SUPPLEMENTAL MATERIAL

Supplemental Methods

16S rRNA gene sequencing

Methods for collecting rectal swabs and for 16S rRNA gene sequencing have been previously described.[1] In brief, deep rectal swabs were performed using a flocked nylon swab (Copan Diagnostics). Swabs were inserted into the anal canal with the patient in the left lateral decubitus position until there was fecal soilage. Swabs were flash frozen at -80°C for batched DNA extraction at the end of the study (PowerFecal, MoBio, Carlsbad, CA). Polymerase chain reaction was performed targeting the V4 hypervariable region of the 16S ribosomal RNA gene with primers derived from the human microbiome project[2-4] on the Illumina HiSeq 4000 platform (Illumina, San Diego, CA). Greengenes[5] was used as a reference database with clustering of taxonomic units made at 97% sequence similarity and final analysis via the QIIME pipeline.[6]

Nutritional intake calculation

For patients with a nutritional assessment completed by a registered nutritionist within 72 hours of ICU admission or within 24 hours before ICU admission, the final recommended target in that assessment was extracted. The recorded final recommended calorie value or the average value of a final recommended range was used as calorie target to calculate the percentage of caloric intake. For patients without a most recent formal assessment available, the calorie target was calculated using the Nutrition Standards of Care published by the Department of Food and Nutrition at Columbia University Irving Medical Center. The Standards of Care are adapted from the American Society of Parenteral and Enteral Nutrition (ASPEN) guidelines.[7] The Standards specified calculations for patients with various conditions, including but not limited to mechanical ventilation, cystic fibrosis, renal failure, transplant, diabetes, obesity, and cardiovascular diseases. When the gold standard of indirect calorimetry was not available, the calculations of caloric needs were based on the ASPEN Core Curriculum.[8] For example, for the critically-ill mechanically-ventilated patients, the Penn State 2003 equation was used for patients with BMI <30 or patients with BMI >30 but less than 60 years old. The Penn State 2010 equation was used for patients with BMI >30 and more than 60 years old. The detailed standard of care for nutritional support in adult patients is attached at the end of the supplemental material.

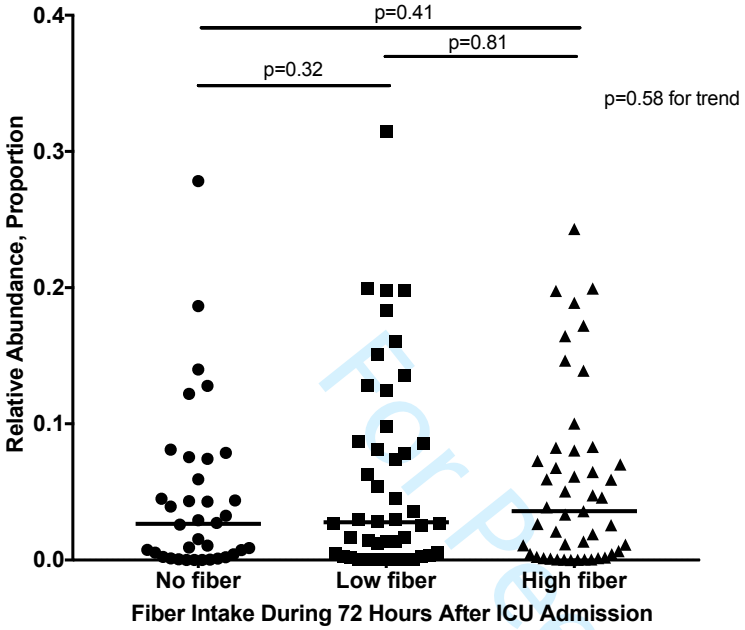
Supplemental Table

Supplemental Table 1. Baseline and ICU characteristics, stratified by fiber index.

Characteristics (n, %)	No fiber (n=36)	Low fiber index (n=46)	High fiber index (n=47)	p-value
Baseline				
Female sex	17 (47)	20 (44)	15 (32)	0.51
Age				0.36
<60	14 (39)	14 (30)	19 (40)	
60-70	10 (28)	22 (48)	15 (32)	
>70	12 (33)	10 (22)	13 (28)	
ICU type				0.69
Medical	21 (58)	25 (54)	23 (49)	
Surgical	15 (42)	21 (46)	24 (51)	
Immunosuppression	6 (17)	6 (13)	8 (17)	0.85
Kidney disease	6 (13)	7 (15)	9 (19)	0.88
Diabetes	16 (44)	11 (24)	14 (30)	0.13
Pulmonary disease	3 (6)	1 (2)	5 (11)	0.26
Intensive care unit				
Sepsis	16 (34)	12 (26)	5 (11)	<0.01
APACHE IV score				<0.01
Lowest tertile (< 45)	7 (19)	16 (35)	23 (49)	
Medium tertile (45-70)	9 (25)	19 (41)	9 (19)	
Highest tertile (>70)	20 (56)	11 (24)	15 (32)	
Antibiotics				<0.01
None	2 (6)	10 (22)	17 (36)	
Narrow-spectrum	12 (33)	8 (17)	12 (26)	
Broad-spectrum	22 (61)	28 (61)	18 (38)	
Proton pump inhibitors	16 (44)	25 (54)	22 (47)	0.63
Mechanical ventilation	14 (39)	4 (9)	3 (6)	<0.01
Hemodialysis	6 (17)	4 (9)	0 (0)	0.02
Vasopressors	14 (30)	8 (17)	5 (11)	<0.01

Supplemental Figure

Figure S1. Relative abundance of short chain fatty acid-producing bacteria at the time of ICU admission, stratified by subsequent fiber intake over 72 hours.



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Department of Food & Nutrition
STANDARDS OF CARE: ADULT PATIENT WITH NUTRITION SUPPORT

INTERVIEW PATIENT OR OBTAIN OBJECTIVE DATA FROM MEDICAL RECORD:	**INTERPRETATION**:
DIET PRIOR TO ADMISSION	Information related to diet history is generally a brief description of diet prior to admission. If patient is intubated, attempt to speak to family to obtain information about previous dietary habits. Note any food preferences, although may not be applicable.
NUTRITIONAL ISSUES	**Complaints of N/V/D or constipation:** More than 3 loose stools per day for >2 consecutive days may indicate poor tolerance of enteral nutrition support. Constipation is defined as less than one bowel movement in three days in a patient receiving enteral nutrition at goal rate. **Functional Capacity Affecting Intake:** Intubation or decreased level of consciousness will alter route of nutrition. **Pain Affecting Intake:** Relate effect of pain to nutritional intake; relate effect of pain-relieving medication to bowel function/nutritional intake. **Chewing or Swallowing Difficulties:** As reported or documented in medical or transfer record; consider a swallowing evaluation, if applicable. Prolonged intubation time may alter swallowing ability.
FOOD ALLERGIES	Per medical record, transfer records or patient/family. Note food allergies and intolerances.
VITAMINS/MINERALS/ HERBALS PTA	Per medical record, transfer records or patient/family
ADMISSION DIAGNOSIS, PMH, AND OTHER FACTORS ASSOCIATED WITH NEED FOR NUTRITION SUPPORT	Malnutrition, Gastrointestinal Disorders, Trauma, Burns, Organ Failure, Neurologic Impairment, AIDS, Cancer, Eating Disorders, Respiratory Failure, Morbid Obesity. Impaired wound healing, sepsis, surgery, cerebral injury increase kcal needs. Pressure ulcers, RRT increase protein needs. May refer to disease-specific nutrition standards of care.
AGE	State in years.
DIET PRESCRIPTION	Determine appropriate EN or PN formula to be used based on current diagnosis, organ function/dysfunction, fluid needs, medical team goal.
PARENTERAL NUTRITION	**PN**: Document the following: ml/hr x duration, Total kcal, gm amino acid, gm Dextrose; ml 20% IV lipid emulsion. Dextrose yields 3.4 kcal/gm; amino acids yield 4 kcal/gm, 20% IV fat emulsion yields 2 kcal per ml. Document vitamins and trace elements (may be ordered individually, or as a trace element package). **Catheter Placement -** Check if central line (**ex:** PICC) is accessible for PN. Must be in and placement confirmed before PN can start. Once PN starts, the central line must be reserved solely for PN infusion.
ENTERAL NUTRITION	**EN**: Document the following: Total Kcal, gm of protein, ml total volume, ml free water, % daily values for vitamin and minerals, and grams of fiber, if applicable. Document administration method: Pump-assisted continuous feeding versus cyclic, gravity-drip versus syringe bolus feeding **Tube Placement -** Check for appropriate enteral tube. Placement of NGT/NJT should be confirmed by radiography before feeds start.

<table>
<tr><td>HEIGHT/WEIGHT/

AND

ANTHROPOMETRICS</td><td>Determine desirable body weight for height. Adjust for amputation and plegia (subtract 5-10% from DBW for paraplegia, 10-15% for quadriplegia) as warranted.

Classification of Overweight and Obesity in Adults using BMI

Classification* BMI (kg per m^2)**

Underweight < 18.5
Normal range 18.5 to 24.9
Overweight 25.0 to 29.9
Obese >= 30.0
Class I 30.0 to 34.9
Class II 35.0 to 39.9
Class III (morbid Obesity) >= 40.0
BMI = body mass index

*--International Obesity Task Force (IOTF) classification as modified by World Health Organization (1997).
**--Values are age-independent and the same for both sexes.
Include serial weights (UBW, Weight referenced in last assessment, current weight)</td></tr>
<tr><td>WEIGHT HISTORY</td><td>Compare UBW with admission weight for initial nutrition assessment and monitor weight trends for determination of significant changes:
≥ 2% x 1 wk
≥ 5% x 1 month
≥ 7.5% x 3 months
≥ 10% x 6 months
≥ 20% x 1 year.
The patient’s weight may often fluctuate day to day due to fluid retention/removal or the time of day the weight was obtained. After several days, the true trend should be visible. Note any observed or anticipated weight changes due to resections or placement of hardware during surgeries.
Weight discrepancies may occur when the patient is weighed on different types of scales (e.g. sling vs. standing vs. bed). All scales need to be appropriately calibrated. Bed scales may be affected by any additional items or equipment on the mattress or bed frame.</td></tr>
<tr><td>PRESENCE OF PRESSURE ULCERS</td><td>Complete nutrition assessment if patient has pressure ulcer. Consider protein, kcal and fluid needs, and need for vitamin and mineral supplements.</td></tr>
<tr><td>LABORATORY DATA</td><td>What systems are working? What systems are impaired? Track and trend; are things getting better or worse?

Renal Function Tests
BUN – This value may be elevated in renal failure, dehydration, when patient is being diuresed, or gastrointestinal bleeding; low values usually indicative of inadequate protein intake and/or malnutrition
Cr – Low values probably indicate depleted muscle mass and/or malnutrition since creatinine values are proportional to muscle mass and are not hydration status sensitive.
BUN: Creatinine ratio - a ratio > 20:1 may indicate the problem is pre-renal, a ratio of < 10:1 indicates intrarenal.
K – May be high in renal failure, metabolic or respiratory acidosis, in the setting of excess K supplementation given intravenously or orally, or with certain medications. Potassium-sparing diuretics (Sprilonolactone), renin-angiotensin-aldosterone system blockers (such as Lisinopril), angiotension II receptor blockers (such as Losartan) have high potential for hyperkalemia (secondary to increased sodium excretion with</td></tr>
</table>

	concurrent potassium retention), and TMP (Trimethoprim such as Bactrim due to decreased Na reabsorption & reduced potassium excretion) particularly in those with compromised renal function. May be low in re-feeding syndrome, with excess insulin administration, vomiting, diarrhea, laxative use, NG tube suction, diuretic us (loop diuretics such as furosemide > thiazide diuretics such as HCTZ and torsemide). **P –** May be high in renal failure, hypoparathyroidism, hypocalcemia, liver disease, sarcoidosis, excess vitamin D, use of phosphate- containing laxative, acidosis (shift into extracellular space), . May be low in malnutrition, respiratory alkalosis (anything that causes hyperventilation), DKA, hyperparathyroidism, hypercalcemia, hyperinsulinism, inadequate vitamin D. **Liver Function Tests:** AST, ALT, GGT (if available) **T. Bilirubin:** If T. Bilirubin >2.0, consider holding Cu and Mn in PN in the trace elements (will need to infuse Zn and Cr if using MTE-4 and Zn, Cr and Se if using MTE 5 trace elements) **Electrolytes: Na, K, P, Mg, Ca –** PN prescriptions are adjusted daily based on current labs. What is the hydration status of the patient? This will affect electrolytes and renal function tests. **Glucose Intolerance:** What is the etiology of the hyperglycemia (DM, steroids, stress, overfeeding)? Is a formula change or better insulin management needed? Is the patient receiving dextrose-containing IVF? **Serum Glucose: Reported level in basic metabolic panel may not be a fasting level** **Finger sticks:** Generally recommended 100-180mg/dL **Triglyceride Level:** With IV lipid provision and Propofol –hold lipid emulsions and alert medical team to additional lipid Kcal from Propofol if triglycerides > 400 mg/dL due to risk of developing pancreatitis. **Albumin and Prealbumin:** They are not valid marker of nutrition status. Refer to NYPH NAB Position paper on albumin and prealbumin posted on infonet. Of note, albumin levels <2.0 mg/dL can contribute to 3rd spacing. **C-Reactive Protein and erythrocyte sedimentation rate (ESR):** Elevated levels indicate inflammation and further weaken validity of albumin/prealbumin as a marker of nutrition status **WBC:** High may indicate infection. Low (< 1) indicates neutropenia, When WBC improving in BMT/SCT patients, may expect to see an improvement in mucositis symptoms.
MEDICATIONS	**Prokinetic Agents: Consider a prokinetic agent, such as Reglan or erythromycin, when gastric residuals reach 250ml.** Reglan/erythromycin are both contraindicated for prolonged QTc interval. Note: 2013 European Medicines Agency (EMA) warning: “risks of extrapyramidal symptoms outweigh benefits: limit use to 5 days; not indicated for long term treatment of gastroparesis.” FDA: **black box warning** recommending that it be reserved for only the most severe cases of gastroparesis due to rare reports of irreversible neurologic side effects. **Fiber supplement:** On pharmacy formulary (benefiber as soluble fiber source, Metamucil (psyllium powder) as mainly insoluble and some soluble fiber source), may be given as medication via feeding tube or taken PO. Use of Metamucil is not recommended via feeding tube, as it may clog the tube. Use fiber-containing EN and supplements with caution in the ICU setting in patients at risk for hemodynamic instability. **Vasopressors: Also referred to as vasoactive and/or inotropic agents** which shunt blood to vital organs and subsequently decrease flow to the mesentery. Includes vasopressin, norepinephrine, epinephrine, phenylephrine, dopamine, dobutamine. Used to help improve low blood pressure. May contribute to enteral nutrition intolerance if the patient is on multiple vasopressors or on increasing doses of vasopressors, or if hemodynamically unstable despite use of vasopressors. Avoid high fiber enteral

	formulas if patient is on pressor agents to avoid the development of a bezoar or the potential for an ischemic bowel. Formula for quantification of norepinephrine equivalents (NEE): = [norepinephrine(mcg/min)] + [dopamine (mcg/kg/min) ÷ 2] + [epinephrine (mcg/min)] + [phenylephrine (mcg/min) ÷ 10] + [vasopressin (units/h) × 8.33] Formula use: NEE > 18 is associated with increased EN intolerance incidence (Mancl EE, Muzevicj KM. Tolerability and Safety of Enteral Nutrition in Critically Ill Patients Receiving Intravenous Vasopressor Therapy. JPEN J Parenter Enteral Nutr 2013;37:641-651)
VITAMIN/MINERAL SUPPLEMENT	Is the patient receiving additional vitamin or mineral supplementation in response to abnormal lab data? Should the enteral formula be changed or PN solution be altered? Consider addition of Selenium if patient on PN > 2-4 weeks and is not receiving MTE-5.
IV FLUIDS	Note major source of IV hydration and calculate kcal provided.
INTAKE Tube Feeding TPN Oral	Generally, goal is to maintain EDW and attenuate fluid retention. Does the daily fluid intake match the daily output? Weight changes should be consistent with fluid shifts. Review daily I/O's. 1000ml of fluid intake/output = 1 kg change in weight
OUTPUT Dialysis Urine GI Tube drainage Residuals Stool/Ostomy Emesis Fistula or wound drainage Abdominal distension	Is the patient on dialysis? Is the GI tube drainage >500ml/day? Ileostomy output>1500ml or no output? Colostomy output >500-800 mL or no output? Are the gastric residuals >500 ml? Are the stool events >3/day for >2 days, or <1BM for > 2-3 days? Is the patient experiencing vomiting? Is the abdomen non-distended vs distended, nontender or tender, soft or firm? What are the drain outputs?
NSS/PN CONSULT	Re-evaluate kcal, protein, & fluid needs based on current status including respiratory status, function of GI tract, fluid status, and other organ dysfunction that will affect nutritional care plan. Evidence has shown the most accurate method to determine REE is through indirect calorimetry. Review metabolic cart reading if available.
ASSESSMENT	**Calorie Requirements** For Medical and surgical Patients on PN/EN: • 20-35 kcal/kg Source: A.S.P.E.N Core Curriculum • 30-40 kcal/kg for weight gain in underweight patients (of note: repletion not indicated in the ICU setting)
NUTRITIONAL REQUIREMENTS	**Prediction Equations for Critically Ill Mechanically Ventilated Patients:** * ADA Evidence Analysis Library. Recommendations Summary Critical Illness Determination of Resting Metabolic Rate (RMR) *** Penn State University 2003b: use with Non-Obese (BMI < 30) - OR - Obese (BMI > 30) and less than 60 years old** *Women*: RMR = [Weight(10) + Height(6.25) – Age(5) +5] 0.96 + VE (31) + Tmax (167) – 6212 *Men:* RMR = [Weight(10) + Height(6.25) – Age(5) -161] 0.96 + VE (31) + Tmax (167) – 6212 (T-max= max body temp in previous 24 hrs (degrees Celsius); VE: minute ventilation: L/min)

	*** Penn State University 2010: use with BMI >30 obese patients who are 60 years or older** *Women*: RMR = [Weight(10) + Height(6.25) – Age(5) +5] 0.71 + Tmax(85) + VE (64) – 3085 *Men*: RMR = [Weight(10) + Height(6.25) – Age(5) -161] 0.71 + Tmax(85) + VE (64) – 3085 ****Penn State equations not appropriate during hypothermia protocols** **For patients with BMI >30, reference the Standards of Care "Obese Adult Patients: Calculating Energy and Protein Needs"** **Recommend obtaining indirect calorimetry if indicated. Gold standard for critically ill patients when feasible.** (See pages 12-14 for Interpretation of Indirect Calorimetry Studies.) **Protein Requirements** • At least 1 gm/kg for all hospitalized patients. Refer to specific standards of care for illnesses, pressure ulcers, etc. • 1.2-2 gm/kg in critical illness based on EDW if BMI < 30 • Acute renal failure or acute kidney injury in the ICU: standard ICU recommendations for protein and calorie provision should be followed (i.e. 1.2-2 gm protein/kg)* • Chronic kidney disease: refer to "Standards of Care for Adult Patients with Renal Failure, End Stage Renal Disease, Renal Transplant and/or Living Kidney Donors" • Continuous Veno-Venous Hemodialfiltraton (CVVHDF) or continuous veno-venous hemodialysis (CVVHD): 1.8 -2.5 gm protein/kg (CVVHDF generally requires higher end of this Pro range) • Note if patient with pressure ulcers. Refer to Nutrition Standards of Care for Pressure Ulcers. • Avoid restricting protein with liver failure or liver transplant in critically ill ICU patients* • Obese patients with BMI > 30 - refer to Standards of Care "Obese Adult Patients: Calculating Energy and Protein needs" * Source: Guidelines for the Provision and Assessment of Nutrition Support Therapy in the Adult Critically Ill Patient: Society of Critical Care Medicine (SCCM) and A.S.P.E.N, May/June 2009 **Vitamin/Mineral Requirements** • Calculate percent of daily values provided by EN. • Compare PN formulation to recommended ASPEN requirements (ASPEN Core Curriculum) **Fluid Requirements** • 1ml/kcal (Recommended Dietary Allowance, Adolph 1933)* • 25 – 35 mL/ kg: 25 mL/kg for CHF or renal disease; 30 mL/kg for average adults; 35 mL/kg with infection, draining wounds (Brummit, 2002; Kobriger, 2005)* • >20 kg, 1500 ml + 20ml/kg for each kg >20 kg (Holliday, 1957)* *Source: Academy of Nutrition and Dietetics, Nutrition Care Manual
HYDRATION STATUS	Maintain hydration status. Monitor fluid status via MD notes, I and O's, lab data, clinical signs and symptoms of dehydration or fluid overload (i.e. shortness of breath, pleural effusions, edema, weight shifts), urine output, use of diuretics. Assess daily intake of fluid in relation to estimated fluid requirements. Always assess what the medical or surgical team's plan is for fluid provision (fluid resuscitation or

	maintenance?) or clearance (diuretics, hemodialysis, CVVHD) as this will guide choice of enteral formula or volume of parenteral nutrition provided.
DIET RX MEETS ESTIMATED NUTRITIONAL REQUIREMENTS	Compare provision of EN/PN to estimated kcal/protein needs. Determine if the diet prescribed can meet the patient's nutritional requirements for calories, protein, fluids and specific vitamin/minerals.
INTAKE PTA	Assess adequacy based on diet history obtained. If patient is intubated, make every attempt to speak to family member or to facility where patient was living PTA.
PATIENT ABLE TO MEET NUTRITIONAL REQUIREMENTS	Upon meal rounds or review of I and O flowsheet, determine if quantity of EN/PN patient received is meeting requirements. Review 24 hour totals from the last assessment to current assessment. Is the patient cooperative/compliant with nutritional care plan? Unless patient pulls out feeding tube or IV line, patients receiving nutritional support are generally compliant.
NUTRITIONAL CARE PLAN AND GOALS	**Enteral Nutrition** • Select appropriate formula. • Divide the estimated calorie needs by the number of calories per mL of the selected formula. This is the volume of formula the patient will need per day. • Divide the above number by the duration of the feeding in hours. Round this number to the nearest increment of 5. This is the target rate in ml/hour. • Initiation of EN: • For patients at risk for refeeding syndrome (negligible nutrition intake for >5 days including malnourished patients and alcoholics), those who are hemodynamically unstable (incomplete fluid resuscitation, MAP <60mm mercury, increasing vasopressor requirements), or those s/p GI surgery, EN should generally be started at a conservative rate and advanced only as tolerated. In the setting of refeeding syndrome, EN should initially provide ~30% of goal calories and advance slowly pending stable serum electrolyte levels. • Enteral nutrition feeding initiation and hemodynamic stability measures: venous lactate values > 2 mmol/L may indicate impaired GI mesenteric perfusion and increased risk non-occlusive mesenteric ischemia (NOMI); (Hendrick's Sepsis Protocol, Cardiovascular Aspects of Septic Shock. Critical Care Nursing 2005;25:14-40) • EN can be initiated at goal rate in stable patients with functioning guts, not at risk for refeeding syndrome • ICU guidelines for resuming enteral nutrition after being held for procedure/test/operation: • EN should ideally be resumed within 1h of return from procedure/test/operation unless the patient has a significant clinical change • For patients who tolerated goal rate prior to holding EN, feeding should be resumed at 2x the goal rate for the number of hours the feeds were held and then returned to goal rate • For patients who experienced feeding intolerance with goal rate, feeds should be resumed at 1.5x the goal rate for twice the number of hours the feeds were held and then returned to goal rate • Clinical judgment should be used to assess if patient is appropriate to receive catch up feeds (i.e. volume overload, uncontrolled hyperglycemia, electrolyte abnormalities) • If patients had not received goal rate prior to holding the feeds, EN should be resumed at the last tolerated rate and increased to goal, as tolerated. • Tolerance measures for tube feedings: Absence of nausea and/or vomiting; Absence of diarrhea (< 3 loose stools/day for > 2 days); Nondistended/nontender abdomen. Does the patient have gastric residuals > 500 ml along with any of the abovementioned symptoms?

	Parenteral Nutrition • Initiate parenteral nutrition at desired volume based on current IV rate or estimated fluid requirements with 100-150 grams dextrose, 100% protein needs and 100% IV fats if TG level <400 mg/dL. May increase dextrose load as tolerated towards 100% goal based on glucose tolerance and electrolyte levels/resolution of refeeding syndrome. Do not exceed glucose infusion rate (GIR) >5 mg carbohydrate/kg/minute (<3 mg carbohydrate/kg/minute for diabetic patients). (ASPEN Parenteral Nutrition Handbook) • Tolerance measures for parenteral nutrition: Glucose 100-180mg/dL on floor; for ICU patients, individualized depending on ICU protocol Phos 2.2-4.2 mg/dL Mg 1.8-2.1 mg/dL K 3.8-5.2 mmol/L For IV fat administration TG< 400 m/gdL and For Copper and Manganese administration, T. Bilirubin <2.0 mg/dL
PATIENT EDUCATION	Identify specific learning needs and readiness to learn. May defer education while patient in ICU setting. Identify barriers to education. Identify impairments to education- vision, hearing, and other physical conditions. Does the patient have language, cognitive, emotional or financial barriers that would limit ability to comprehend and follow prescribed diet? Comprehension of diet, EN or PN and assessment for need of further education. Has the patient received counseling on prescribed diet, EN or PN from an RD in the past? Can the patient verbalize comprehension of the diet? Is further education needed?
DISCHARGE PLANNING	Patient Care Rounds Diet Instruction Referral to Nutrition Wellness Center, Home Health and/or other community resources.
REFERENCES	• The ASPEN Nutrition Support Core Curriculum: A Case-Based Approach- The Adult Patient, 2012 • ADA Evidence Analysis Library. Recommendations Summary Critical Illness Determination of Resting Metabolic Rate (RMR) • New York-Presbyterian Hospital Enteral Nutrition Formulary • New York-Presbyterian Hospital Guidelines for Ordering Enteral Feedings PROC #554

REFERENCES ATTACHED

1. Formula Selection Guidelines; Standard Formulas, Formulas for Special Needs, Modular Nutrients
2. Adult ICU Enteral Feeding Protocol
3. Interpretation of Indirect Calorimetry

FORMULA SELECTION GUIDELINES

STANDARD FORMULAS (Polymeric and Elemental)	**INDICATIONS FOR USE**
ISOTONIC FORMULA Isotonic Tube Feeding Formula (Osmolite 1.0)	Isotonic tube feeding. Used as initial enteral feeding. Lactose free. Gluten free. Low residue. Requires normal digestive/absorptive capacity. Unflavored.
CALORIE DENSE WITH FIBER FORMULA Calorie Dense with Fiber Tube Feeding Formula (Jevity 1.5)	Calorie dense, high Nitrogen tube feeding with fiber (22g dietary fiber/liter). Used to moderate bowel function. Lactose free. Gluten free. Low residue. Requires normal digestive/absorptive capacity. Unflavored. Contains FOS.
CALORIE DENSE FORMULA Calorie Dense Tube Feeding Formula 2 kcal (Two Cal HN)	High calorie, high nitrogen tube feeding. Lactose free. Gluten free. Low residue. Requires normal digestive/absorptive capacity. Used for fluid/volume restrictions, Vanilla flavored. Contains FOS.
CALORIE DENSE FORMULA Calorie Dense Tube Feeding Formula 1.5 kcal (Osmolite 1.5)	High calorie and protein. Lactose free. Gluten free. Low Residue. Used for those with limited volume tolerance. Requires normal digestive/absorptive capacity. Unflavored.
SEMI-ELEMENTAL (Vital 1.5)	Peptide based. Calorically dense. Low residue. Used for patients with chronically impaired gastrointestinal function. Vanilla flavored.
FORMULAS FOR SPECIAL NEEDS (Disease Specific)	**INDICATIONS FOR USE**
FORMULA FOR TREATMENT OF RENAL INSUFFIENCY (Nepro with Carb Steady 1.8)	High calorie. Moderate protein. Low in electrolytes. Tube feeding for hemodialysis renal patients or patients with hyperkalemia/hyperphosphatemia. Lactose free. Gluten free. Requires normal digestive/absorptive capacity. Vanilla flavored. Contains FOS.
WOUND HEALING FORMULA (Promote)	Used for patients recovering from surgery, burns, or pressure ulcers. Tube feeding. Lactose free. Gluten free. High protein enhanced with Vitamins C, A, and Zinc for wound healing. Requires normal digestive/absorptive capacity. Vanilla flavored.
MODULAR NUTRIENTS	**INDICATIONS FOR USE**
CARBOHYDRATE MODULE (Polycose)	Used to enhance formulas. Powdered carbohydrate supplement. 6g (1 Tbsp) = 23 calories.
FAT MODULE Medium Chain Triglyceride (MCT Oil)	Liquid fat supplement containing medium chain triglycerides. Used for compromised fat digestion. 15 ml (1 Tbsp) = 116 calories.
PROTEIN MODULE (Prostat)	Used to enhance formulas. Liquid protein supplement. One 30 ml packet = 15 grams protein, 100Kcals, 10gm carbohydrate

INTERPRETATION OF INDIRECT CALORIMETRY

Indirect calorimetry is when gas exchange (VO2, VCO2) is measured under steady state conditions to assess metabolic rate.

Indirect calorimetry should be considered for:

- Patients who have an inadequate response to nutrition support using predictive equations (ex: poor wound healing or unexplained weight loss).
- Patients with metabolic and respiratory abnormalities that may result from under/overfeeding (ex: hyperglycemia, failure to wean from the ventilator, fluid overload or dehydration)
- Patients with a clinical condition resulting in an inability to estimate caloric requirements accurately (ex: multiple trauma, burn, malnutrition, altered body composition, sepsis).

The REE is based on the abbreviated Weir equation:

Energy Expenditure = (3.94 x VO2) + (1.11 xVCO2)

RQ is often thought to be useful in the determination of substrate utilization. RQ = VCO (carbon dioxide production) ÷ VO2 (oxygen consumption)

Evaluating RQ**

- RQ <0.82 may suggest underfeeding.
- RQ 0.85-0.95 may suggest mixed substrate utilization indicating that the nutrition regimen is appropriate
- RQ >1 may suggest overfeeding and potential lipogenesis

*** Note – Recent literature suggests that RQ is considered the weaker piece of information obtained from IC. If the RQ is within normal biological range (0.67-1.3), it can serve as a marker of test reliability and validity. However, the RQ should not be used as an indicator of substrate utilization in the traditional sense as described above.*

Translating IC Results into a Plan

1. Assess the validity of the data from the study. There are two aspects to validity – technical and clinical. A variety of technical factors can affect the measurements of gas exchange such that the data do not reflect the patient's actual energy expenditure during the study.

Technical Aspects:

a. Air Leak – The most common pitfall. This can occur in the ventilator circuit, around the endotracheal tube, or through the lung and out a chest tube. In that situation, some of the patient's minute ventilation (the total volume of gas in liters expelled from the lungs per minute) is lost, and the values for minute ventilation, VO_2, VCO_2, and REE will all be falsely low. The air leak may be apparent (audible gurgling) or subtle. Ask the respiratory therapist or MD if the patient has an air leak prior to beginning the study. Children with uncuffed endotracheal tubes often have air leaks, and the results from the study would not be valid because they would be lower than the patient's true VO_2, VCO_2, and REE. If the values obtained in a study seem much lower than expected, suspect a subtle air leak.

b. FiO_2 Variability – The measurement of VO_2 is based on the difference between the O_2 concentrations in the inspired and expired gases. Even a small amount of variability in the FiO_2 will markedly alter the O_2 difference. This can result in widely disparate VO2 values or confuse the metabolic cart so much that it will not give any readings at all. If the patient's rate and depth of breathing are highly variable, the volume and O2/CO2 concentrations of exhaled gas may be affected. This will also result in highly variable IC results. Patients who are restless, coughing, become detached from the ventilator briefly, or require suctioning during a study will commonly have highly variable measurements. Additionally, errors in calculation increase as FiO2 increases. Studies have shown that this error increases significantly when FiO2 gets to 60%. For that reason, patients requiring a high level of FiO2 (> 60%) are not good candidates for indirect calorimetry.

c. REE and RQ values – If highly variable, the patient cannot be considered to be in a steady state. The results of the study must be interpreted with caution. The coefficient of variation is a statistic describing the variation of the measurements, and it can be calculated with the software on the instrument. The goal should be a coefficient of variation of REE and RQ ≤ 10 %. During the processing of results, you should look for time periods of reasonably steady data points for REE and RQ. Use these data points to determine average values. It is also acceptable to discard some values that are very high or very low compared with the others. Trimming the data is risky, because we do not know for sure which data points are accurate and which are not.

Clinical Aspects:

d. Once you have technically valid data, you must decide how those results are related to the patient's true energy expenditure over 24 hours. How clinically valid are they for estimating caloric needs? There are several patient and treatment factors that affect the relationship between the values you measure and the patient's requirements over a 24-hour period, and you must account for these in your recommendations.

i. The conditions under which you will usually conduct IC studies in patients will be far from 'basal.' The patients will be acutely ill, the environment harsh, and multiple drugs and procedures can affect energy needs minute by minute. Some will be receiving nutritional support and some will not. Nonetheless, it is reasonable to try to come close to 'basal' by performing the studies in the morning and assuring that the patient is calm, comfortable, undisturbed and comfortably warm. If you can achieve that, then the steady state data determined during the study are considered to reflect Resting Energy Expenditure (REE).

ii. If appropriate, consider that the patient's 24-hour energy requirement to be the REE + 10-20%, depending on the patient's activity level for the rest of the day. However, activity and stress factors in critically ill patients should be used with caution. Instead, it is best to feed no more than 100% of the REE to avoid overfeeding.

Factors Affecting REE: Although a steady state may be achieved in many settings, there are several in which the measured values will not be a good indicator of resting needs.

Increase measured REE:
- Fever
- Painful procedures
- Increased work of breathing
- Restlessness
- Overfeeding
- Cool ambient temperature

Decrease measured REE:
- Hypovolemia or shock
- Early post-op period after major surgery
- Hemodialysis
- Sedatives
- Paralytic agents

Variable effect on measured REE:
- Vasoactive drugs (e.g. dopamine, norepinephrine)
- Sepsis
- Hypoxemia

These factors are often not constant 24 hours a day, and that makes it difficult to know how to relate the IC results to a 24-hour caloric requirement. In these situations, it is reasonable to recommend a caloric load equivalent to the Measured Energy Expenditure, and then to repeat the study when the patient is more clinically stable.