Learning Objectives

- Identify factors that place patients at high risk for impaired wound healing
- Review the phases of wound healing
- Discuss the nutritional components involved in the wound healing process
- Demonstrate competency in understanding and interpreting commonly used laboratory data
- Summarize various nutrition support protocols used in treating wounds
Significance

- At least 2.8 million wound patients in the U.S suffer from the following:
  - Pressure Ulcers
  - Diabetic Foot Ulcers
  - Fistulas
  - Surgical Wounds
- Excess of $25 Billion per year in health care costs
- Poor nutritional status and malnutrition impact wounds

Wound Repair Regen. 2010

Negative Impact of Malnutrition on Wound Healing

- Compliment and antibody levels
- T-cell function and phagocytic activity
- Collagen accumulation and fibroblast proliferation
- Epithelialization and angiogenesis
- Wound tensile strength
- Healing & treatment effectiveness

- Risk of developing more pressure ulcers
- Wound severity as prolongs the inflammatory phase
- Risk of local and/or systemic infection
- Hospital LOS
- Mortality

Identify Patients at Risk

Major Risk Factors
- Bed or chair-bound
- Reduced feeding ability
- Poor nutritional status
- Dehydration
- Circulatory issues
- Urinary or stool incontinence
- History of pressure ulcers or poor skin condition

Intrinsic Risk Factors
- Loss of lean body mass
- Infection
- Aging/concurrent illness
- Medications
- Immunosuppression
- Stress
- Hyperglycemia
- Vascular disease/Atherosclerosis
Stress Response

- Increase in catecholamines (eg. cortisol and glucagon)
- Hypermetabolic-catabolic state
- Increase in energy demands
- Depletion of lean body mass (protein stores)
  - (30% loss of LBM = 50% Mortality)
  - (LBM losses > than 15% = impaired wound healing)

Inflammatory Conditions are a PU trigger as they Increase Wound Risk and Decrease Wound Healing

Examples:
- Obesity
- Advanced Age
- Hypoxia/Vascular Disease
- Malnutrition
- Infection/Sepsis/Wound debridement
- Chronic Diseases like Diabetes/CRF
- Various drugs/chemo Rx

Conditions or Diseases Associated with Inflammation

Inflammation is not the same as infection

• Infection is caused by a bacterium, virus or fungus
• Inflammation is the body's response to infection, injury, acute and chronic illness, etc.

Severe acute inflammatory response

• Critical illness, major infection/sepsis, ARDS, SIRS, severe burns, major abdominal surgery, multi-trauma, and closed head injury

Mild/moderate chronic inflammatory response

• Many other conditions or diseases – CVSD, CHF, Cystic Fibrosis, COPD, Crohn's disease, celiac disease, chronic pancreatitis, rheumatoid arthritis, diabetes, sarcopenic obesity, metabolic syndrome, malignancies, infections, CVA, dementia, neuromuscular disease, pressure wounds, periodontal disease, organ failure/transplant

Wound Healing

• Inflammatory Phase
• Proliferative Phase
• Remodeling Phase

Jensen GL, et al. JPEN. 2010;34;156-159
Phase 1

Inflammatory Phase
- Platelets form clot to halt bleeding
- Macrophages start healing process
- Collagenases begin to clean the wound

Wounds get stuck in inflammatory phase and healing is halted

Phase 2

Proliferative Phase (Fibroplasia)
- Granulation tissue forms in the wound
- Epithelialization - migration of epidermal cells to help form new tissue
- Development of fibroplasia (granulation tissue)
Phase 3

Remodeling Phase (Maturation)

- Epithelium thickens
- Mature Scar production
- Collagen fibers form bonds
- Tensile strength of scar tissue improves
- Complete healing can take up to 1-2 years

Screening/Clinical Assessment Tools

- MNA*1 (Mini Nutritional Assessment)- validated nutrition screening and assessment tool to identify geriatric patients age 65 and above who are malnourished
- MUST*2 - Malnutrition Universal Screening Tool: 5 step screening tool to identify adults at risk for malnutrition
- Risk Assessment Tool*3: helps identify those at high risk for PU’s, urinary tract infections, constipation and those needing help in maintaining intestinal microbiota balance
- Eat 10 Swallowing Screen*1: helps to determine measure swallowing difficulties
- Malabsorption Index *1: helps to identify problems with malabsorption and provide guidance in the selection of enteral products
- Dehydration Risk Appraisal Checklist *4: tool to help measure the risk for hydration problems

1Property of Nestle Health Science
2 BAPEN 2003 first published May 2003 by MAG (Malnutrition Advisory Group)
3 Property of Nutricia Advanced Medical Nutrition
4 Mentes, JC., Iowa Veterans Affairs Nursing Research Consortium 2004
### Contributors to Adult Undernutrition

<table>
<thead>
<tr>
<th>Category</th>
<th>Causes</th>
</tr>
</thead>
</table>
| Deficient Intake              | • Unable/unwilling to eat  
• Lack of access to food                                                  |
| Increased Requirements        | • Disease states  
• Pregnancy                                                             |
| Complications of Disease      | • ↓ Appetite  
• Malabsorption/excessive nutrient losses  
• Inflammation  
  • Positive and negative acute phase reactants  
  • Altered hormone secretion and target organ function                  |
| Aging                         | • ↓ sex hormones  
• Apoptosis                                                              |
| Inactivity/Loss of Function   |                                                                        |
| Any combination of the Above  |                                                                        |

*Int J Environ Res Public Health 2011;8:514-527*

### A.S.P.E.N. & ADA's Characteristics to Diagnose/Document Malnutrition*

<table>
<thead>
<tr>
<th>Category</th>
<th>Characteristics</th>
</tr>
</thead>
</table>
| Inadequate Intake             | • <50-75% estimated needs  
  • Hx/observed                                                          |
| Unintended Weight Loss        | • Any BMI  
  • Blackburn Criteria                                                   |
| Physical Exam                 | • Muscle Loss  
• Subcutaneous Fat Loss  
• Fluid Accumulation  
  • Localized  
  • Generalized                                                          |
| Functional Status             | • Hand Grip Strength                                                 |

*Any 2 Characteristics Recommended for Diagnosis*

*SOURCE: ADA Nutrition Care Manual 2013*
The Big Three

<table>
<thead>
<tr>
<th>Calories</th>
<th>Protein</th>
<th>Fluid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories are the fuel</td>
<td>Proteins are the building blocks</td>
<td>Fluid is the medium</td>
</tr>
</tbody>
</table>

Calories

Calories-energy is needed for anabolism
- nitrogen synthesis
- collagen formation
- wound healing

National Pressure Ulcer Advisory Panel 2014 indicates:
- 30-35 calories/kg/day
- 35-40 calories/kg/day if underweight or losing weight
Calories

• Dambach, 2005 showed that elderly patients with pressure ulcers (PU) did NOT have increased energy needs.
• 25-30 kcal/kg which was the same for the control group.
• PU group averaged 300-500 calorie deficit daily.

Calories

• For obese, geriatric or limited mobility pts their needs should be evaluated on an individualized basis
• Indirect calorimetry is the gold standard
  – utilized in difficult pts with multiple wounds, morbid obesity or pts with complicated medical conditions where healing is not progressing as expected
Protein

Function: tissue repair and maintenance
• Needed for all stages of wound healing
• Necessary for the synthesis of enzymes involved in proliferation of cells and collagen and formation of connective tissue
• Depletion impairs wound healing as inhibits fibroblast proliferation and collagen synthesis

Protein Needs

• 1.2-1.5 g/kg/day for chronic wounds
• 1.5-2 g/kg/day for catabolic individuals, multiple wounds or stage III or IV PU

National Pressure Ulcer Advisory Panel 2014
Protein

- Greater than 2g/kg/day can contribute to dehydration
- Negative pressure wound therapy increases protein losses (estimated 12.5 grams of protein per liter of fluid loss)
- Elderly need more protein because of the loss of muscle mass associated with aging

Fluid Needs

- 30-35 mL/kg per day
- 1 mL/Cal for enteral tube feeding (free water)
- 1500-2000 mL/day or 6-8 glasses
- Additional 10-15 mL/kg per day when air beds used
Dehydration

- Promotes dessication of the wound bed
- Decrease angiogenesis and oxygen to the wound
- Increases susceptibility to infection

Edema

- Barrier to healing
- High level of inflammatory cytokines
- Lower level of growth cytokines
- Inhibits fibroblast proliferation
- Moisture balance is essential

Vitamins and Minerals

• Supplementation is supported if a deficiency is confirmed or suspected

• Difficult to assess if a pt is deficient because laboratory tests are often inaccurate during infection/inflammation

• **Generally give a standard multivitamin with minerals. Maybe extra Vitamin C, Zinc and Vitamin A based on clinical judgment**

• MVI usually sufficient
Vitamin C

- Deficiency is more likely if pt is a smoker, ETOH history or malnourished
- Serum Vitamin C is unstable and not a good predictor of body levels; Leukocyte ascorbic acid level is a better predictor
- Contraindicated if have kidney stones
- Patients with renal failure: maximum is 100 mg/day (found in most renal multivitamins)

Vitamin C in healing

- Cofactor in collagen synthesis
- Helps prevent wound infections, needs are also increased if pt has infection
- Will not accelerate healing in non-deficient pts.
- **Supplementation: 500-1000 mg x 10 days**
- Spread dosing out, give with iron if pt anemic
- Low risk of toxicity
Zinc

• Deficiency common in malnourished pts., diarrhea, malabsorption, stressed pts.
• Serum zinc levels are falsely low due to infection/inflammation, pregnancy and use of oral contraceptives
• Vegetarian diet reduces zinc absorption by 50%
• May cause nausea, vomiting, diarrhea

Zinc in healing

• Cofactor for the synthesis of protein
• Supplementation in deficient pts helps wound healing
• Supplementation: 40-50 mg/day for 10 days
• Excessive intake can cause copper deficiency (helps form red blood cells, cofactor in collagen synthesis)
Vitamin A

- Role in cellular proliferation, collagen synthesis, epithelial development
- Deficiency can result in delayed wound healing

Vitamin A in healing

- Stimulates immune system-inflammatory phase increases the # of macrophages and monocytes
- Increases collagen formation
- Important in pts on steroids-has been shown to reverse their anti-inflammatory effects
- **Supplementation:** 10,000-25,000 IU orally for 10 days for pts on steroids
B Complex

- Required for rebuilding of tissue/RBC formation
- Involved in energy production (converts glucose, amino acids, fat)
- Protein and amino acid metabolism
- Maintains immune function
- Formation of new cells/cell division
- Deficiency of pyridoxine, pantothenic acid and folic acid results in suppressed antibody formation and leukocyte function
- Thiamine deficiency (B₁) may affect collage synthesis

Dorner 2006; Newfoundland 2011

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Arginine

Semi-essential amino acid
Show promise in increasing collagen, improving nitrogen balance, enhancing immune function
Nitric oxide is a product of arginine metabolism
>>>powerful vasodilator that promotes angiogenesis (blood flow)
Arginine

- Nitric oxide in septic patients can lead to hypotension
- Society of Critical Care Medicine and A.S.P.E.N. suggest arginine is acceptable in mild to moderate sepsis
- Canadian Clinical Practice Guideline Committee do not recommend any in critically ill patient
- NPUAP 2014 – 6-9 g/day of Arginine (adjust as needed based on hydration and renal function)

Arginine studies

- R.D van Anholt, 2010 looked at well nourished pts w/PU in a prospective, randomized, controlled study-43 pts, 8 weeks
  1. High caloric supplement with 3 g arginine, antioxidants and other micronutrients
  2. Non-caloric placebo
     Size of pressure ulcer significantly smaller
     PUSH scores significantly better (P=.011)
Arginine in prevention

- 420 hip fracture pts-quasi-experiment
- Supplement enriched with arginine, zinc and vit C 2 x day (100 kcal)
- Reduced PU by 50%(P=.009)

Hommel A, 2007

Glutamine

- Conditionally essential during catabolic illness
- Fuel source for enterocytes, lymphocytes and macrophages
- Supports gut integrity, collagen synthesis
- Improves nitrogen balance and enhances immune function
Glutamine Studies

- Prospective randomized, controlled trials of enteral glutamine supplements have shown significant improvements in infectious complications and LOS in burn patients
  - Use is supported in burn pt. by evidence based practice guidelines of the American and European Societies for Parenteral and Enteral Nutrition
  - 0.3-0.5 g/kg/day in divided doses 2-3 times daily

Anemia

- Without oxygen fibroblast can’t replicate and decrease in collagen production
- Identify the type – acute or chronic
- Replete deficiencies – 150-200 mg of iron daily for 3-4 months
- Administer oral or intravenous – oral should be given with Vit C to optimize absorption
Evaluate appropriate lab data

- Malnutrition/Inflammatory status: Pre-albumin, Albumin, CRP
- Absence or prevalence of Diabetes: BS, HgB A1C
- Hydration status- serum sodium, BUN/Cr
- Infection or UTI: CBC, Urinalysis (specific gravity)
- Anemia: H/H

Common Problems with Eating
Causes of common eating problems

• Poor appetite
  – Chronic or non-healing wounds stuck in the inflammatory cause high levels of cytokine
  – Cytokines can cause anorexia
• Depression often causes poor appetite resulting in weight loss

Start with Dietary Guidelines
Build a healthy diet with these recommendations

2015 – 2020 Dietary Guidelines for Americans
Key Recommendations:
Consume a healthy eating pattern that accounts for all food and beverages within an appropriate calorie level.

- A variety of vegetables from all of the subgroups – dark green, red and orange, legumes (beans and peas), starchy, and other
- Fruits, especially whole fruits
- A variety of protein foods, including seafood, lean meats and poultry, eggs, legumes (beans and peas), and nuts, seeds, and soy products
- Grains, at least half of which are whole grain
- Fat-free or low-fat dairy, including milk, yogurt, cheese, and/or fortified soy beverages
- Healthy fats and oils – olive oil, nuts, avocados, fatty fish
Choosing a Balanced Diet
Focus on variety, amount and nutrition

Each day, consume a minimum of:
- Fruit: 1.5 to 2 cups
- Grains: 5 to 6 servings
- Dairy: 2 to 3 servings
- Protein: 5 to 6 oz.
- Vegetables: 2 to 2.5 cups

Use the My Plate tool as a reference to help assess an individual's intake.

It is important to encourage consumption of a balanced diet which includes good sources of calories, protein, fluids, vitamins, and minerals.

Effectiveness of Supplements

- Meta-analysis of 4 randomized, controlled trials showed that high-protein oral nutrition supplementation providing 250-500 calories was associated with a 25% reduction in pressure ulcer development

Stratton RJ, 2005
Medication Pass

- Give daily medications with supplement rather than water
  - Sample regimen:
    - 30 ml (med cup) 6 x day of a concentrated supplement is about 270 calories and 10 g protein

Nutrition Support

- If the gut works use it
- Try food and/or oral supplements – if fail
- Tube feedings:
  - Placed at bedside by specialized team
  - Small bore, soft tube
  - Can continue to eat without the pressure of forcing themselves to eat
Criteria to Help Assess the Need for Tube Feeding

- Inadequate oral intake despite oral nutritional supplements
- Continued weight loss and poor wound healing
- Dysphagia issues and aspiration risk
- Extensive assistance required for eating
- Nutrition screening tool indicates malnutrition or at risk for malnutrition
- Clinical and physical assessment
- Weight loss ≥5% x 1 month or ≥10% in 3 months
- Inadequate fluid intake and/or dehydration (≤1500 mL/day)

Adapted from presentation by Evelyn Phillips, MS, RD, LDN, CDE on 2/18/16 and Nutrition Management Protocol for Pressure Ulcers: www.nutritioncaremanual.org

Appetite Stimulants

- Currently there are no appetite stimulants approved by the FDA for specific purpose of wound healing
- Some medications have side effects that can stimulate appetite (Megestrol, Dronabinol, Mirtazapine)
Requirements for Wound Healing

Estimate Nutrient Needs:
• Calories: 30-35 kcalories/kg/body weight (adjust per clinical condition)
• Protein: 1.25-1.5 grams/kg/body weight (adjust per clinical condition)
• Fluid: 1 mL per day per calorie consumed
  – Unless adjustments required due to various conditions like: CHF, COPD or CKD
  – Monitor hydration status and fluid losses (wound drainage, fever, vomiting, diarrhea, sweating, air-fluidized beds)
• Offer preferred food/beverage at appropriate texture and temperature
• Liberalize restrictive diets
• Offer vitamin/mineral supplement with 100% of RDIs if intake is poor or deficiencies are suspected or confirmed
• Weigh weekly or per facility policy


Micronutrients

<table>
<thead>
<tr>
<th>Micronutrients</th>
<th>Role in Skin Integrity</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin C</td>
<td>• Connective tissue and collagen synthesis&lt;br&gt;• Supports formation of new blood vessels and wound strength&lt;br&gt;• Enhances activation of leukocytes and macrophages to the wound site</td>
<td>RDA&lt;br&gt;• 90 mg/day for males&lt;br&gt;• 75 mg/day for females&lt;br&gt;UL&lt;br&gt;• 2000 mg/day</td>
</tr>
<tr>
<td>Zinc</td>
<td>• Essential trace mineral for DNA synthesis, cell division, collagen formation, protein synthesis, and immunity&lt;br&gt;• Required for all necessary processes for tissue regeneration and repair</td>
<td>RDA&lt;br&gt;• 11 mg/day for males&lt;br&gt;• 8 mg/day for females&lt;br&gt;UL&lt;br&gt;• 40 mg/day</td>
</tr>
<tr>
<td>L-Arginine</td>
<td>• A biological precursor to nitric oxide, which increases blood flow, which can support collagen in wounds</td>
<td>Supplemental arginine has shown benefits in wound healing&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Citrulline</td>
<td>• Metabolizes into arginine which can help increase nitric oxide production&lt;sup&gt;3&lt;/sup&gt;</td>
<td>• Consumption can raise plasma arginine levels more efficiently than supplemental arginine&lt;br&gt;• Bypasses intestinal and liver breakdown&lt;sup&gt;1,3&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

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### Recommendations for Key Nutrients

<table>
<thead>
<tr>
<th>Stages</th>
<th>MVI</th>
<th>Vitamin C</th>
<th>Zn</th>
<th>Vitamin A</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Daily as needed</td>
<td>100-200 mg/day</td>
<td>15 mg/day; if deficient: 50 mg 2x/day for 10-14 days</td>
<td>5,000 IU/day; if deficient: 10,000-50,000 IU/day for 10 days</td>
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### Monitoring Outcomes
Monitor Outcomes

• Decreased wound surface area
• Improved weight
• Improved appetite
• Glycemic control
• Monitor lab data

Nutritional Monitoring

• Skin condition and/or wound status
• Acceptance and tolerance of oral intake and/or supplement
• Calorie, protein & fluid adequacy compared to estimated requirements
• Weight status
• Ability to meet nutrient and fluid needs orally
• Consider enteral feeding consistent with individual’s wishes, if intake is inadequate
• Laboratory values
Nutrition Support Wisdom

- Prevention is the key
- Wound healing takes time
- Chronic wounds don’t happen overnight
- Provide consistent and adequate nutrition support
- Nutrition is only one aspect of treatment
- There is no magic pill or supplement to heal wounds
- Develop Quality Indicators for pressure ulcer prevention and treatment

Summary

Employ Standards of Care
Use assessment driven interventions
Demonstrate competency
Treat underlying etiology
Prevention is key – reduce mechanical forces, ensure adequate nutrition and hydration
Keep educated on products and treatments
Recognized Standards of Care

NPUAP (National Pressure Ulcer Advisory Panel)
www.npuap.org

AAWC (Association for the Advancement of Wound Care)
www.aawcone.org

AHRQ (Agency for Health Care Policy and Research)
www.ahrq.gov/guiidelines

WOCN (Wound, Ostomy, Continence Nurses Society)
www.wocn.org

References


