, sacchar. 320 g
3	**basic (rational)**	9 500	Proteins 80 g, lipids 70 g, sacchar. 320 g
4	with fat restriction	9 500	Limited lipid content 55 g.
5	residue-free	9 500	Without dietary fibres.
6	with protein restriction	9 500	Limited protein content 50 g.
8	reducing	5 300	Limited energy value.
9	**diabetic**	7 400	Limited saccharides content 225 g.
10	saltless	9 500	Limited salt content.
11	nutritive	12 000	Increased energy value.
12	infant	5 500	1.5 – 3 years.
13	pediatric	7 000, 8 800	4 - 6, 6 - 12 years.

1 kcal = 4.19 kJ

DIET SYSTEM IN CR – SPECIAL DIETS

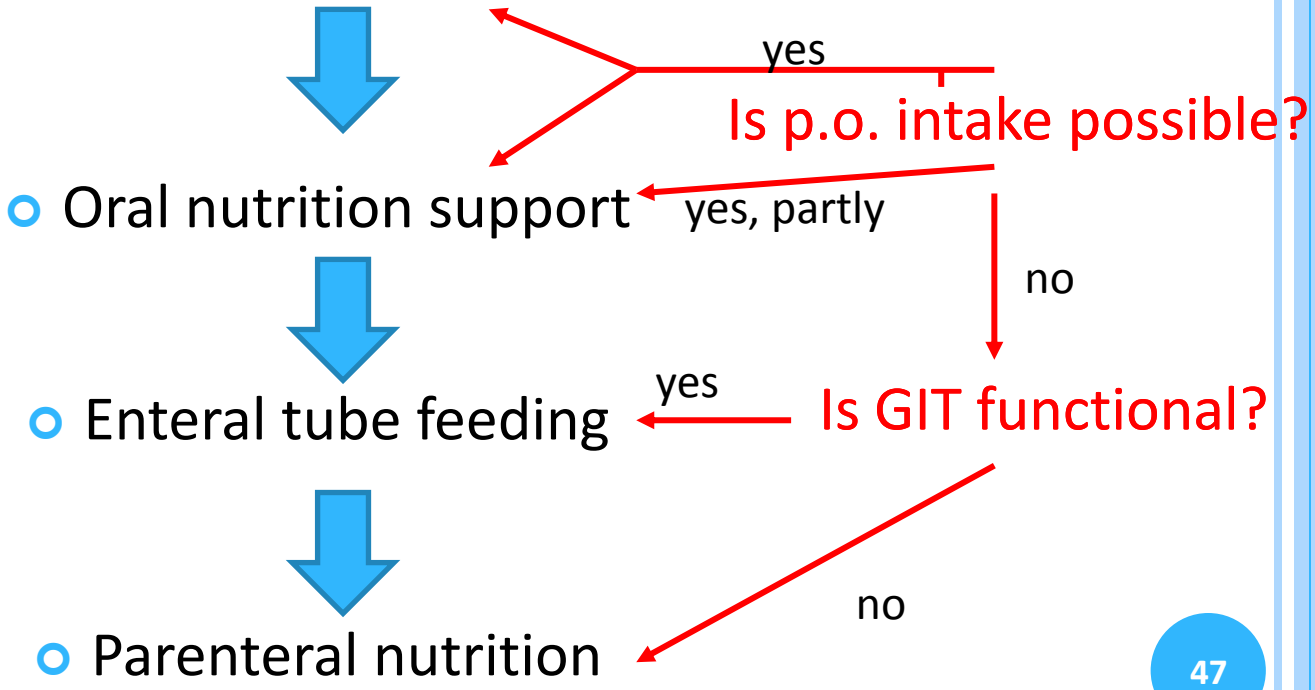
No.	Name	Energy value	Specification
0S	tea		Nutritionally deficient!!!
0-ND	**nutritionally defined**	**8 000 - 12 000 kJ**	**Individual.**
4S	with strict fat restriction	7 000 kJ	Limited energy and lipid content.
9S	diabetic chary	7 400 kJ	Limited carbohydrates content 225 g + fried food – free.

DIET SYSTEM IN CR – STANDARDIZED AND SPECIAL DIETS

- Gluten-free diet
- Lactose-free diet
- Pancreatic diet – in accute pancreatitis
- Renal diet – in chronic renal failure
- Vegetarian diet etc.

ALGORITHM OF NUTRITIONAL SUPPORT

- Why?
- Normal food?
- Feeding of patient, insreased supervision, individual diet



Algorithm of nutritional support

- **Nutritional therapy in stable patients**

  early initiation of **enteral nutrition**
  correct supply of macro- and micronutrients
  careful monitoring of glycaemia

- **Nutritional therapy in hemodynamically unstable patients**

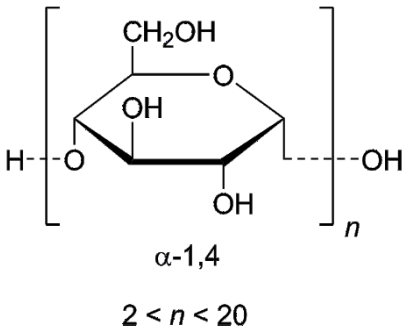
  requiring significant circulatory support by catecholamines, volume expansion or administration of blood derivatives

  nutritional support by **parenteral route**
  in case of normalization of blood pressure possible recovery of EN

KINDS OF NUTRITIONAL SUPPORT

- Fortified diet
- Enteral nutrition
- Parenteral nutrition

Normal meal enriched with energy, macronutrients, or micronutrients.



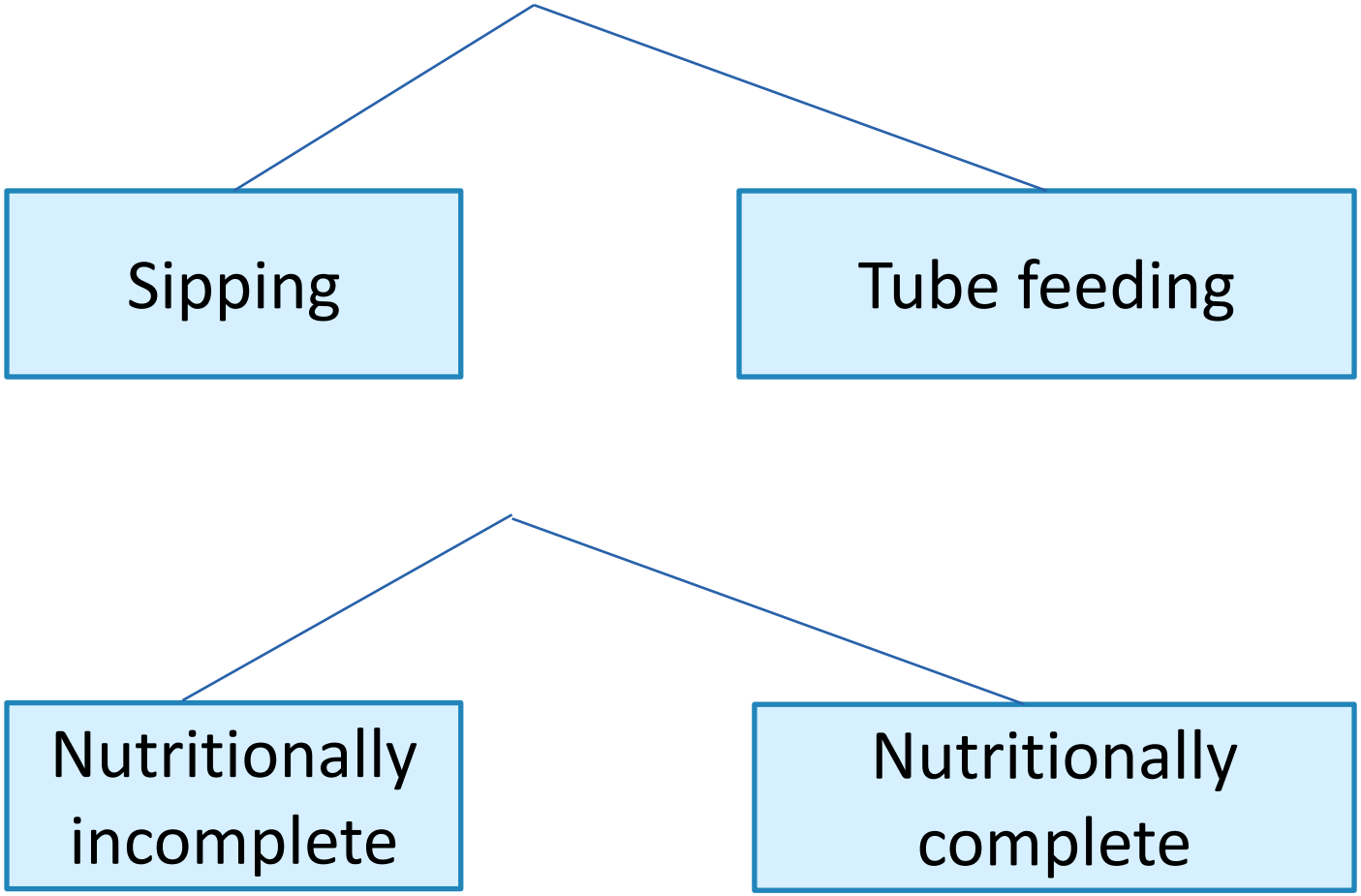
α-1,4

$2 < n < 20$

maltodextrin
(enzymatically digested corn starch)

concentrated milk protein,
emulsifier (soya lecithin)

ENTERAL NUTRITION



Energy (calorific) value of nutrition support

- hypocaloric < 1 kcal/1 ml = < 4.19 kJ/1 ml
- isocaloric 1 kcal/1 ml = 4.19 kJ/1 ml
- hypercaloric > 1 kcal/1 ml = > 4.19 kJ/1 ml

SIPPING

- = oral nutrition support
- the most used nutrition support
- advantages:
  - ready to use, easy to consume
  - defined content of energy and nutrients
  - defined content of vitamins and trace elements
  - easily absorbed
  - good bioavailability

SIPPING

Proteins – milk, soya
Carbohydrates – maltodextrin, sucrose
Vegetable oils
Vitamins
Trace elements
Minerals

SIPPING

- Generally 1 – 1.5 kcal/ml (4.19 – 6.28 kJ/ml)
- 16-20 % proteins, 25-30 % lipids and 50-54 % carbohydrates

- *Products with higher energy content:* 1.2 – 1.6 – 2.0 kcal/ml
  5 – 6.7 – 8.4 kJ/ml

  - requirement for highly energy-rich diet (Tu), limited oral intake (organic reasons, dysorexia)

- *Products with higher protein content:*
  - Better wound healing; surgery, Tu, seniors.

- *Products with diet. fiber:* ↑ bowel motility, ↓ constipation soften stools, ↓ absorption of diet. fat and chol, source of short FA (C2-4) after fermentation

SIPPING – SPECIAL PRODUCTS

- DM – maltodextrin is replaced with starch, other dextrins or fructose, lower content of proteins and energy

- ↑ Gln – better immune response, regeneration precesses

- Patients with s decubiti (↑ proteins, Arg, vit. C, A, E, trace elements)

(ENTERAL) TUBE FEEDING

- = complete nutrition via a tube to patients who cannot obtain nutrition by mouth, are unable to swallow safely, or need nutritional supplementation

Through the nose	Percutaneous (through the abdomen)
Nasogastric tube	Faryngostomy Esophagostomy **Gastrostomy (PEG)**
Nasoduodenal tube	Extended gastrostomy
Nasojejunal tube	**Jejunostomy (PEJ)**

STERILE!

Mode of delivery

- Bolus method - only into the stomach
  boluses 50 – 300 ml
  2 - 3 hour intervals

- Continuously - enteral pump
  steady over 16–24 hours daily
  intermittently during the day with night break
  intermittently during the night with day break

What is administered

- Mixed hospital diet
- Polymer nutrition (defined nutritionally)

Intact proteins (kasein)
Polysaccharides
Lipids (TG with long-chain FA = LCT)
Dietary fiber
Osmolarity ≤ 400 mmol/l
Stomach, duodenum

- Oligomer nutrition (defined chemically)

AA, di-, tripeptides
Disaccharides, maltodextrin
Lipids (MCT + LCT)
Osmolarity > 450 mmol/l
Jejunum

Vitamins
Minerals
Trace elements

Which is the most common side effect during administration of oligomer nutrition?

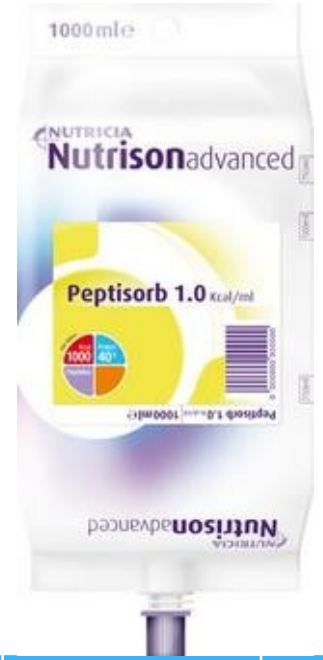
POLYMER NUTRITION

- undigested nutrients ≈ similarity to natural food in terms of absorption
- In patients with functional GIT with digestion enzymes production.

- Hypocaloric, isocaloric, hypercaloric
  We start with hypocaloric nutrition and raise the energy content according to patient´s tolerance.
- *Special products with increased protein content*
  with dietary fiber
  DM etc.

Oligomer nutrition

- Sterile, isocaloric (1 kcal/1 ml)



Název	Energy (kcal/ 100 ml)	Proteins (g/100 m)	Carbohydrates (g/100 ml)	Lipids (g/100 ml)	Fiber (g/100 ml)
Nutrison Advanced Peptisorb Pack	100	4-0	17.6	1.7	0
Survimed OPD	100	4.5	15.0	2.4	0
Novasource Peptide	100	3.8	12.5	3.9	< 0.3

PARENTERAL NUTRITION

= THE DELIVERY OF NUTRITION INTRAVENOUSLY

Indications

- people who are malnourished or at risk of malnutrition, respectively, and meet either of the following criteria:
- inadequate or unsafe oral and/or enteral nutritional intake
- a non-functional, inaccessible or perforated (leaking) gastrointestinal tract

PARENTERAL NUTRITION

Advantages

- Exactly defined intake of nutrients
- Possibility of nutrition modulation according to actual needs
- Rapid treatment of any metabolic collapse
- Suitable for patients with a complete absence of small intestine

Disadvantages

- Non-physiological
- Complications (catheter tunnelling, infection, blood clot, metabolic)
- Costs

Parenteral nutrition

- Complete
- Incomplete

- Short-term (< 2 weeks)
- Long-term (> 2 weeks)

Mode of delivery

- Continuous administration
  - preferred method of infusion

- Cyclical delivery
  - when using peripheral venous cannulae with planned routine catheter change

- A gradual change from continuous to cyclical delivery should be considered in patients requiring parenteral nutrition for more than 2 weeks.

Route of access

Central venous catheter	Peripheral venous catheter
V. cava sup. - v. subclavia l. dx. - v. jugularis - (v. brachiocephalica sin.)	Peripheral vein in a limb For short-term parenteral nutrition (< 14 days)
V. cava inf. - v. femoralis	< 850-900 mmol/l < 600 mmol/l children
≥ 900 mmol/l	glc ≤ 15% (= 833 mmol/l), AA ≤ 5%

Different balanced regimens for peripheral and central venous application!

Selected recommendations of ESPEN (European Society of Clinical Nutrition and Metabolism) for parenteral nutrition

- **Why parenteral nutrition**
  - the patient is unable to take oral food, it is necessary to supply nutrients bz different route than GIT

Nutritional requirements must not be underestimated, especially in ICU patients, who are more likely to develop malnutrition (according to studies, up to 43% of patients in the ICU).

- **When and how to start PN**
  - within 24 hours after patient´s administration
  - as supplementary nutrition to enteral nutrition (if energy intake via enteral nutrition is not sufficient) after 2 days
  - all-in-one

← risk of malnutrition, increased risk of mortality and morbidity

- **Composition of PN**
- Amino acids + glucose + lipids + electrolytes + microelements + vitamins

What is administered

- Water + electrolytes: 30 - 40 ml/kg/day (according to current patient´s needs)
- Energy: ± 120 kJ/kg/day (according to current patient´s needs)
  min. 105 kJ (25 kcal)/kg/day

What is administered

- Carbohydrates: glc 2 - 6 g/kg/day

  xylitol max 0.125 g/kg/hour

  Rate of administration 0.5 g/kg/hour,
  under the stress conditions 0.25 g/kg/hour
  (the half-speed!)

No sucrose, fru, sorbitol!

Avoid hyperglycaemia!

WHAT IS ADMINISTERED

- AA: 1.0 – 1.5 g/kg/day
  all (essent., semiessent., nonessent.)
  essential 45-50% of the total share
  No protein hydrolysates, blood plasma fractions!
  Rate of administration 0.1 g/kg/hour
  Gln in critically ill pat. 0.2-0.4 g/kg/day

Gln separately as Ala-Gln

AA = proteosynthesis substrates and skeletal muscle protection.

With insufficient energy supplies, part of AAs is used for energy yield => to provide sufficient protein synthesis, the total energy of infused nutrients must be covered with 20% AA and 80% carbohydrates + lipids.

What is administered

- Lipids: 0.7 – 1.5 g/kg/day
  ratio of energy from lipids : saccharides = 1 : 1

- 10-20% lipid emulsions – 270 – 410 mmol/kg H_2O;
  of soya, olive, fish oil (LCT),
  coconut fat (MCT);
  separate (S, F) or combinations (S+O, S+C+F, S+O+C+F);
  emulsifier = lecithin), particle size max. 1 μm, utilisation as CM

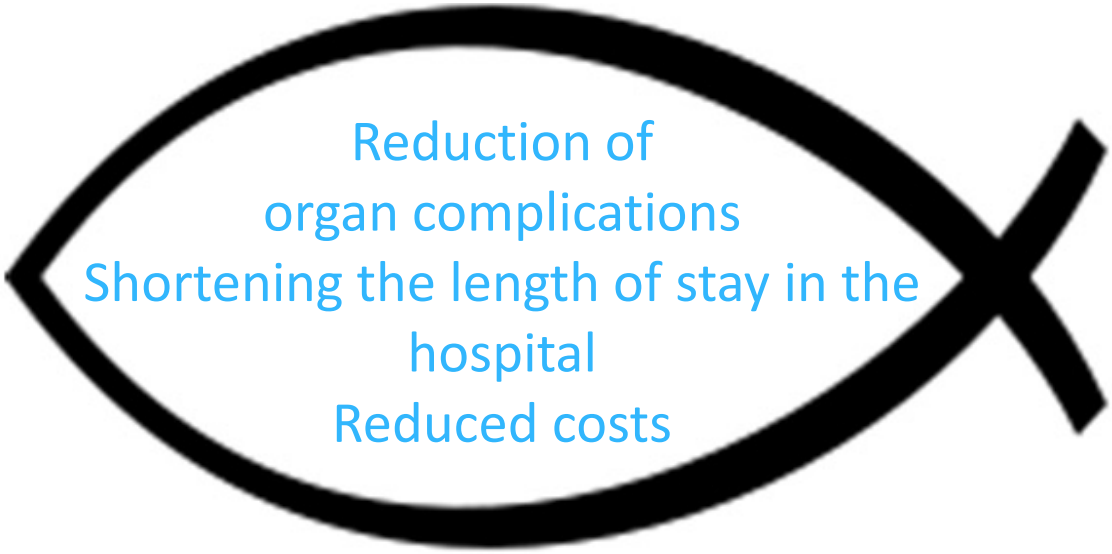
ESPEN compared parenteral olive oil and soybean based products and made recommendations for the use of olive oil based emulsions.

- Rate of administration 100-150 mg/kg/hour

Lipid preparations with the addition of fish oil

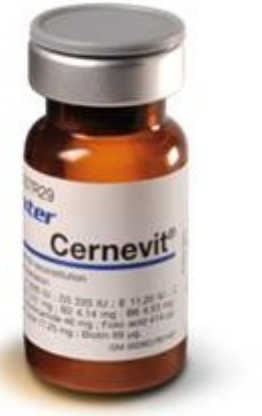
- **Source of ω-3 fatty acids,** high content of EPA and DHA
- **Example: NuTRIflex® Omega: ω-6:ω-3 PUFA = 3:1**

(Optimal benefit ratio ω-6: ω-3 PUFA = 2:1 to 4:1)



Emulsions made from pure soybean oil
should not be fat of the first choice in critically ill patients!

What is administered



- Vitamins and trace elements: from day one
- Medicines: hydrophilic vit. (Soluvit)
  lipophilic vit. (Vitalipid)
  hydrophilic + lipophilic vit. (Cernevit)
  microelements (Tracutil, Addaven, Elotrace, Nutryelt)

F, Mn, Cu, Zn, Se, I, Cr, Mb
Fe

- RDI or individual needs

Select correct answers: With regard to vitamins in the diet:

A. Body stores of water-soluble vitamins are typically higher than those of fat-soluble vitamins.

B. Vitamin C is an antioxidant vitamin which helps maintain iron in the reduced (ferrous) form.

C. Thiamine deficiency can be found in chronic alcoholism when it may contribute to neurological and cardiac problems.

D. Folic acid in excess can lead to increased incidence of neural tube defects in pregnancy.

E. Retinol (vitamin A) can be partially derived from dietary hydrolysis of β-carotene.

SELECT CORRECT ANSWERS: WITH REGARD TO VITAMINS IN THE DIET:

A. Body stores of water-soluble vitamins are typically higher than those of fat-soluble vitamins.

There are normally relatively large stores of fat-soluble vitamins (e.g. A and D) but little storage of water-soluble vitamins.

B. Vitamin C is an antioxidant vitamin which helps maintain iron in the reduced (ferrous) form.

Ferrous iron is the more reduced ionic form of iron whose formation is assisted by the anti-oxidant qualities of vitamin C.

C. Thiamine deficiency can be found in chronic alcoholism when it may contribute to neurological and cardiac problems.

Poor nutrition and associated thiamine deficiency is a recognised serious problem in chronic alcoholism.

D. Folic acid in excess can lead to increased incidence of neural tube defects in pregnancy.

There is a clear association between folic acid *deficiency* and an increase in neural tube defects in pregnancy. Folic acid supplementation in pregnancy is advised.

E. Retinol (vitamin A) can be partially derived from dietary hydrolysis of β-carotene.

Dietary β-carotene can be hydrolysed in the intestine to form retinol.

APPLICATION SYSTEMS

ESPEN recommends

Multi-bottle system

- Original system
- Risk of infection, imprecize dosage, rate of administration of distinct nutrients
- Uneven nutrient intake
- Unhandy
- Suitable for emergency care
- Possibility of fast composition change, addition of medications

All-in-one system

- ↓ risk of infection
- Comfortable
- Better utilisation of nutrients
- Allows the simultaneous administration of required nutrients out of one container
- It is impossible to change the composition
- Costs

All-in-one solutions

One-chamber

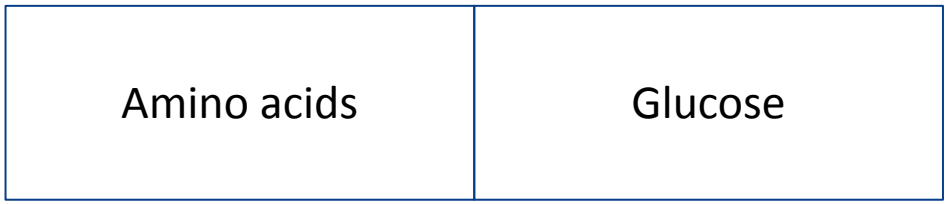
- Individually prepared in hospital pharmacy just before administration

Multi-chamber

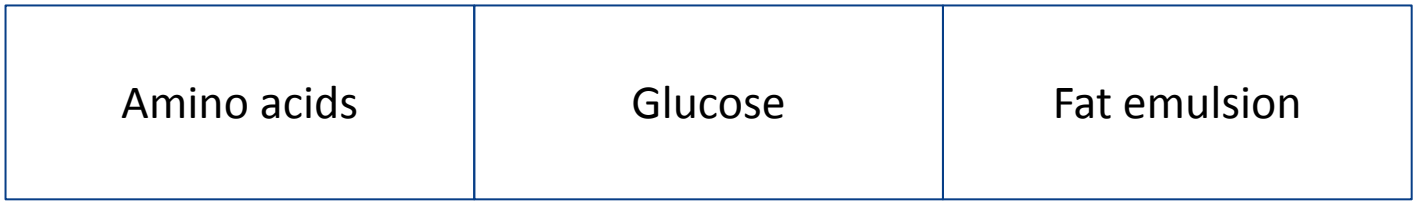
- Commercially-produced
- Two-chamber (AA + sugars)
- Three-chamber (AA + sugars + lipid emulsion)
- Chambers are separated by a seal, which is broken just before application
- 1 bag / 24-hours

2 KINDS OF MULTI-CHAMBER BAGS

- **2-chamber bags**



- **3-chamber bags**



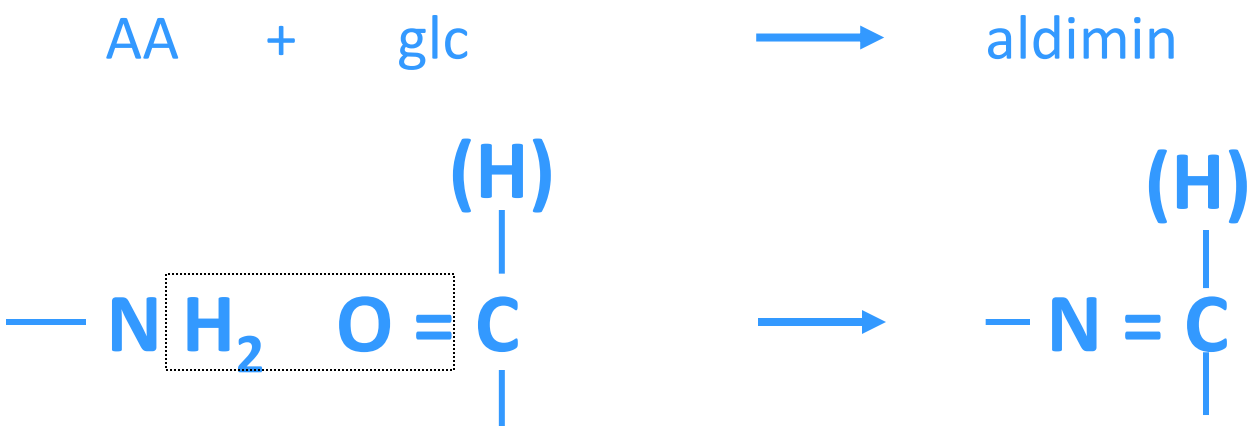
the chamber with amino acids
and electrolytes

peel seal

the chamber with glucose
and electrolytes

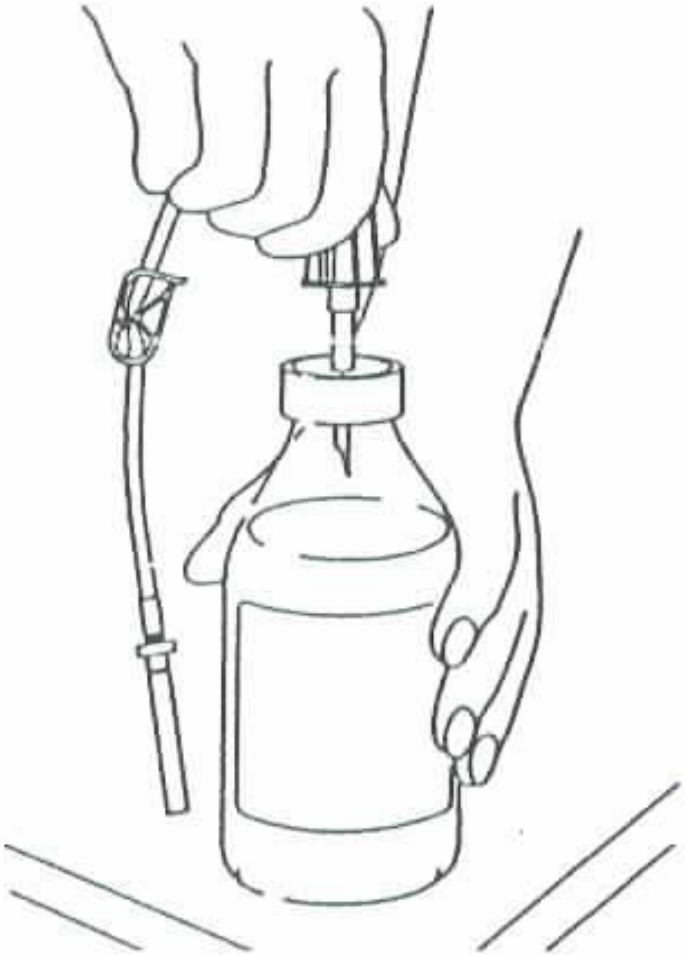
TWO-IN-ONE SOLUTION OF GLC AND AAs

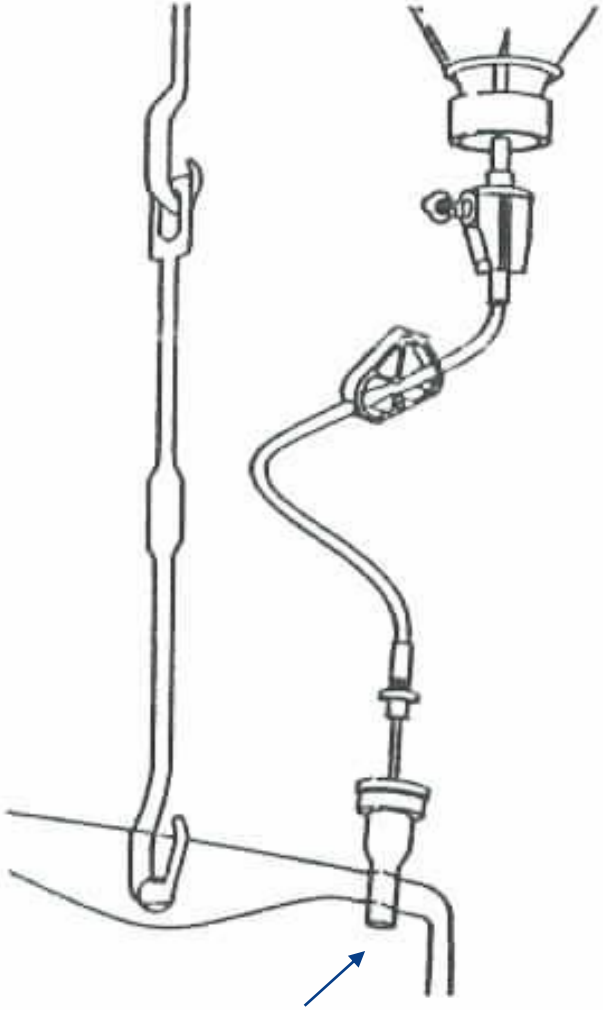
WHY ARE THE BAGS PRODUCED IN PHARM. COMPANIES MULTI-CHAMBER?



- The amino group $-NH_2$ from amino acids reacts with the carbonyl group of saccharides giving aldimin, e.g. „Schiff´s base“ (Maillard´s reaction).
- Therefore the solution of amino acids cannot be sterilized in the mixture with saccharides.

HOW TO ADD LIPIDS OR ELECTROLYTES TO A 2-CHAMBER BAG





Additive port

HOW TO ADD MEDICATIONS TO AN ALL-IN-ONE BAG

Injection port

EXAMPLE AND POSSIBILITIES OF A 2-CHAMBER ALL-IN-ONE BAG

ALL-IN-ONE BAGS - EXAMPLES

HOME PARENTERAL NUTRITION

Static mode

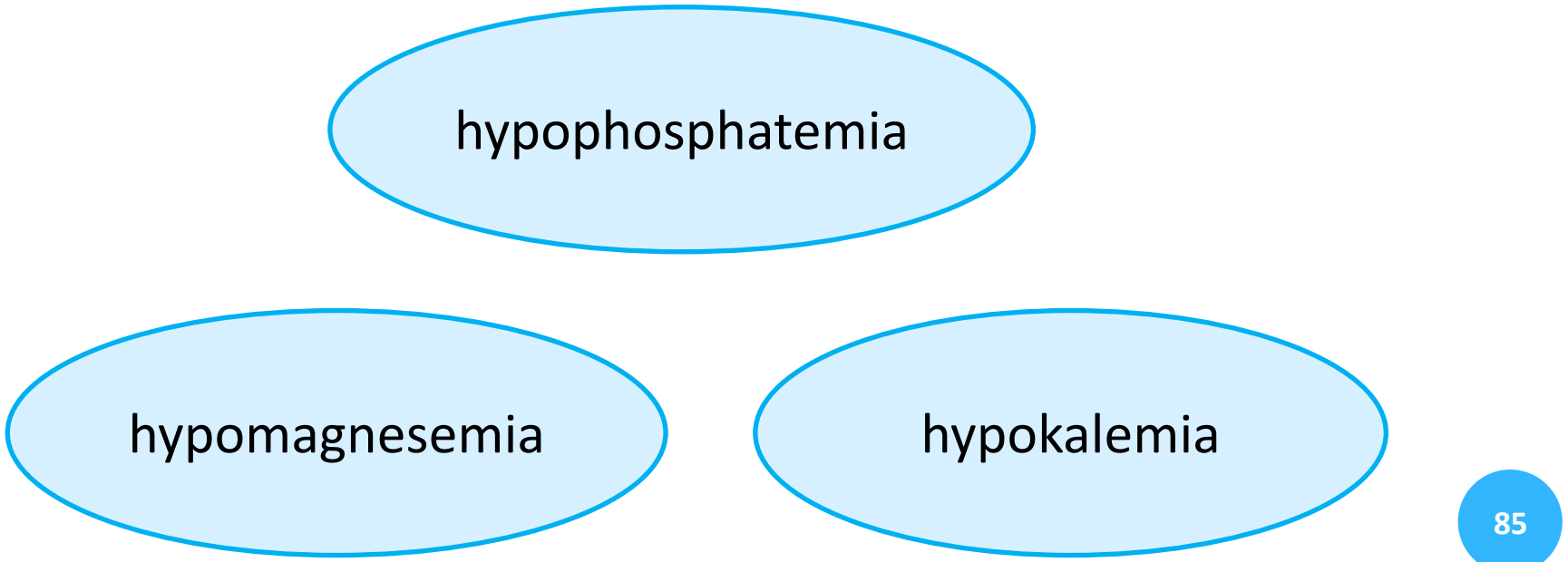
- classic infusion pump stand
- infusion connection at about 16:00, the next morning at 8:00 will disconnect
- equipped with alarms triggered when moving

Mobile mode

- From 1 Jan 2015, a new reimbursement code has been approved in CR: a mobile pump + backpack is included, the necessary nutrients and solutions for use.
- ↑ mobility of patients (> 50% out of bed)
- Pump weight 300-700 g, battery life 12-24 h + external battery

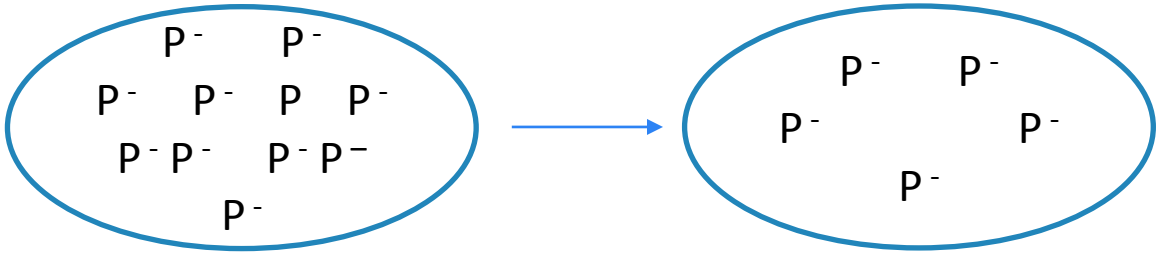
Refeeding syndrome

- syndrome consisting of metabolic disturbances that occur as a result of reinstitution of nutrition to patients who are starved or severely malnourished
- Etiology:

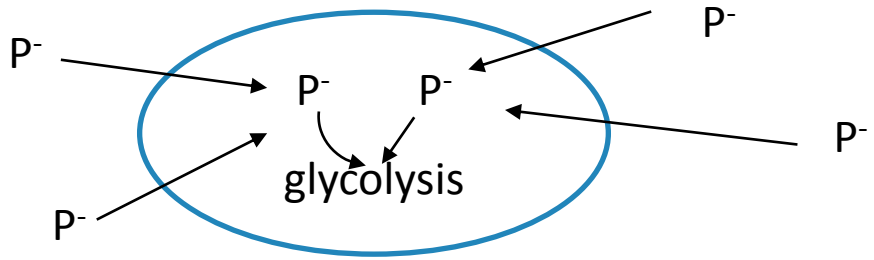


Development of Refeeding syndrome

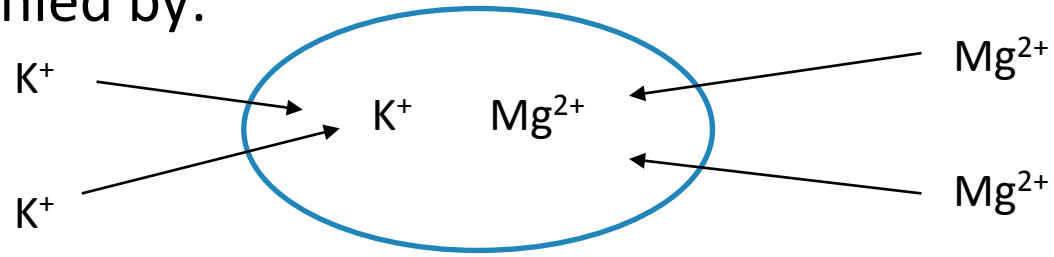
- Starvation →



- Refilling of glc →



- Accompanied by:



SYMPTOMATOLOGY

- paresthesias, weakness, muscle paralysis, inability to breathe
- mental changes (confusion, delirium)
- retention of water and Na^+
- arrythmias
- cardiac arrest, heart failure
- coma and even death

Criteria for determining people at high risk of developing refeeding syndrome

Patient has one or more of the following:

- BMI less than 16 kg/m^2
- unintentional weight loss > 15% within the last 3–6 months
- little or no nutritional intake for more than 10 days
- low levels of potassium, phosphate or magnesium prior to feeding.

Or patient has two or more of the following:

- BMI less than 18.5 kg/m^2
- unintentional weight loss > 10% within the last 3–6 months
- little or no nutritional intake for more than 5 days
- a history of alcohol abuse or drugs including insulin, chemotherapy, antacids or diuretics.

The prescription for patients at high risk of developing refeeding syndrome should consider:

- starting nutrition support at a maximum of 10 kcal (42 kJ)/kg/day, increasing levels slowly to meet or exceed full needs by 4–7 days
- using only 5 kcal/kg/day in extreme cases (for example, BMI less than 14 kg/m^2 or negligible intake for more than 15 days) and monitoring cardiac rhythm continually in these people and any others who already have or develop any cardiac arrythmias
- restoring circulatory volume and monitoring fluid balance and overall clinical status closely
- providing immediately before and during the first 10 days of feeding: thiamin 200–300 mg daily, vitamin B complex full dose daily and a balanced multivitamin/trace element supplement
- providing oral, enteral or intravenous supplements of
  K (2–4 mmol/kg/day),
  P (0.3–0.6 mmol/kg/day),
  Mg (0.2 mmol/kg/day intravenous, 0.4 mmol/kg/day oral)
  Pre-feeding correction of low plasma levels is unnecessary.

Overfeeding syndrome

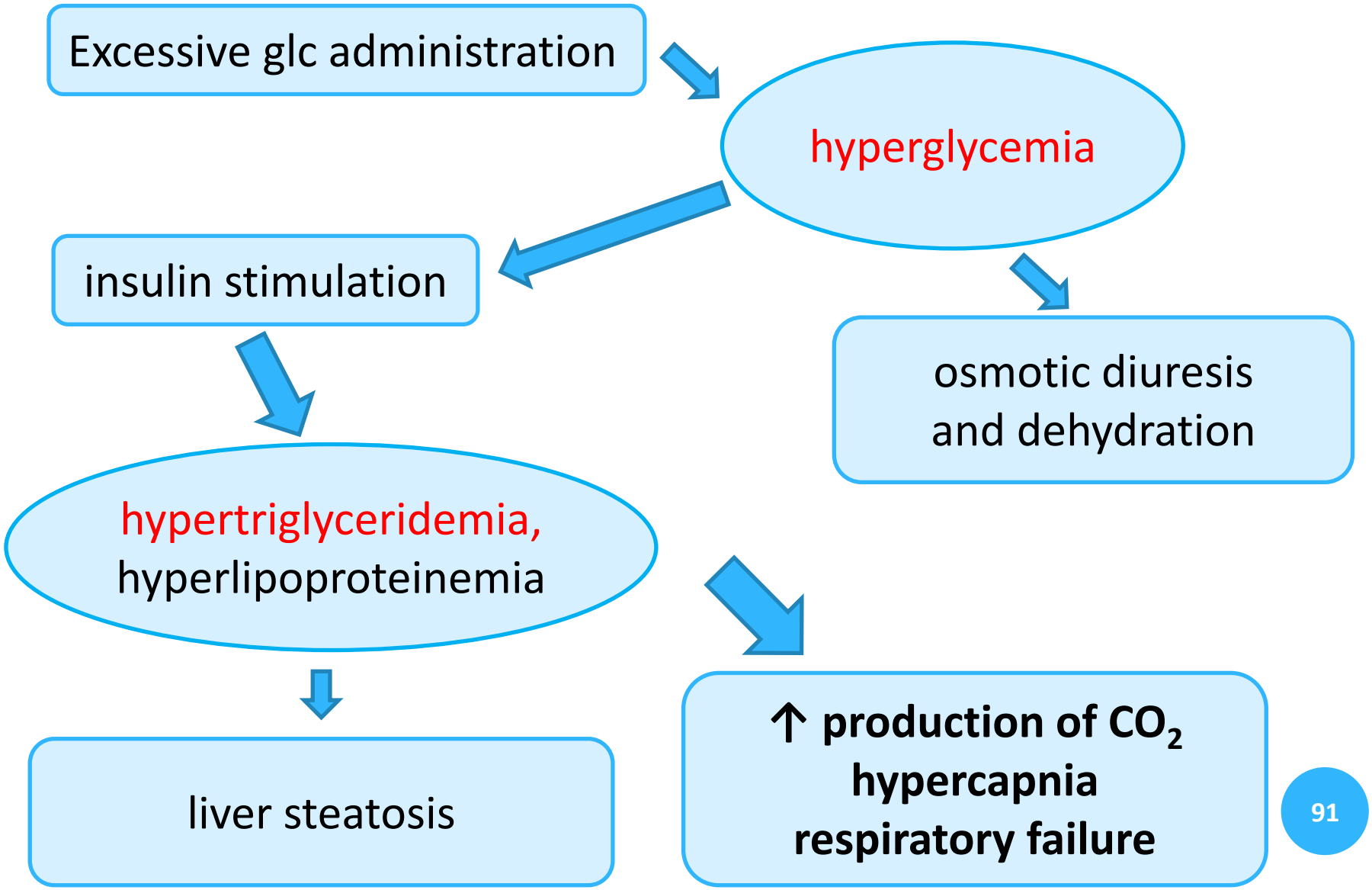
- = metabolic complications from overfeeding the patient

- patients at high risk of developing overfeeding problems = malnutrition pacients with too high total daily dose of nutrients
- Energy need 125–145 kJ/kg/day of *actual* weight,

  at the beginning of nutr. support RDA of energy and

  nutrients should be reduced by up to half

OVERFEEDING SYNDROME



Select correct answers: parenteral nutrition

A. Is usually delivered via a central vein.

B. Can be used to maintain nutrition at home in some patients who require constant nutritional support.

C. Must provide adequate calories from carbohydrate, typically using 5% dextrose.

D. May lead to low levels of potassium, magnesium and phosphate as part of the refeeding syndrome.

SELECT CORRECT ANSWERS: PARENTERAL NUTRITION

A. Is usually delivered via a central vein.

The hyperosmolar glc and AA solutions are irritant and can lead to thrombophlebitis if a peripheral vein is used.

B. Can be used to maintain nutrition at home in some patients who require constant nutritional support.

With careful supervision and patient education this is possible in those who require long-term nutritional support.

C. Must provide adequate calories from carbohydrate, typically using 5% dextrose.

In order to deliver adequate calories from carbohydrate, a hypertonic solution of 20% glc is required. Otherwise, the volume of 5% glc to deliver adequate calories is excessively high.

D. May lead to low levels of potassium, magnesium and phosphate as part of the refeeding syndrome.

All these ions are incorporated into the cells and can be rapidly depleted from the extra cellular compartment when nutrients are provided to allow cell growth and repair. The high glc levels stimulate insulin secretion which encourages movement of the these ions into the cell.

What is the formulation of individually prepared parenteral nutrition bag?

We have solutions:
glc 5%, 10%, 15%, 20%, 40%
AA (Aminoplasmal, Neonutrin) 5%, 10%, 15%
lipids (Lipofundin, SMOFlipid, Lipoplus) 20%

- **Man, 35 years, height 185 cm, weight 60 kg, m. Crohn, hospitalization for subileus, stenosis of terminal ileum**

Fluids: 30 - 40 ml/kg/day = 1800 - 2400 ml

Nutrients: anabolic ratio:

- Glc 6 g/kg actual weight:

6 x 60 = 360 g glc: 900 ml 40% glc – central vein!

- AA 1 g/kg ideal weight:

1 x 85 = 85 g AA: 850 ml 10% solution – central vein!

- Lipids 1 g/kg actual weight:

1 x 60 = 60 g: 300 ml 20% solution

We have solutions:
glc 5%, 10%, 15%, 20%, 40%
AA (Aminoplasmal, Neonutrin) 5%, 10%, 15%
lipids (Lipofundin, SMOFlipid, Lipoplus) 20%

- **Man, 40 years, height 180 cm, weight 85 kg, hospitalization for severe burns**

Fluids: 30 - 40 ml/kg/day = 2550 - 3400 ml

Nutrients: Stress ratio:

- Glc 2.5 g/kg actual weight:

2.5 x 85 = 212,5 g glc: 500 ml 40% glc (1 000 ml 20% glc) – central vein!

- AA 2 g/kg ideal weight:

2 x 80 = 160 g AA: 1000 ml 15% (1600 ml 10%) solution – central vein!

- Lipids 0,7 g/kg actual weight:

0.7 x 85 = 60 g: 300 ml 20% solution

We have solutions:
glc 5%, 10%, 15%, 20%, 40%
AA (Aminoplasmal, Neonutrin) 5%, 10%, 15%
lipids (Lipofundin, SMOFlipid, Lipoplus) 20%

- **Man, 25 years, height 190 cm, weight 80 kg, in ICU after surgery of comminuted fracture of tibia**

Fluids: 30 - 40 ml/kg/day = 1800 - 2400 ml

Nutrients: stress ratio:

- Glc 2.5 g/kg actual weight:

2.5 x 80 = 200 g glc: 500 ml 40% glc (1 000 ml 20% glc) – central vein!

- AA 2 g/kg ideal weight:

2 x 90 = 180 g AA: 1 200 ml 15% solution (1800 ml 10%) – central vein!

- Lipids 0.7 g/kg actual weight:

0.7 x 80 = 56 g: 280 ml 20% solution