PARENTAL NUTRITION SUPPORT

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Objectives

- Explain the indications and contraindications of PN
- Describe the types of PN
- How to set PN
- Explain the starting, monitoring and tapering of PN
- Troubleshooting

Guidelines for nutrition support for critically Ill Patients

1- Society of Critical Care Medicine (SCCM)

2- American Society for Parenteral and Enteral Nutrition (ASPEN)

3- Critical Illness Evidence-based Nutrition Practice Guideline by the Academy of Nutrition and Dietetics

4- The European Society of Parenteral and Enteral Nutrition (ESPEN)

Providing PN to surgical patients Challenging

Data from 2 international prospective observational studies of nutrition practices in ICU compared with nonsurgical ICU;

	EN	PN
Surgical ICU	54.6%	13.9%
Nonsurgical ICU	77.8%	4.4%

Gramlich, L etal. Nutrition, 2004: 843-848

Nutrition Intervention

- Screening and assessment of nutrition status
- Tailoring an individualized nutritional plan
- Implementation of nutritional care plan
- Monitoring of the critical score

Types of Nutritional Intervention

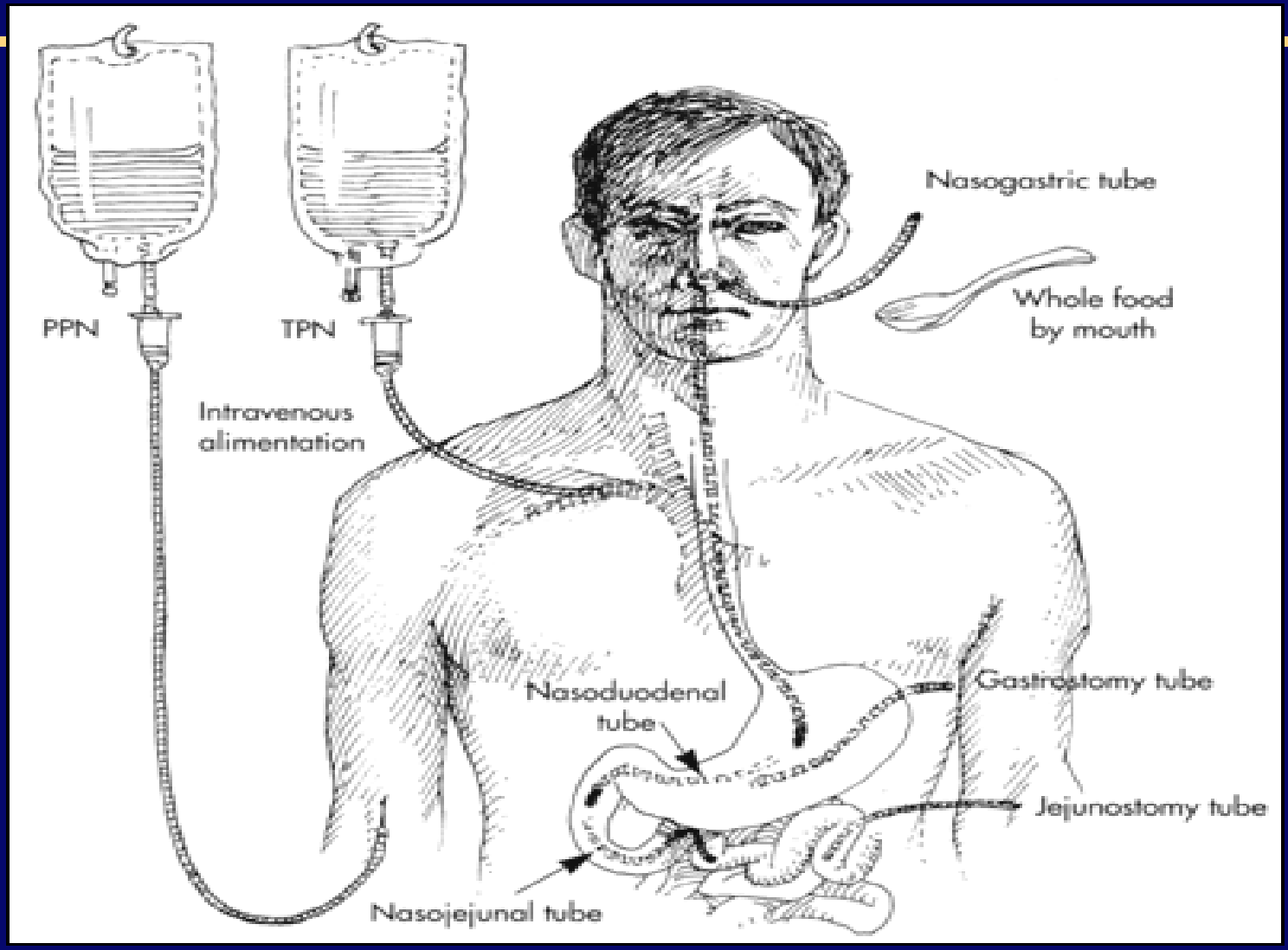
- Oral supplementation
- Total enteral nutrition
- Peripheral parenteral nutrition
- Total parenteral nutrition

IF THE GUT WORKS, USE IT

Parenteral Nutritional Therapy

Parenteral nutritional therapy is intravenous nutrition, partial or complete. It is administered by peripheral or central venous access.

Parenteral Nutrition



PN Central Access

- May be delivered via femoral lines, internal jugular lines, and subclavian vein catheters in the hospital setting
- Peripherally inserted central catheters (PICC) are inserted via the cephalic and basilic veins
- Central access required for infusions that are toxic to small veins due to medication pH, osmolarity, and volume

PN: Peripheral Access

PN may be administered via peripheral access when

- Therapy is expected to be short term (10-14 days)
- Energy and protein needs are moderate
- Formulation osmolarity is <900 mOsm/L
- Hyperosmolar solutions cause thrombophlebitis in peripheral vein
- Do not exceed final dextrose 10% and AA 3%
- Fluid restriction is not necessary
- Use lipid to protect veins and increase calories

A.S.P.E.N. Nutrition Support Practice Manual, 2005; p. 94

Indications for PNT

- Non-functioning GI tract
- Inability to use GI tract
- ‘Bowel rest’ necessary

Common Indications for PN

- Patient has failed EN with appropriate tube placement
- Severe acute pancreatitis
- Severe short bowel syndrome
- Mesenteric ischemia
- Paralytic ileus
- Small bowel obstruction
- GI fistula unless enteral access can be placed distal to the fistula or where volume of output warrants trial of EN

Adapted from Mirtallo in ASPEN, The Science and Practice of Nutrition Support: A Case-Based Core Curriculum. 2001.

Contraindications for PN

- Functional and accessible GI tract
- Patient is taking oral diet
- Prognosis does not warrant aggressive nutrition support (terminally ill)
- Risk exceeds benefit
- Patient expected to meet needs within 14 days

Contraindications to Peripheral Parenteral Nutrition

- Significant malnutrition
- Severe metabolic stress
- Large nutrition or electrolyte needs (potassium is a strong vascular irritant)
- Fluid restriction
- Need for prolonged PN (>2 weeks)
- Renal or liver compromise

From Mirtallo. In ASPEN, The Science and Practice of Nutrition Support: A Case-Based Core Curriculum. 2001, 222.

Parenteral Nutritional Formulas

Dextrose

- Provides 3.4 kcal/g
- Rate of dextrose infusion should not exceed 5 mg/kg/minute
- Closely related to the osmolality of the solution
- Minimum of 100 g/day is required to prevent ketosis
- Carbohydrate level in diet should provide 60-70% of non-protein calories during stress

Parenteral Nutritional Formulas

Amino Acids

- Standard concentrations range from 3 to 15%
- kcal from amino acids 4 kcal/g
- N_2 = grams of protein / 6.25

Parenteral Nutritional Formulas

Lipids

- Used to prevent essential fatty acid deficiency
- Used as a source of non-protein kcal
- Available in 10%, 20% or 30% concentrations
- May be added daily to the base PN solution or given separately

Compounding Methods

- Total nutrient admixture (TNA) or 3-in-1
  - Dextrose, amino acids, lipid, additives are mixed together in one container
  - Lipid is provided as part of the PN mixture on a daily basis and becomes an important energy substrate
- 2-in-1 solution of dextrose, amino acids, additives
  - Typically compounded in 1-liter bags
  - Lipid is delivered as piggyback daily or intermittently as a source of EFA

Fluid Requirements

- Maintenance

Kg increment	mL/kg/24hr	mL
Fluid		
First 10 kg	100	1000
Next 10 kg	50	500
All other kg (age < 50)	20	

- Replacement of NG losses

Factors that Affect Fluid Requirements

Factor	Increase in fluid requirements
Fever	12.5% for each 1^{o} C above normal
Sweating	10 – 25 %
Hyperventilation	10 – 60%
Hyperthyroidism	25 – 50%
Extraordinary gastric and or renal fluid loss	Varies (adjust on average 24 hour output)

Factors that Decrease Fluid Requirements

- Acute or chronic renal failure
- Nephrotic syndrome
- Cirrhosis
- Heart failure
- Pulmonary edema

Calculating Nutrient Needs

- Provide adequate calories so protein is not used as an energy source
- Avoid excess kcal (>35 kcal/kg)
- Determine energy and protein needs using usual methods, kcals/kg
- Use specific PN dosing guides for electrolytes, vitamins, and minerals

Nutritional Requirements

Body weight - Actual vs. Ideal

- IBW – Hamwi method

Build	Women	Men
Medium	Allow 100 lb (45.5 kg) for first 5 ft (152 cm) of height plus 5 lb (2.3 kg) for each additional inch (2.5 cm)	Allow 100 lb (45.5 kg) for first 5 ft (152 cm) of height plus 6 lb (2.3 kg) for each additional inch (2.5 cm)
Small	Subtract 10%	Subtract 10%
Large	Add 10%	Add 10%

- Adjusted BW = [ABW- IBW] x 0.25 + IBW
- Actual BW
- Usual BW

Nutritional Requirements

- Energy
  - Harris Benedict Equation (BEE) x stress factor x activity factor
  - “Rule of thumb”: 25 - 30 kcals
- Protein
  - Stable 0.8 - 1.0 g/kg BW
  - Stress 1.2 - 2.0 g/kg BW

Nutrient	Recommendation	Guideline Source
(per kg recommendations infer per kg per 24 hours.)		
ENERGY	Use 25-30kcal/kg, or predictive equations, or indirect calorimetry.	ASPEN 2009, 2016
	Consider hypocaloric feeding in critically ill obese (BMI >30kg/m2), e.g. 60-70% of target energy requirements, or 11-14 kcal/kg actual body weight, or 22-25 kcal/kg ideal body weight.	ASPEN 2009, 2016
	20-25kcal/kg in acute phase of critical illness. 25-30kcal/kg in recovery phase.	ESPEN 2016
	25 kcal/kg	ESPEN 2009, ASPEN 2016

Recommended Macronutrient

Nutrient	Recommendation	Guideline Source
(per kg recommendations infer per kg per 24 hours.)		
PROTEIN	1.3-1.5 g protein/kg.	ESPEN 2009
	1.2-2.0 g protein/kg if BMI<30kg/m2. 2g/kg ideal weight if BMI 30-40kg/m2. 2.5g/kg ideal weight if BMI >40kg/m2.	ASPEN 2009
GLUCOSE	Minimum 2 g/kg	ESPEN 2009
	Maximal glucose oxidation rate is 4-7 mg/kg/minute/24hours. Ideally keep to ≤5mg/kg/minute/24hours.	ASPEN 2009, 2016
LIPID	0.7-1.5 g/kg.	ESPEN 2009, ASPEN 2016

Determining Protein Needs of the Hospital Patient

Stress Level	Non-Stressed	Mildly Stressed	Severely Stressed
Calorie Nitrogen Ratio	> 150 : 1	150 - 100 : 1	< 100 : 1
Percent Protein/ Total Calories	< 15% Protein	15 - 20% Protein	> 20% Protein
Protein/kg Body Weight	0.8 g/kg/day	1.0 - 1.2 g/kg/day	1.5 - 2.0 g/kg/day

Refeeding Syndrome

During starvation	During refeeding
•Insulin concentrations decrease and glucagon levels rise •Glycogen stores rapidly converted to glucose •Gluconeogenesis activated – glucose synthesis from protein and lipid breakdown •Catabolism of fat and muscle → loss of lean body mass, water and minerals	•Switch from fat to carbohydrate metabolism •Insulin release stimulated by glucose load •↑ cellular glucose, phosphorus, potassium and water uptake •Extracellular depletion of phosphate, potassium, magnesium •Clinical symptom

Effects: Increase of cardiac workload, oxygen consumption, carbon dioxide production, increased work for respiratory system
Effects of low serum phosphorous levels: Respiratory failure, cardiac failure, arrhythmias

Refeeding Syndrome Prevention/Treatment

- Monitor and supplement electrolytes, vitamins and minerals prior to and during infusion of PN until levels remain stable
- Initiate feedings with 15-20 kcal/kg or 1000 kcals/day and 1.2-1.5 g protein/kg/day
- Limit fluid to 800 ml + insensible losses (adjust per patient fluid tolerance and status)

Fuhrman MP. Defensive strategies for avoiding and managing parenteral nutrition complications. P. 102. In Sharpening your skills as a nutrition support dietitian. DNS, 2003.

Nutritional Requirements

- Lipid
  - Stable 25 - 30% of calories
  - Stress 20 - 55% of calories
- Carbohydrate
  - Stable ~50% of calories

Diabetes mellitus, hyperglycemia, COPD, hypercapnia may benefit from ↓ carbohydrate, ↑ lipid calories

Nutritional Requirements

- Vitamins and minerals
  - Stable 100% RDI
  - Stress 100% RDI, ↑ antioxidants
  - Renal Failure ↓ Na, ↓ K, ↓ Cl, ↓ PO_4, ↓ vitamin A
  - HIV^+/AIDS 100% RDI, ↑ antioxidants, ↑ vitamins B_6, B_{12}

The Formula for TPN calculation is:

- $N_1V_2=N_2V_1$

Where as

N_1 = Normality of solution.

V_2 = Volume of given solution/ml.

N_2 = Normality of solution/gm.

V1 = Volume of standard solution.

Osmotic concentration of PN

- A rough estimate of osmotic concentration (in mOsm/kg)=

(100xAA %)+(50xCHO%)+ 2xTotal electrolyte meq)

Calculating the Osmolarity of a Parenteral Nutrition Solution

1. Multiply the grams of dextrose per liter by 5. Example: 100 g of dextrose x 5 = 500 mOsm/L
2. Multiply the grams of protein per liter by 10. Example: 30 g of protein x 10 = 300 mOsm/L
3. Multiply the grams of lipid per liter by 1.5.
   Example: 40 g lipid x 1.5 = 60.
4. Multiply the (mEq per L sodium + potassium + calcium + magnesium) X 2
   Example: 80 X 2 = 160
5. Total osmolarity = 500 + 300 + 60 + 160 = 1020 mOsm/L

Source: K&M and PN Nutrition in ADA, Nutrition in Clinical

Macronutrients: Carbohydrate

- Source: Monohydrous dextrose
- Properties: Nitrogen sparing
  Energy source
  3.4 Kcal/g
  Hyperosmolar
- Recommended intake:
  4 – 7 mg/kg/min in stressed
  less than 4 mg/kg/min in critically ill
  50-65% of total calories

Formula for determining dextrose

Patient wt (kg) X desired glucose infusion rate X

1440 mg/ day/ 1000 = g dextrose per day

Example: 70 kg X 5 mg/kg/min X 1440 / 1000

= 504 g dextrose

Glycemic Control in PN

For Patients Previously on Insulin

- Determine amount of insulin needed prior to illness
- Determine amount of feedings to be given
- Provide a portion of daily insulin needs in first PN along with sliding scale or insulin drip to maintain glucose levels (generally insulin needs will increase while on PN)

Charney P. A Spoonful of Sugar: Glycemic Control in the ICU. In Sharpening your skills as a nutrition support dietitian. DNS, 2003

Macronutrients: Carbohydrate

Potential Adverse Effects:

- Increased minute ventilation
- Increased CO_2 production
- Increased RQ
- Increased O_2 consumption
- Lipogenesis and liver problems
- Hyperglycemia

Macronutrients: Amino Acids

- Nitrogen varies ;Specialized Amino Acid Solutions
  - Branched chain amino acids (BCAA)
  - Essential amino acids (EAA)
- Not shown to improve patient outcome
- More expensive than standard solutions
- Electrolyte varies

Recommended rate 0.8 – 2.5 g/kg/day

Macronutrients: Lipid

Prevents essential fatty acid deficiency

10%, 20% (from peripheral or CV-line)

1.1 kcal/ml (10%), 2 kcal/ml (20%)

30-40% of calorie requirements should be provided with lipid

- Recommended intake:
- 0.5 – 1.5 g/kg/day (not >2 g/kg)
- 12 – 24 hour infusion rate

Effects of Propofol on PN

Nutrient composition of propofol

- 1.1 kcal/ml (0.1 g /ml) fat
- 15 mmol/L phosphorus
- Oil source: Soybean
- Fatty acid composition: linoleic acid (50%) (an omega 6 Fatty acid) oleic acid (26%), palmitic acid (10%), linolenic acid (9%) (an omega-3 fatty acid), stearic acid (3.5%)
- 0.3 mcg/ml of vitamin K
- Egg lecithin

support line , 2009, p13

Adverse effect of propofol,use (more than 72 hs)

- Hypotension
- Hypertrigliceridemia
- Hyperphosphotemia
- Low zinc concentration

High infusion rate, long-term usage, concurrent administration of parenteral lipids for nutrition

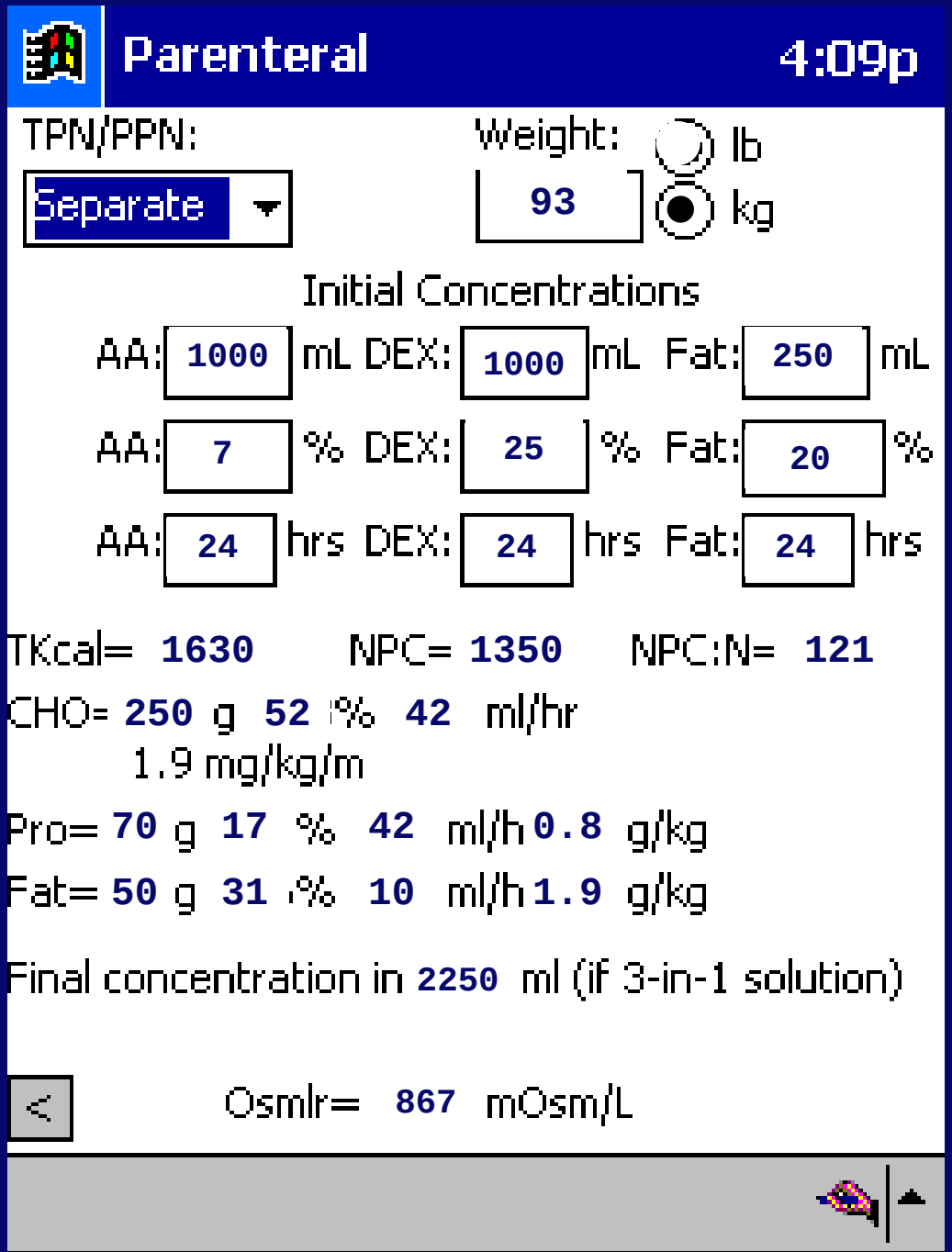
Modification of NS or change to other sedation

PN Contaminants

- Components of PN formulations have been found to be contaminated with trace elements
- Most common contaminants are aluminum and manganese
- Aluminum toxicity a problem in pts with renal compromise on long-term PN and in infants and neonates
- Can cause osteopenia in long term adult PN patients

ASPEN Nutrition Support Practice Manual 2005; p. 109

Example of TPN



Parenteral Nutritional Monitoring

Metabolic

- Glucose
- Fluid and electrolyte balance
- Liver and renal function
- Cholesterol and triglycerides

Monitoring Observations for TPN

Observation	Initial Frequency	Stabilized Frequency
Vital Signs	6hr	8hr
Strict intake & output	Shift	Shift
Serum Glucose	Daily	3 x week
Blood urea nitrogen	Daily	3 x week
Albumin	Weekly	Weekly
Na, K, Ca, P	Daily	3 x week
Mg	Every other day	Weekly
Hepatic enzymes	Every other day	Weekly
Triglycerides	Weekly	Weekly

Parenteral Nutritional Complications

Metabolic

- Hyper- or hypoglycemia
- Electrolyte imbalance
- Prerenal azotemia
- Acid/base abnormality

Parenteral Nutritional Complications

Gastrointestinal

- Gastritis and ulceration
- Hepatic dysfunction
- Gastrointestinal atrophy

Parenteral Nutritional Complications

Overfeeding

- More than 35 kcal/kg may lead to:
  - Hepatic steatosis
  - Hyperglycemia
  - Increased BUN
  - Hypertriglyceridemia
  - Respiratory distress syndrome
  - Increased CO_2 production

Tapering off TPN

Decrease PN rate by 50% for 15 minutes

Another 50% for 15 minutes

Disconnect

PN Administration:Transition to Enteral Feedings in Adults

- Controversial
- In adults receiving oral or enteral nutrition sufficient to maintain blood glucose, no need to taper PN
- Reduce rate by half every 1 to 2 hrs
  or switch to 10% dextrose IV) may prevent rebound hypoglycemia (not necessary in PPN)
- Monitor blood glucose levels 30-60 minutes after cessation

Troubleshooting

- Hyper- / Hypo- glycemia
- Hyper- / Hypo- kalemia, natremia
- Hyper- / Hypo- calcemia, magnesemia, phosphatemia
- Hypertriglyceridemia
- Hypercapnia (Respiratory failure)
- Refeeding Syndrome

Standardized transitional feeding challenges and management

Technique used to shift from PN to oral or EN while continuing to meet daily requirements.

Rationale for Transitional Feeding

Providing PN to unsuitable patients

- increase morbidity and mortality
- Increase hospital costs
- If EN not contraindicated RD should recommend EN over PN
- septic morbidity decrease, fewer infectious complications and significant cost savings in critically ill adult patients who received EN vs. PN.

Critical Illness Evidence-based Nutrition Practice Guideline 2012 by the Academy of Nutrition and

Considerations for Transitional Feeding

- is the patient receiving/tolerating the prescribed amount of food/ formula?
- is the formula appropriate for the patient's needs (energy and protein needs, RDI volume)?
- is oral intake (if applicable) increasing or decreasing? Hospital flow sheet or fluid balance charts Pump with "total volume delivered" function Medical record documentation Food charts/observation Patient report of intake Daily in acute care situation; 2-3 times weekly in stable hospital patients; weekly – monthly in long term care.

Transitional feeding selection

- This process ideally takes 2 to 3 days; however, it may become more complicated, depending on the degree of gastrointestinal function. At times this weaning process may not be practical, and parenteral therapy can be stopped sooner.
- This will depend on overall treatment decisions and likelihood for tolerance of enteral feeding.

Transitional feeding selection

- Patient's oral intake usually is inadequate to meet nutrition needs for some time caused by – swallowing difficulties or medications that cause nausea, poor appetite, and constipation
- Some patients may remain on enteral feeding to supplement an oral diet until they can meet their goals
- Patients who fail to tolerate at least 50% of their goal rate via enteral feeding by post injury day 7 should be supplemented with PN

Calorie counts should be done regularly

ASPEN,2016

Transitional Feeding

- The American Society for Parenteral and Enteral Nutrition (A.S.P.E.N) guidelines recommend beginning to wean PN once EN has met 33% to 50% of the patient's daily caloric needs.
- After a patient has demonstrated that EN is being tolerated and is meeting 75% of the patient's nutritional needs, the PN can be discontinued.

Monitoring parameters should include

- Physical assessment, including clinical signs of fluid and nutrient excess or deficiency
- Functional status
- Vital signs
- Actual nutrient intake (oral, enteral, and parenteral)
- Weight
- Laboratory data
- Review of all medications
- Changes in gastrointestinal function

Barriers of appropriate transitional feeding

- Delays in line/tube placement
- Physicians orders; untimely delay, ignore RD/team recommendaions, errors
- Physicians unawareness of policy and protocols
- Lack of dedicated nutrition professionals, lack of nutrition monitoring and education
- Lack of administrative support
- Nutrition is often not viewed as important by others.
- Thinking of this is somebody else's job
- Absence of Nutrition Support Team to oversee the process

Transitional Feeding Complications

Gastrointestinal

- aspiration, gastroesophageal, reflux, nausea, vomiting
- Diarrhea
- Constipation
- Malabsorption, abdominal distention, bloating, cramping, flatus
- Dehydration and increased electrolytes
- Metabolic
- Decrease in hepatic secretory proteins
- Edema or decreased electrolytes
- Refeeding syndrome
- Vitamin mineral deficiencies
- Mechanical
- Obstructed feeding tube
- Nasopharyngeal irritation, acute otitis, media, acute sinusitis, dental caries (oral tubes), esophagial/laryngeal ulceration/stenosis

Appropriate PN order

- Peritonitis, gastrointestinal bleeding or ileus lasting for more than 7 days, intestinal obstruction
- esophageal stricture, bowel perforation, ischemic bowel
- inadequate oral intake for > 7 days due to intractable vomiting, vomiting and/or diarrhea, high output
- enterocutaneous fistula, intestinal failure and gastrointestinal graft-vs-host disease.

Critical Illness Evidence-based Nutrition Practice Guideline 2012 by the Academy of Nutrition and Dietetics

Inappropriate PN order

- Pancreatitis
- hyperemesis
- inadequate oral intake for < 7 days due to non-intractable nausea, vomiting and/or diarrhea
- lack of enteral excess and hypocaloric intake

Critical Illness Evidence-based Nutrition Practice Guideline 2012 by the Academy of Nutrition and Dietetics

Physician Rationales for Ordering PN That is Deemed Inappropriate

- Patient keeps removing nasal feeding tube
- Unable to place nasogastric feeding tube in ICU
- Postpyloric feeding tube required
- Wired jaw
- Respiratory distress
- Poor oral intake; had received PN in past
- Pancreatitis
- Unwilling to use existing enteral access tube

Most common rationales for inappropriate PN

1- When patients are not sedated and/or restrained properly, they pull out their nasogastric (NG) tubes, and physicians do not order repeated replacements. Many physicians sedate and/or restrained patients to ensure the status of a central line, but they did not take similar actions for EN support.

Most common rationales for inappropriate PN

2- When patients are unable to tolerate either NG tubes or intragastric EN or are considered at high risk for aspiration, physicians opted for

PN rather than having a postpyloric tube

placed by interventional radiology

Most common rationales for inappropriate PN

3- most of the inappropriate PN is ordered because the patient had received PN in the

past and had poor oral intake.

Rather than consulting the RD, ordering oral supplements, ordering a calorie count, or initiating EN, physicians order PN.

Recommended Standard Process for PN

- Ordering PN
- Labeling PN formulations
- Nutrient requirement
- Screening the PN order
- PN administration
- PN monitoring

JADA support line,08,p 24

Applicable nutrition support situations

- Predicted suboptimal or excessive energy intake
- Predicted food-medical interactions
- Inadequate or excessive PN infusion
- Less than optimal PN

JADA, Support line august,2011

Barriers of appropriate/standardized PN

- Lack of physicians knowledge
- Physicians unawareness of policy and protocols
- Lack of dedicated nutrition professionals
- Lack of administrative support
- Nutrition is often not viewed as important by others.
- Thinking of this is somebody else's job
- Pharmaceutical representatives misguidance

Summary

- A safe PN system must minimize procedural incidents and maximize the ability to meet individual patient requirements
- Nutritionist should be involved in the design, implementation and monitoring of PN. This can decrease inappropriate PN use and improves standardized process in hospital settings
- Dietitians can improve the utilization of nutrition support and contribute to institutional savings
- Transitional feeding is a challenge
- Patients can be transferred from PN to EN / Oral feeding through the use of proper planning, appropriate implementation, and adequate monitoring

See Quiz

QUIZ

1- A so-called “3-in-1”solution contains

a. amino acids, carbohydrates, and sterile water.

b. amino acids, dextrose, and lipids.

c. amino acids, free water, and lipids.

2- The two types of parenteral nutrition solutions used are

a. partial and total parenteral solutions.

b. high-protein and high-carbohydrate solutions.

c. commercially premixed and custom-blended solutions.

3- True or false:

Parenteral nutrition is used almost exclusively in the critical care setting.

4.-Suitability of parenteral nutrition is determined through

a. a thorough physical exam and history only.

b. a combination of anthropometric measurements, lab tests, diet and health history, clinical observations, and patient and family expectations.

c. a comparison of the patient’s body mass index (BMI) at the time of admission with his current BMI.

QUIZ

5- What is the most common carbohydrate used for TPN?

A. Dextrose

B. Fructose

C. Invert sugar

D. Lactose

6- Which of the following is indicated to treat essential fatty acid deficiency?

- A. 50% dextrose

B. Branched chain amino acids

C. Lipids

D. Selenium

7- Potential TPN-associated metabolic complications include which of the following?

A. Sepsis, glucose intolerance, and electrolyte imbalances
B. Cachexia, glucose intolerance, and essential fatty acid deficiency
C. Lipoid nephrosis, glucose intolerance, and electrolyte imbalances
D. Glucose intolerance, electrolyte imbalances, and essential fatty acid deficiency

8- Which one of the following statements accurately reflects principles of peripheral parenteral nutrition?

- A. Designed for acutely stressed patients
- B. Used for therapies of 6 to 12 weeks
- C. Crystalline amino acids used are within the 2-5% range
- D. Standard dextrose concentration is usually 20%