Nutrition Support: Enteral And Parenteral Nutrition Implication
### Concept of Nutrition Management

<table>
<thead>
<tr>
<th>Nutrition Support</th>
<th>Nutrition Therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Preserve lean body mass</td>
<td>• Attenuate metabolic response to stress</td>
</tr>
<tr>
<td>• Maintain immune function</td>
<td>• Prevent oxidative cellular injury</td>
</tr>
<tr>
<td>• Avert metabolic complication</td>
<td>• Modulate immune response</td>
</tr>
</tbody>
</table>

#### Key Points:
- **Nutrition Support**:
  - Preserve lean body mass
  - Maintain immune function
  - Avert metabolic complication

- **Nutrition Therapy**:
  - Attenuate metabolic response to stress
  - Prevent oxidative cellular injury
  - Modulate immune response
Nutrition Support

- Oral diet
  - Soft
  - Regular
- For specific disease
  - Diabetic diet
  - High protein diet
  - Renal diet
  - Low sodium diet
  - Low fat diet
  - Pureed diet
- Oral nutritional supplement (ONS)
Artificial Nutrition Support

- **Enteral tube feeding (ETF)**
  - Gastric feeding
    - Naso/Orgastric
    - Gastrostomy
  - Enteric feeding:
    - Naso-duodenostomy, Naso-jejunostomy
    - Jejunostomy, PEJ, PEG-J

- **Parenteral nutrition**
  - PPN
  - TPN
Conditions That Require Nutrition Support

• Enteral
  o Impaired ingestion
  o Inability to consume adequate nutrition orally
  o Impaired digestion, absorption, metabolism
  o Severe wasting or depressed growth

• Parenteral
  o Gastrointestinal incompetency
  o Hypermetabolic state with poor enteral tolerance or accessibility
## TABLE 23-1  Conditions That Often Require Nutrition Support

<table>
<thead>
<tr>
<th>RECOMMENDED ROUTE OF FEEDING</th>
<th>CONDITION</th>
<th>TYPICAL DISORDERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enteral nutrition</td>
<td>Impaired nutrient ingestion</td>
<td>Neurologic disorders</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HIV/AIDS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Facial trauma</td>
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<td></td>
<td></td>
<td>Oral or esophageal trauma</td>
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<tr>
<td></td>
<td></td>
<td>Congenital anomalies</td>
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<tr>
<td></td>
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<td>Respiratory failure</td>
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<td></td>
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<td>Cystic fibrosis</td>
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<td></td>
<td></td>
<td>Traumatic brain injury</td>
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<tr>
<td></td>
<td></td>
<td>Hyperemesis of pregnancy</td>
</tr>
<tr>
<td></td>
<td><strong>Inability to consume adequate nutrition orally</strong></td>
<td>Hypermetabolic states such as with burns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comatose states</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anorexia in congestive heart failure, cancer, COPD, ED</td>
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<tr>
<td></td>
<td></td>
<td>Congenital heart disease</td>
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<tr>
<td></td>
<td></td>
<td>Impaired intake after orofacial surgery or injury</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spinal cord injury</td>
</tr>
</tbody>
</table>

*AIDS, acquired immunodeficiency syndrome; COPD, chronic obstructive pulmonary disease; ED, eating disorder; HIV, human immunodeficiency virus.*
Why Enteral?
Enteral Nutrition: Advantage

**GI**
- More physiological
- Gut functional integrity
  - Maintain tight junction
  - Blood flow
  - Maintain GI mucosa function, repair and replication
  - Trophic endogenous agents (CCK, gastrin, bombesin and bile salt)
  - Luminal nutrients GLN and SCFA used as fuel to bowel
    - Maintain normal gut pH and flora
- Feeding gut immune system
  - Produce Ig’s esp. IgA
  - Maintain GALT and MALT
- Modulate stress and the systemic immune response, and attenuate severity
- Means for stress ulcer prophylaxis
- Lesser cardiac work
- Safer and more efficient
- Better tolerated by the patient
- More safety and cost benefit

Enteral Nutrition Advantage

- Maintain gut mucosal physiology
- Preserves gut barrier function
- Promote peristalsis
- May modulate immune response

EN vs. PN

Anatomical changes

A

C

Effects Of Nutrition On Intestinal Mucosa

A: TPN
B: EN
C: IMN
D: Control

Disuse Causes Loss of Functional and Structural Integrity
Increased Gut Permeability

Characteristics:
- Time-dependent
- Correlation to disease severity

Consequences:
- Risk of infection
- Risk of Multiple Organ Failure syndrome (MOFs)

“If the gut works, use it.”
Nutritional Support For A Patient At Risk Of Malnourishment

Patient is or is at risk of malnourishment

- Safe swallow
  - Oral nutritional support
    - Gastrointestinal tract intact
      - Enteral nutritional support
    - Gastrointestinal tract non-functional or perforated
      - Parental nutritional support
- Unsafe swallow or poor oral intake
  - Parental nutritional support

Source: Stu BMJ © 2009 BMJ Publishing Group Ltd
Oral Nutritional Supplements (ONS)

Between meals
Added to foods
Added into liquids for medication pass by nursing
Enhances otherwise poor intake
Effect Of Supplement On Protein And Energy Intakes

Fouque et al, NDT 2008;23:2902
Oral supplement

18 trial, 5 RCT+13 CCT  429pts

<table>
<thead>
<tr>
<th>Study</th>
<th>Comparison (study length)</th>
<th>Trial size</th>
<th>Trial format</th>
<th>Effect (95% CI)</th>
<th>Supplement not favourable</th>
<th>Supplement favourable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sharma et al 2002</td>
<td>Nutritional support (disease-specific ONS) vs routine care (1 month)</td>
<td>47 (10:14)</td>
<td>RCT</td>
<td>0.73 (-0.11 to 1.57)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beutler et al 1997</td>
<td>Nutritional support (disease-specific ONS) vs routine care (4 months)</td>
<td>11 (6:5)</td>
<td>Non-RCT</td>
<td>0.16 (-1.03 to 1.35)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shah et al 1999</td>
<td>Nutritional support (disease-specific ONS) vs routine care (3 months)</td>
<td>88 (44:44)</td>
<td>Non-RCT</td>
<td>0.37 (-0.05 to 0.79)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meta-analysis nutritional support (disease-specific ONS) vs routine care (Non-RCT only)</td>
<td>Test for heterogeneity Q test 0.002, 1 df, p=0.962</td>
<td></td>
<td></td>
<td>0.35 (-0.05 to 0.75) *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meta-analysis nutritional support (disease-specific ONS) vs routine care (All studies)</td>
<td>Test for heterogeneity Q test 0.704, 2 df, p=0.703</td>
<td></td>
<td></td>
<td>0.42 (0.06 to 0.78) **</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analysis was based on change from baseline results
- Nutritional support (disease-specific ONS) had an increase of 1.89g/L, 95%CI (-0.21, 3.99). (Non-RCT only)
- Nutritional support (disease-specific ONS) had an increase of 2.27g/L, 95%CI (0.37, 4.18). (All studies)

Trial size column represents total subjects recruited in study (no. of subjects on nutritional support (disease-specific ONS): no. of subjects on routine care)

- Increase in alb by 4 g/L (p<0.01)
- RR of death: 5% /1 g/L Alb(Combe 2001)
Effect of ONS on BW  Smyth RL et al. BMJ 2006

Comparison: 01 Oral supplements versus no intervention or additional nutritional advice
Outcome: 01 Change in weight in kg

<table>
<thead>
<tr>
<th>Study or sub-category</th>
<th>N</th>
<th>Supplements Mean (SD)</th>
<th>N</th>
<th>Control Mean (SD)</th>
<th>WMD (fixed) 95% CI</th>
<th>Weight %</th>
<th>WMD (fixed) 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 3 months</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Kalnins 1996</td>
<td>7</td>
<td>1.46 (2.15)</td>
<td>6</td>
<td>2.15 (2.59)</td>
<td>-0.69 (-3.30 to 1.92)</td>
<td>100</td>
<td>-0.69 (-3.30 to 1.92)</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>7</td>
<td></td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for heterogeneity: not applicable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for overall effect: z=0.52, P=0.60</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

| 02 6 months           |   |                       |   |                   |                   |         |                   |
| Hanning 1993          | 9 | 2.52 (1.33)           | 7 | 1.33 (1.35)       | 1.19 (-0.13 to 2.51) | 100     | 1.19 (-0.13 to 2.51) |
| Subtotal (95% CI)     | 9 |                       | 7 |                   |                   |         |                   |
| Test for heterogeneity: not applicable |
| Test for overall effect: z=1.76, P=0.08 |
Enteral Tube Feeding

- **Placement of Tube**
  - Gastric
  - Small bowel (post pyloric)

- **Duration of Feeding**
  - Short term
    - Naso/ oro: gastric or enteric
  - Long term
    - Gastric or enteric
Gastric vs. Small Bowel Feeding

- Small bowel feeding: should be used in
  - high risk of aspiration
  - gastric intolerance
- Aspiration risk
  - Oropharynx phase (Structural, Conscious)
  - Esophageal phase (LES, Motility)
  - Gastric phase (Gastric emptying time, Pylorus)
- Aspirate pneumonia reduction in post-pyloric feeding
- One meta-analysis show significant reduction in VAP ??
- But other study show no difference
Formula Selection

- Functional status of GI tract
- Digestion and absorption capability of patient
- Physical characteristics of formula (osmolality, fiber content, caloric density, viscosity)
- Macronutrient ratios
- Specific metabolic needs
- Contribution of the feeding to fluid and electrolyte needs or restriction
- Cost effectiveness
Enteral Formulas: Categories

• Digestability
  ○ Polymeric formulas (intact protein, general purpose)
    ▪ Commercial
    ▪ Hospital or home made Blenderized diet
  ○ Oligomeric formulas
  ○ Monomeric formulas

• Disease-specific formulas

• Modular formulas (concentrated protein and carbohydrate preparations)
Enteral Selection

- **Substrates**
  - CHO, protein, fat: consider pt’s ability to digest, absorb nutrients

- **Elemental vs intact formulas**
  - Use products with MCTs if unsure of ability to digest fats
  - Peptides may be used as well as aa’s for most

- **Tolerance factors**
  - Osmolality, calorie and nutrient densities, residue content, etc.
Enteral Selection

- Blenderized
  - Hospital made, homemade, Compleat
- Standard Isotonic
  - Isocal, Nutren optimum, Ensure X gen, Blendera
- Added fiber
  - Jevity, Nutren with Fiber, fresubin original fiber
- Extra calories/volume restricted
  - 1.2-2.0 formulae
- High nitrogen (high protein)
Enteral Selection

• Poly-/oligo-/monomeric
  o Oligopeptide
    ▪ Nutramigen, pregestimil
  o Peptide based
    ▪ Peptamen
  o Free Amino Acids
    ▪ Vivonex varieties, f.a.a.

• Disease specific
  o Diabetes: Choice DM, Glucerna, Nutren balance
  o Critical care/trauma: Neomune, Impact
  o Pulmonary: Pulmocare
  o Renal: Nepro, Suplena
  o Liver: Aminoleban EN
  o Cancer: Prosure

• Modulars
  o Whey, caceine, white egg
  o Glutamine
  o MCT oil, oil
Physical Properties of Enteral Formulas

- Osmolality
  - GI emptying
  - Retention
  - Nausea
  - Vomiting
  - Diarrhea
  - Dehydration
- Residue
- Viscosity
  - Size of tube is important

- Isotonic formula = osmolality ~300 mOsm
- Body attempts to restore the 280 - 300 mOsm
- Enteral feedings range from < 300 - 700 mOsm/kg
- High osmolality \(\rightarrow\) shift of water into intestinal space = rapid transit, diarrhea
Dose of Nutrition Support
Energy Requirement

- Predictive equations (less accuracy)
  - Harris-Benedict Equation
    - Men: $66.47 + (13.75 \times \text{weight}) + (5 \times \text{height}) - (6.76 \times \text{age})$
    - Women: $655.1 + (9.56 \times \text{weight}) + (1.85 \times \text{height}) - (4.67 \times \text{age})$
  - Activity factor = 1.2 (low), 1.3 (moderate), 1.5 (high)
  - Stress factor = mild 1-1.1, moderate 1.2-1.4, severe 1.5-2

- ASPEN Guidelines:
  - 25 - 30 kcal/kg per day*
  - 22-25 kcal/kg IBW/d in BMI ≥ 30kg/m2

- ESPEN Guidelines:
  - Acute/initial phase: if 20-25 kcal/kg/d may be α less favorable outcome
  - Anabolic recovery phase: 25-30kcal/kg/d
  - Severe malnutrition: 25-30 kcal/kg/d (increase to target in 2-3d)

In malnutrition, energy expenditure must be calculated based on actual body weight.
In obesity, energy expenditure must be calculated on ideal weight or adjusted weight.

Adjusted weight = 0.25(actual BW - IBW) + IBW
## Protein Requirement

<table>
<thead>
<tr>
<th>Population</th>
<th>Rates (g/kg/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>normal/unstress</td>
<td>.8</td>
</tr>
<tr>
<td>postoperative*</td>
<td>1.1-1.5</td>
</tr>
<tr>
<td>septic</td>
<td>1.2-1.5</td>
</tr>
<tr>
<td>multiple trauma</td>
<td>1.5-1.75</td>
</tr>
<tr>
<td>burned</td>
<td>1.5-2.0</td>
</tr>
</tbody>
</table>

**Determinant of protein requirement**

- Body weight
- Age
- Type of protein daily requirements:
Nitrogen Balance

\[ \text{N balance} = \text{N output} - \text{N intake} \]

\[ \text{N output} = \text{UUN} + \text{UNUN} + \text{misc} \]

\[ = \text{UUN} + (2-4) \text{ (g)} \]

\[ \text{N intake} = \text{Protein intake (g)} \]

\[ 6.25 \]

Catabolic phase: less negative N-balance
Anabolic phase: +1-2 gN
Carbohydrates

- Provide 50-60% of total calories
- Necessary to maintain protein anabolism
- EN:
  - Polysaccharide: starch (hospital BD), maltodextrin
  - Disaccharide: sucrose, fructose
- 4 kcal/g by enterally and 3.4 kcal/g intravenously
Fat

- Long chain TG (LCT): soy, safflower, corn..
- Medium chain TG (MCT): not require bile salt, or pancreatic enzyme
- Source of essential fatty acids
  - linoleic: 4% of total calorie
  - linolenic: 0.2-0.4% of total calorie
- Provide **20% to 35%** of total calories
  - ~1 g/kg/day
- In special disease management
  - 45+% of total calories from fat may be beneficial
    - **Glycemic control**
    - **Reduction of CO₂ production**
<table>
<thead>
<tr>
<th></th>
<th>Enteral</th>
<th>Parenteral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>500 mg (22 mEq)</td>
<td>1–2 mEq/kg</td>
</tr>
<tr>
<td>Potassium</td>
<td>2 g (51 mEq)</td>
<td>1–2 mEq/kg</td>
</tr>
<tr>
<td>Chloride</td>
<td>750 mg (21 mEq)</td>
<td>As needed to maintain acid-base balance</td>
</tr>
<tr>
<td>Acetate</td>
<td>—</td>
<td>As needed to maintain acid-base balance</td>
</tr>
<tr>
<td>Calcium</td>
<td>1200 mg (60 mEq)</td>
<td>10–15 mEq</td>
</tr>
<tr>
<td>Magnesium</td>
<td>420 mg (35 mEq)</td>
<td>8–20 mEq</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>700 mg (23 mmol)</td>
<td>20–40 mmol</td>
</tr>
</tbody>
</table>

Recommended Water

- Healthy adult: 1 ml/kcal or 35 ml/kg
- Healthy infant: 1.5 ml/kcal or 150 ml/kg
- Normal tube feeding: 1 kcal/ml; 85% water
- Elderly: consider 25 ml/kg with renal, liver, or cardiac failure; or consider 35 ml/kg if history of dehydration
Meeting **Fluid Needs in Enterally-Fed Patients**

- Water in Enteral Products
  - Calculate free water:
    - 1:1 kcal/ml) = 85% free water
    - 1.2:1 kcal/mL = 80%
    - 1.5:1 kcal/mL = 75%
    - 2:1 kcal/mL = 70%
  - Subtract free water from needs
  - Provide additional water via flushes
How is Nutritional Support Prescribed?

• Average nutritional prescription should include
  o 25-35 kcal/kg/day total energy,
  o 0.8-1.5 g protein (0.13-0.24 g nitrogen)/kg/day,
  o 30-35 ml fluid/kg,
  o electrolytes, minerals, micronutrients, and fiber
Administration: Feeding Rate

- **Bolus method =** may give 200-400 ml over 5-10 mins 5-8 x/d

- **Intermittent method =** 250 to 400 ml of feeding over 30-60 mins given in 5-8x/d

- **Continuous method =** slow rate of 40-120 ml/hr for 12 to 24 hours
  - Start with 25-40 ml/hr increment 25 ml/12 hr, titrate up to 120 ml/hr, full strength
  - Should not be given overnight in patients who are at risk of aspiration
Disadvantages—Enteral Nutrition

- GI, metabolic, and mechanical complications—tube migration; increased risk of bacterial contamination; tube obstruction; pneumothorax
- Costs more than oral diets
- Less “palatable/normal”
- Labor-intensive assessment, administration, tube patency and site care, monitoring
Contraindication of Nutrition Support

- Unstable hemodynamics
- Severe fluid imbalance: overload or dehydration
- Severe electrolyte, acid-base disorder
- Uncontrolled sepsis

- Severe postprandial pain
- Short bowel syndrome
- Intractable vomiting
- Severe diarrhea
- Severe malabsorption, inflammation
- Massive GI bleeding
- Intestinal ischemia (no flow)
- Severe malabsorption

- End stage malignancy: EOL determined
- Uncontrolled sepsis
- Unstable hemodynamics
- Severe fluid imbalance: overload or dehydration
- Severe electrolyte, acid-base disorder
- Severe malabsorption, inflammation
- Severe diarrhea
- Severe postprandial pain
- Short bowel syndrome
- Intractable vomiting
- Massive GI bleeding
- Intestinal ischemia (no flow)
- Severe malabsorption
Common Complications: ETF

- **Mechanical**
  - Irritation or infection
  - Tube displacement
  - Aspiration
  - Tube clogging

- **Gastrointestinal**
  - Nausea
  - Vomiting
  - Abdominal distention
  - Diarrhea
  - Constipation

- **Metabolic**
  - Dehydration
  - Hyperglycemia
  - Elevated serum electrolytes
  - Low serum electrolytes

Monitoring of EN

Assessment of GI tolerance

- Abdominal discomfort (fullness, cramping, pain)
- Nausea and vomiting
- Abdominal distention
- Bowel sound
- Stool pattern
  - Diarrhea
  - Constipation

Bristol Stool Chart

- Type 1: Separate hard lumps, like nuts (hard to pass)
- Type 2: Sausage-shaped but lumpy
- Type 3: Like a sausage but with cracks on its surface
- Type 4: Like a sausage or snake, smooth and soft
- Type 5: Soft blobs with clear-cut edges (passed easily)
- Type 6: Fluffy pieces with ragged edges, a mushy stool
- Type 7: Watery, no solid pieces. Entirely Liquid
Monitoring of EN

- **Aspiration precaution**
  - Head lift $\geq 30^\circ - 45^\circ$
  - Monitor GI tolerance
    + Tube feeding residual: Gastric residual volume (GRV)
  - Continuous drip

- **Aspiration detection**
  - Clinical signs and symptoms
  - CXR

- **Hydration status**
  - Assessment of hydration status
    - Physical exam
    - I/O
  - Determine fluid requirement
    - 30-35 ml/kg/d
    - Extra fluid

- **Assessment of nutrition intake**
  - Caloric count
Enteral Nutrition Monitoring: Gastric Residuals

- Monitoring of gastric residuals in tubefed pts assumes that high residuals occur only in tubefed pts
- In one study, 40% of normal volunteers had RVs that would be considered significant based on current standards
- For consistency, all hospitalized pts, with or without EN should have their RVs routinely assessed to evaluate GI function

Enteral Nutrition Monitoring: Gastric Residuals Volume (GRV)

- Clinically assess the patient for abdominal distension, fullness, bloating, discomfort
- Place the pt on his/her right side for 15-20 minutes before checking a RV to avoid cascade effect
- Try a prokinetic agent or antiemetic
- Seek transpyloric access of feeding tube
- Raise threshold for GRV to 200-300 mL
- Consider stopping GRV checks in stable pts
Reduce Risk Of Aspiration

- Head of the bed (HOB): 30°- 45° (C)
- High-risk (ET with MV, NG, >70yr, altered conscious) or patients with gastric feeding intolerance:
  - continuous infusion (D)
  - Prokinetic drugs or narcotic antagonists (naloxone) should be initiated (C)
  - Post-pyloric tube placement considered (C)
- Chlorhexidine mouthwash 2x/d ↓ risk of VAP (C)
Remember –
Optimize delivery of enteral nutrition –
Elevate head of bed to 45°*

45° Optimal elevation

30° Minimum elevation
*Unless contraindicated

CANADIAN GUIDELINES FOR
Achieving Best Practice
CRITICAL CARE NUTRITION

A collaboration of Critical Care Nutrition and Nestlé Nutrition
Enteral Nutrition Monitoring

- Wt (at least 3 times/week)
- Signs/symptoms of edema (daily)
- Signs/symptoms of dehydration (daily)
- Fluid I/O (daily)
- Adequacy of intake (at least 2x weekly)
- Nitrogen balance: becoming less common (weekly, if appropriate)
- Serum electrolytes, BUN, creatinine (2-3 x weekly)
- Serum glucose, calcium, magnesium, phosphorus (weekly or as ordered)
- Stool output and consistency (daily)
Nutritional Support For A Patient At Risk Of Malnourishment

Patient is or is at risk of malnourishment

Safe swallow

 Unsafe swallow or poor oral intake

Oral nutritional support

Gastrointestinal tract intact

Gastrointestinal tract non-functional or perforated

Enteral nutritional support

Parental nutritional support

Source: Stu BMJ © 2009 BMJ Publishing Group Ltd
Parenteral Nutrition
Definition: Total Parenteral Nutrition (TPN)

The administration of complete and balanced nutrition by IV infusion in order to support anabolism, body weight maintenance or gain, and nitrogen balance, when oral or enteral nutrition are not feasible or are inadequate.
Total Parenteral Nutrition

- Nomenclature
- TPN: Total Parenteral Nutrition
- IVH: Intravenous Hyperalimentation
- TNA: Total Nutrient Admixture
- TPN: Total Parenteral Nutrition
- 3-In-1 Admixture
- All-In-One Admixture
- PPN: Peripheral Parenteral Nutrition or Partial Parenteral Nutrition
A.S.P.E.N Guidelines* (Indication for nutritional support)

- Non-stressed / normal nourished NPO > 10 days
- Moderate stress or malnutrition NPO > 7-10 days
- Severe stress or malnutrition NPO > 4-5 days
- No indication for TPN < 4 days
Indications For TPN

- Intestinal obstruction
- Severe malabsorption syndromes: SBS(<100 cm small bowel remains)
- Proximal intestinal fistula
- Inflammatory bowel disease
- Severe paralytic ileus
- Severe pancreatitis with inadequate EN
- Practically all patients requiring nutrition support but can’t tolerate enteral feeds, or C/I to enteral feeding.
Indications for TPN

- Conditions requiring complete bowel rest for prolonged periods
- Pre and post-operative support in patients with pre-existing malnutrition, in whom GI function is impaired
- Malignancy undergoing treatment, surgery, radiation, chemo who are unable to obtain adequate nutrition by an enteral route
Parenteral Nutrition (PN)

- PPN vs. TPN

<table>
<thead>
<tr>
<th></th>
<th>Central</th>
<th>Peripheral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Veins</td>
<td>Subclavian, jugular</td>
<td>Basilic/cephallic</td>
</tr>
<tr>
<td>Osmolarity</td>
<td>&gt;850 mosm/L</td>
<td>&lt;850 mosm/L</td>
</tr>
<tr>
<td>Period</td>
<td>Long time (&gt;2 weeks)</td>
<td>Short term (&lt;2 weeks)</td>
</tr>
</tbody>
</table>
TPN formulation

**Normal Diet**
- Carbohydrates: Dextrose
- Protein: Amino Acids
- Fat: Lipid Emulsion
- Vitamins: Multivitamin Infusion
- Minerals: Electrolytes and Trace elements

**TPN**
- Carbohydrates: Dextrose
- Protein: Amino Acids
- Fat: Lipid Emulsion
- Vitamins: Multivitamin Infusion
- Minerals: Electrolytes and Trace elements
Carbohydrate

- Dextrose: 5-50%, provide 3.4 kcal/g
- Can be the only source of energy
- Closely related to solution osmolality
- Dextrose infusion rate should not exceed 5 mg/kg/min
- Over feeding
  - ↑ minute ventilation
  - ↑ CO₂ production (VCO₂)
  - ↑ O₂ consumption (VO₂)
  - ↑ RQ
  - Lipogenesis and hepatic steatosis

Lipids

- Prevent essential fatty acid deficiency (4-10% of calrorie)
- Non-protein source of energy
- Recommended dose: 0.8-1.5 g/kg/day (~1g/kg/d)
- Available in 10%, 20% and 30% concentrations
- Included as LCT or a mix of MCT/LCT at 10% and 20%
- Added to basic parenteral nutrition solutions or administered individually
- Less hyperglycemia
- Lower concentrations of serum insulin
- Less risk of hepatic damage
- High doses can interfere with immune functions
- High infusion rates can affect respiratory functions
- Should be used with care in:
  - Hyperlipidemia
  - thrombocytopenia
  - Critical illness

Intravenous lipid emulsion

- **Zero gen**: cotton seed oil
- **First gen**:
  - soy base: intralipid
- **Second gen**:
  - Mixed MCT/LCT, structure lipid (mixed MCT/LCT)
- **Third generation**
  - Fish oil: omegaven
  - Mixed: SMOF, lipidem (soy, MCT, fish oil)
- **Concentration**: 10% $\rightarrow$ 1.1 kcal/ml
  20% $\rightarrow$ 2 kcal/ml
Amino Acid

- **Standard**
  - Gen I: aminosol
  - Gen II: amiparen, aminosteril, aminoplasma-l

- **Disease specific**
  - Nephro formula
  - Hepatic formula
  - Glutamine -dipeptide

- **Concentration**
  - 3, 3.5, 5, 7, 8.5, 10, 15% concentration

- **Provide**
  - 4kcal/g
  - 6.25g/gN
Other Requirements

- Fluid: 30 to 40 ml/kg
- Electrolytes
  - Calcium, magnesium, phosphorus, chloride, potassium, sodium, and acetate
  - Forms and amounts are titrated based on metabolic status and fluid/electrolyte balance
- Must consider calcium-phosphate solubility
- Use acetate or chloride forms to manage acidosis or alkalosis
- Vitamins
- Trace elements
Calculating the Osmolarity of a Parenteral Nutrition Solution

- Multiply the grams of dextrose per liter by 5. Example: 50 g of dextrose x 5 = 250 mOsm/L
- Multiply the grams of protein per liter by 10. Example: 30 g of protein x 10 = 300 mOsm/L
- Fat is isotonic and does not contribute to osmolarity.
- Electrolytes further add to osmolarity. Total osmolarity = 250 + 300 = 500 mOsm/L
TPN: Compounding Methods

• 2-in-1 solution of dextrose, amino acids, additives
  o Typically compounded in 1-liter bags
  o Lipid is delivered as piggyback daily or intermittently

• Total nutrient admixture (TNA) or 3-in-1
  o Dextrose, amino acids, lipid, additives are mixed together in one container
  o Lipid is provided as part of the daily PN mixture → Important energy substrate
<table>
<thead>
<tr>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>• ↓nursing time</td>
<td>• ↓stability and compatibility</td>
</tr>
<tr>
<td>• ↓risk of touch contamination</td>
<td>• IVFE (IV fat emulsions) limits the amount of nutrients that can be compounded</td>
</tr>
<tr>
<td>• ↓pharmacy prep time</td>
<td>• Limited visual inspection of TNA; reduced ability to detect precipitates</td>
</tr>
<tr>
<td>• Cost savings</td>
<td></td>
</tr>
<tr>
<td>• Easier administration in HPN</td>
<td></td>
</tr>
<tr>
<td>• Better fat utilization</td>
<td></td>
</tr>
<tr>
<td>• Physiological balance of macronutrients</td>
<td></td>
</tr>
</tbody>
</table>
Type of Infusion: Continuous PN

Advantages
- Well tolerated
- Requires less manipulation
  - ↓ nursing time
  - ↓ potential for “touch” contamination

Disadvantages
- Persistent anabolic state
  - altered insulin: glucagon ratios
  - ↑ lipid storage by the liver
- ↓ mobility in ambulatory patients
Type of Infusion: Cyclic PN

- The intermittent administration of PN, usually over a period of 12 - 18 hrs

**Advantages**

- Approximates normal physiology of intermittent feeding
- Maintains:
  - Nitrogen balance
  - Visceral proteins
- Ideal for ambulatory patients
  - Allows normal activity
  - Improves quality of life
Complication of PN

- Line sepsis: CRI
- Metabolic derangement/ re-feeding syndrome
- Fluid/ electrolyte/ acid-base imbalance
- Overfeeding syndrome
- Liver complication
Infectious Complication
‘Catheter related infection’ (CRI)

- Tunnel site infection
- Hub contamination
- Infusate contamination
- Seeding of other site of infection

Guideline for prevention of intravascular device-related infection. Infectious control and hospital epidemiology 1996;17(7):438-473
Refeeding Syndrome (Nutrition Recovery Syndrome)

Metabolic complication occurs when nutritional support given to severely malnourished

- **Electrolyte abnormalities**
  - Hypo $K^+$, $Mg^{2+}$, $PO_4^{3-}$ from intracellular shift
    - Weakness
    - Respiratory failure
    - arrhythmia
  - Na/fluid retention from $\uparrow$Insulin/Glucagon ratio (antinatriuresis)
    - Refeeding edema, Fluid overload

- **Metabolic**
  - $\uparrow$ thiamin demand
  - Substrate shift: from FA to glu $\rightarrow$ $\uparrow$VCO$_2$/O$_2$ and work of breathing
Risk For Refeeding Syndrome

- ≥ 1
  - BMI < 16
  - Unintentional weight loss > 15% in 3-6 months
  - ≥ 10 days with little or no nutritional intake
  - Low Mg²⁺, K⁺, or PO₄³⁻ before feeding
- ≥ 2
  - BMI < 18.5
  - Unintentional weight loss < 15% in 3-6 months
  - ≥ 5 days with little or no nutritional intake
  - Alcohol misuse, chronic diuretic, antacid, insulin use, or chemotherapy
How To Prevent and Management of Refeeding Syndrome

**In high risk patients**

- Start 10 kcal/kg/d, gradually ↑ within a week
- Before/during of 1st 10 d of feeding
  - Oral thiamin 200-300 mg/day
  - +1-2 vitamin B co strong tablets 3 times/d or IV vitamin B
  - +balanced multivitamin and mineral supplement each day
- Monitor and supplement oral, enteral, or intravenous K, PO₄³⁻ and Mg intake.
  - K⁺ 2-4 mmol/kg/day
  - PO₄³⁻ 0.3-0.6 mmol/kg/d
  - Mg²⁺ 0.2 mmol/kg/d IV or 0.4 mmol/kg/d oral
Metabolic Complication to Overfeeding

- Hyperglycemia
- Hypertriglyceridemia
- Hypercapnia
- Fatty liver
- Hypophosphatemia, hypomagnesemia, hypokalemia
Hepatobiliary Complication

Adults

- Steatosis
- Steatohepatitis
- Cholestasis
- Biliary sludge
- Cholelithiasis
- Acalculous cholecystitis
- Fibrosis
- Micronodular cirrhosis
Monitoring

• PN tolerance
  o Vital sign as needed-daily
  o BW daily- weekly
  o Fluid: I/O daily
  o Electrolyte: daily in first 3-5 d then 2/wk
  o CBC, LFT 1-2/weeks
# Monitoring Patient on Parenteral Nutrition

<table>
<thead>
<tr>
<th><strong>Metabolic</strong></th>
<th><strong>Assessment</strong></th>
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</thead>
<tbody>
<tr>
<td>• Glucose</td>
<td>• Body weight</td>
</tr>
<tr>
<td>• Fluid and electrolyte balance</td>
<td>• Nitrogen balance</td>
</tr>
<tr>
<td>• Renal and hepatic function</td>
<td>• Plasma protein</td>
</tr>
<tr>
<td>• Triglycerides and cholesterol</td>
<td>• Creatinine/height index</td>
</tr>
</tbody>
</table>

• Type of feeding formula and tube
• Method (bolus, drip, pump)
• Rate and water flush
• Intake energy and protein
• Tolerance, complications, and corrective actions
• Patient education