Fluids, electrolytes, nutrition in surgery
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 $\rightarrow$ potassium, magnesium, phosphate, bicarbonate; minor $\rightarrow$ sodium, chloride and calcium</td>
</tr>
<tr>
<td>Protein</td>
<td>20% to 30% of cell mass</td>
</tr>
<tr>
<td></td>
<td>Structural 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>
<tbody>
<tr>
<td>Sodium</td>
<td>142</td>
<td>10</td>
<td>• Fluid balance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Osmotic pressure</td>
</tr>
<tr>
<td>Potassium</td>
<td>5</td>
<td>100</td>
<td>• Neuromuscular excitability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Acid base balance</td>
</tr>
<tr>
<td>Calcium</td>
<td>5</td>
<td>-</td>
<td>• Bones</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Blood clotting</td>
</tr>
<tr>
<td>Magnesium</td>
<td>2</td>
<td>123</td>
<td>• Enzymes</td>
</tr>
<tr>
<td>Total</td>
<td>154</td>
<td>205</td>
<td></td>
</tr>
</tbody>
</table>
## 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

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)
### Homeostasis needs energy

<table>
<thead>
<tr>
<th></th>
<th>ECF (mmol/L)</th>
<th>ICF (mmol/L)</th>
<th>Mechanism</th>
</tr>
</thead>
<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

Kumar, Cotran, Robbins editors. 2003.
The inflammatory process

Cell injury, foreign body (virus, bacteria) → Recognition: macrophage → T-cell defense (Lymphoid system) → eicosanoids → Resolution of the inflammatory process

Cell injury, foreign body (virus, bacteria) → Recognition: neutrophils → Antibody defense (Humoral system) → eicosanoids → Resolution of the inflammatory process

Cell injury, foreign body (virus, bacteria) → Bone marrow → Eicosanoids → Complement (Liver) → Cytokines → Resolution of the inflammatory process

Inadequate/inappropriate response/management lapse → Exacerbation of the inflammatory process
Inflammation

A. FREE RADICAL GENERATION

- Endoplasmic reticulum
  - P-450 and b5 oxidases
- Mitochondrion
  - P-450 and b5 oxidases
  - Respiratory chain oxidation
- Plasma membrane
  - NADPH oxidase
- Cytosol
  - Xanthine oxidase
  - Transition metals (Cu, Fe)
- Peroxisomes
  - Multiple oxidases
- Lysosomes (in phagocytes)
  - Myeloperoxidase
  - NO synthase

O\(_2\), H\(_2\)O\(_2\), OH\(^-\), NO

\(O_2^\bullet^-\), H\(_2\)O\(_2\), OH\(^-\), NO

Membrane lipid peroxidation

DNA fragmentation

Protein cross-linking and fragmentation

B. CELL INJURY BY FREE RADICALS

C. NEUTRALIZATION OF FREE RADICALS—NO CELL INJURY

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

Mitoses
Granulation tissue
Macrophage
Fibroblast
New capillary

3 to 7 days

Fibrous union
Wound contraction

HEALING BY SECOND INTENTION

Inflammation: surgery

ADAPTED FROM:
Surgery induced immunosuppression

Surgery induced immunosuppression

Surgery

↑CD16+ granulocytes express arginase 1

↓Plasma arginine by 50%

Arginine Deficiency (resistant to post-operative supplementation)

↓T-lymphocyte growth and function

Impairment of Acquired Immunity

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

## NUTRITION CARE PLAN

**Date Admitted**

**Room / Bed No.**

**File No.**

**PIN**

<table>
<thead>
<tr>
<th>Patient’s Name (Last, First, Middle Name)</th>
<th>Weight (kg)</th>
<th>Age</th>
<th>Sex</th>
</tr>
</thead>
</table>

**Attending Physician**

<table>
<thead>
<tr>
<th>Actual Body Weight</th>
<th>Ideal Body Weight</th>
<th>Corrected Body Weight</th>
</tr>
</thead>
</table>

## Parameters & Data

**Total Caloric Requirement**

\[ \text{Total Caloric Requirement} = \text{Weight (kg)} \times \text{calories per kg} \times \text{days} \]

**Total Protein Requirement**

\[ \text{Total Protein Requirement} = \text{Weight (kg)} \times \text{protein per kg} \times \text{policy} \]

### Electrolytes

- [ ] Standard dose
- [ ] Specific

### Vitamins

- [ ] Standard dose
- [ ] Specific

### Trace Elements

- [ ] Glutamine
- [ ] Omega-3 Fatty Acid
- [ ] Specific

### Pharmaceutics

- [ ] Standard dose
- [ ] Specific

### Formulation

- [ ] Standard diet
- [ ] Special Diet
- [ ] Oral supplement
- [ ] Enteral
- [ ] Parenteral

### Access / Route

- [ ] Oral
- [ ] NGT
- [ ] Jejunostomy (surgical)
- [ ] PEG
- [ ] PEG-J
- [ ] Peripheral parenteral
- [ ] Central parenteral

## Standard Diet Specifics

### Delivery Method

- [ ] Enteral
- [ ] Bolus
- [ ] Gravity
- [ ] Enteral Pump
- [ ] Parenteral Nutrition

### Monitoring

- [ ] Calorie count
- [ ] Weight
- [ ] Serum Albumin
- [ ] Others

## Accomplished by:

**Signature over Printed Name**

**Date**
How much calories?

Usual: 20-25 kcal/kg/day
Very sick: 15-20 kcal/kg/day

Energy utilization – normal state

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

60 kg x 30 kcal/kg = 1600 kcal/day

Principles of Surgery, Schwartz, 17th ed, 1999
How much protein?

Nitrogen Loss in Urine

Major Surgery

Infection

Severe Sepsis

Elective Surgery

Moderate to Severe Burn

Basal Metabolic Rate

Protein requirement (g/kg/day)

0.8

1.0

1.5

2.0

2.5

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**
  - Oral
  - **< 75% intake**
    - Short term
      - Parenteral nutrition
    - Long term
      - Parenteral nutrition
  - More than 3-4 weeks
    - NGT
      - Nasoduodenal or nasojejunal
  - No
    - Parenteral nutrition

- **No**
  - Parenteral nutrition
  - **Inability to use the GIT**
    - Peripheral PN
    - Central PN

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 oral feeding within 7 days

- yes
- no

EARLY DAY 1 - 14

- yes
- no

within 4 days

- yes
- no

“Fast Track”

Parenteral hypocaloric

Adequate calorie intake within 14 days

Eneteral access (NCJ)

ENTERAL ACCESS

- yes
- no

- enteral nutrition
- immunonutrition for 6-7 days

Oral intake of energy requirements

- yes
- no

combined enteral / parenteral

LATE DAY 14

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

E: Endoscopic
G: Gastrostomy
J: Jejunostomy
L: Laparoscopic
NC: Needle Catheter
S: Sonographic
F: Fluoroscopic

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

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>Oral</th>
<th>Enteral</th>
<th>Tube Flush</th>
<th>Parenteral</th>
<th>IVDex</th>
<th>IVF2</th>
<th>Others</th>
<th>Total Intake</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<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>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Date</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>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4

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></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral</td>
<td>IV Dextrose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral</td>
<td>Parenteral</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral</td>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral</td>
<td>Tube Feed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral</td>
<td>IV Dextrose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral</td>
<td>Parenteral</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral</td>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral</td>
<td>Tube Feed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral</td>
<td>IV Dextrose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral</td>
<td>Parenteral</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral</td>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral</td>
<td>Tube Feed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral</td>
<td>IV Dextrose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral</td>
<td>Parenteral</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral</td>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</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>
</tr>
</thead>
<tbody>
<tr>
<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>
</tr>
<tr>
<td></td>
<td>Tube Feed</td>
<td>250</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1240</td>
</tr>
<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></td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>1150 k</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2340 ml</td>
</tr>
<tr>
<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>
<td>240</td>
</tr>
<tr>
<td></td>
<td>Tube Feed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1200</td>
</tr>
<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>1150</td>
<td></td>
<td></td>
<td>62</td>
<td></td>
<td></td>
<td>1440 ml</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>1350 k</td>
<td></td>
<td></td>
<td>70 g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/6/07</td>
<td>Oral</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tube Feed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<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></td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<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>60 kg wt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insensible perspiration</td>
<td>Ventilation with 100% water = almost zero loss</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  
                                  | • Volumes up to 15 mL/kg/hour are recommended in the first hour of abdominal surgery, with decreasing volumes in subsequent hours. | • Measure  
                                  | • 300 ml |
| Total                          | • Within one hour (crystalloids not recommended) | 350 first hour |

Adapted from: Brandstrup B. Fluid therapy for the surgical patient.  
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><strong>Na</strong></td>
<td>135-145</td>
<td>154</td>
<td>131</td>
<td>140</td>
</tr>
<tr>
<td><strong>K</strong></td>
<td>3.5-5.3</td>
<td>-</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td><strong>Ca</strong></td>
<td>2.2-2.6</td>
<td>-</td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td><strong>Mg</strong></td>
<td>0.7-1.2</td>
<td>-</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Cl</strong></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</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>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</td>
<td>Total body fluid volume</td>
<td>According to need for correction</td>
<td>KCL Glucose 5% Mannitol</td>
</tr>
<tr>
<td>(solutions for correction)</td>
<td></td>
<td></td>
<td></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
  
  \[\uparrow\text{K}^+\text{ release from cells}\]
  
  \[\downarrow\text{K}^+ \text{ and } \uparrow\text{Na} \text{ intracellular}\]
  
  Sick cell syndrome of critical illness

\[\uparrow\text{vasodilation effect of anesthetic agents}\]

\[\uparrow\text{albumin escape from intravascular space}\]

\[\text{ Fluid Retention + Electrolyte Imbalance}\]

\[\uparrow\text{hypotonic fluid infusion}\]

\[90\%\text{ cause of hyponatremia in surgery}\]
Ileus and dehiscence

Salt and water overload

↑ intra-abdominal pressure
↓ mesentery blood flow
/stat3 activation
↓ myosin phosphorylation
↓ muscle contractility

Intestinal edema

↓ tissue OH-proline

Intramucosal acidosis

Impaired wound healing

ILEUS

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>HCO3 (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

Inflammation & organ failure in the ICU

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

Tissue inflammation, Early organ failure and death

Goal of nutrition/ pharmaconutrition

Inflammatory balance

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


Insult (trauma, sepsis)

Immunosuppression

2nd Infections

Delayed MOF and death

days

weeks
Sarcopenia in elderly

Sarcopenia: Vandewoude M. Abbott Symposium, ESPEN 2011, Goteborg, 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

Sarcopenia: Vandewoude M. Abbott Symposium, ESPEN 2011, Goteborg, Sweden
Cancer Cachexia

TUMOR

↓ intake/obstruction
PIF → proteolysis
LMF → lipolysis

WBC → Cytokines →

Cell ischemia
Cell destruction

BODY

↓ Appetite
↑ Satiety

↑ 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

CASE DISCUSSION
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?
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
  - \([2\times135] + [\frac{160}{18}] + [6] = 284.8 \text{ mOsm/kg H}_2\text{O}\)
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