### Inclusion Criteria
- Surgical incisions or open full thickness wounds with delayed healing (dehisced, deteriorating, stalled healing, infected)
- Severe skin breakdown (e.g., Stevens-Johnson Syndrome, GVHD, epidermolysis bulosa, necrotizing fasciitis, ulcerative diaper dermatitis, radiation burns, staph scalded skin)
- Wound Vac
- Pressure ulcers (stage III and IV)

### Exclusion Criteria
- At risk for pressure ulcer (if low Braden per hospital nutrition risk screening)
- Normal healing surgical incisions (please refer to service specific coverage plans)
- Pressure ulcers stage I and II

### Nutrition Status
- Assess for presence of malnutrition
- Estimate nutritional needs

### Physical
- Obtain description of wound type, size, and location (review documentation and/or discuss with care providers)

### Diet History
- Assess adequacy of intake
- Assess ability to eat
- Assess for gastrointestinal symptoms (diarrhea, emesis, nausea)

### Ensure Adequate Intake of All Nutrients
- Initiate protein intake minimum of 1.5-2 X RDA (or per disease specific condition)
- Start Multivitamin-Mineral Supplement (MVMS) if not on TPN or receiving adequate intake from enteral nutrition (EN)
- Order Calorie Counts and offer oral supplements if patient is taking PO
- Liberalize diet restrictions as appropriate
- Involve diet technician for education and plan to improve intake
- If unable to meet >75% estimated needs with oral intake, initiate EN or TPN per SCH guidelines
- If feasible, order Indirect Calorimetry / Metabolic Cart study for patients in the ICU or with a diagnosis of malnutrition

### Dietitian to Re-assess Wound Status in 5-7 Days
- Determine wound healing progress per discussion with practitioners involved in patient’s wound care or per review of written documentation
- Assess adequacy of nutrient intake (i.e., I/O, calorie counts)
- Monitor adequacy and tolerance of protein per BUN, creatinine levels and ratio
- Assess anthropometrics (i.e., weight trends, BMI, weight/length)

### Discharge Instructions:
- If patient discharges with wound vac or before wound is healed, provide education to the family on adequate nutrition for wound healing
- Help coordinate ambulatory nutrition follow-up plan with medical team
- Nutrition for Wound Healing (PE2115)

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For questions concerning this pathway contact nutritioninwoundmanagement@seattlechildrens.org
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Last Updated: April 2015
Next Expected Review: April 2020
Nutritional Intervention

- Increase protein starting at a minimum of 20-25% > current dose unless already maximized. Consider Nitrogen Balance study to assess protein adequacy. See Special Considerations.
- Check serum vitamin C and zinc levels and start empiric supplementation as outlined below while awaiting levels. Continue supplementation ONLY if a deficiency is confirmed.
- Order or repeat Indirect Calorimetry / Metabolic Cart study
- Discuss with team other factors causing delayed wound healing (i.e., poor dressings, inadequate turning)

Supplement Vitamin C & Zinc
(See Special Considerations)

- Supplementation is in ADDITION to what patient is already receiving from diet, EN, PN, and MVMS.
- Follow SCH formulary for vitamin C and zinc clinical indications and dosing.

*Note* Above recommendations exclude current supplementation for disease specific conditions (i.e., BMT, GI losses, iron therapy)

Continue Current Intervention

- Dietitian to continue to reassess wound healing status every 5-7 days.
- For vitamin C and zinc deficiencies, recheck levels every 2 weeks until replete. Discontinue supplementation once levels are replete.
- Discontinue above nutrition intervention once wound is healed

Discharge Instructions:

- If patient discharges with wound vac or before wound is healed, provide education to the family on adequate nutrition for wound healing
- Assess need for vitamin/mineral supplementation after discharge and develop plan
- Help coordinate ambulatory nutrition follow-up plan with medical team
- Nutrition for Wound Healing (PE2115)
Malnutrition Diagnosis Criteria

<table>
<thead>
<tr>
<th>Primary Indicators*</th>
<th>Mild Malnutrition</th>
<th>Moderate Malnutrition</th>
<th>Severe Malnutrition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight for height z score</td>
<td>-1 to -1.9 z score</td>
<td>-2 to -2.9 z score</td>
<td>-3 or greater z score</td>
</tr>
<tr>
<td>BMI a for age z score</td>
<td>-1 to -1.9 z score</td>
<td>-2 to -2.9 z score</td>
<td>-3 or greater z score</td>
</tr>
<tr>
<td>Length/height z score</td>
<td>No data</td>
<td>No data</td>
<td>-3 or greater z score</td>
</tr>
<tr>
<td>Mid-upper arm circumference (MUAC)</td>
<td>-1 to -1.9 z score</td>
<td>-2 to -2.9 z score</td>
<td>-3 or greater z score</td>
</tr>
<tr>
<td>Weight gain velocity (&lt;2 years of age)</td>
<td>&lt;75% of the norm b for expected weight gain</td>
<td>&lt;50% of the norm b for expected weight gain</td>
<td>&lt;25% of the norm b for expected weight gain</td>
</tr>
<tr>
<td>Weight loss (2 to 20 years of age)</td>
<td>≥5% usual body weight</td>
<td>≥7.5% usual body weight</td>
<td>≥10% usual body weight</td>
</tr>
<tr>
<td>Deceleration in weight for length/height z score</td>
<td>Decline of 1 z score</td>
<td>Decline of 2 z score</td>
<td>Decline of 3 z score</td>
</tr>
<tr>
<td>Inadequate nutrient intake</td>
<td>51 to 75% estimated energy/protein need</td>
<td>26 to 50% estimated energy/protein need</td>
<td>≤ 25% estimated energy/protein need</td>
</tr>
</tbody>
</table>

*Only one primary indicator is needed to diagnose malnutrition. However, the more indicators used, the stronger the diagnosis.

aBody Mass Index
bWorld Health Organization data for patients younger than 2 y old

**Indirect Calorimetry**

**Indirect calorimetry** (IC) uses measurements of the oxygen (O2) a patient consumes and the carbon dioxide (CO2) produced to calculate energy expenditure (EE) and the respiratory quotient (RQ). A **Metabolic Cart** is a machine or device that uses IC to measure EE. A **metabolic cart study** is ordered when you want to use IC to measure a patient’s energy expenditure to determine energy needs. Metabolic Cart studies usually take 15-30 minutes to complete.

**Respiratory Quotient** is the volume of CO2 produced divided by the volume of O2 consumed. In the hospital setting, it is used primarily to judge the validity of the EE result. If the RQ is between 0.7 to 1.0 - 1.1, the EE result should be considered valid. If the RQ is outside this range, the literature says the EE result should be questioned. However, sometimes perfectly believable EE results are reported with RQ’s outside the recommended range. In this case, consider using it, and recheck in 1-2 weeks. The literature also states that an RQ >1 may indicate overfeeding.

<table>
<thead>
<tr>
<th>Definitions</th>
<th><strong>Indirect calorimetry</strong> (IC) uses measurements of the oxygen (O2) a patient consumes and the carbon dioxide (CO2) produced to calculate energy expenditure (EE) and the respiratory quotient (RQ). A <strong>Metabolic Cart</strong> is a machine or device that uses IC to measure EE. A <strong>metabolic cart study</strong> is ordered when you want to use IC to measure a patient’s energy expenditure to determine energy needs. Metabolic Cart studies usually take 15-30 minutes to complete. <strong>Respiratory Quotient</strong> is the volume of CO2 produced divided by the volume of O2 consumed. In the hospital setting, it is used primarily to judge the validity of the EE result. If the RQ is between 0.7 to 1.0 - 1.1, the EE result should be considered valid. If the RQ is outside this range, the literature says the EE result should be questioned. However, sometimes perfectly believable EE results are reported with RQ’s outside the recommended range. In this case, consider using it, and recheck in 1-2 weeks. The literature also states that an RQ &gt;1 may indicate overfeeding.</th>
</tr>
</thead>
</table>
| Which patients should be considered for IC? | • Underweight (BMI < 5th) or Overweight/Obese (BMI >95th)  
• Children with >10% weight loss or gain during hospital stay  
• Failure to wean from or need to escalate respiratory support  
• Need for muscle relaxants (e.g., vecuronium) for > 7 days  
• Neurologic trauma/hypoxia with evidence of dysautonomia  
• Oncologic diagnoses (including BMT)  
• Children with thermal injuries  
• Children requiring mechanical ventilation > 7 days  
• Children suspected to be severely hypermetabolic (status epilepticus, hyperthermia, SIRS, dysautonomic storming) or hypometabolic (hypothermia, pentobarbital coma)  
• Any patient with ICU length of stay > 4 week  
• Patients on Nutrition Management of Wounds Pathway |
| Prerequisites for IC | • Inpatient (can be on room air or on mechanical ventilation). Patients on room air must be big enough to fit the face mask and be willing to keep the mask on for the duration of the test.  
• Weight > or = 7 kg  
• FiO2 should be <50%  
• Hemodynamic and temperature stability |
| Conditions That Disqualify Patients For IC (see also prerequisites) | • Need for supplemental oxygen via HFNC, BiPAP and CPAP  
• ECMO (extra corporeal mechanical oxygenation)  
• Need for Nitric oxide or anesthetic gas therapy  
• Agitation, pain, fevers, seizures during the test  
• Large air leak in the circuit (e.g., leaking chest tubes) |
### Indirect Calorimetry

#### How do you order a Metabolic Cart Study?
- Direct the ordering physician to enter “Metabolic Cart Study” in the Orders tab. Once ordered, it will appear under the “Diagnostic Tests” order tab.
- E-mail the “Pulmonary Lab” and cc both Kevin Jacques and Rob DiBlasi. Tell them who you want tested and why. They can e-mail you the results; or they can let you know why they were unable to do the study.
- Metabolic Cart Studies can be done Mon-Fri 8am to 4pm. Kevin Jacques, the principle Respiratory Therapist trained to use the Metabolic Cart, only works 4 days/week and his day off changes from week to week.

#### What to do with the results once you get them.
- Look for the “REE (Kcal/day)” result on the mid-upper left side of the results print-out. Next to it (to the right) is the software’s “Predicted” REE based on the patient’s height, weight, gender and age.
- Look at the RQ just below the REE. If RQ > 1-1.1, the results may not be valid (use your judgement—do the results make sense?).
- Consider padding the REE result by 5-15% to account for energy expenditure due to regular nursing care and some minor movement when patient is awake. If the patient is agitated or moves quite a bit, you may need to pad results more.
- If the result is significantly higher than is reasonable to expect, talk with the Respiratory Therapist who did the study and see if it can be repeated.
- Day to day variation in EE results is to be expected (by as much as 30%).

#### Other miscellaneous information
- A Metabolic Cart Study costs $986.40. Insurance coverage is not known at this time.
- Metabolic Cart studies can be done when patients are on continuous drip feeds or when they are fasting (5 hr fast is ideal). Since patients should be completely at rest during the study, IC should not be done during or just following a meal.
- There is some evidence that IC can be done with patients on Continuous Renal Replacement Therapy (CRRT) or intermittent dialysis, though traditionally, IC has been discouraged during dialysis therapy due to the effect dialysis has on acid/base balance.
- Metabolic Cart studies may be available to outpatients in the Pulmonary Function Lab in the future. The logistics for this (scheduling, billing insurance, reporting results) need to be worked out.

#### References
### Vitamin C, Zinc and Protein Requirements

| Age                  | Vitamin C | | Zinc | | Protein |
|----------------------|-----------|---|------|---|----------|---|
| RDA (mg)             | Upper Limit (mg) | RDA | Upper Limit (mg) | Age | RDA g/day | Upper Limit |
| Infants 0-6 mo       | 40        | ND | 2    | 4 | Infants 0-6 mo | 1.52g/kg |
| Infants 7-12 mo      | 50        | ND | 3    | 5 | Infants 7-12 mo | 1.2g/kg  |
| Children 1-3 y       | 15        | 400 | 3    | 7 | Children 1-3 y | 1.05g/kg |
| Children 4-8 y       | 25        | 650 | 5    | 12 | Children 4-13 y | 0.95g/kg |
| Males 9-13 y         | 45        | 1200 | 8    | 23 | Adol 14-18 y | 0.85g/kg |
| Males 14-18 y        | 75        | 1800 | 11   | 34 | Adults >18 y | 0.8g/kg  |
| Males 19-30 y        | 90        | 2000 | 11   | 40 |           |          |
| Females 9-13 y       | 45        | 1200 | 8    | 23 |           |          |
| Females 14-18 y      | 65        | 1800 | 9    | 34 |           |          |
| Females 19-30 y      | 75        | 2000 | 8    | 40 |           |          |
### Special Considerations

| **Protein** | 1) Patients with Chronic Kidney Disease* or Acute Kidney Injury**:  
| | a. Consider a more modest increase in protein ~10-15% if BUN or Creatinine levels are significantly elevated  
| | 2) Patients with Chronic Liver Failure:  
| | a. Monitor Ammonia levels  
| | 3) Patients with metabolic disorders, organic acidemia and inborn errors of amino acid metabolism:  
| | a. Discuss protein adjustments for wound healing with metabolic team  
| **Vitamins** | 1) Patients who are prone to forming kidney stones or with renal insufficiency:  
| | a. Avoid intake of vitamin C from diet and/or supplementation greater than 2x RDA  
| | b. Substitute renal vitamin (Nephronex/Nephro-Vite) for standard Multi-vitamin Mineral Supplement to prevent vitamin A toxicity. Consider adding the RDA for zinc as renal vitamins do not contain zinc  
| | 2) Additional vitamin C may not be appropriate if Ferritin levels are elevated  
| **Zinc** | 1) Monitor copper and iron levels in patients who have been on prolonged therapeutic zinc doses as there is a risk of deficiency due to reduced absorption of copper and iron  
| | 2) Note- Zinc supplementation can sometimes cause diarrhea or loose stools  

*Chronic Kidney Disease (K/DOQI):*  
- Defined as either kidney damage or GFR <60 for >3 months  
- Disease stage 1-5 is assigned by level of kidney function using the GFR  

**Acute Kidney Injury:**  
- Not as easily defined  
- Determined by decreases in either GFR or urine output, and/or increase in serum Creatinine
**Recommendation:** Consider giving a specialized protein supplement, **Proteinex**, if the wound is not healing after all other nutrition interventions have been tried. Proteinex contains arginine, a non-essential amino acid that becomes conditionally essential in critical illness and stress.

### PROTEINEX INFORMATION

**PRODUCT SPECIFICATIONS:**

- **Nutrients per 30 mls:**
  - Arginine 5 g
  - Protein 15 g
  - CHO 10 g
  - Calories 100
  - Zinc sulfate 10 mg
  - Vitamin C 175 mg
  - Copper 200 mcg
  - Sodium 40 mg
  - Potassium 40 mg

  **Also contains:** Purified water, hydrolyzed collagen, Fructose, L-Arginine, Propylene Glycol, natural and artificial flavor, ascorbic acid, L-Tryptophan, potassium sorbate, Sodium Benzoate, zinc sulfate, methylparaben, propylparaben, Sucralose and cooper sulfate.

**DOSSING:**

- **Do not use in infants <1 year of age.**
  - Recommend starting dose at 0.5g/kg (1 ml = 0.5g protein).
  - For example:
    - 10 kg=10 mls
    - 20 kg=20 mls
    - 30 kg=30 mls

**ADMINISTRATION:**

- **Oral:** May be more palatable if mixed with applesauce, pudding, juices, sodas, oral supplements, milkshakes or smoothies.
- **Feeding tube:** Flush tube with water before and after administration. May be mixed with enteral formulas with the exception of Promote.

**CLINICAL CONSIDERATIONS:**

- May not be appropriate for the short gut population due to the fructose content.
  - Use cautiously in patients with renal failure or liver failure due to the increased protein load and risk of hyperkalemia.
  - Patients taking separate vitamin C or zinc supplements may need dose adjustment of those supplements.
  - Possible side effects associated with larger doses of arginine include:
    - **Endocrine & metabolic:** Hyperglycemia, hyperkalemia, increased serum gastrin concentration, hyperchloremia
    - **Gastrointestinal:** Nausea, vomiting, abdominal pain, bloating
- See [SCH formulary](#) for more information on Arginine
This pathway was developed through local consensus based on published evidence and expert opinion as part of Clinical Standard Work at Seattle Children’s. Pathway teams include representatives from Medical, Subspecialty, and/or Surgical Services, Nursing, Pharmacy, Clinical Effectiveness, and other services as appropriate.

When possible, we used the GRADE method of rating evidence quality. Evidence is first assessed as to whether it is from randomized trial or cohort studies. The rating is then adjusted in the following manner (from: Guyatt G et al. J Clin Epidemiol. 2011;4:383-94.):

**Quality ratings are downgraded** if studies:
- Have serious limitations
- Have inconsistent results
- If evidence does not directly address clinical questions
- If estimates are imprecise OR
- If it is felt that there is substantial publication bias

**Quality ratings are upgraded** if it is felt that:
- The effect size is large
- If studies are designed in a way that confounding would likely underreport the magnitude of the effect OR
- If a dose-response gradient is evident

Guideline – Recommendation is from a published guideline that used methodology deemed acceptable by the team.

Expert Opinion – Our expert opinion is based on available evidence that does not meet GRADE criteria (for example, case-control studies).

**Quality of Evidence:**
- ⭐⭐⭐⭐ High quality
- ⭐⭐⭐ Moderate quality
- ⭐⭐ Low quality
- ⭐⭐⭐⭐ Very low quality

Guideline
Expert Opinion
Summary of Version Changes

- **Version 1 (12/05/2011)**: Go live
- **Version 2 (04/22/2015)**: Periodic review; updated literature search and recommendations
- **Version 2.1 (5/7/2015)**: Correction to Proteinex page
Executive Summary

Objective
To create and implement a standardized nutrition management plan for patients with complex wounds at Seattle Children’s Hospital.

Recommendations
1. Formal nutrition assessment by a dietitian including diet history, adequacy of intake, ability to eat, presence of malnutrition, estimation of nutritional needs, and analysis of pertinent biochemical data to develop an appropriate nutritional intervention and monitoring plan specific to the patient’s needs.
2. Order calorie counts and offer oral supplements if patient is taking PO.
3. Initiate protein intake goals at a minimum of 1.5-2g/kg or per disease-specific condition. Increase protein by 20-25% if wound is not healing appropriately at reassessment 5-7 days after initial intervention.
4. If unable to tolerate or meet > 75% estimated needs with oral intake, initiate EN or TPN per SCH guidelines.
5. Involve diet technician for education and plan to improve intake.
6. Start multi-vitamin mineral supplement (MVMS) if not on PN or receiving adequate intake from EN.
7. Test serum vitamin C and zinc levels if wound is not healing appropriately at reassessment 5-7 days after initial intervention. Start empiric supplementation while awaiting levels (may take up to 2-7 days) and continue supplementation ONLY if a deficiency is confirmed.
8. Consider use of a specialized protein supplement, ProteineX, which contains arginine, if wound is not healing appropriately 2 weeks after all other interventions have been attempted. Arginine is a non-essential amino acid that becomes conditionally essential in critical illness and stress. Consult with a dietitian before use.
9. If feasible, order indirect calorimetry (metabolic cart study) for patients that meet the following criteria: a) diagnosis of malnutrition, b) wound is not healing appropriately at reassessment 5-7 days after initial intervention, c) patients in the ICU.

Rationale
Safety: The Nutrition Management of Wounds Pathway offers a standardized nutrition management plan for patients with complex wounds highlighting the rationale behind various decision points.
Quality: Care will improve as result of nutritional assessment and treatment as recommended by the best available evidence. We believe that this pathway represents “state of the art” care.
Delivery: Care delivery will be improved by defining eligible patient populations and standardizing nutrition management plans for patients with complex wounds.
Engagement: The pathway has been developed by Dietitians, ARNP’s, and RNs. The CSW Pathway Owner sought broad input during the development and review of this Pathway.
Patient/Family Satisfaction: Patient and family satisfaction will be improved through implementing clinical standard work that will assure the highest quality of care.
Costs: Costs will be monitored as a CSW Core Metric. As part of this periodic review, the pathway was reviewed for opportunities to increase value and several changes were made, including eliminating unnecessary labs, and recommending a standard specialized protein supplement.
**Evidence**
A gap search was completed to determine best practices for nutritional treatment of wounds from the initial pathway search. Searches were also performed on arginine, glutamine and indirect calorimetry.

**Implementation Items**
- Revised Nutritional Management of Wounds algorithm
- New power plan for Nutrition Management of Wounds pathway with phases of care
- A trigger to alert providers when patients are eligible for the pathway
- New Patient Education handout on “Nutrition for Wound Healing” (PE2115)

**Metrics Plan**
- CSW Core Metrics
- Percent of encounters with specific orderables (zinc, vitamin C, etc.)
- Percent of discharges with wound consult that received Nutritional Management of Wounds Powerplan.

**PDCA Plan**
Quarterly Improvement Meetings

**Revision History**
Date Approved: April 2015
Next Review Date: April 2020
Executive Summary

Approved by the CSW Nutrition Management of Wounds Team on April 22nd, 2015

CSW Nutrition Management of Wounds Team:

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CIS Analyst:
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Heather Marshall
Susan Klawansky, MLS
Asa Herrman
Nutrition Management of Wounds Citation

**Title:** Nutrition Management of Wounds

**Authors:**
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- Kirsten Thompson
- Elizabeth Austin
- Polly Lenssen
- Michael Leu
- Sharon Nielsen
- Jean Popalisky
- Ashley Van Drunen

**Date:** April 2015

**Retrieval Website:**

**Examples:**
Medicine is an ever-changing science. As new research and clinical experience broaden our knowledge, changes in treatment and drug therapy are required.

The authors have checked with sources believed to be reliable in their efforts to provide information that is complete and generally in accord with the standards accepted at the time of publication.

However, in view of the possibility of human error or changes in medical sciences, neither the authors nor Seattle Children’s Healthcare System nor any other party who has been involved in the preparation or publication of this work warrants that the information contained herein is in every respect accurate or complete, and they are not responsible for any errors or omissions or for the results obtained from the use of such information.

Readers should confirm the information contained herein with other sources and are encouraged to consult with their health care provider before making any health care decision.
Studies were identified by searching electronic databases using search strategies developed and executed by a medical librarian, Susan Klawansky. Searches were performed in April and October 2014. The April 2014 search was performed in the following databases: on the Ovid platform – Medline and Cochrane Database of Systematic Reviews (both 2012 to date); elsewhere – Embase (2012 to date), CINAHL (2012 to date), Clinical Evidence, National Guideline Clearinghouse, TRIP (2012 to date), Cincinnati Children’s Evidence-Based Care Guidelines and Royal Nurses’ Association of Ontario Best Practice Guidelines. Retrieval was limited to humans (any age) and English language. In Medline, Embase and CINAHL, appropriate Medical Subject Headings (MeSH), Emtree headings and CINAHL subject headings were used respectively, along with text words, and the search strategy was adapted for other databases using textwords. Concepts searched were wound healing, wounds and injuries (many different kinds), skin ulcers and many different terms representing nutrition, food, fluid therapy, diet, nutritional requirements, nutrition assessment, etc. All retrieval was further limited to certain evidence categories, such as relevant publication types, index terms for study types and other similar limits.

In October 2014, the search above was replicated exactly. Searches were also performed on two additional clinical questions on the concepts of arginine, gluamine and indirect calorimetry. Those two questions were searched as above with the following additions: Cochrane Central Register of Controlled Trials (2012 to date) and the inclusion of more expansive evidence limits such Clinical Queries and others more relevant to primary literature studies. Additional articles were identified by team members and added to the results.

**Identification**

- 226 records identified through database searching
- 9 additional records identified through other sources

**Screening**

- 235 records after duplicates removed

**Eligibility**

- 235 records screened
- 201 records excluded
- 34 records assessed for eligibility
- 24 full-text articles excluded, 18 did not answer clinical question, 3 did not meet quality threshold, 3 outdated relative to other included study

**Included**

- 10 studies included in pathway

Flow diagram adapted from Moher D et al. BMJ 2009;339:bmj.b2535


