Fluids, electrolytes, nutrition in surgery

PSGS Review
Bonaventure Plaza, Greenhills, San Juan
3-5 PM; April 26, 2012
Case

- 62 y/o male
- Height=1.6 m, weight=52 kg, weight two months ago=60 kg
- Anorexia, vomiting; weight loss
- Diagnosis: head of pancreas cancer
- Referred for surgery:
- Labs: Hb=11, WBC=5600, N=60%, L=6%, platelet=240k; Na=135 mmol/L; K=3.2 mmol/L; glucose=160 mg/dL; BUN=6 mmol/L; albumin=3 gm/dL; creatinine=1.1 mg/dL
Questions

• Will you operate on this patient tomorrow?
• If you plan to build up – how?
  – Route? Duration? What to give?
• How will you know your build-up attempts are okay?
• During surgery:
  – Will you monitor the fluid input?
  – How will you give the fluids? Will you leave everything to the anesthesiologist?
  – What are your choices of fluids?
  – Will you place a jejunostomy?
Questions

• In the post-operative period:
  – Will you place an NGT?
  – Will you place drains?
  – Will you place on NPO? How long?
  – How often will you check the electrolytes? Glucose?
  – When will you start enteral feeding? Oral feeding?
  – How? When?
  – Will you give parenteral nutrition? When?
SURGERY BASICS
Essentials for wound healing

1. Homeostasis
   • Normal ECF and ICF
   • Optimum balance mechanisms
2. Optimum cell structure and function
3. Adequate energy provision
   • Optimum antioxidant activity
4. Adequate nutrition
   • Macronutrients
   • Micronutrients
5. Adequate perfusion
6. Adequate oxygenation
7. Adequate waste removal
Homeostasis

• Essential for optimum body function
• Fluids, electrolytes, acids and bases must be balanced
• Balance = a set desired level
  – More than desired level = increasing excretion
  – Below desired level = increasing absorption
Cell structure and function

Illustrations from Guyton’s Textbook of Physiology
# The cell: basic components

<table>
<thead>
<tr>
<th>Component</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>70% to 85% except in fat cells</td>
</tr>
<tr>
<td>Ions</td>
<td>major → potassium, magnesium, phosphate, bicarbonate; minor → sodium, chloride and calcium</td>
</tr>
<tr>
<td>Protein</td>
<td>20% to 30% of cell mass</td>
</tr>
<tr>
<td></td>
<td>Structural</td>
</tr>
<tr>
<td></td>
<td>Functional</td>
</tr>
<tr>
<td>Lipids</td>
<td>(mainly phospholipids and cholesterol): 2% of cell mass</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>small part but has major role in metabolism</td>
</tr>
</tbody>
</table>
100 trillion cells

- Nervous system
- Musculoskeletal system
- Cardiovascular system
- Respiratory system
- Gastrointestinal system
- Genitourinary system
- Reproductive system
- Endocrine system
- Hemopoietic system
Body composition and water

Human body composition (% of weight):
- Water: 60%
  - ECF (extracellular fluid): 20%
    - Intravascular fluid
    - Extravascular interstitial fluid
  - ICF (intracellular fluid): 40%
- Mass: 40%
  - Lean body mass
  - Fat mass

TBF = ICF + ECF = 42 liters (60% of weight)
- ECF = 14 liters
  - Plasma
  - Interstitial Fluid
- ICF = 28 liters

• Computation of usual fluid requirement per day:
  - 30 ml/kg
  - or 1.5 to 2.5 L/day
Normal routes of water gain and loss at room temp (=23°C)

<table>
<thead>
<tr>
<th>Water intake</th>
<th>ml/day</th>
<th>Water loss</th>
<th>ml/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid</td>
<td>1200</td>
<td>Insensible</td>
<td>700</td>
</tr>
<tr>
<td>In Food</td>
<td>1000</td>
<td>Sweat</td>
<td>100</td>
</tr>
<tr>
<td>Metabolically produced from food</td>
<td>300</td>
<td>Feces</td>
<td>200</td>
</tr>
<tr>
<td>Total</td>
<td>2500</td>
<td>Urine</td>
<td>1500</td>
</tr>
</tbody>
</table>

Electrolytes

• Chemicals that can carry an electrical charge
• Dissolved in the body fluids
• Fluid and electrolyte levels are interdependent
  – Electrolyte increases, water is added
  – Electrolyte decreases, water is removed
# Positive Ions

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Extracellular mEq/L</th>
<th>Intracellular mEq/L</th>
<th>Function</th>
</tr>
</thead>
</table>
| Sodium          | 142                 | 10                  | • Fluid balance  
|                 |                     |                     | • Osmotic pressure                           |
| Potassium       | 5                   | 100                 | • Neuromuscular excitability  
|                 |                     |                     | • Acid base balance                          |
| Calcium         | 5                   | -                   | • Bones  
|                 |                     |                     | • Blood clotting                             |
| Magnesium       | 2                   | 123                 | • Enzymes                                     |
| Total           | 154                 | 205                 |                                               |
# Negative Ions

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Extracellular mEq/L</th>
<th>Intracellular mEq/L</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride</td>
<td>105</td>
<td>2</td>
<td>• Fluid balance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Osmotic pressure</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>24</td>
<td>8</td>
<td>• Acid base balance</td>
</tr>
<tr>
<td>Proteins</td>
<td>16</td>
<td>55</td>
<td>• Osmotic pressure</td>
</tr>
<tr>
<td>Phosphate</td>
<td>2</td>
<td>149</td>
<td>• Energy storage</td>
</tr>
<tr>
<td>Sulfate</td>
<td>1</td>
<td>-</td>
<td>• Protein metabolism</td>
</tr>
<tr>
<td>Total</td>
<td>154</td>
<td>205</td>
<td></td>
</tr>
</tbody>
</table>
Osmolality

• Normal cellular function requires normal serum osmolality
• Water homeostasis maintains serum osmolality
• The contributing factors to serum osmolality are: Na, glucose, and BUN
• Sodium is the major contributor (accounts for 90% of extracellular osmolality)
• Acute changes in serum osmolality will cause rapid changes in cell volume
How to compute for plasma osmolality

Osmolality = 2 x [Na] + [glucose]/18 + [BUN]/2.8

Na = 140 mmol/L
Glucose = 110 mg/dL
BUN = 20 mg/dL

Division of glucose and BUN by 18 and 2.8 converts these to mmol/L

Osmolality = (2x140) + (110/18) + (20/2.8)

Osmolality = 280 + 6.1 + 7.1

Osmolality = 293.2 mmol/L

(Normal = 275 to 295 mmol/L or mOsm/kg)
Regulation of Sodium and Water Balance

1. ADH
2. Sodium Reabsorbed
3. Sodium Excreted

- Adrenal Gland
- Kidney
- Aldosterone
- ANH
- Ureter
- Heart
Homeostasis needs energy

<table>
<thead>
<tr>
<th></th>
<th>ECF (mmol/L)</th>
<th>ICF (mmol/L)</th>
<th>Mechanism</th>
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<tbody>
<tr>
<td>Na+</td>
<td>140</td>
<td>10</td>
<td>Active transport</td>
</tr>
<tr>
<td>K+</td>
<td>4</td>
<td>140</td>
<td>Active transport</td>
</tr>
<tr>
<td>Ca++</td>
<td>2.5</td>
<td>0.1</td>
<td>Active transport</td>
</tr>
<tr>
<td>Mg++</td>
<td>1.5</td>
<td>30</td>
<td>Active transport</td>
</tr>
<tr>
<td>Cl-</td>
<td>100</td>
<td>4</td>
<td>Active transport</td>
</tr>
<tr>
<td>HCO3-</td>
<td>27</td>
<td>10</td>
<td>Active transport</td>
</tr>
<tr>
<td>PO4-</td>
<td>2</td>
<td>60</td>
<td>Active transport</td>
</tr>
<tr>
<td>Glucose</td>
<td>5.5</td>
<td>0-1</td>
<td>Facilitated diffusion</td>
</tr>
<tr>
<td>Protein</td>
<td>2 gm/dL</td>
<td>16 gm/dL</td>
<td>Active transport</td>
</tr>
</tbody>
</table>
Wound healing

Essentials:
1. Adequate protein
   - Essential / non-essential AA
2. Adequate carbohydrate
3. Adequate fat
   - Essential fatty acids
4. Adequate micronutrients
   - Vitamins
   - Trace elements

The inflammatory process

Cell injury, foreign body (virus, bacteria)

- Recognition: macrophage
- Bone marrow neutrophils
- Complement

- eicosanoids
- Cytokines

- T-cell defense
  Lymphoid system
- Antibody defense
  Humoral system

- eicosanoids
- eicosanoids

Resolution of the inflammatory process

Inadequate/inappropriate response/management lapse

Exacerbation of the inflammatory process
Inflammation
Energy requirements and antioxidants

- Glutathione reductase
- Glutathione peroxidase
- Superoxide dismutase
- Oxygen radicals
- Catalase
- Hydrogen peroxide
- Vitamin C

Chemical reactions:

- \( \text{Oxygen radicals} \rightarrow \text{Hydrogen peroxide} \rightarrow \text{Glutathione peroxidase} \rightarrow \text{Glutathione reductase} \)

References:

- Munoz C. Trace elements and immunity: Nutrition, immune functions and health; Euroconferences, Paris; June 9-10, 2005;
Wound healing

**Basement membrane:**
1. Cell support
2. Exchange
3. Transport
4. Development
5. Repair
6. Defense
7. Integrity of structure and environment

**Intercellular environment**
1. Tissue support/shape
2. Exchange
3. Growth
4. Repair
5. Defense
6. Movement
Wound healing

HEALING BY FIRST INTENTION
- Scab
- Neutrophils
- Clot

24 hours

HEALING BY SECOND INTENTION

3 to 7 days
- Mitoses
- Granulation tissue
- Macrophage
- Fibroblast
- New capillary

Weeks
- Fibrous union

Wound contraction

Inflammation: surgery

ADAPTED FROM:

Surgery induced immunosuppression

Surgical stress

↓ T-helper cells
↓ Cytotoxic T-cells
↓ NK cells
↓ IL2 receptor+ cells

↑ T-suppressor cells

↑ cortisol
↑ immuno-suppressive acidic protein?

↓ Lymphocyte number and function up to 2 weeks post-op

Surgery induced immunosuppression

1. \( \uparrow \text{CD16+ granulocytes express arginase 1} \)
   \[ \downarrow \text{Plasma arginine by 50\%} \]

2. \( \downarrow \text{T-lymphocyte growth and function} \)

3. \( \downarrow \text{Impairment of Acquired Immunity} \)

References:
1. Bryk JA et al. J Trauma 2010
PRACTICAL SURGERY
Pre-operative checklist

• Check nutritional and fluid status (nutritional assessment)
• Check fluid and electrolyte status (=homeostasis):
  – Na, K, Cl (then may add Mg, Ca if needed)
  – Glucose, BUN, serum osmolality
  – Fluid intake and output record
• Wound healing capacity
  – Energy and protein requirements
  – Micronutrient requirements
  – Need for pharmaconutrition
1. DETECT MALNUTRITION
Nutrition screening & assessment

Nutrition screening

Nutritional assessment
Malnutrition and complications

Surgical patients

- 9% of moderately malnourished patients → major complications
- 42% of severely malnourished patients → major complications
- Severely malnourished patients are four times more likely to suffer postoperative complications than well-nourished patients

Detsky et al. *JPEN* 1987
Detsky et al. *JAMA* 1994
Malnutrition and complications

Malnutrition and cost

Malnutrition is associated with increased cost and the higher the risk the higher the number of complications plus cost

2. DETERMINE REQUIREMENTS
# Nutrition Care Plan Form

## Clinical Nutrition Services

### NUTRITION CARE PLAN

**Date Admitted**

**Room/Bed No.**

**File No.**

**PIN**

**Patient's Name (Last, First, Middle Name)**

**Weight (kg)**

**Age**

**Sex**

**Attending Physician**

**Actual Body Weight**

**Ideal Body Weight**

**Corrected Body Weight**

### Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Data</th>
<th>Remarks/Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Calorie Requirement</td>
<td>weight (kg)</td>
<td>kcal/day</td>
</tr>
<tr>
<td>Total Protein Requirement</td>
<td>weight (kg)</td>
<td>protein need</td>
</tr>
<tr>
<td>Electrolytes</td>
<td>Standard dose</td>
<td>Specific</td>
</tr>
<tr>
<td>Vitamin</td>
<td>Standard dose</td>
<td>Specific</td>
</tr>
<tr>
<td>Trace Elements</td>
<td>Standard dose</td>
<td>Specific</td>
</tr>
<tr>
<td>Pharmacological Nutritional Support</td>
<td>Glutamine</td>
<td>Standard dose</td>
</tr>
<tr>
<td>Formulation</td>
<td>Standard diet</td>
<td>Specific</td>
</tr>
<tr>
<td>Access/Route</td>
<td>Oral</td>
<td>Surgical Gastrostomy</td>
</tr>
<tr>
<td></td>
<td>PEG</td>
<td>Jejunostomy (surgical)</td>
</tr>
<tr>
<td>Standard Diet Specifics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery Method</td>
<td>Oral</td>
<td></td>
</tr>
<tr>
<td>Monitoring</td>
<td>Calorie count</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weight</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Serum Albumin</td>
<td></td>
</tr>
</tbody>
</table>

**Accomplished by:**

[Signatures and Dates]
How much calories?

Usual: 20-25 kcal/kg/day

Very sick: 15-20 kcal/kg/day


Jeejeebhoy K. 4th Asia Pacific Parenteral Nutrition Workshop. June 7-9, 2009; Kuala Lumpur, Malaysia
Energy utilization – normal state

- Brain - glucose: 25% (400k)
- Heart - fat: 18% (280k)
- RBC - glucose: 3% (50k)
- Lungs - both: 3% (50k)
- Immune defense - glutamine: 2% (30k)
- Gastrointestinal tract - glutamine: 4% (65k)
- Skeletal muscles – both: 35% (480k)

Principles of Surgery, Schwartz, 17th ed, 1999

60 kg x 30 kcal/kg = 1600 kcal/day
How much protein?

How much carbohydrate and fat?

Carbohydrate- and Lipid-Oxidation during Sepsis

Carbohydrate-Oxidation

Lipid-Oxidation

- H.B. Stoner -

3. DETERMINE ROUTE OF FEEDING
Feeding algorithm

Can the GIT be used?

Yes

“Inability to use the GIT”

No

Parenteral nutrition

Oral

“inadequate intake”

< 75% intake

Short term

Long term

Peripheral PN

Central PN

Tube feed

More than 3-4 weeks

No

Yes

NGT

Gastrostomy

Jejunostomy

Nasoduodenal or nasojejunal

PRE-OPERATIVE PHASE

malnutrition

no

slight, moderate

severe

Scheduled
• esophageal resection
• gastrectomy
• pancreaticoduodenectomy

Enteral nutrition for 10-14 days

oral immunonutrition for 6-7 days

SURGERY

POST-OP

EARLY DAY 1 - 14

Early oral feeding within 7 days

yes

no

within 4 days

yes

“Fast Track”

no

Parenteral hypocaloric

Adequate calorie intake within 14 days

ENTRAL access (NCJ)

ental nutrition

immunonutrition for 6-7 days

Enteral access (NCJ)

Oral intake of energy requirements

yes

no

Combined enteral / parenteral

Oral intake of energy requirements

yes

no

supplemental enteral diet

no

yes
Surgical nutrition pathways: Pre-operative phase

Nutritional Assessment
- Normal to moderate malnutrition
- Severe Malnutrition
  - Condition: When oral or enteral feeding not possible
    - Esophageal resection
    - Gastrectomy
    - Pancreaticoduodenectomy

Parenteral nutrition + Omega-3-Fatty Acids + Antioxidants (+ glutamine); 6-7 days

SURGERY

Enteral nutrition

**STOMACH**

- Nasogastric tube
- PEG
- BUTTON
- PLG
- Witzel, Stamm, Janeway
- PSG
- PFG

**JEJUNUM**

- Nasojejunal tube
- PEJ
- JET-PEG
- PLJ
- NCJ
- PSJ
- PFJ

Loser C et al. ESPEN guidelines on artificial enteral nutrition – Percutaneous endoscopic gastrostomy (PEG)

\[E: \text{Endoscopic} \quad G: \text{Gastrostomy} \quad L: \text{Laparoscopic} \quad NC: \text{Needle Catheter} \quad S: \text{Sonographic} \quad F: \text{Fluoroscopic}\]
Parenteral nutrition

- Central PN
- Peripheral / peripheral central PN (PICC)

PICC = peripherally inserted central catheter
EARLY ENTERAL NUTRITION
Rationale

• Enteral feeding 24 to 72 hours after surgery or when patient is hemodynamically stable
• Provide nutrients required during metabolic stress
• Maintain GI integrity
• Reduce morbidity compared with parenteral nutrition
• Reduce cost compared with parenteral nutrition
Early enteral nutrition vs standard nutritional support on mortality

Comparison: mortality
Outcome: early enteral nutrition vs. control

<table>
<thead>
<tr>
<th>Study</th>
<th>Treatment n/N</th>
<th>Control n/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerra et al 1990</td>
<td>1/11</td>
<td>1/9</td>
</tr>
<tr>
<td>Gottschlich et al, 1990</td>
<td>2/17</td>
<td>1/14</td>
</tr>
<tr>
<td>Brown et al, 1994</td>
<td>0/19</td>
<td>0/18</td>
</tr>
<tr>
<td>Moore et al, 1994</td>
<td>1/51</td>
<td>2/47</td>
</tr>
<tr>
<td>Bower et al, 1996</td>
<td>24/163</td>
<td>12/143</td>
</tr>
<tr>
<td>Kudsk et al, 1996</td>
<td>1/16</td>
<td>1/17</td>
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<tr>
<td>Ross Products, 1996</td>
<td>20/87</td>
<td>8/83</td>
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<tr>
<td>Engel et al, 1997</td>
<td>7/18</td>
<td>5/18</td>
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<td>Mendez et al, 1997</td>
<td>1/22</td>
<td>1/21</td>
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<td>Rodrigo et al, 1997</td>
<td>2/16</td>
<td>2/13</td>
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<td>Weimann et al, 1998</td>
<td>2/16</td>
<td>4/13</td>
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<td>Atkinson et al, 1998</td>
<td>96/197</td>
<td>86/193</td>
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<tr>
<td>Galban et al, 2000</td>
<td>17/89</td>
<td>28/87</td>
</tr>
</tbody>
</table>

**Pooled Risk Ratio**

Heyland et al. JAMA, 2001
4. DETERMINE ADEQUACY OF INTAKE
Calorie Count

**Nutrition and Fluid Balance Sheet**

<table>
<thead>
<tr>
<th>Date</th>
<th>Unit</th>
<th>Oral</th>
<th>Enteral</th>
<th>Tube Flush</th>
<th>Parenteral</th>
<th>IV Dex</th>
<th>IVF2</th>
<th>Others</th>
<th>Total Intake</th>
</tr>
</thead>
</table>

**Fluid Output Record**

<table>
<thead>
<tr>
<th>Date</th>
<th>Unit</th>
<th>Urine</th>
<th>Drain1</th>
<th>Drain2</th>
<th>Stool</th>
<th>Insensible</th>
<th>Total Output</th>
<th>Fluid Balance</th>
</tr>
</thead>
</table>

**Calorie Intake Record**

<table>
<thead>
<tr>
<th>Date</th>
<th>Unit</th>
<th>Oral Calorie</th>
<th>Enteral Calorie</th>
<th>Parenteral Calorie</th>
<th>IVDex Calorie</th>
<th>Others</th>
<th>Total Calories</th>
<th>TCR</th>
<th>Calorie Balance</th>
</tr>
</thead>
</table>

**Protein Intake Record**

<table>
<thead>
<tr>
<th>Date</th>
<th>Unit</th>
<th>Oral Protein</th>
<th>Enteral Protein</th>
<th>Parenteral Protein</th>
<th>Others</th>
<th>Total Protein</th>
<th>TPR</th>
<th>Protein Balance</th>
</tr>
</thead>
</table>

**CALORIE MONITORING FORM**

<table>
<thead>
<tr>
<th>Date and Shift</th>
<th>Nutrient Source</th>
<th>Calorie Intake</th>
<th>TCR</th>
<th>% Calorie Intake</th>
<th>Protein Intake</th>
<th>TPR</th>
<th>% Protein Intake</th>
<th>Total Fluid Intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral</td>
<td>Tube Feed</td>
<td>IV Dextrose</td>
<td>Parenteral</td>
<td>TOTAL</td>
<td>Oral</td>
<td>Tube Feed</td>
<td>IV Dextrose</td>
<td>Parenteral</td>
</tr>
<tr>
<td>Oral</td>
<td>Tube Feed</td>
<td>IV Dextrose</td>
<td>Parenteral</td>
<td>TOTAL</td>
<td>Oral</td>
<td>Tube Feed</td>
<td>IV Dextrose</td>
<td>Parenteral</td>
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<tr>
<td>Oral</td>
<td>Tube Feed</td>
<td>IV Dextrose</td>
<td>Parenteral</td>
<td>TOTAL</td>
<td>Oral</td>
<td>Tube Feed</td>
<td>IV Dextrose</td>
<td>Parenteral</td>
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</table>
Monitor actual nutrient intake

<table>
<thead>
<tr>
<th>Date And Shift</th>
<th>Nutrient Source</th>
<th>Calorie Intake</th>
<th>TCR</th>
<th>% Calorie Intake</th>
<th>Protein Intake</th>
<th>TPR</th>
<th>% Protein Intake</th>
<th>Total Fluid Intake</th>
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<td>2/1/07</td>
<td>Oral</td>
<td>900</td>
<td>1600 kcal</td>
<td>72%</td>
<td>36</td>
<td>52 g</td>
<td>69%</td>
<td>1100</td>
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<td></td>
<td>Tube Feed</td>
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<td>1240</td>
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<tr>
<td></td>
<td>Parenteral</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>1150 kcal</td>
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<td></td>
<td></td>
<td></td>
<td>2340 ml</td>
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<td>2/3/07</td>
<td>Oral</td>
<td>200</td>
<td>1600 kcal</td>
<td>84%</td>
<td>8</td>
<td>52 g</td>
<td>135%</td>
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<td></td>
<td>Tube Feed</td>
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<td></td>
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<td>1200</td>
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<tr>
<td></td>
<td>IV Dextrose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parenteral</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1440 ml</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>1350 kcal</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>2/6/07</td>
<td>Oral</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Tube Feed</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>IV Dextrose</td>
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<td></td>
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<tr>
<td></td>
<td>Parenteral</td>
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</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Effect of nutrition intake on outcome

Nutrition care led to reduced morbidity and mortality of surgical patients assessed as severely malnourished and high risk (n=103)

Intra-operative checklist

• Fluid intake
  – Monitor and estimate fluid losses
  – Only infuse what is required
  – Determine whether to give balanced electrolyte solutions or colloids; avoid saline and “water only” infusions like D5W or D10W

• Nutrition access
  – Determine the need for long term enteral nutrition (jejunostomy: surgical jejunostomy or nasojejunostomy)
## How much fluid loss in surgery?

<table>
<thead>
<tr>
<th>Fluid Loss</th>
<th>Description</th>
<th>60 kg wt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insensible perspiration</td>
<td>Ventilation with 100% water = almost zero loss</td>
<td>0 ml</td>
</tr>
</tbody>
</table>
| Evaporative loss              | • moderate incisions with partly exposed but non-exteriorised viscera = 8.0 ml/hour  
   • major incisions with completely exposed and exteriorised viscera = 32.2 ml/hour | 8-30 ml per hr            |
| Third space loss              | • Ascites or other fluids – measurable                                       | • Measure                 
   • Volumes up to 15 mL/kg/hour are recommended in the first hour of abdominal surgery, with decreasing volumes in subsequent hours. | • 300 ml                  |
| Total                         | • Within one hour (crystalloids not recommended)                            | 350 first hour            |

Which fluid is the most appropriate?

<table>
<thead>
<tr>
<th></th>
<th>Plasma</th>
<th>0.9% Saline</th>
<th>Hartmann’s</th>
<th>Sterofundin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na</td>
<td>135-145</td>
<td>154</td>
<td>131</td>
<td>140</td>
</tr>
<tr>
<td>K</td>
<td>3.5-5.3</td>
<td>-</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Ca</td>
<td>2.2-2.6</td>
<td>-</td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>Mg</td>
<td>0.7-1.2</td>
<td>-</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Cl</td>
<td>95-105</td>
<td>154</td>
<td>111</td>
<td>127</td>
</tr>
<tr>
<td>Bicarb precursor</td>
<td>24-32</td>
<td>-</td>
<td>Lactate 29</td>
<td>Acetate 24 Malate 5</td>
</tr>
<tr>
<td>Na:Cl ratio</td>
<td>1.28-1.45:1</td>
<td>1:1</td>
<td>1.18:1</td>
<td>1.43:1</td>
</tr>
<tr>
<td>Osmolality</td>
<td>275-295</td>
<td>308</td>
<td>276</td>
<td>294</td>
</tr>
</tbody>
</table>
# Fluid management

<table>
<thead>
<tr>
<th>Use</th>
<th>Compartment</th>
<th>Composition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume Replacement</td>
<td>Intravascular fluid volume</td>
<td>Iso-oncotic</td>
<td>6% HES 130 in balanced solution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Isotonic Iso-ionic</td>
<td></td>
</tr>
<tr>
<td>Fluid Replacement</td>
<td>Extracellular fluid volume</td>
<td>Isotonic Iso-ionic</td>
<td>Balanced solution: normal saline; ringer’s lactate</td>
</tr>
<tr>
<td>Electrolyte or osmotherapy (solutions for correction)</td>
<td>Total body fluid volume</td>
<td>According to need for correction</td>
<td>KCL Glucose 5% Mannitol</td>
</tr>
</tbody>
</table>

Reference: Zander R, Adams Ha, Boldt J. 2005; 40; 701-719
Post-operative checklist

• Fluids and electrolytes
  – Daily accumulated fluid balance
  – Goal: “zero” fluid balance
  – Serum electrolytes
  – Give balanced electrolyte solutions

• Adequacy of nutrient intake
  – Early enteral nutrition
  – Daily nutrient balance (=nutrient intake)
  – Good glucose control
SURGICAL COMPLICATIONS
Common peri-operative surgical complications

- Fluid and electrolyte problems
- Wound infection and sepsis
- Wound dehiscence
Fluid management

• Average perioperative fluid infusion:
  – Intra-op = 3.5 to 7 liters
  – 3 liters/day for the next 3 to 4 days
  – Average gain post-op = 3 to 6 kg weight gain

• Leads to:
  – Delay of gastrointestinal function
  – Impair wound anastomosis healing
  – Affects tissue oxygenation
  – Prolonged hospital stay

Fluid and electrolyte imbalance

**INJURY = SURGERY**

- **Inflammatory mediators**
  - ↑K+ release from cells
  - ↓K+ and ↑ Na intracellular
  - Sick cell syndrome of critical illness

- ↑vasodilation effect of anesthetic agents
  - ↑albumin escape from intravascular space

- ↑hypotonic fluid infusion
  - 90% cause of hyponatremia in surgery

**Fluid Retention + Electrolyte Imbalance**

Ileus and dehiscence

Salt and water overload

↑ in intra-abdominal pressure

↓ in mesentery blood flow

STAT3 activation

↓ in myosin phosphorylation

↓ in muscle contractility

ILEUS

Intestinal edema

↓ in tissue OH-proline

Impaired wound healing

DEHISCENCE

Anastomosis leak

• Points to bowel preparation:
  – meta-analyses show that bowel preparation is not beneficial
  – in elective colonic surgery, and 2 smaller recent RCTs suggest that it increases the risk for anastomotic leak
  – Promote longer ileus duration

• Points to fluid management

What is the worst fluid to give?

<table>
<thead>
<tr>
<th></th>
<th>Plasma</th>
<th>0.9% saline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na (mmol/L)</td>
<td>135 – 145</td>
<td>154</td>
</tr>
<tr>
<td>Cl (mmol/L)</td>
<td>95 – 105</td>
<td>154</td>
</tr>
<tr>
<td>K (mmol/L)</td>
<td>3.5 – 5.3</td>
<td>0</td>
</tr>
<tr>
<td>HCO\textsubscript{3} (mmol/L)</td>
<td>24 – 32</td>
<td>0</td>
</tr>
<tr>
<td>Osmolality (mOsm/kg)</td>
<td>275 – 295</td>
<td>308</td>
</tr>
<tr>
<td>pH</td>
<td>7.35 – 7.45</td>
<td>5.4</td>
</tr>
</tbody>
</table>

Inflammation: surgery

ADAPTED FROM:

Inflammation: sepsis

Inflammation & organ failure in the ICU

**SIRS**
- TNFα, IL-1β, IL-6, IL-12, IFNγ, IL-3
- Tissue inflammation, Early organ failure and death

**CARS**
- IL-10, IL-4, IL-1ra, Monocyte HLA-DR suppression
- Immunosuppression
- 2nd Infections
- Delayed MOF and death

Goal of nutrition/pharmaceutical nutrition

Inflammation & organ failure in the ICU

SIRS
TNFα, IL-1β, IL-6, IL-12, IFNγ, IL-3

Tissue inflammation, Early organ failure and death

PRO
Inflammatory balance

ANTI

Inflamatory balance

Days

weeks

Goal of nutrition/pharmaconutrition

1. Early enteral nutrition
2. Supplement with parenteral nutrition
3. Pharmaconutrition: Fish oils and glutamine
4. Zero fluid balance

Sarcopenia in elderly

Sarcopenia: Vandewoude M. Abbott Symposium, ESPEN 2011, Göteborg, Sweden
Sarcopenia in elderly

1. Early enteral nutrition
2. Supplement with parenteral nutrition
3. Adequate nutrient intake
4. Pharmaconutrition: Fish oils and glutamine
5. Zero fluid balance
Cancer Cachexia

- TUMOR
  - ↓ intake/obstruction
  - PIF → proteolysis
  - LMF → lipolysis

- BODY
  - WBC → Cytokines →
  - ↓ Appetite
  - ↑ Satiety
  - Cell ischemia
  - Cell destruction
  - ↑ inflammation

- WEIGHT LOSS
  - CACHEXIA

Cancer Cachexia

1. Early enteral nutrition
2. Supplement with parenteral nutrition
3. Adequate nutrient intake
4. Pharmaconutrition: Fish oils and glutamine
5. Zero fluid balance

ANSWERS
Surgical case

• 62 y/o male
• Height=1.6 m, weight=52 kg, weight two months ago=60 kg
• Anorexia, vomiting; weight loss
• Diagnosis: head of pancreas cancer
• Referred for surgery:
• Labs: Hb=11, WBC=5600, N=60%, L=6%, platelet=240k; Na=135 mmol/L; K=3.2 mmol/L; glucose=160 mg/dL; BUN=6 mmol/L; albumin=3 gm/dL; creatinine=1.1 mg/dL
Questions

• Will you operate on this patient tomorrow?
  – Yes if emergency needed, but needs intraop enteral access and will give early enteral nutrition
  – No; optimize patient through nutrition and fluid management
Available data

- BMI=21
- Weight loss in two months=13%
- Cancer, head of pancreas
- Albumin=3 gm/dL
- Total lymphocyte count (TLC)=336
- Na=135, K=3.2
- Compute for the osmolality
  - \([2 \times 135] + [160/18] + [6] = 284.8 \text{ mOsm/kg H}_2\text{O}\)
Question

• If you plan to build up the patient how?
Build up

• Total fluid (ml)/day = 52 kg x 30 ml/day = 1560-1600 ml/day
• Total calories/day = 52 kg x 30 kcal/day = 1560 kcal/day
• Total protein/day = 52 kg x 1.5 gm/day = 78 gm/day
• Total carbo and fat: get the non-protein calories: 1560 – (78x4kcal/gm) = 1248 NPC
  – Carbo (60%): 1248 x 0.60 = 748.8 kcal/(4kcal/g) = 187 gm
  – Fat (40%): 1248 x 0.40 = 499.2 kcal/(9kcal/g) = 55.5 gm
• Vitamins and trace elements?
Build up

• What is the route?
  – Oral? Tube feed? Parenteral nutrition? Combination?

• Duration of build up?

• How to ensure adequate intake?
  – Measure calorie count daily
  – Monitor and ensure normalization of the electrolyte and fluid status
Build up

• What are the indicators of build up success?
  – Normalization of abnormal values?
    • TLC? Albumin? Na? K?
  – “zero” fluid balance?
  – Adequate nutrition intake?
Intra-operative

• Will you monitor the fluid input?
• How much fluid loss do you expect?
  – Will you leave everything to the anesthesiologist?
• What are your choices of fluids?
• Will you place a jejunostomy?
Post-operative

• Will you place an NGT?
• Will you place drains?
• How will you monitor the post-op course?
  – Will you place on NPO? How long?
  – How often will you check the electrolytes? Glucose?
• When will you start enteral feeding? Oral feeding?
  – How? When?
• Will you give parenteral nutrition?
Take home message

• Fluid and nutritional status
• Fluid and electrolyte balance
• Nutrient balance/adequate nutrient intake
THANK YOU