Nutrition in the Surgical Trauma ICU: *why and how?*

Nestlé Nutrition Institute

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Disclosure

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Objectives

After this presentation participants should be able to:

1) Describe the importance of early enteral immunonutrition after trauma
2) List different aspects of formulations which support tolerance of immunonutrition
3) Discuss evidence showing the benefits of volume-based feeding (VBF) of surgical trauma patients

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UNIVERSITY OF SOUTH CAROLINA School of Medicine

AMERICAN COLLEGE OF SURGEONS Verified Trauma Center

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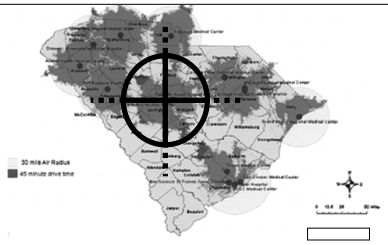
South Carolina Trauma Centers



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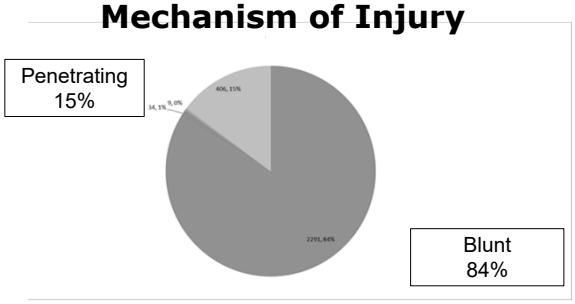
Mechanism of Injury



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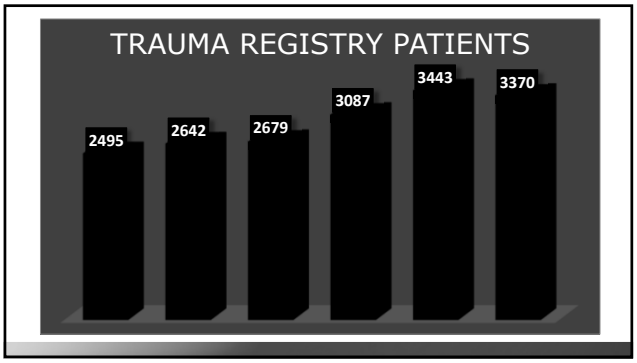

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Surgical Trauma Intensive Care Unit

- 18 bed STICU
- Average age 25 – 45
- Approximately 600 admissions per year

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Significant Polytrauma

- Head injury
- Spine injury
- Pulmonary contusions
- Rib fractures
- ARDS
- Open abdomens
- Solid organ injury
- Pelvic fractures

…and on and on and on

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Physiology of Trauma

- Significantly increased catabolic state
- Significant fluid requirements
- Significant inflammation leading to capillary leak

Feliciano DV, Mattox KL & Moore EE. (2007). Trauma. 6th ed. McGraw-Hill Professional

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Fighting the Lethal Triad

- Acidosis
- Hypothermia
- Hypercoagulability

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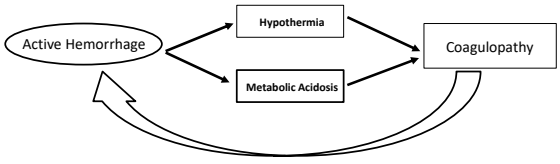
"The Bloody Vicious Cycle"



"The Bloody Vicious Cycle" Adapted from Moore, EE. Am J Surg. 1996;172:405-410.

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Fighting (impending) Infection

- Trauma patients don't come in septic (unlike MICU) – we allow it
  - Central lines
  - Foley catheters
  - Hardware
  - Contaminated wounds
  - etc…etc…etc

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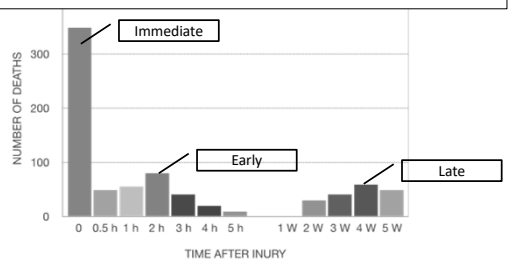
Trimodal Distribution of Trauma Deaths



Adapted from The American College of Surgeons Trauma Evaluation And Management (TEAM) Course

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Where we started: 2011

Parameter	Results
Initiation of Enteral Feeds	Day 4
Variation in reaching 80% of goal	Day 9-never
Meeting caloric needs	49%
Meeting protein needs	44%

- No formal enteral nutrition feeding protocol
- Using whole protein formula and protein boluses

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We knew better:

- 2009 Critical Care Nutrition Guidelines:
  - Supported early enteral nutrition
  - Emphasis on volume or calories
  - So we knew where we needed to get to, but didn't know how to safely get there…

McClave SA et al. JPEN 2009; 33(3): 277-316.

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So let's figure this out

- *When* to feed?
- *What* to feed (and how much)?
- *How* to safely and effectively accomplish it?

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WHEN TO FEED?

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Early and Enteral!

- 2016 Critical Care Nutrition Guidelines
  - Suggest the use of EN over PN in critically ill
  - Early enteral nutrition (EEN) recommended to start within 24-48 hrs
  - *More emphasis on protein adequacy*

McClave SA et al. JPEN 2016;40(2):159-211.

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Early Enteral Access- in the ER

- Critical
- Any patient who can't feed himself/herself
- No exceptions
- Sump port open

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Benefits of EEN

Early vs. Delayed or No EN

Meta-analysis of 21 RCTs; 13 reporting on infection

- Infectious Morbidity
  - RR = 0.74; 95% CI, 0.58–0.93; p=.01)
- Mortality
  - RR = 0.70; 95% CI, 0.49–1.00; p= .05)

Maintain gut integrity

Modulate Stress / reduce SIRS

Independent of disease severity

McClave SA et al. JPEN 2016;40(2):159-211.

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WHAT TO FEED?

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Different Types of Nutrition

- Standard Nutrition
  - Benefit derived primarily from protein and calories
  - Addresses malnutrition by improving nutritional status
  - ≥ 2-4 weeks duration required

- Surgical Immunonutrition
  - Benefit is not derived primarily from protein and calories
  - Additive ingredients modulate immune, vascular and inflammatory responses.
  - Meets distinct nutritional requirements of the surgery and trauma patient to improve recovery
  - Shorter term (5-10 day perioperative period) duration

Kabata P et al. Supp Care Canc 2014;pub on line. Ekinci O et al. NCP 2016; pub on line. Alito Aprelino M and de Aguilar-Nascimento JE. Nutr Journal 2016;15:34. Drover JW et al. JACS 2011;212(3):385-399. Zhu X et al. Ann Surg 2014;259(1):171-8. Braga M et al. Surg 2002;132:805-14. Hess JR and Greenberg NA. NCP 2012;27(2):281-94. Morris CR et al. NCP 2017;32(1):30S-47S.

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Critical Care Nutrition Guidelines –

Immunonutrition: Surgery and Trauma

Society of Critical Care Medicine/ American Society of Enteral and Parenteral Nutrition				
Population	Peri-op SICU	Post-op SICU	Severe Trauma	Traumatic Brain Injury (TBI)
Guideline	Immune-modulating formulas containing **arginine with other agents** (including EPA, DHA, glutamine, nucleic acid) are **suggested** (E2,O3)	Immune-modulating formulas containing **arginine and fish oils** are suggested for **routine use** (O3)	Immune-modulating formulas containing **arginine and fish oils** are **suggested** (M1b)	Immune-modulating formulas containing **arginine with other agents** (including EPA, DHA, glutamine, nucleic acid) are **suggested based on expert consensus** (E2, M2b)

Taylor BE et al. CCM 2016;44(2):390-438.

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Evidence Based Outcomes:
Drover et al Meta-Analysis

- **35 RCTs in major elective surgery (n= 3438)**
  - 25/35 studies in elective GI surgery
- **Evaluated pre-, peri- and post-operative use of arginine-supplemented immunonutrition (IM) on outcomes:**

Primary Outcome
Infectious complications reduced by 41%
(p<0.00001)
Reduced 41%

Secondary Outcomes
Hospital LOS reduced WMD 2.38 days (p<0.00001)
Mortality: No change
Reduced 2.38 Days

Various sub-analyses

Drover et al. J Am Coll Surg 2011;212(3):385-399.

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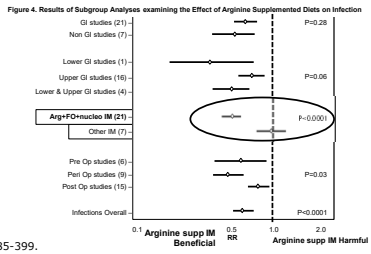
Sub-analyses
Arginine-Supplemented IM Formulas on Infection

- Only Arg-n3-nucleotide formula showed statistically significant benefit when compared with other arginine supplemented (IM) formulas (p<0.0001)



Drover et al. J Am Coll Surg 2011;212(3):385-399.

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Arginine Simplified

T-Cell Dysfunction → **Risk of INFECTION**

Depleted Arginine → **Decreased nitric oxide production/ Decreased tissue oxygenation** → **Risk of WOUND BREAKDOWN**

Popovich PJ et al. J of Nutr 2006;137:1681S-1686S. McClave et al. JPEN 2016;40(2):159-211.
Zhu X et al. Ann Surg 2014;259(1):171-178.

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Arginine is Not the Whole Story

- n-3 fatty acids
  - EPA and DHA from Fish Oil
    - Minimize inflammatory response by decreasing production of inflammatory mediators
    - Increase immune response by enhancing lymphocyte function
    - **Arginase expression may be modified by the type of fatty acid**

Calder P. Biochimica et Biophysica Acta 2015;1851:469-484. Bansal and Syres et al. JPEN 2005;29:S75.

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Prevalence of n-3 PUFA Deficiency

- Study subjects were US residents
- 655 adults screened
- 89% were n-3 PUFA deficient (OS <6.1%)
  - Omega-Score (OS) = blood EPA + DHA + DPA

Shaikh NA et al. Mol Cell Biochem 2014;396:9-22.

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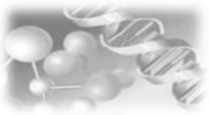
The Role of Nucleotides

- Building blocks for DNA and RNA
- Indispensable in stressed states
- Essential for rapidly replicating cells to help support immune function



Hess JR and Greenberg NA. NCP 2012;27(2):281-294. Santora and Kozar et al. J Surg Res 2010;161:288-294.
Gil A. Eur J Clin Nutr 2002;56(Suppl 3):S1.

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Tolerance Matters

- **Objective:** Determine if there was a difference in the incidence of diarrhea between two formulas used in the SICU.
- **Methods:**
  - Consecutive 3 month periods of retrospective chart review
  - Formula A = IM - more hydrolyzed**; 50% MCT (n=52)
  - Formula B= IM - less hydrolyzed**; 20% MCT (n=61)
- **Results:**
  - No statistical difference in the following: number of C. difficile tests ordered or the number of antibiotics, laxatives or antimotility agents received

**Data on file. Multiple batches tested by an external laboratory using the SDS-PAGE (sodium dodecyl sulfate-polyacrylamide gel electrophoresis) method.
Intact protein defined as having a weight of 19 kDa (kilodaltons) or greater.

Rumberger L et al. 2014 Clinical Nutrition Week, Abstract 1835637

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Tolerance Matters: Results

IM Formula	Days of diarrhea
Formula A- More Hydrolyzed; 50% MCT	1.42
Formula B- Less Hydrolyzed; 20% MCT	4.25

p<0.001

- Need for rectal tube to manage diarrhea:

Rumberger L et al. 2014 Clinical Nutrition Week, Abstract 1835637

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HOW TO <u>SAFELY</u> FEED?

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STICU Patients are High Risk:

Nutritional Risk Screening (NRS-2002)

- Trauma patients not typically malnourished on admission
- Injury puts them at high risk

Severity of disease (~stress metabolism)	
Absent Score 0	Normal nutritional requirements
Mild Score 1	Hip fracture Chronic patients, in particular with acute complications: cirrhosis, COPD Chronic hemodialysis, diabetes, oncology
Moderate Score 2	Major abdominal surgery. Stroke Severe pneumonia, hematologic malignancy
Severe Score 3	Head injury Bone marrow transplantation Intensive care patients (APACHE 10+)

Adapted from Table 2, Kondrup J. Clin Nutr 2003

NUTRIC Score

- Pre-existing malnutrition and Severity of

Variable	Range	Points
Age	<50	0
	50 - <75	1
	≥ 75	2
APACHE II	<15	0
	15 - <20	1
	20 - <28	2
	≥ 28	3
SOFA	<6	0
	6 - < 10	1
	≥ 10	2
Number of Co-morbidities	0-1	0
	≥ 2	1
Days from hospital to ICU admission	0 - < 1	0
	≥ 1	1

High Score= 5-9

- Associated with worse clinical outcomes (mortality, ventilation)
- These patients are most likely to benefit from aggressive nutrition

Heyland DK et al. Crit Care 2011

ASPEN Adult Nutrition Support Core Curr, 3rd Ed. 2017; Chapter 24 Trauma, Surgery and Burns: 36-56.

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High Protein Needs

- After major injury, 90-130 g/d protein are lost in wound exudate and urine x first 10 days
- 20%-25% of calories (1.5-2.0 g/kg)
  - Morbidly obese (2.0-2.5 g/kg)
  - CRRT (2-2.5 g/kg)

1. SICU Patients achieving ≥80% of protein target achieve a 33% reduction in stay.
2. Achieving >80% of prescribed protein intake is associated with reduced mortality in critically ill patients.

ASPEN Adult Nutrition Support Core Curr, 3rd Ed. 2017; Chapter 24 Trauma, Surgery and Burns: 36-56.
Yeh et al. NCP 2017;32(2);175-181. Nicolo M et al. JPEN 2016; 40(1):45-51.

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Calorie Needs

- 20-40 kcal/kg/day (my practice)
- Penn State Equation

$$RMR = Mifflin(0.96) + V_E(31) + T_{max}(167) - 6212$$

- Indirect calorimetry on qualifying patients

Academy of Nutrition and Dietetics. Evidence Analysis Library. Critical Illness. Determination of RMR. 2010.
www.andeal.org

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Feeding Challenges in the STICU

- Multiple surgeries requiring NPO status at midnight
- "ortho add-on diet"
- Open abdomens
- Abdominal pathologies/gastric intolerance

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Step One: Nutrition Bundle

1. Assess patients on admission to the ICU for nutrition risk, and calculate both energy and protein requirements to determine goals of nutrition therapy.
2. Initiate EN within 24-48 hours following the onset of critical illness and admission to the ICU and increase to goals over the first week of ICU stay.
3. Take steps as needed to Reduce Risk of aspiration or improve tolerance to gastric feeding (use prokinetic agent, continuous infusion, chlorhexidine mouthwash, elevate the head of bed and divert level of feeding in the GI tract).
4. **Implement enteral feeding Protocols with institution-specific strategies to promote delivery of EN.**
5. **Do not use gastric residual volumes as part of routine care to monitor ICU patients on EN.**
6. Start PN early when EN is not feasible or sufficient in high risk or poorly nourished patients.

McClave S, et al. JPEN 2016;40:159-211. Reignier J et al. JAMA 2013;309:249-56.

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History of Volume Based Feeding → PEP uP

Enhanced **P**rotein-**E**nergy **P**rovision via the Enteral Ro**u**te Feeding **P**rotocol

- 24-hour volume based EN protocol
  - Start with semi-elemental, peptide-based formula
  - Day #1- Start at 25 ml/hr; add motility agent and protein powder
  - Day #2- Change rate to provide 24 hr target volume (not to exceed 150 mL/hr)
  - Tolerate higher GRV threshold (300 mL or more)
- Initial work included only 4 trauma patients and did not utilize peptide-based immunonutrition

Heyland DK. Crit Care 2010;14(2):R78.

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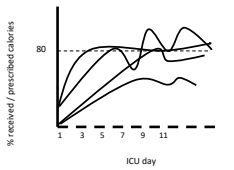
PEP uP Results:

- Multi-Center Trial
- PEP uP
  - 60.1% of prescribed energy
- Control
  - 49.1 % of prescribed energy



Keep NPO
Trophic feeds only
Progress to hourly goal rate
Start at rate determined by 24 hr volume goal

Heyland, D. K., et al. JPEN 2015; 39: 698-706.

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Comparison of Feeding Methods

Traditional Method	PEP uP Method
• Delayed start times	• Starting within 24- 48 hours of hemodynamic stability
• Varying tube feed formulas	• Specific high protein, semi-elemental, immunonutrition formula, with supplemental arginine, n-3 fatty acids and nucleotides used within the intensive care unit
• Start at 10 ml/hr and increase by 10 ml per MD instructions	• Start at 25 ml/hr and increase straight to goal on day 2 of initiating enteral feeds.
• Held for procedures and then restarted at lower rates before titrating to goal	• Volume/day provided so nursing can catch up for time missed
• Held for prolonged periods of time due to differing intolerance definitions	• Defined intolerance and "what to do" guidelines for nursing
• No formalized protocol or guidelines	• Formalized protocol

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Surgical Trauma ICU Orders:

Tube Feedings: Patient to start within 24 to 48 hours of admission to the ICU AND after proper resuscitation (Lactate < 2.0 and pressor support < 12 mcg/min levophed mEq). Formula is peptide-based immunonutrition with supplemental arginine, n-3 fatty acids and nucleotides.

- ❑ Continuous
  - ❑ 10 ml/hr Initial Rate, Surgical Trauma ICU. TROPHIC rate DO NOT advance without MD order.
- ❑ Continuous
  - ❑ 25 ml/hr Initial Rate, Surgical Trauma ICU. Day # 1 Rate to start at 25 ml/hr
- ❑ Continuous
  - ❑ Surgical Trauma ICU. Day #2 at 6 am advance to weight based volume: < 50 kg = 700 ml/24 hr, 50.1-65 kg = 900 ml/24 hr, 65.1-80 kg = 1100 ml/24 hr, > 80 kg = 1300 ml/24 hr
- ❑ Continuous
  - ❑ Surgical Trauma ICU. Day #2 at 6 am advance to goal based volume: 960 ml/day, 1080 ml/day, 1200 ml/day, 1320 ml/day, 1440 ml/day, 1560 ml/day.

Nursing Orders:

- ❑ Do Not Check Gastric Residuals
  - ❑ Check Gastric Residuals if patient demonstrates signs of intolerance such as nausea, vomiting, distention, or abdominal pain. If greater than 500 ml, decrease to 25 ml/hr and notify MD.

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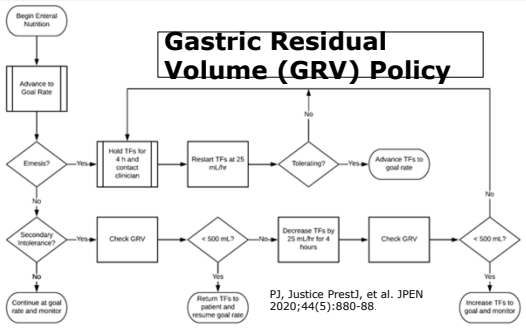
Gastric Residual Volume (GRV) Policy



PJ, Justice PrestJ, et al. JPEN 2020;44(5):880-88.

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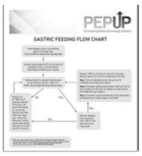
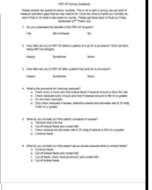
Volume Based Feeding (Pep uP) Implementation

- Started in August 2013 – 6 months of education
- Dietitian on rounds, and automatic dietitian consult
- Nursing and Resident education
- Continued follow-up
- Survey at 4 years





Heyland DK, et al. Crit Care 2010;14(2):R78. Heyland DK et al. JPEN 2018;42(2):308-317.
https://www.criticalcarenutrition.com/pepup/study-tools

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Does any of this work?

- Feasibility Pilot- Retrospective review in TBI (2014-2016)
- Larger Retrospective review from our STICU database
  - Primary outcomes
    - Time to feeding initiation
    - Delivery of nutrients
  - Secondary outcomes
    - LOS
    - Mortality
    - Infections
    - Glycemic control
    - Mechanical ventilation
    - Transfusions
    - Refeeding syndrome

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Feasibility Pilot Early and Adequate Feeding in the Critically Ill Brain Injured (TBI) Patient

- Retrospective review
- n=50 TBI patients ordered a volume-based feeding protocol with IM containing arginine/n3/nucleotides
- 78% of patients met protein and calorie needs by Day 5
  - 100% by Day 7

Justice J et al. CNW 2017 abstract.

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Larger Retrospective Review

Original Communication

A Volume-Based Feeding Protocol Improves Nutrient Delivery and Glycemic Control in a Surgical Trauma Intensive Care Unit

Phillip J. Prest, DO, FACOS, FACS[1,2]; Jessica Justice, RD, LDN, CNSC[1]; Nathaniel Bell, PhD[3]; Richard McCarroll, MD[1,2]; and Christopher M. Watson, MD, FACS[1,2]

aspen

Journal of Parenteral and Enteral Nutrition

WILEY

- All STICU patients (n=492)
- Ordered a volume-based feeding protocol with IM containing arginine/n3/nucleotides

Prest PJ, Justice J, et al. JPEN 2020;44(5):880-88.

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Results:

Table 1. Patient Clinical, Demographic, and Nutrition Characteristics.

Patient Data	Pre-PEP uP	Post-PEP uP	*P*-Value
Male	141 (71.6%)	202 (69.7%)	.649
Age (SD)	46.2 (18)	46.1 (17.1)	.906
STICU LOS[a]	13 (10–18)	13 (9–17)	.898
Injury severity score[a]	17 (12–25)	21 (14–26)	.008
Complication (pneumonia)	83 (42.1%)	37 (12.5%)	<.0001
Blood glucose >200 mg/dL, d	356 (14.1%)	264 (8.7%)	<.0001
Blood glucose <70 mg/dL, d	29 (1.2%)	19 (0.6%)	.037
Emesis, d	29 (1.2%)	34 (1.1%)	.93
Met/exceeded energy goal, d	678 (26.9%)	1726 (57.0%)	<.0001
Met/exceeded protein goal, d	470 (18.6%)	1737 (57.4%)	<.0001
Energy, kcal/kg/d	347.4 (476.4)	1310.4 (624.4)	<.0001
Protein, g/kg/d	18.2 (25.8)	83.6 (40.2)	<.0001
Protein deficit, g/d	100.1 (34.5)	46.9 (39.9)	<.0001

Prest PJ, Justice J, et al. JPEN 2020;44(5):880-88.

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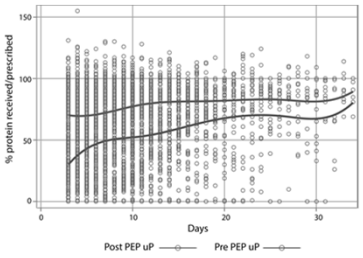
Effect of Pep uP on Protein Goal



Effect plots by PEP uP group and meeting daily protein needs over the duration of STICU length of stay.

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Odds of Meeting Protein Goal (80%)

Characteristic	OR (95% CI)	p value
Pre PEP uP	[reference]	<0.0001
Post PEP uP	11.84 (7.94 - 17.64)	

Odds ratios for meeting or exceeding 80% protein goals using the PEP uP Protocol. All models adjusted for patient injury severity and presence of complications

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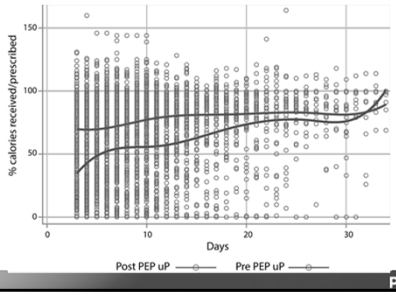
Effect of PEP uP on Caloric Goal



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Odds of Meeting Caloric Goal (80%)

Characteristic	OR (95% CI)	p value
Pre PEP uP	[reference]	<0.0001
Post PEP uP	4.98 (3.49 - 7.10)	

Odds Ratio for meeting or exceeding 80% calorie goals using the PEP uP Protocol. All models adjusted for patient injury severity and presence of complications

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VBF Results: GRV Checks and Adequacy

	Pre PEP uP	Post PEP uP GRV Checks	Post PEP uP No GRV Checks	p Value
Caloric Intake (days)				
Met 80%	695 (26.6%)	984 (55.9%)	895 (57%)	<0.0001
< 80%	1914 (73.4%)	775 (44.1%)	676 (43.0%)	
Protein Intake (days)				
Met 80%	489 (18.7%)	990 (56.3%)	900 (57.3%)	< 0.001
< 80%	2120 (81.3%)	769 (43.7%)	671 (42.7%)	

Data on file

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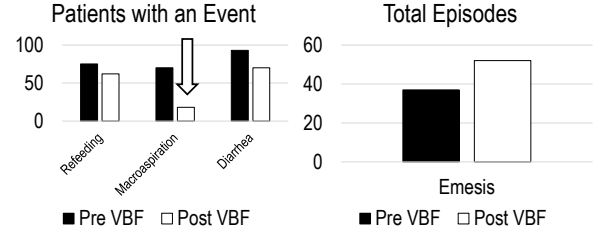
VBF Results: Safety



Prest PJ, Justice J, et al. JPEN 2020;44(5):880-88.

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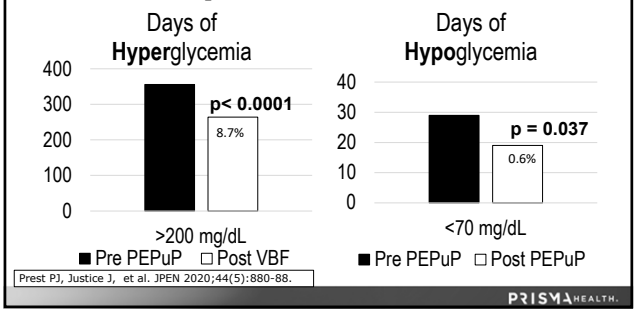
Glycemic Control



Prest PJ, Justice J, et al. JPEN 2020;44(5):880-88.

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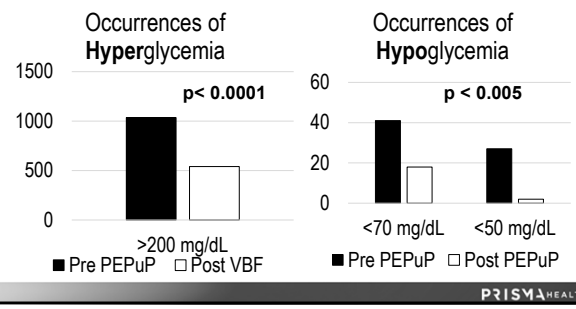
Glycemic Control



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But wait, there's more…

- More pts in the post-PEP uP group that carried the diagnosis of DM
- So it should have been worse…but it was better!

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Hyperglycemia in the ICU

Studies show hyperglycemia in the ICU can lead to poor patient outcomes:

- Higher risk of mortality
- Hyperglycemia is an independent risk factor for infections
- Blood glucose is an independent predictor of length of stay in the ICU and hospital

Corstjens AM et al. Crit Care 2006; 10(3):216. Deckers JW et al. Am J Cardiol 2013; 112(9):1306-10.
Kadri Z et al. Heart 2006; 92(7): 910-5.
Falciglia M et al. CCM 2009; 37(12):3001-9. Ingels C. Clin Microbiol Infect 2018.

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Secondary Outcomes

- No significant change in mechanical ventilation days
- No significant change in STICU LOS
- No significant change in hospital LOS
- Pneumonias reduced 42.1% pre-PEP uP and 12.5% post-PEP uP ($p<0.0001$)

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An Added Bonus: TPN Usage

	Pre PEP uP	Post PEP uP
Number of Patients	43 patients	26 patients
Days on TPN	345 days	260 days

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Study Conclusions

- PEP uP (VBF) with no GRV checks in STICU:
  - Safe
  - More effective delivery of nutrients, including immunonutrients
  - Preferentially effective at delivering protein
  - Improved glycemic control
  - Decreased use of TPN

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STICU Summary

- Feed early
- Use well-tolerated and evidence-based semi-elemental immunonutrition formula
- Form a change team and implement VBF to improve adequacy and assist blood glucose management

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So why *not* everywhere?

- Data recently published
- Need the right people
  - Strong physician leadership
  - Strong dietitian willing to actively participate
  - Strong nursing leadership with a dedicated nursing staff

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Thank you!

QUESTIONS?

Nutrition-related resources and tools are available from Nestlé Nutrition Institute:
nestlenutrition-institute.org

Visit MyCE at
MyCEeducation.com
Offering CE to dietitians and nurses

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