Percutaneous Endoscopic Gastrostomy (PEG) and Enteral Feeding

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2012
Indications for PEG

- Prediction or evidence of oral intake quantitatively or qualitatively inadequate for more than 3 weeks.
- Inability to stabilize or improve the nutritional status with the use of oral supplements and tips to improve swallowing (if needed).
- Expectation that the PEG feeding will maintain or improve the quality of life.
- Palliative drainage of juices in gastrointestinal stenosis or chronic bowel ileus
- Purpose:
  - prevent loss of weight,
  - correct nutritional deficiencies,
  - rehydrate,
  - promote the growth of children with growth retardation, and
  - improve the quality of life.
# Types of Enteric Access

<table>
<thead>
<tr>
<th>Gastric Tubes</th>
<th>Jejunal Tubes</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Nasogastric tube</td>
<td>• Nasojejunal tube</td>
</tr>
<tr>
<td>• PEG *(Ponsky, Sachs-Vine, Russell, o Brown-Muller (Versa))</td>
<td>• Direct Percutaneous Endoscopic Jejunostomy</td>
</tr>
<tr>
<td>• Laparoscopic gastrostomy</td>
<td>• Laparoscopic Jejunostomy</td>
</tr>
<tr>
<td>• Surgical Gastrostomy <em>(Witzel, Stamm, Janeway)</em></td>
<td>• Surgical Needle Catheter Jejunostomy</td>
</tr>
<tr>
<td>• Ultrasound guided Percutaneous Gastrostomy</td>
<td>• Ultrasound Guided Percutaneous Jejunostomy</td>
</tr>
<tr>
<td>• Fluoroscopy Guided Percutaneous Gastrostomy</td>
<td>• Fluoroscopy Guided Percutaneous Jejunostomy</td>
</tr>
<tr>
<td>• Gastrostomy with Jejunal tube</td>
<td></td>
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</tbody>
</table>
**ORAL NUTRITION:**

- no longer possible
- no longer adequate

**Short-term (unknown duration):**
- no surgery
  - no risk of aspiration
    - nasogastral tube
  - risk of aspiration
    - nasojejunal tube

**Long-term (> 2 - 3 weeks):**
- no surgery
  - no risk of aspiration
    - PEG
  - risk of aspiration
    - PEJ JET-PEG
- surgery
  - NCJ

**Prolonged requirement**
Advantages of PEG

• Less discomfort and complications than NG tube for a long time:
  – Less: irritation, ulceration, esophageal bleeding, displacement, obstruction of tube, reflux, aspiration pneumonia, cosmetic inconvenience, and
  – Greater: social acceptance.
• Weight gain is higher than that obtained with NG tube.
• Fewer complications than with surgical and laparoscopic gastrostomy
• The literature on prevention of reflux and aspiration using DPEJ or PEG with jejunal tube is controversial.
Long Term Complications of PEG

• General Complications 4.9-10.8%
  – Complications needing intervention: 1-4%
  – Complications needing surgery: 0.5%

• Risk Factors – Malnutrition, advanced cancer, outpatient procedure.

• Mortality
  Procedure related: <1%
  Long Term: 0.6-2.0%

• Little change in Mortality and Morbidity over the last 10-15 years.

Larson (Gastro 1987;93:48) Lin (Laryngoscope 2001;111:1847)
Effects of PEG Feeding on the Weight of Patients

Loser et al., Dig Dis Sci 1998; 43: 2549-2557
## Modifying Risk of Pneumonia
### Alimentation Site

<table>
<thead>
<tr>
<th>Incidence Pneumonia Study</th>
<th>small bowel n/N</th>
<th>gastric n/N</th>
<th>RR (95%CI Random)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Davies</td>
<td>2 / 31</td>
<td>1 / 35</td>
<td></td>
</tr>
<tr>
<td>Kearns</td>
<td>4 / 31</td>
<td>3 / 23</td>
<td></td>
</tr>
<tr>
<td>Kortbeek</td>
<td>10 / 37</td>
<td>18 / 43</td>
<td></td>
</tr>
<tr>
<td>Minard</td>
<td>6 / 12</td>
<td>7 / 15</td>
<td></td>
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<tr>
<td>Montecalvo</td>
<td>4 / 19</td>
<td>6 / 19</td>
<td></td>
</tr>
<tr>
<td>Taylor</td>
<td>18 / 41</td>
<td>26 / 41</td>
<td></td>
</tr>
<tr>
<td>Montejo</td>
<td>16 / 50</td>
<td>20 / 51</td>
<td></td>
</tr>
<tr>
<td><strong>Total (95%CI)</strong></td>
<td>60 / 221</td>
<td>81 / 227</td>
<td></td>
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</tbody>
</table>

- Favors SB
- Favors Gastric

n = # pneumonia, N = # in group

** RR 0.76 (95% CI 0.59 – 0.99)

PEG Contraindications

**CURRENT**
- Coagulopathy (INR > 1.7, PTT > 50, platelets < 50000)
- Interposed Organ (liver, colon).
- Severe Peritoneal Carcinomatosis
- Severe Non-cirrhotic Ascites
- Cirrhotic Ascites
- Peritonitis
- Anorexia Nervosa (?)
- Severe Psychosis
- Gastric Tumor infiltration in site of PEG
- Short Survival
- Advanced Dementia
- Peritoneal dialysis in adult

**HISTORICAL: Now False**
- Negative Diaphanoscopy (now we use “Foutch safe tract”)
- Ventriculo-peritoneal Shunt.
- Peritoneal Dialysis (in children)
- Esophageal Stricture
- Previous Gastric Surgery
- Crohn Disease
- Non-cirrhotic mild or moderate ascites
Precautions to Minimize PEG Complications

- Cleaning of the oral cavity before the procedure
- Cefazolin 2 g IV 1 hour before PEG.
- Skin Cleansing with chlorhexidine
- Use “Foutch Safe Tract” technique.
- Skin Incision slightly loose (> 8 mm).
- External “Bumper” slightly loose (free movement > 5 mm while patient at 45°).
- Place sterile gauze with “Y” shape between the skin and the external bumper; change daily for 14 days, cleaning with sterile saline solution.
- After 14 days, cleanse with soapy water every 2-3 days, and place a new sterile gauze with “Y” shape.
- Feeding can start 2 hours after PEG placement.
Foutch Safe Tract Technique

A

Bubbles Appear Before Visualization

B

Bubbles Appear as the Needle Enters the Stomach
Precautions to Ensure Adequate Volume Administration of Enteral Nutrition

- Calculate the nutritional need of the patient.
- Give the formula without dilution (adding water facilitates infection)
- Keep thorax and head elevated 30°-45°
- When starting, advance the volume/hour rapidly:
  - 35% of desired volume/hour for 4-8 hours, then
  - 70% for 4-8 hours, then
  - 100% thereafter.
- If the patient is malnourished or has not been fed for 2 weeks or more, watch carefully for development of “Re-feeding Syndrome”.
  - Obtain K, P, Ca and Mg every 8-12 h and replace deficiencies; give thiamine 300-500 mg, followed by 100 mg/d + B-complex TID + Multivitamins with Minerals daily
  - Advance to the feeding “goal rate” more slowly (start with 10 kcal/kg/d, and increase by 5 kcal/kg/d every 2-3 days).
Precautions to Ensure Adequate Volume Administration of Enteral Nutrition

• Order the total volume to be fed, and deliver it over 12-20 hours (calculate volume/hour over that period)
  – Multiple studies show that when feeding in the hospital over 24 hours, the delivered volume is < 80% of the one ordered.

• Watch for “gastric residual volume” only in gastric feeds.
  – If “residual volume” is < 400 mL, return it to the stomach and continue feeding, unless there is evidence of regurgitation.
  – If “residual volume” is > 400 mL, return it to the stomach and add pro-kinetics, or change to small bowel feeding.

• Open feeding systems must be changed every 4 hours; close feeding systems can last up to 48 hours.
Groups with Strong Evidence of Benefits from PEG Feeding

• AIDS/ HIV Infection:
  – Improve treatment compliance in children.
  – Improves nutrition in adults with “wasting syndrome”.

• Cystic Fibrosis:
  – Night feeding by PEG improves nutrition, stabilizes lung function, and is superior to naso-gastric feeds.
  – Maximal improvement is reached with early PEG placement.

• Amyotrophic Lateral Sclerosis (ALS):
  – PEG must be placed early in the illness (Vital Capacity > 50% of predicted; VC >/= 1 L, and pCO₂ < 45 mm Hg)
  – The stomach must be actively decompressed at the end of the procedure, to improve diaphragmatic function.

• Severe Mental and Physical Retardation:
  – Improves nutrition and quality of life in adults and children.
Enteral Nutrition in Specific Groups
Indications for Oral Supplements in Geriatric Patients
(sick elderly: protein $\geq 1$g/kg/d & calories $= 30$ kcal/kg/d)

- Malnourished or at Risk of Under-nutrition
  - Loss of 5% of weight / 3 months, or
  - Loss of 10% of weight /6 months, or
  - BMI $< 20/m^2$
- Frail Elderly (> 64 y/o)
  - Decreases frequency of falls
  - Decreases mortality
- Hip fracture or Orthopedic Surgery
  - Decreases complications and mortality
- Mild or Moderate Dementia
- Prevention of pressure ulcers
  - Decrease incidence by 25%
Indication for Tube Feeding in the Geriatric Patient
(sick elderly: protein $\geq 1\text{g/kg/d}$ & calories = 30 kcal/kg/d)

- Non-terminal Frail Elderly
- Depression with severe anorexia.
- Treatment of pressure ulcers
- Severe Neurologic Dysphagia
  - Immediate naso-enteric tube + intensive swallowing therapy (decreases hospital stay)
  - After an stroke, 73-86% of patients recover from dysphagia within the initial 2 weeks:
    - Place PEG if not improved in 2 weeks
  - PEG feeding gives 90% of prescribed calories, vs NGT gives on 62%.
- Mild to Moderate Dementia (occasional use)
- If expected need for tube feed is $> 4$ weeks, place PEG.
- Add fiber to the formula.
Enteral Nutrition in Patients with Crohn Disease

- **Indications:**
  - Prevention and Treatment of Malnutrition.
  - Improvement in Growth and Development in Children and Adolescents.
  - Improvement in Quality of Life.
  - Peri-Operative Nutrition.
  - Treatment of Active Disease:
    - Children: Therapy of choice (60% remission = corticosteroids);
    - Adults: when corticosteroids are not well tolerated (EN 60% remission vs corticoids 60-80%) , or in combination with corticosteroids in patients with malnutrition or inflammatory stricture of the bowel.
  - Maintenance of Remission:
    - Oral night supplement, after induction of remission, prolongs free-recurrence interval independently of disease location (small bowel, colon, or both).
Enteral Nutrition in Patients with Crohn Disease

• **Route:**
  – If caloric supplement needs are < 600-750 kcal/d, give oral supplementation at hs.
  – If needed caloric supplementation is higher, give by NGT or PEG, by continuous infusion (not by bolus).
    • Discontinuation of supplements is higher when given orally (34%), than when given by NGT (8%).

• **Formula:** (25-30 kcal/kg/d of total intake: oral + tube)
  – Standard (whole protein) which should be high on (n6 PUFA) linoleic acid and low in (n9 MUFA) oleic acid.
  – Calcium 1200 mg/d, Vitamin D 1000 UI/d.
  – May need supplements of: Vitamin B$_{12}$ (involved ileum), Folate (sulfasalazine use), Mg, P, K, and Zn.
Enteral Nutrition in Patients with Ulcerative Colitis

• **Indications:**
  – Risk of Malnutrition due to Low Nutritional Intake.
  – Malnutrition
    – *(There is no evidence that enteral or parenteral nutrition affect inflammatory activity, nor affect the frequency of flare ups in active UC).*

• **Route:**
  – Oral or by tube

• **Formula:**
  – Whole Protein.
  – Omega-3 enriched formulas improve the “histologic index” but have no proven clinical effect.
Enteral Nutrition in Patients with Short Bowel

• **Indications:**
  
  – Maintenance or Improvement of Nutritional Status.
  
  – Improvement of Residual Intestinal Function.
  
  – Reduction of diarrhea.
  
  – Improvement of Quality of Life.
Enteral Nutrition in Patients with Short Bowel

• Route:
  – *Hypersecretory Phase* (*Stool output > 2500 mL/d*): Parenteral + Oral Rehydration Solution
  – *Adaptation Phase* (*Stool output < 2500 mL/d*): Parenteral + Enteral with increasing volume.
    • Start peptide-based formula (like Vital 1.5) + Na supplementation (NaCl or NaHCO₃) to make a total Na of 80-100 mEq/L of formula (to use the co-transport of Na and glucose)
  – *Maintenance Phase*: oral diet + supplements or tube feeds as needed.
    • May still need Oral Rehydration Solution.
    • If Stool output weight is 3 kg/d or more while feeding 2500 kcal/d, patient likely will need supplemental parenteral nutrition.
Enteral Nutrition in Patients with Short Bowel

• **Formula:**
  – Regular Diet
  – Peptide-based formula with Na supplementation during “adaptation”, and
  – Whole-protein Formula for “Maintenance”.
  – Calorie-intake should be corrected by the % of absorbed fat (example: if when giving 100 g fat/day diet, the patient absorbs only 40 g (40%), the patient should receive enterally $100%/0.4 = 250\%$ of the nutrients that he/she needs.
  – When supplementing with Parenteral nutrition, subtract from calorie-needs the calories absorbed in GI tract, by multiplying (oral calorie intake) by (% of fat absorbed).
Enteral Nutrition in Patients with Alcoholic Hepatitis

• **Indications:**
  - Alcoholic Hepatitis with Malnutrition.
  - Severe Alcoholic Hepatitis
    • with Maddrey Discriminant Function > 32;
      \[ \text{Discriminant Function} = 4.6 \times (PT_{\text{patient}} - PT_{\text{control}}) + \text{Total Bilirubin} \]
    • not fulfilling his/her nutritional needs with oral diet

• **Nutritional Needs:**
  - Calories: 35-40 kcal/kg/d
  - Protein: 1.2-1.5 g/kg/d
Enteral Nutrition in Patients with Alcoholic Hepatitis

• **Route:**
  - Oral supplementation with meals and at bedtime (500-750 kcal + 20 g protein @ hs)
  - Naso-enteric Tube
  - **HIGH RISK** for REFEEDING SYNDROME.
  - Do not use PEG: high complication risk in these patients

• **Formula:**
  - Whole-protein Formula
  - Branched-chain amino acid enriched Formula in “Hepatic Encephalopathy” (NUTRIHEP).
  - Aggressive Nutrition increases Survival at 1, 3, and 12 months.
Enteral Nutrition in Patients with Cirrhosis

• **Indications:**
  – Malnourished cirrhotic
  – Inability to fulfill nutritional needs with oral diet (usually 2 g sodium/d)

• **Nutritional Needs:**
  – Protein: 1.2-1.5 g/kg/d
  – Calories: 30-40 kcal/kg/d
Enteral Nutrition in Patients with Cirrhosis

• **Route:**
  – Oral: 3 meals + 3 snacks + 500-750 kcal with >/= 20 g protein at bedtime (2 Ensure-plus or 2 Glucerna)
  – Naso-enteric tube.
  – **Do not place PEG due to high complication risk.**

• **Formula:**
  – Whole-protein Formula
  – Brached-chain amino acid enriched Formula (NUTRIHEP) in hepatic encephalopathy.
  – Aggressive nutrition improves encephalopathy and nutritional status, decreases complications, and improves survival.
  – Early feeding after liver transplantation, oral or enteral, decreases infectious complications..
Enteral Nutrition in Patients with Acute Pancreatitis

- **Indications:**
  - Mild acute pancreatitis with persistent pain for 5 or more days.
  - Severe acute necrotizing pancreatitis (even with ascites, fistula, or pseudocyst), defined by one of the following:
    - Three or more Ranson criteria
    - CT of abdomen with evidence of pseudocyst, abscess, or necrosis.
    - SIRS defined by 2 or more of the following criteria, for more than 48 hours:
      - pulse >90 beats/min;
      - rectal temperature < 36° C or > 38° C;
      - leucocytes < 4000 or >12,000 per mm³;
      - respirations > 20/min or pCO₂ < 32 mm Hg.
    - Persistent failure of 1 of the following organs for 3 consecutive days:
      - **Respiratory:** (pO₂/FiO₂) <= 201; or
      - **Renal:** Creatinine >= 1.9; or
      - **Circulatory:** systolic pressure < 90 mm Hg and not responsive to fluids.
Enteral Nutrition in Patients with Acute Pancreatitis

• **Route:** (all patients should receive aggressive intravenous fluid resuscitation)
  – Naso-gastric tube feeding (unless post-pyloric obstruction is present)
  – Naso-jejunal tube feeding (placed beyond point of obstruction)
  – Parenteral Nutrition, only if can not feed in the GI tract for 5 or more days (start the 6\textsuperscript{th} day).

• **Formula:**
  – Peptide-based Formula
  – Some patients may tolerate whole-protein formula.
Enteral Nutrition in Patients in the Intensive Care Unit

• **Indications:**
  – Any patient who is likely not to eat within 3 days and who is hemodynamically stable.

  – **Timing:**
    • Start within the first 24 hours from ICU admission, as soon as the patient has been “resuscitated”, with a MAP of 60 mm Hg or more while on low-dose vasopressors or without them.
    • Intestinal borborigmy is not needed to start enteral feedings.
Enteral Nutrition in Patients in the Intensive Care Unit

• Nutritional Needs:
  – Calories in the initial 96 hours (count propofol calories)
    • If BMI < 30: 20 kcal/kg/d.
    • If BMI > 30: 14 kcal/kg actual weight (20-25 kcal/kg ideal body weight)
  – Calories while in recovery (> 96h): 25-30 kcal/kg/d (count propofol calories)
  – Protein:
    • BMI < 30: 1.2 to 2 g/kg of “Ideal body weight”;
    • BMI 30-40: 2 g/kg of “Ideal body weight”;
    • BMI > 40 or hemodialysis patients: > 2.5 g/kg “Ideal body weight”
Enteral Nutrition in Patients in the Intensive Care Unit

- **Route:** (All patients in ventilator should have mouth washing with chlorhexidine every 12 h)
- Naso-gastric (+/- pro-kinetics) or Naso-jejunal
  - Do not hold feeding unless:
    - Residual gastric volume is > 500 mL (change to naso-enteric tube), or
    - Patient can not tolerate feeding (abdominal pain, abdominal distention, ileus in abdominal X-Ray)
  - Give parenteral nutrition only if:
    - Can not feed in GI tract for more than 7 days
    - There is evidence of malnutrition at ICU admission, and can not feed in GI tract (start parenteral nutrition from day 1)
Enteral Nutrition in Patients in the Intensive Care Unit

• **Formula:**
  – Whole-protein formula in: most cases.
  – **Immune Formula (Pivot, Crucial, Impact, Peptinex 1.5)** in:
    • patients needing upper GI tract surgery for cancer,
    • mild sepsis (APACHE II < 15),
    • trauma,
    • burns,
    • head and neck cancer needing surgery.
  – **Antioxidant Formula (Oxepa)** in:
    • ARDS, or
    • Acute Lung Injury
  – **Add supplement of 0.5 g/kg Glutamine/day, divided TID, in:**
    • Burns,
    • Trauma.
  – **Control hyperglycemia with insulin, keeping “moderate control” with goal between 144-180 mg/dL (to minimize hypoglycemia episodes)**
Enteral Nutrition in Patients in the Surgical Patient

• **Pre-Operative Indications:** (give enteral nutrition for 10-14 days before surgery).
  
  – Weight loss > 10% in 6 months.
  – BMI < 18.5 kg/m²
  – Albumin < 3 g/L (not due to liver nor renal disease)
  – Subjective Global Assessment C:
    • Severe loss of subcutaneous tissue, muscular wasting, and edema.
  
  – High probability or current evidence of
    • Not eating for > 7 days, or
    • Food intake < 60% of nutritional needs for > 10 days
Enteral Nutrition in Patients in the Surgical Patient

• **Post-operative Indications:** High probability or current evidence of
  - not eating > 7 days, or
  - Food intake < 60% of needs for > 10 days
  - Mayor surgery for head and neck cancer
  - Mayor upper GI tract surgery for cancer
  - Severe Trauma
  - Malnutrition before surgery

• **Timing & Location:**
  - start within the 1st 24 hours after surgery, giving 20 mL/h of formula and increasing rate progressively.
  - Place “needle jejunostomy” or naso-enteric tube reaching beyond intestinal anastomosis site.
Enteral Nutrition in Patients in the Surgical Patient

• Route:
  – Prefer oral or enteral nutrition; add parenteral nutrition only if enteral provides < 60% of needs.
  – Parenteral only in:
    • intestinal obstruction,
    • paralytic ileus,
    • severe shock, or
    • intestinal ischemia.
  – **NO NPO after MN:** Give “Carbohydrate Load” to all patients having elective surgery (decreases post-operative insulin resistance and negative nitrogen balance):
    • 800 mL of water with 17 level tablespoons of Polycose (102 g) (osmolarity 225) [or 800 mL of Pre-OP, Nutricia] given orally the night before surgery, and
    • 400 mL of water with 8.5 leveled tablespoons of Polycose (50 g) [or 400 mL of Pre-OP, Nutricia], 2 hours before surgery.
Enteral Nutrition in Patients in the Surgical Patient

• **Formula:**
  - Whole-Protein in most patients.
  - Immune Formula (omega-3, arginine, nucleotides) in the following groups:
    • Major neck surgery (laryngectomy, pharyngectomy),
    • Cancer of the upper GI tract (esophagus, stomach, duodenum, pancreas) with surgery
    • Major Trauma.
Enteral Nutrition in Acute Kidney Injury, or Acutely Ill with Chronic Kidney Disease

- Macronutrient needs are driven by:
  - the severity of the underlying disease, and
  - presence of underweight or obesity.
- Patients with CKD with acute illness behave metabolically as AKI patients.
- Protein Catabolism is increased:
  - Several non-essential amino acids become conditionally essential (tyrosine).
- Micronutrients:
  - Plasma retinol levels are elevated; toxicity risk.
  - Vitamin C in excess of 50 mg/d may cause oxalosis.
  - There is increased needs of Ca, Mg, Se, and Thiamine.
Enteral Nutrition in Acute Kidney Injury, or Acutely Ill with Chronic Kidney Disease

• Hyperglycemia develops from:
  – insulin resistance and
  – gluconeogenesis that is not suppressed by exogenous nutrients.
• There is inhibition of lipolysis with hypertriglyceridemia.
• Undernutrition in AKI patients:
  – increases length of stay and
  – Increases in-hospital mortality.
• Use of “Continuous Renal Replacement Therapy” (CRRT) causes
  significant loss of small molecules (protein & AA loss of 15-25 g/d;
  loss of water soluble vitamins).
• CAPD increases protein loss by 5-15 g/d + trace elements;
  absorption of glucose in PD fluid causes obesity,
  hypertriglyceridemia, hyperglycemia, and worsens diabetes.
• Intermittent hemodialysis increases losses in a lesser degree.
Enteral Nutrition in Acute Kidney Injury, or Acutely Ill with Chronic Kidney Disease

• Indications:
  – Undernutrition.
  – Inability to cover nutritional needs with oral diet + supplements.
  – Unlikely to eat within 3 days.
• Timing: within 24 hours
• Route:
  – Oral + night supplements;
  – If not enough NG tube;
  – If poor gastric emptying, NJ tube;
  – Sometimes parenteral supplementation.
• Formula:
  – Standard in most patients.
  – Renal formula for electrolyte problems.
Enteral Nutrition in Acute Kidney Injury, or Acutely Ill with Chronic Kidney Disease

• Nutritional Needs:
  – Energy: 20-30 kcal/kg/d (adapted to obesity or undernutrition).
  – Carbohydrates: 3-5 g/kg/d (max 7 g/kg/d)
  – Fat: 0.8-1.2 g/kg/d (max 1.5 g/kg/d)
  – Protein:
    • Conservative therapy: 0.6-0.8 g/kg/d (max 1 g/kg/d)
    • CRRT or hypercatabolism: up to 1.7 g/kg/d
    • Intermittent hemodialysis: 1-1.5 g/kg/d
Enteral Nutrition in CKD on Conservative Therapy

• Indications:
  – When diet + night supplements do not cover needs;
  – Give special attention to elderly patients.

• Nutritional Needs:
  – Calories:
    • 35 kcal/kg/d if in IBW +/- 10%;
    • increase if undernourished; decrease if overweight.
  – Protein:
    • GFR 20-70 mL/min: 0.55-0.6 g/kg/d (2/3 High Biological Value)
    • GFR < 25 mL/min: 0.6 g/kg/d (2/3 High Biological Value), or
      0.28 g/kg/d + {Essential AA +/- Ketoanalogues}
  – Minerals:
    • Phosphate 600-1000 mg/d
    • Potassium 1500-2000 and mg/d
    • Sodium 1800-2500 mg/d
Enteral Nutrition in CKD on Conservative Therapy

• Route:
  – Oral + Night supplements; if not enough;
  – Overnight or continuous tube feeds.

• Formula:
  – If < 5 days: Standard
  – If for 5 or more days:
    • Renal formula, or
    • Very low protein formula PLUS essential aminoacids and ketoanalogues
Enteral Nutrition in CKD on Maintenance Hemodialysis

- **Indication:** Undernutrition as documented by
  - BMI < 20 kg/m²
  - Weight loss > 10% over 6 months
  - Albumin < 3.5 g/dL, or pre-albumin < 30 mg/dL

- **Nutritional Needs:**
  - **Calories:**
    - HD or CAPD = 35 kcal/kg/d
  - **Protein:**
    - HD: 1.2-1.4 g/kg/d (> 50% High Biological Value)
    - CAPD: 1.2-1.5 g/kg/d (>50% High Biological Value)
  - **Minerals & Vitamins:**
    - Phosphate 800-1000 mg/d; Potassium 2000-2500 mg/d; Sodium 1800-2500 mg/d; Fluid: 1000 mL + urine volume/d; Zn 15 mg/d; Se 50-70 mcg/d
    - Folic acid 1 mg/d; Pyridoxine 10-20 mg/d; Vitamin C 30-60 mg/d; Vitamin D
Enteral Nutrition in CKD on Maintenance Hemodialysis

• Route:
  – Oral + bedtime supplements +/- supplement during dialysis; if not enough, then
  – Tube feeds: NGT or NJT; may need PEG or DPEJ

• Formula: Renal formula
Enteral Nutrition (EN) in Cardiology

- **EN is indicated in cardiac cachexia to stop or reverse weight loss (physiologic plausibility).**
  - 1% of population has CHF; mortality is 50% at 5 y.
  - **Cardiac cachexia:** weight loss of >= 6% of weight over 6 months.
  - 12-15% of NYHA class II-IV have cardiac cachexia.
  - In NYHA class III-IV cardiac cachexia will develop @ 10%/year.
  - Muscular atrophy develops in 50% patients without weight loss with CHF NYHA II-III.
  - Patients with cardiac cachexia have increased **resting** energy expenditure; overall energy expenditure is decreased b/o decreased activity.
  - Anorexia is present in 10-20% of cardiac cachexia patients.
Enteral Nutrition (EN) in Cardiology

• EN is indicated in cardiac cachexia to stop or reverse weight loss.
  – Mortality in CHF with cardiac cachexia is 2-3 fold higher than in non-cachecetic CHF.
  – Weight gain associated with beta-blocker use (anti-catabolic effect) leads to better survival and less hospitalizations. ACE inhibitors prevent weight loss.

• RECOMMENDATION:
  – We need studies evaluating the effect of nutritional support (oral or by feeding tube) in Cardiac Cachexia.
  – Until data are available, give supplementation at bedtime, to cover increased resting energy expenditure and increase lean body mass (500 – 750 kcal, with >/= 20 g protein at bedtime)
Enteral Nutrition (EN) in Pulmonology

• **Cystic Fibrosis:**
  - Maximal improvement is reached with early PEG placement.

• **COPD:**
  - Effects of COPD in nutrition and in Energy and Substrate Metabolism:
    - 25-40% of patients with advanced COPD are malnourished.
    - Severe weight loss (5% of weight over 3 months, or 10% of weight over 6 months) is seen in 25-40% of patients with FEV1 < 50%.
    - Muscular wasting (fat-free mass index < 16 kg/m2 in males or < 15 kg/m2 in females is present in 25% of GOLD stages 2 and 3, and in 35% of GOLD 4.
    - Lean body mass depletion is more common than low BMI.
    - There is increased rate of osteoporosis in COPD.
    - Patients with COPD are hyper-catabolic (increased resting energy expenditure, increased respiratory work, chronic inflammation)
    - Compensatory anabolism is insufficient due to hormonal resistance in COPD.
    - Anorexia and decreased food intake are common in COPD.
Enteral Nutrition (EN) in Pulmonology

- Influence of nutrition on the prognosis of COPD.
  - Underweight and low fat-free mass are associated with poor prognosis in respiratory insufficiency (FEV1 < 50%) (mean survival of 2-4 years).
  - Patients with BMI < 25 have best survival if they gain weight.
  - Patients with BMI >/= 25 do better when weight remains stable.
- There is limited evidence that COPD patients benefit from EN
  - Cochrane review of caloric supplementation in stable COPD (Ferreira IM et al. Cochrane Database Syst Rev. 2002;1:CD0000998) did not show benefit, however many patient did not increase calorie intake (exchanged food for supplements). In patients who increased calorie intake there was functional improvement.
  - Studies that provide nutritional support as part of pulmonary rehabilitation show beneficial effects.
Enteral Nutrition (EN) in Pulmonology

• EN plus anabolics and exercise can potentially improve nutrition and function.
  – In a study (Schols AMWJ et al Am J Respir Crit Care Med 1998;157:1791-7) patients with COPD received a supplement with 420 kcal (51% as fat), and 14.7 g protein and intramuscular nandrolone decaonate 50 mg in males, and 25 mg in females, given every 14 days. Fifty % of the patients gained > 2 kg over 8 weeks, and they had lower mortality.

• RECOMMENDATION:
  – There is need for prospective, randomized studies of nutrition supplementation in patients with advanced lung disease. Studies could compare bedtime supplementation alone and in combination with anabolic steroids, vs placebo.
  – Meanwhile, supplementation with “Nepro with Carb Steady” [425 kcal (48% cal from fat), with 19 g protein] at hs could improve nutrition without replacing other meals.
Re-Feeding Syndrome

- **DEFINITION:** Severe fluid and electrolyte shifts associated with initiating nutrition support in malnourished patients, and the metabolic implications which occur as a result of this shifts.

- Although are not part of the definition, vitamins and Trace elements are also affected in re-feeding syndrome and need intense replacement.
Pathogenesis of Re-Feeding Syndrome

- Starvation causes adaptive reductions in cellular activity and organ function, accompanied by electrolyte and micronutrient depletion.
- Insulin concentrations decrease and glucagon levels rise, resulting in gluconeogenesis and the breakdown of protein and lipid.
- Free fatty acids and ketone bodies replace glucose as the major energy source.
- Re-feeding (whether it’s oral, enteral or parenteral nutrition) triggers a switch from fat to carbohydrate metabolism, with consequent insulin release, and increased uptake of K+, PO4, Mg and water into cells.
Pathogenesis of Re-Feeding Syndrome

• Consequences include;
  – hypokalemia,
  – hypophosphatemia,
  – hypomagnesemia (possibly causing refractory hypokalemia and hypocalcaemia),
  – altered glucose metabolism,
  – abnormalities in fluid balance, and
  – impaired cardiac, renal and liver function.

• The serum concentrations of electrolytes can appear normal in the starved state, due to alterations in renal excretion rates.
  – monitor electrolyte levels in the early stages of feeding, as this is when biochemical shifts will occur.
## Consequences of Altered Electrolytes in Re-Feeding Syndrome

<table>
<thead>
<tr>
<th></th>
<th>Cardiac</th>
<th>Respiratory</th>
<th>Hepatic</th>
<th>Renal</th>
<th>GI</th>
<th>Neuromuscular</th>
<th>Hematologic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low PO₄</strong></td>
<td>Altered myocardial function&lt;br&gt;Arrhythmia&lt;br&gt;Congestive heart failure</td>
<td>Acute ventilatory failure</td>
<td>Liver dysfunction</td>
<td></td>
<td></td>
<td>Lethargy&lt;br&gt;Weakness&lt;br&gt;Seizures&lt;br&gt;Confusion and/or Coma&lt;br&gt;Paralysis&lt;br&gt;Rhabdomyolysis</td>
<td>Hemolytic anemia&lt;br&gt;WBC dysfunction&lt;br&gt;Thrombocytopenia&lt;br&gt;Haemorrhage&lt;br&gt;Red Cell 2, 3 diphosphoglycerate deficiency</td>
</tr>
<tr>
<td><strong>Low K</strong></td>
<td>Arrhythmia&lt;br&gt;Cardiac Arrest</td>
<td>Respiratory depression</td>
<td>Exacerbation of hepatic encephalopathy</td>
<td>Decreased urinary concentrating ability&lt;br&gt;Polyuria and Polydipsia&lt;br&gt;Decreased GFR</td>
<td>Constipation&lt;br&gt;Illeus</td>
<td>Paralysis&lt;br&gt;Rhabdomyolysis&lt;br&gt;Weakness</td>
<td></td>
</tr>
<tr>
<td><strong>Low Mg</strong></td>
<td>Arrhythmia&lt;br&gt;Tachycardia</td>
<td>Respiratory depression</td>
<td></td>
<td>Abdo pain&lt;br&gt;Anorexia&lt;br&gt;Diarrhea&lt;br&gt;Constipation</td>
<td></td>
<td>Ataxia&lt;br&gt;Confusion&lt;br&gt; Muscle tremors&lt;br&gt;Weakeness&lt;br&gt;Tetany</td>
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</table>
Patients at Risk for Re-Feeding Syndrome
NICE Criteria 2006

• Extremely High Risk:
  – BMI < 14 k/m²
  – Negligible intake > 15 days.
• High Risk:
  – One or more of the following:
    • BMI < 16 kg/m²
    • Unintentional weight loss > 15% over last 6 months.
    • Little or no nutritional intake for > 10 days.
    • Low K, PO₄, or Mg before feeding.
  – Two or more of the following:
    • BMI < 18.5 kg/m²
    • Unintentional weight loss > 10% over last 6 months.
    • Little or no nutritional intake for > 5 days.
    • History of alcohol abuse, or Use of the following drugs: insulin, chemotherapy, diuretics, or antacids with Mg or Al.
Macronutrients, Vitamins, and Micronutrients in “High Risk” Refeeding Syndrome

• Total Energy and Composition:
  – Start with 10 kcal/kg/d and increase by 5 kcal/kg/d q 2-3 days until intake calorie-goal is reached, monitoring symptoms and laboratory.
  – Ratio: 50-60% carbohydrates, 15-25% fat, 20-30% protein.
• Water: total initial volume (IV + PO) ≤ 30 mL/kg/d.
• Vitamins: At least for 10 days
  – Thiamine: 300-500 mg IV before feeding; then 100 mg/d
  – B complex: Pyridoxine (B_6) 1.7 mg/d, vitamin B_{12} 2.4 mcg/d, Folic Acid 400-1000 mg/d (can be done with B Complex 1 tablet TID)
  – Multivitamins with Minerals daily.
• Micronutrients:
  – Selenium: load with 100-400 mcg; then 20-70 mcg/d
  – Zinc: load with 30 mg/d; maintain 2.5-5 mg/d.
  – Iron: 10-15 mg/day
Prophylactic Electrolyte Replacement

- If Serum K is normal, give:
  - KCl, usually 2-4 mEq/kg daily.
- If serum Mg is normal, give:
  - Mg Oxide, usually 0.4 mM/kg/d
    - 100 mg of Mg Oxide gives 2.47 mM of Mg.
- If serum Phosphate is normal, give:
  - K or Na Phosphate usually 0.3-0.6 mM/kg/day
    - 500 mg “K-Phos Original” gives 3.6 mM of phosphate, and 3.6 mEq of K;
    - 250 mg of “K-Phos Neutral” gives 8 mM Phosphate, 1.1 mEq K, and 13 mEq of Na)
Therapeutic Electrolyte Replacement in “High Risk” Refeeding Syndrome

• Sodium: Correct hypovolemia with 0.9% NaCl but avoid hypervolemia that may facilitate CHF. Then keep Na intake low to minimize volume overload.

• Phosphate Replacement
  – Mild (2.3-3 mg/dL or 0.75-1 mM/L) = 0.32 mM/kg/d PO or IV of Kphos, or 32 mM PO.
  – Moderate (1.6-2.2 mg/dL or 0.5-0.74 mM/L) = 0.64 mM/kg/d IV of Kphos or 32 mM PO.
  – Severe (< 1.6 mg/dL or < 0.5 mM/L) = 1 mM/kg/d IV Kphos (max 50 mM over 24h), checking serum P at 12 hour intervals.

• Potassium Replacement
  – Asymptomatic or mild to moderate: 1-4 mEq/kg/d of PO KCl.
  – Symptomatic or severe hypoK (2.5-2.9 mM/L): may require IV 40 mM over 8 h, with close monitoring. Consider EKG monitoring during 1st week.

• Magnesium Replacement
  – Mild to moderate (1.2-1.7 mg/dL or 0.5-0.7 mM/L) = 10-15 mM/day as Mg Oxide
  – Severe (< 1.2 mg/dL or < 0.5 mM/L) =
    • Asymptomatic give 15 mM/d Mg Oxide.
    • Symptomatic give 25 mM Mg sulfate IV over 6 h and reassess q 8-12 hours; repeat if needed (up to 50 mM/d)