# Medical Nutrition Therapy in Burns

Optimizing Healing and Recovery

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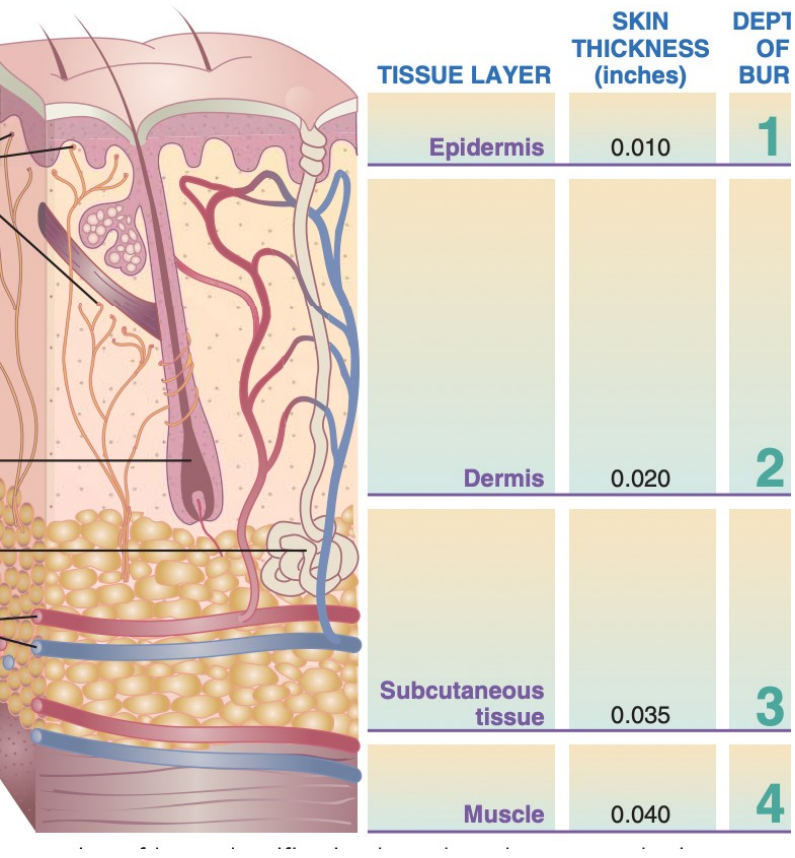
# OUTLINE

- Burn classification
- Body's Systemic Response
- Importance of Nutrition in Burn patients
- Goals of Nutritional Management
- Metabolic Changes
- Nutrition Assessment
- Macronutrient and Micronutrient Requirement
- Nutrition Intervention
- Non-nutritional Management
- Conclusion

# Burn Classification




→ **First-degree/Superficial burns.**

- Burn site: red, painful, dry, and has no blisters.

→ **Second-degree/Partial thickness burns.**

- Burn site: red, blistered, and may be swollen and painful.

→ **Third-degree/Full thickness burns.**

- Burn site: white or blackened and charred.

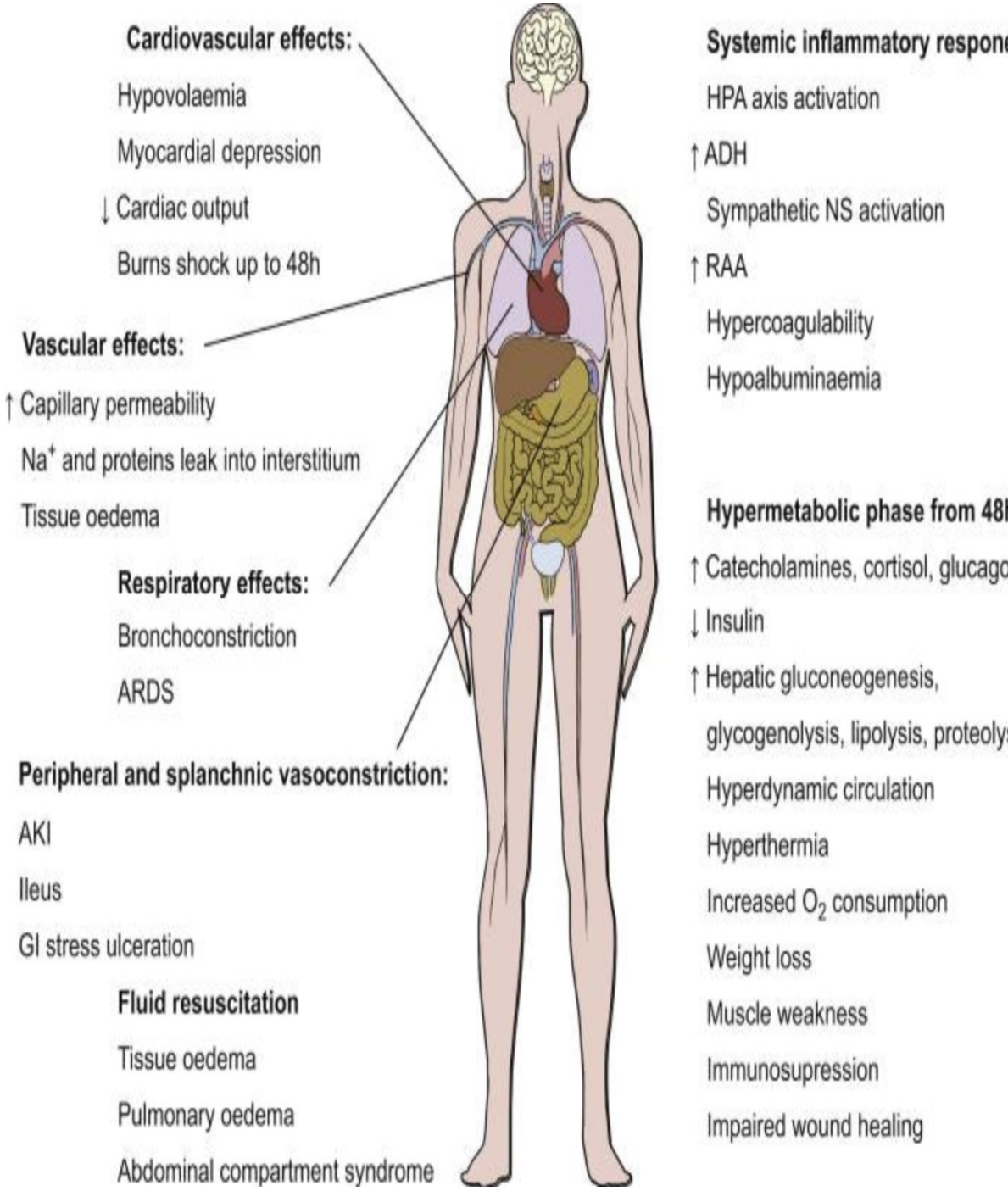
→ **Fourth-degree burns**

- Nerve endings are destroyed → no feeling in the area.

lassifications of Burns. Retrieved from https://www.urmc.rochester.edu/encyclopedia/content.aspx?ContentTypeID=90&ContentID=P09575

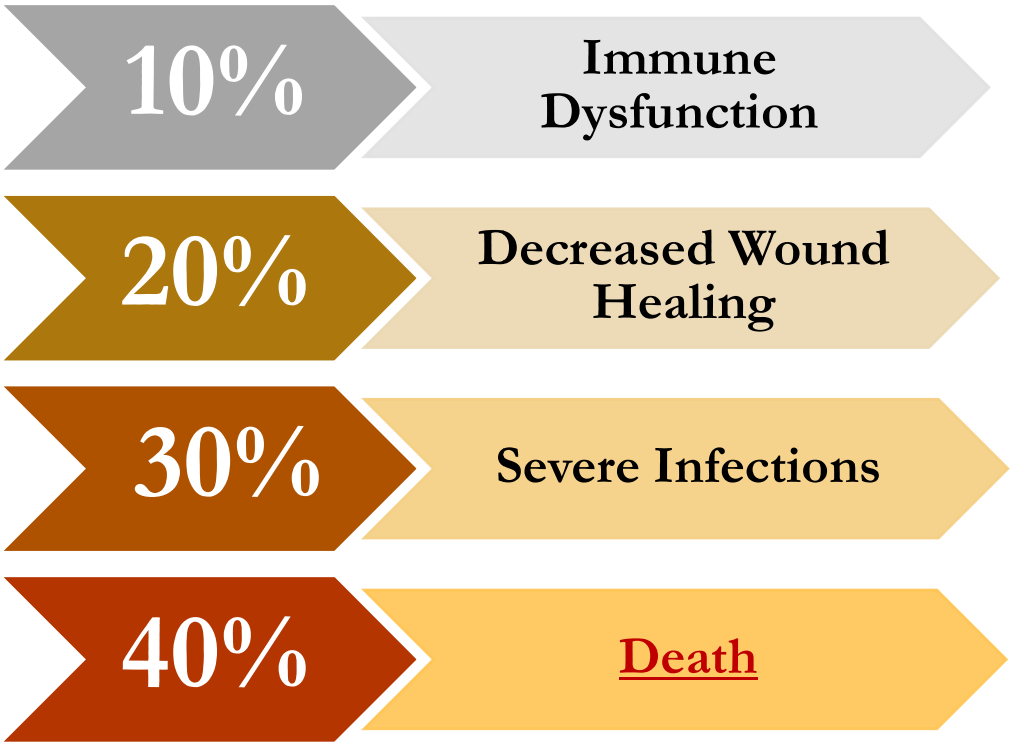
# Body's Systemic Response to Burns

est PJ;Justice J;Bell N;McCarroll R;Watson CM; (n.d.). *A ume-based feeding protocol improves nutrient delivery and glycemic control a Surgical Trauma Intensive Care Unit*. JPEN. Journal of enteral and enteral nutrition. ps://pubmed.ncbi.nlm.nih.gov/31529520/



# Importance of Nutrition in Burn Patients

- Severely burned, catabolic patients can lose **up to 25%** of pre-burn weight
- Impact of percent weight loss:




Williams, F. N., Branski, L. K., Jeschke, M. G., & Herndon, D. N. (2011). What, how, and how much should patients with Burns be fed? Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3255093 /

# Goals of Nutritional Management

A multidisciplinary approach to burn management is essential for optimal functional and cosmetic outcome to:

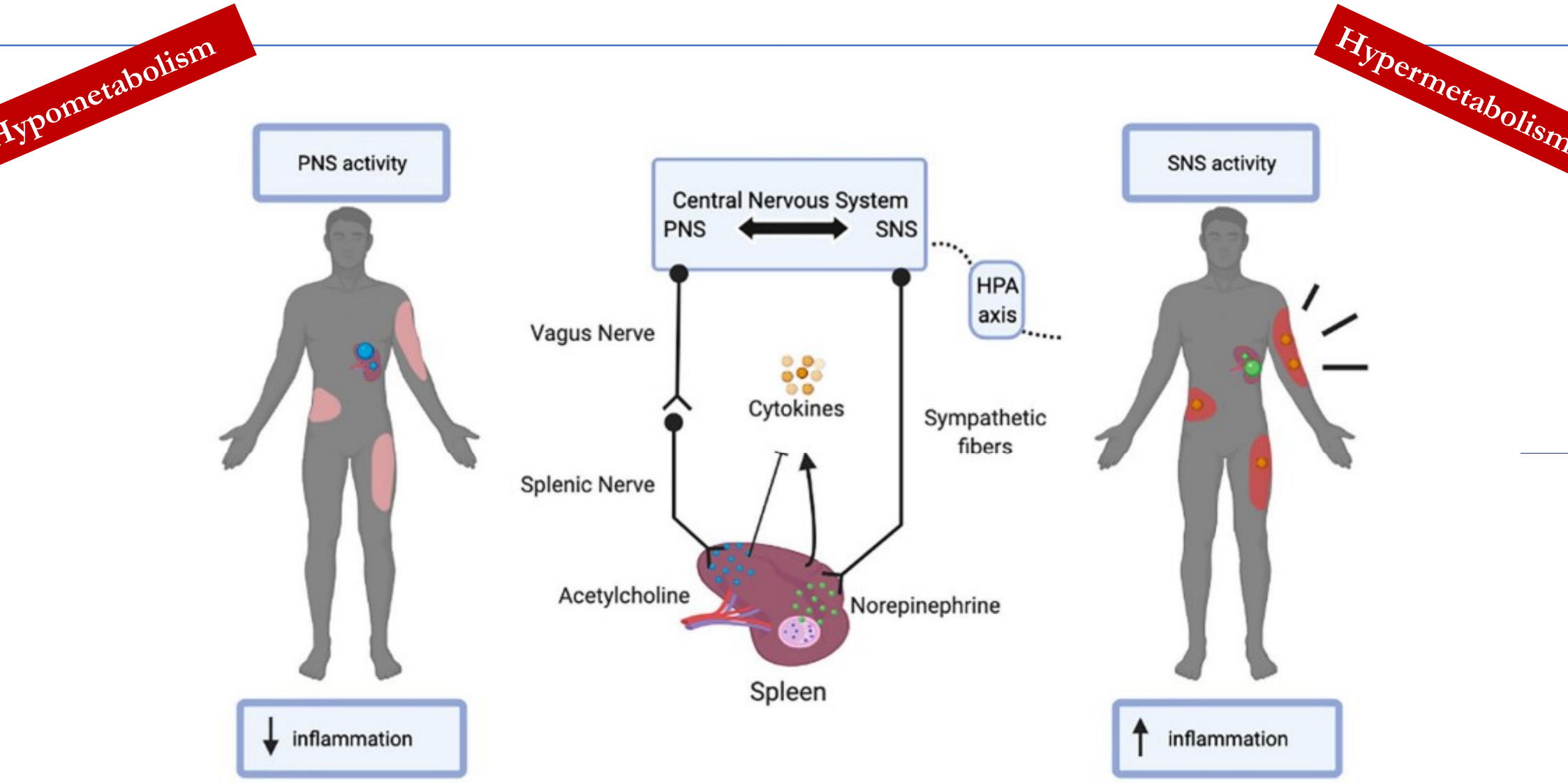
1. Promote optimal wound healing and rapid recovery from burn injuries
2. Minimize risk of complications, including infections during the treatment period
3. Attain and maintain normal nutritional status
4. Minimize metabolic disturbances during the treatment process

# Metabolic Changes

# Interesting Fact

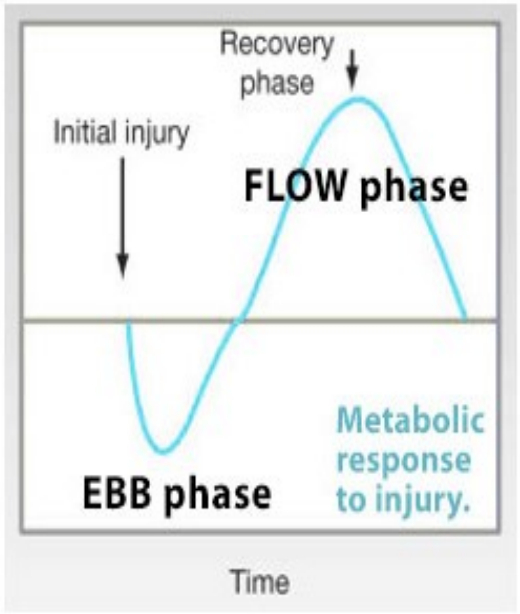
Post-burn myocardial oxygen consumption values far surpass values of a marathon runner & are well-sustained in the rehabilitation phase.

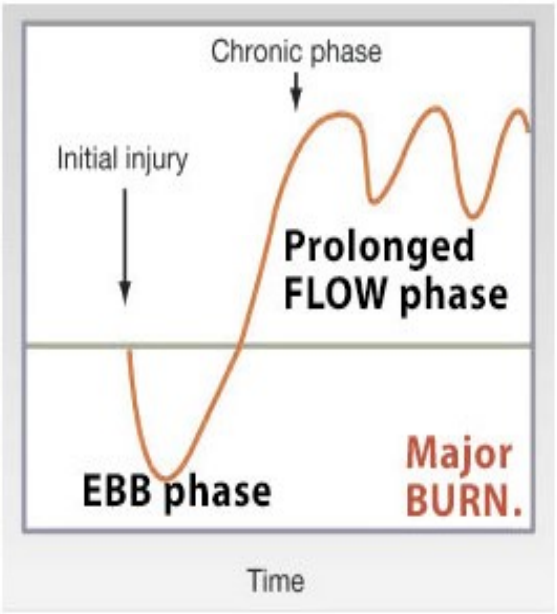

Williams, F. N., Branski, L. K., Jeschke, M. G., & Herndon, D. N. (2011, June). *What, how, and how much should patients with Burns be fed?*. The Surgical clinics of North America. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3255093/




MG;, K. N. S. C. (n.d.). CNS-spleen axis - a close interplay in mediating inflammatory responses in burn patients and a key to novel Burn therapeutics. https://pubmed.ncbi.nlm.nih.gov/34539655/

# Metabolic Changes



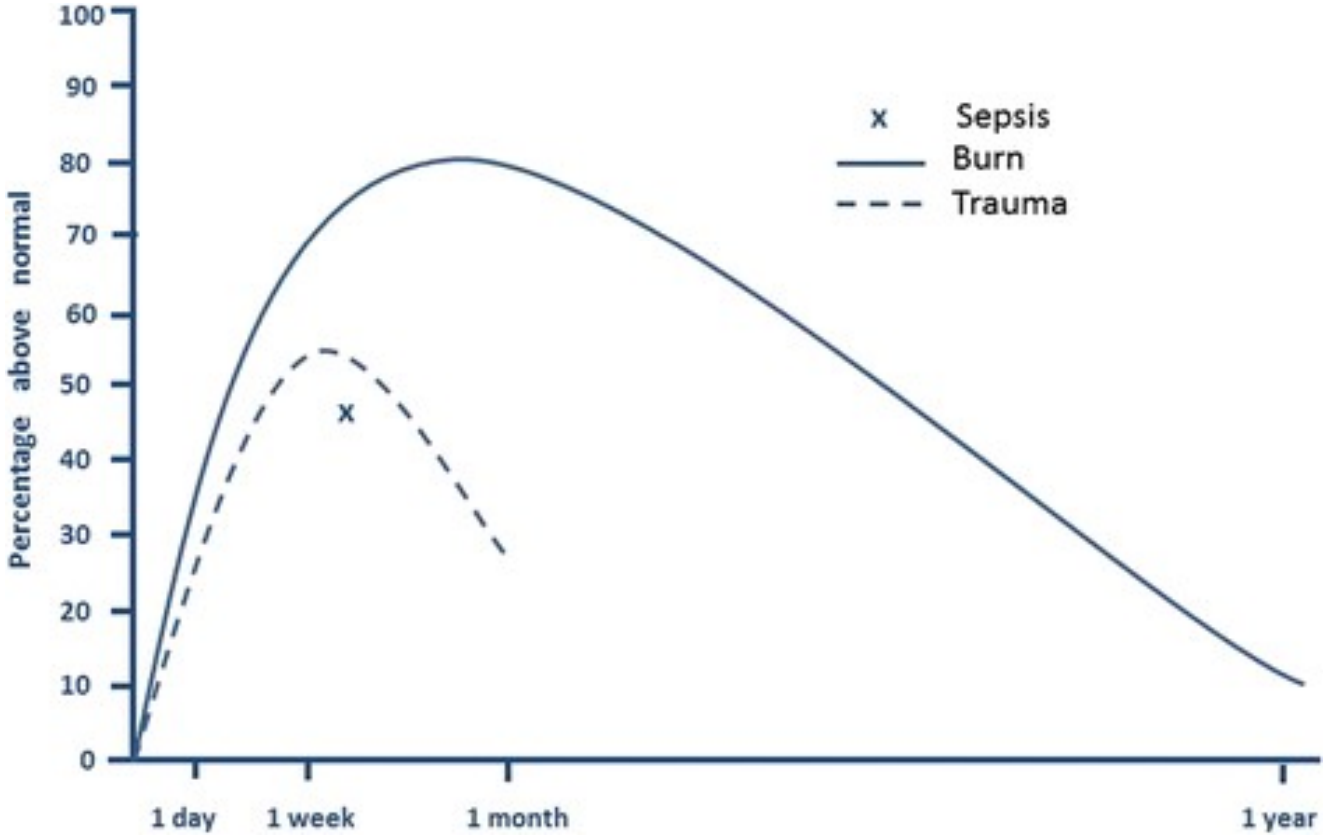




- "Ebb phase" or the burn shock: 1st 24 to 48 h after a burn
- During which, the body experiences:
  - ✓ ↓ Cardiac output
  - ✓ ↓ Tissue perfusion
  - ✓ ↓ Oxygen consumption
  - ✓ ↓ Metabolic rate
  - ✓ ↓ Body temperature
  - ✓ ↓ Stress hormones (Adrenaline & Cortiso
  - ✓ Hyperglycemia

er, B. A. (n.d.). *Critical care of the burn patient: The first 48 Hours*. Critical care medicine. https://pubmed.ncbi.nlm.nih.gov/19707133/
ns, F. N., Branski, L. K., Jeschke, M. G., & Herndon, D. N. (2011). What, how, and how much should patients with Burns be fed? Retrieved from /www.ncbi.nlm.nih.gov/pmc/articles/PMC3255093 /

# Hypermetabolic Response Post Severe Burn

The anabolic phase/hypermetabolic hyperdynamic response p
in 10-14 days after the injury after which condition slowly rec
to normal as the burn wounds heal naturally or surgically close
applying skin grafting.




Clark, A., Wolf, S. E., Madni, T., & Imran, J. (n.d.). *Nutrition and metabolism in burn patients*. Burns & trauma (2017). https://pubmed.ncbi.nlm.nih.gov/28428966/

# Metabolic Changes

Severe burns are typically followed by hypermetabolism (flow phase) characterized by:

- Hyperdynamic circulatory response
- Increased body temperature
- Glycolysis
- Proteolysis
- Lipolysis

Williams, F. N., Branski, L. K., Jeschke, M. G., & Herndon, D. N. (2011). What, how, and how much should patients with Burns be fed? Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3255093/

# Nutrition Indicators

All burn patients are at nutritional risk, especially those with the following conditions:

- Burns exceeding 25% of total body surface area
- Concomitant injury such as trauma or inhalation injury
- Chronic disease
- Elderly
- Malnourished

Nutrition Care Manual. (n.d.-b). https://www.nutritioncaremanual.org/

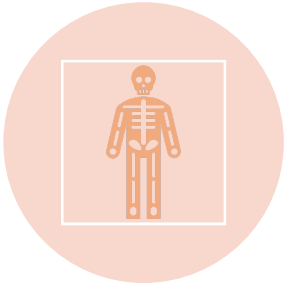
# Nutrition Assessment

# Nutrition Assessment

Components of a comprehensive nutrition assessment for individuals with burns include the following:

**Food and Nutrition-Related History**

**Anthropometric Measurements**



**Nutrition-Focused Physical Findings**

**Biochemical Data, Medical Tests & Procedures**

Nutrition Care Manual. (n.d.-b). https://www.nutritioncaremanual.org/

# Nutrition Assessment

- **Biomedical data, Medical tests, Procedures**
  - ✓ Nitrogen balance: used to evaluate adequacy of prote intake

$$\text{Nitrogen Balance} = \text{Nitrogen Intake} - \text{Nitrogen Output}$$

$$\text{Nitrogen Balance} = \frac{protein\ intake\ (g)}{6.25} - \frac{UUN}{0.8} + 4$$

Nitrogen losses through burned tissue are difficult to quanti but may be estimated based on the burn size using th following formula (Gottschlich, 1993):

| |
|---|
| < 10% open wound = 0.02 g nitrogen/kg/day |
| 11-30% open wound = 0.05 g nitrogen/kg/day |
| > 31% open wound = 0.12 g nitrogen/kg/day |

**Nitrogen losses should begin to decrease as wounds heal or eng**

Nutrition Care Manual. (n.d.-b). https://www.nutritioncaremanual.org/

# Nutrition Assessment

- **Laboratory data:**

  The following laboratory data may be helpful to monitor patients in the acute burn phase:

**Diagnostic tests are affected by hydration, clinical condition, inflammation, and hypermetabolism → albumin, prealbumin, and transferrin are NOT useful in assessing the protein intake of patients with burns.**

| Parameter | Monitoring Frequency |
|---|---|
| Electrolytes | Daily |
| BUN & Creatinine | Daily |
| Glucose | Daily |
| 24-hour urine urea nitrogen (nitrogen balance) | Weekly |

Nutrition Care Manual. (n.d.-b). https://www.nutritioncaremanual.org/


# Global Leadership Initiative on Malnutrition

Jensen GL et al.(n.d.). *GLIM criteria for the diagnosis of malnutrition: A report from the Global Clinical Nutrition Community*. JPEN. Journal of p and enteral nutrition (2019) https://pubmed.ncbi.nlm.nih.gov/30175

# Macronutrient & Micronutrient Requirements

# Energy Requirements

- Indirect Calorimetry is the **gold standard** (in fed state) to assess energy requirement at several time points during hospitalization to match the dynamic changes in nutrient needs.

  It can detect underfeeding/overfeeding through calculating the Respiratory Quotient (RQ):
  - RQ > 1.0 → Overfeeding
  - RQ < 0.7 → Underfeeding

If not available, use:

- **Children:** Schofield Equation
- **Adults:** Toronto Equation

**NO predictive equation is accurate:**

**Rapid formula (25-30 kcal/kg/day) tend to underfeed patients.**

**Curreri formula tend to overestimate calorie needs.**

Rousseau, A.-F., Losser, M.-R., Ichai, C., & Berger, M. M. (n.d.). *ESPEN endorsed recommendations: Nutritional therapy in major Burns*. Clinical nutrition (Edinburgh, Scotland) (2020) https://pubmed.ncbi.nlm.nih.gov/23582468/

# Schofield Equation

Pediatrics Population

| Age category | Equation | Requirement (kcal/day) |
|---|---|---|
| Girls 3–10 yrs | Schoffield | (16.97 × weight in kg) + (1618 × height in cm + 371.2 |
| Boys 3–10 yrs | Schoffield | (19.6 × weight in kg) + (1033 × height in cm) + 414.9 |
| Girls 10–18 yrs | Schoffield | (8365 × weight in kg) + (4.65 × height in cm) + 200 |
| Boys 10–18 yrs | Schoffield | (16.25 × weight in kg) + (1372 × height in cm + 515.5 |

# Toronto Equation

dult Population

**For all patients:**
**REE (kcal) = -4343 + (10.5 x TBSA burned) + (0.23 x kcals) +**
**(0.84 x Harris Benedict) + (114 x T (°C)) - (4.5 x days post-burn)**

TBSA = total body surface area burned;
kcals = calorie intake in past 24 hours;
Harris Benedict = basal requirements in calories using the Harris Benedict equati
with no stress factors or activity factors;
T = body temperature in degrees Celsius;
days post-burn = the number of days after the burn injury is sustained using the d
itself as day zero.

# Proteins

*Invited Review*

aspen

Nutrition in Clinic
Volume 34 Numbe
October 2019 673–
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Parenteral and En
DOI: 10.1002/ncp.
wileyonlinelibrary.
WILEY

CE PODCAST

## Energy Expenditure and Protein Requirements Following Burn Injury

**Amy K. Wise, MD; Kathleen A. Hromatka, MD; and Keith R. Miller, MD, FACS**

Dickerson et al (2012) assessed trauma patients through the **nitrogen balance** and found that **net positivity** was observed in:

- **29%** of pateints receiving 1 – 1.49 g/kg/day
- **38%** of patients receiving 1.5 – 1.99 g/kg/day
- **54%** of pateints receiving >2 g/kg/day

**If** positive nitrogen balance **alone** is sufficient to maintain lean body mass & shorten the hypermetabolic state
→ **the requirement should be > 2g/kg/d.**

Allingstrup et al (2012) examined ICU patients with sepsis and burns covering >15% TBSA which showed an:

- **Increase in mortality** when patients are provided with **low** protein and amino acid supplementation (≅ 1g/kg/day) compared to those provided with **high** protein (≅ 1.7g/kg/day)

se, A. K., Miller, K. R., & Hromatka, K. A. (n.d.). Energy expenditure and protein requirements following burn injury. https://aspenjournals.onlinelibrary.wiley.com/doi/10.1002/ncp

# Protein Requirements


Vise, A. K., Miller, K. R., & Hromatka, K. A. (n.d.).Energy xpenditure and protein requirements following burn jury(2019) ttps://aspenjournals.onlinelibrary.wiley.com/doi/10.1002/ncp.0390

ousseau, A.-F., Losser, M.-R., Ichai, C., & Berger, M. M. .d.). *ESPEN endorsed recommendations: Nutritional therapy in major urns.* Clinical nutrition (Edinburgh, Scotland( (2013) ttps://pubmed.ncbi.nlm.nih.gov/23582468/



Clinical Nutrition 32 (2013) 497–502

Contents lists available at SciVerse ScienceDirect

Clinical Nutrition

journal homepage: http://www.elsevier.com/locate/clnu


## ESPEN endorsed recommendations: Nutritional therapy in major burns☆


Anne-Françoise Rousseau [a], Marie-Reine Losser [b], Carole Ichai [c], Mette M. Berger [d,*]


**Higher than in other category of patients**

**Adults:**
**ESPEN/ASPEN:** 1.5-2 g/kg/day

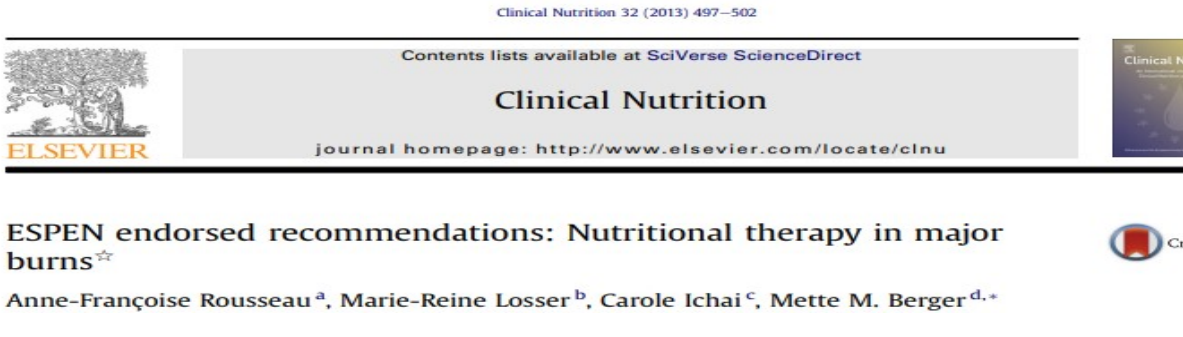
**Children:** 3 g/kg/day

**Non-protein calorie to nitrogen ratio should be maintained between:**

| % burn | protein/kgBwt/d | NPC:N ratio |
|---|---|---|
| <15 | 1.0-1.5 | 150:1 |
| 15-30 | 1.5 | 120:1 |
| 31-49 | 1.5-2 | 100:1 |
| 50+ | 2-2.3 | 100:1 |

- **Adequacy of protein intake can be evaluated by:**
  - ✓ **Wound healing of burn and donor sites**
  - ✓ **Adherence of skin grafts**
  - ✓ **Nitrogen balance**

# Carbohydrates




- Major source of energy to:
  - ✓ Provide glucose for metabolic pathways
  - ✓ Spare amino acids
- 55-60% of total energy requirements (prescribed for nutritional and drug dilution purpos without exceeding:
  - 5 mg/kg/minute in both adults and children = 7g/kg/day
- **Glucose targets:**
  - ASPEN: between 140 or 150 and 180 mg/dL = 7.8 or 8.3 – 10 mmol/L (similar to critica ill patients in general)
  - ESPEN: between 81 and 144 mg/dL = 4.5 – 8 mmol/L

Rousseau, A.-F., Losser, M.-R., Ichai, C., & Berger, M. M. (n.d.). *ESPEN endorsed recommendations: Nutritional therapy in major Burns*. Clinical nutrition (Edinburgh, Scotland). https://pubmed.ncbi.nlm.nih.gov/23582468/

McClave, S. A. et al.(n.d.). *Guidelines for the provision and assessment of Nutrition Support Therapy in the adult critically ill patient: Society of Critical Care Medicine (SCCM) and American Society for Pa Enteral Nutrition (A.S.P.E.N.)*. JPEN. Journal of parenteral and enteral nutrition. https://pubmed.ncbi.nlm.nih.gov/26773077/

# Lipids


- Minimal amounts are needed to prevent essential fatty acid deficiency
- < 35% of total energy requirements
- Monitor:
  - Total fat delivery
  - Non-nutritional lipids (from propofol) which can reach 15-30 g/day in adults

Rousseau, A.-F., Losser, M.-R., Ichai, C., & Berger, M. M. (n.d.). *ESPEN endorsed recommendations: Nutritional therapy in major Burns*. Clinical nutrition (Edinburgh, Scotland) (2013) https://pubmed.ncbi.nlm.nih.gov/23582468/

# Vitamin A

## Vitamin A-Induced Hypercalcemia in Burn Patients: A Case Study

Ferris Zeitouni, MS*,, Christina Zhu, BS, BA*, Alan Pang, MD*, Scott O'Banion, PharmD†, Deepak Bharadia, MD, MPH*, and John Griswold, MD*

*Department of Surgery, Texas Tech University Health Sciences TX, USA; †University Medical Center, Lubbock, TX, USA

Conflict of interest statement. None declared.

Address correspondence to Ferris Zeitouni, MS, Department of Tech University Health Sciences Center, 5204 CR 7940, Lub USA. Email: ferris.zeitouni@ttuhsc.edu



https://doi.org/10.1093/jbcr/irac101

## Recommendation:

Burn patients:
- BMI<18
- Who present chronically malnourished
- Age<18

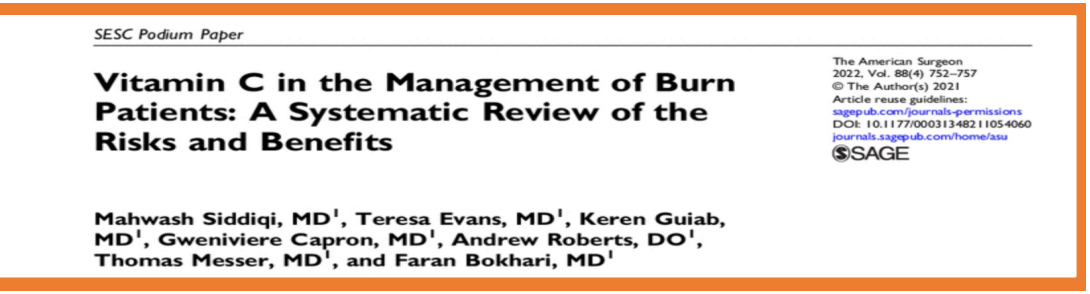
→ Half the dose of vitamin A and discontinuation once the patient's wounds are < 10% open.

✓ Clinicians should be aware of potential hypercalcemia secondary to Vitamin A overdose.

✓ It is important to assess Vitamin A levels in burn patients with asymptomatic hypercalcemia, normal PTH, & Vitamin D levels

Zeitouni F;Zhu C;Pang A;O'Banion S;Bharadia D;Griswold J; (n.d.). *Vitamin a-induced hypercalcemia in burn patients: A case study*. Journal of burn care & research : official publication of the American Association (2022). https://pubmed.ncbi.nlm.nih.gov/35867995/

# Vitamin C



SESC Podium Paper

**Vitamin C in the Management of Burn Patients: A Systematic Review of the Risks and Benefits**

The American Surgeon
2022, Vol. 88(4) 752–757
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DOI: 10.1177/00031348211054060
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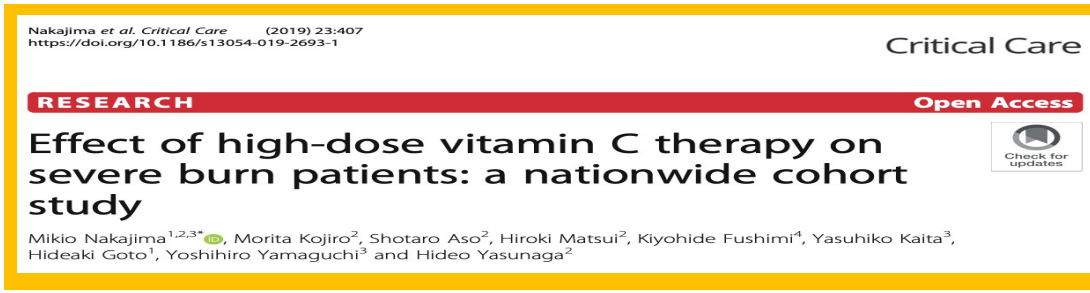
SAGE

Mahwash Siddiqi, MD[1], Teresa Evans, MD[1], Keren Guiab, MD[1], Gweniviere Capron, MD[1], Andrew Roberts, DO[1], Thomas Messer, MD[1], and Faran Bokhari, MD[1]

High-dose Vitamin C supplementation (66 mg/kg/hr):

- Decreases fluid requirements
- Improves edema, healing time, and post burn infections in adults on the first day of admission

Continuous infusion for 24 hours in 1st and 2nd degree burn (10 to 40% TBSA) **but** there is a risk of AKI and renal failure.



Nakajima *et al. Critical Care* (2019) 23:407
https://doi.org/10.1186/s13054-019-2693-1

Critical Care

RESEARCH Open Access

**Effect of high-dose vitamin C therapy on severe burn patients: a nationwide cohort study**

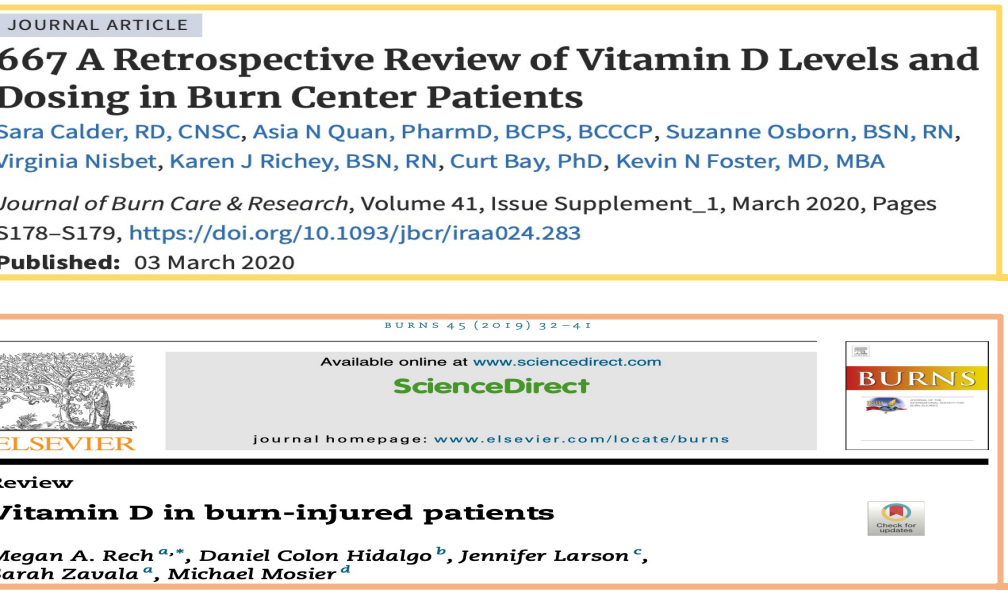
Mikio Nakajima[1,2,3*], Morita Kojiro[2], Shotaro Aso[2], Hiroki Matsui[2], Kiyohide Fushimi[4], Yasuhiko Kaita[3], Hideaki Goto[1], Yoshihiro Yamaguchi[3] and Hideo Yasunaga[2]

High-dose Vitamin C therapy was associated with **reduced in-hospital mortality** in patients with severe burns under a minimum threshold of **10 g within the first 2 days of admission.**

Siddiqi M;Evans T;Guiab K;Capron G;Roberts A;Messer T;Bokhari F; (n.d.). *Vitamin C in the management of burn patients: A systematic review of the risks and Benefits*. The American surgeon. (2022) https://pubmed.ncbi.nlm.nih.gov/34743580/

Nakajima M;Kojiro M;Aso S;Matsui H;Fushimi K;Kaita Y;Goto H;Yamaguchi Y;Yasunaga H; (n.d.). *Effect of high-dose vitamin C therapy on severe burn patients: A nationwide cohort study*. Critical care (London, England) (2019). https://pubmed.ncbi.nlm.nih.gov/31831039/

# Vitamin D



JOURNAL ARTICLE

**667 A Retrospective Review of Vitamin D Levels and Dosing in Burn Center Patients**

Sara Calder, RD, CNSC, Asia N Quan, PharmD, BCPS, BCCCP, Suzanne Osborn, BSN, RN, Virginia Nisbet, Karen J Richey, BSN, RN, Curt Bay, PhD, Kevin N Foster, MD, MBA

*Journal of Burn Care & Research*, Volume 41, Issue Supplement_1, March 2020, Pages S178–S179, https://doi.org/10.1093/jbcr/iraa024.283

**Published:** 03 March 2020

Vitamin D deficiency is present in >90% of burn patients **(profound degree)** → Vitamin D deficiency is **not** easily corrected for; taking **3 weeks** to reach therapeutic level using an **aggressive** supplementation regimen



BURNS 45 (2019) 32–41

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/burns

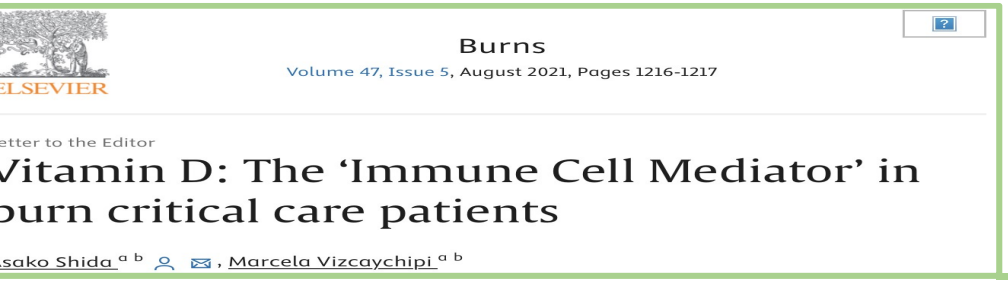
BURNS

Review

**Vitamin D in burn-injured patients**

*Megan A. Rech [a,*], Daniel Colon Hidalgo [b], Jennifer Larson [c], Sarah Zavala [a], Michael Mosier [d]*

Vitamin D supplementation is a **low-cost**, **low-risk** intervention that may be beneficial especially in **reducing length of stay**



Burns

Volume 47, Issue 5, August 2021, Pages 1216-1217

Letter to the Editor

**Vitamin D: The 'Immune Cell Mediator' in burn critical care patients**

Isako Shida [a b], Marcela Vizcaychipi [a b]

Administer Vitamin D ( safe & cheap) to all critically unwell burn patients in the UK where sunlight is limited + **Long-term** Vitamin D supplement may be required for bone homeostasis


Calder, S., Quan, A. N., Osborn, S., Nisbet, V., Richey , K. J., Bay, C., & Foster , K. N. (n.d.). *A Retrospective Review of Vitamin D Levels and Dosing in Burn Center Patients.* Academic.oup.com. https://academic.oup.com/jbcr/article/41/Supplement_1/S178/5776031

Rech MA;Colon Hidalgo D;Larson J;Zavala S;Mosier M; (n.d.). *Vitamin D in BURN-injured patients.* Burns : journal of the International Society for Burn Injuries. https://pubmed.ncbi.nlm.nih.gov/29776863/

M;, S. A. (n.d.-a). *Vitamin D: The "immune cell mediator" in burn critical care patients.* Burns : journal of the International Society for Burn Injuries. https://pubmed.ncbi.nlm.nih.gov/33840552/

# Vitamin E

## The Role of Vitamin E in Thermal Burn Injuries, Infection, and Sepsis: A Review

Marc A. Thompson, PhD,*,[] Kameel Zuniga, PhD,* Linda Sousse, PhD,* Robert Christy, PhD,* and COL Jennifer Gurney, MD†

From the *US Army Institute of Surgical Research, Con JBSA Ft. Sam Houston, San Antonio, Texas, USA; †1 Institute of Surgical Research, Joint Trauma System, San Antonio, Texas, USA

Conflict of interest statement. There are no conflicts of in
Address correspondence to Marc A. Thompson, PhD, 369 3611, JBSA Ft. Sam Houston, TX 78234, USA. Ema ctr@mail.mil



https://doi.org/10.1093/jbcr/irac100

**Findings:**

- ✓ Vitamin E supplementation has shown the ability to **alleviate stress** on skeletal muscle caused by increases in glucocorticoids
- ✓ Enteral or Parenteral Vitamin E supplementation can **prevent, mitigate, and even reverse** the effects of *thermal* burn injuries, infection, and sepsis
- ✓ **Direct application** of Vitamin E on the wound resulted in improved wound outcomes

Thompson MA;Zuniga K;Sousse L;Christy R;Gurney CJ; (n.d.). *The role of vitamin E in thermal burn injuries, infection, and sepsis: A Review*. Journal of burn care & research : official publication of the American Burn Association (2022) https://pubmed.ncbi.nlm.nih.gov/35863690/

# Vitamins


- Mainly Vitamin A, B, C, E and D + Thiamin (normalize lactate & pyruvate metabolism)
  → Intake of multivitamin once per day
- Vitamin D deficiency → osteoporosis in burn people
  ✓ Standard intake of 400 IU/day is <u>insufficient</u> & does not improve bone density
- Vitamin C and E of doses <u>1.5-3 times</u> higher than RDA → ↓oxidative stress & ↑ wound healing
  ✓ Vitamin C needs remain ↑ in acute phase → <u>Recommendation:</u> 0.5 – 1 g/day
- Vitamin A: 10,000 IU once per day

Rousseau, A.-F., Losser, M.-R., Ichai, C., & Berger, M. M. (n.d.). *Espen endorsed recommendations: Nutritional therapy in major Burns*. Clinical nutrition (Edinburgh, Scotland) (2013) https://pubmed.ncbi.nlm.nih.gov/23582468/

# Minerals

Clinical Nutrition 38 (2019) 246–251

Contents lists available at ScienceDirect

Clinical Nutrition

journal homepage: http://www.elsevier.com/locate/clnu

Original article

Trace element repletion following severe burn injury: A dose-finding cohort study

Olivier Pantet [a, *], Patricia Stoecklin [b], Mélanie Charrière [a], Pierre Voirol [c], Arnaud Vernay [d], Mette M. Berger [a]

[a] Service of Adult Intensive Care Medicine and Burns, University Hospital, Lausanne, Switzerland
[b] Department of Intensive Care Medicine, Bern University Hospital, Switzerland
[c] Service of Pharmacy, University Hospital, Lausanne, Switzerland
[d] Department of Computer Sciences, University Hospital, Lausanne, Switzerland

**Aim 1:** To check if adjusting the Trace Elements (TE) repletion plan could correct TE levels i burn patients.

**Aim 2:** To check whether patients needing continuous renal replacement therapy (CRRT) required different TE amounts.

The study spanned from 1999 to 2015, with changes made to the protocol during differen periods.

Data collection: daily TE intake and TE levels in the blood over the first 21 days in the ICU.

Pantet, O., Stoecklin, P., Charrière, M., Voirol, P., Vernay, A., & Berger, M. M. (2019). Trace element repletion following severe burn injury: a dose-finding cohort study. Clinical nutrition, 38(1), 246-251.

# Study Protocol

Clinical Nutrition 38 (2019) 246–251

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Clinical Nutrition

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Original article

## Trace element repletion following severe burn injury: A dose-finding cohort study

Olivier Pantet [a, *], Patricia Stoecklin [b], Mélanie Charrière [a], Pierre Voirol [c], Arnaud Vernay [d], Mette M. Berger [a]

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[d] Department of Computer Sciences, University Hospital, Lausanne, Switzerland

Evolution of the ICU's nutritional recommendations.

| Variable | Period 1 (99–01) | Period 2 (02–05) | Period 3 (06–10) | Period 4 (11–15) |
|---|---|---|---|---|
| Initial resuscitation | 4 ml/kg/% TBSA burned | 4 ml/kg/% TBSA burned | 2 ml/kg/% TBSA burned | 2 ml/kg/% TBSA burned |
| Energy target | MEE[a] × 1.3 | MEE[a] × 1.2 | MEE[a] (or Toronto) | MEE[a] (or Toronto) |
| Nutritive solution | Standard | Standard | Protein-enriched<br>Low fat | Protein-enriched<br>Low fat |
| Protein target | Not explicit | Not explicit | 1.3–2.0 g/kg | 1.3–2.0 g/kg |
| Enteral glutamine[e] (*Intestamin®*) | None | None | 30 g/day for 10 days (TBSA >20%) | 30 g/day for 10 days (TBSA 20–60%)<br>30 g/day for 30 days (TBSA >60%) |
| Specific burn IV trace element preparation | 1 Specific burn TE-flex[b]:<br>5 days/20–30% BSA<br>10 days/30–40% BSA<br>21 days/>40% BSA | | 1 Specific burn TE-flex[b]<br>5 days/20–30% BSA<br>10 days/30–40% BSA<br>21 days/>40% BSA | 1 Specific burn TE-flex[b]<br>5 days/20–30% BSA<br>14 days/30–60% BSA<br>30 days/>60% BSA |
| Standard ICU IV micronutrient | None | Stress profile 1[c] | Stress profile 2[d] | |
| Max total daily intravenous TE's intake | Copper 3.75 mg<br>Selenium 375 μg<br>Zinc 37.5 mg | Copper 5.05 mg<br>Selenium 507 μg<br>Zinc 54 mg | Copper 4.23 mg<br>Selenium 545 μg<br>Zinc 52.5 mg | |
| Max total daily intravenous and enteral TE's intake | No additional enteral intake except minor quantities in enteral feeds | | Additional 300 μg Se, 20 mg Zn contained in Intestamin[e]:<br>Copper 4.23 mg<br>Selenium 845 μg<br>Zinc 72.5 mg | |

The TE doses are indicated as elemental doses.

[a] **MEE** = indirect calorimetry measured energy expenditure.

[b] **Specific burn TE flex**: Cu 3.75 mg, Se 375 μg, Zn 37.5 mg.

[c] **Stress profile 1** (Indication = parenteral nutrition or acute inflammatory condition): 1 Addamel® N vial (Cu 1.3 mg, Se 32 μg, Zn 6.5 mg and 6 other TE) + 100 μg Se and 10 mg Zn.

[d] **Stress profile 2** (Indication = parenteral nutrition or acute inflammatory condition): 1 Decan® vial (Cu 0.48 mg, Se 70 μg, Zn 10 mg and 7 other TE) + 100 μg Se and 5 mg Zn.

[e] **Intestamin®** 500 ml: Glutamine 30 g, Se 300 μg and Zn 20 mg, (Fresenius Kabi, Switzerland AG).

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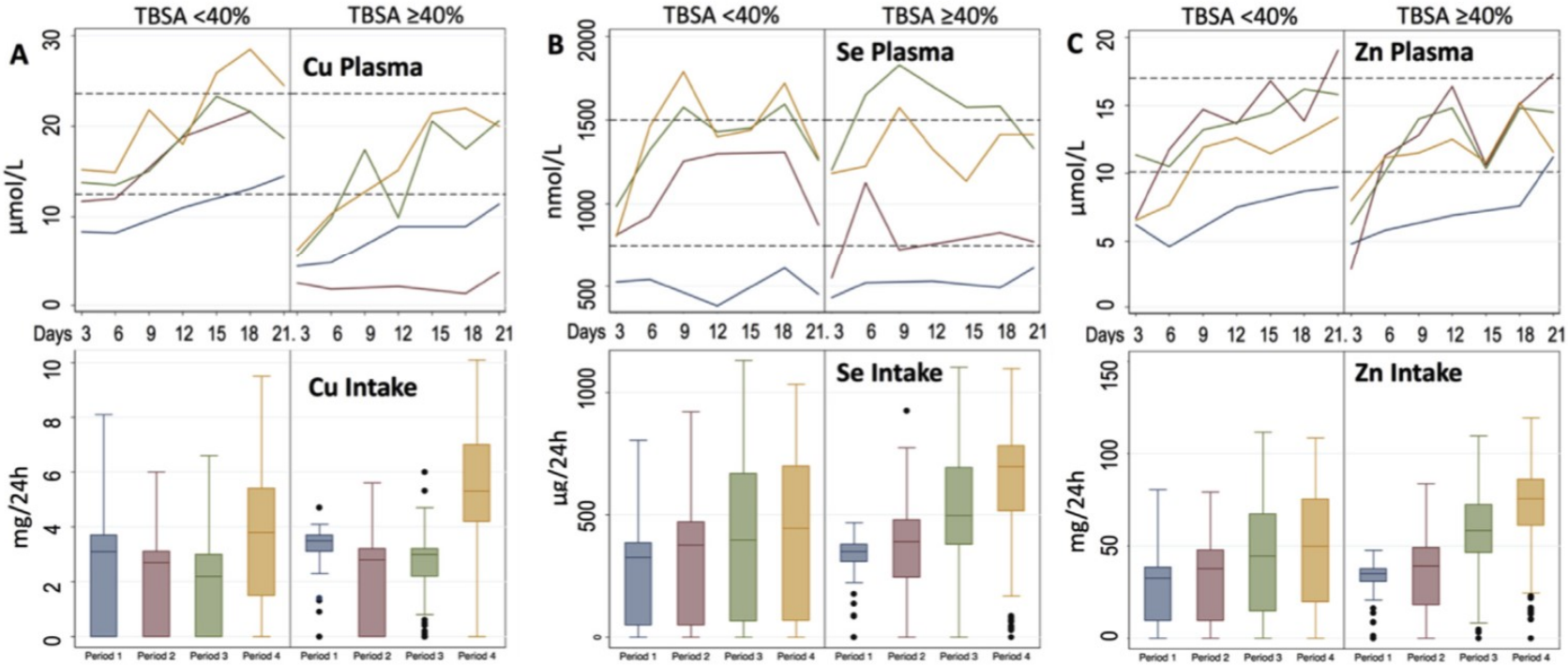


**Fig. 2.** For copper (A) selenium (B) and zinc (C):

- Median plasma concentrations of TE's concentrations over 21 days and by period, according to burn size (<or ≥40% TBSA burned). The dashed lines represent the reference values. Note the supra-normal selenium values.
- Median daily intakes by period and according to burn size. Note the increased delivery of the three elements.

Pantet, O., Stoecklin, P., Charrière, M., Voirol, P., Vernay, A., & Berger, M. M. (2019). Trace element repletion following severe burn injury: a dose-finding cohort study. Clinical nutrition, 38(1), 246-251.

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## Recommendations for Maximum Daily Intravenous Intake

**Copper (Cu): 4.77 mg**

**Selenium (Se): 273 µg**

**Zinc(Zn): 45.5 mg**

**V/S**

## RDA

**Copper (Cu): 900µg**

**Selenium (Se): 55µg**

**Zinc(Zn): 11 mg**

Pantet, O., Stoecklin, P., Charrière, M., Voirol, P., Vernay, A., & Berger, M. M. (2019). Trace element repletion following severe burn injury: a dose-finding cohort study. Clinical nutrition, 38(1), 246-251.

# Conclusion

- ✓ TE repletion is safe, with reduced infectious complications.
- ✓ Monitoring, when available, enhances precision.
- ✓ Special attention needed for patients on CRRT, requiring higher doses.

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**Table 2**
Patient characteristics.

| Variable | All periods | Period 1 (1999–01) | Period 2 (2002–05) | Period 3 (2006–10) | Period 4 (2011–15) | p-value |
|---|---|---|---|---|---|---|
| Number of patients | 139 | 11 | 29 | 57 | 42 | |
| Number of patients ≥40% BSA | 59 | 5 | 10 | 24 | 20 | |
| Age (years)[b] | 37 (28) | 50 (37) | 31 (24) | 37 (25) | 38 (30) | 0.74[c] |
| Gender (male)[a] | 94 (68%) | 7 (64%) | 19 (66%) | 35 (61%) | 33 (79%) | 0.33[d] |
| TBSA burned (%)[b] | 35 (25) | 38 (32) | 35 (23) | 35 (19) | 36 (35) | 0.32[c] |
| Full thickness burn size (%)[b] | 23 (28) | 28 (30) | 23 (17) | 20 (28) | 25 (38) | 0.36[c] |
| Inhalation injury[a] | 83 (60%) | 5 (45%) | 19 (66%) | 34 (60%) | 25 (60%) | 0.72[c] |
| ABSI score[b] | 8 (3) | 9 (2) | 9 (3) | 8 (3) | 9 (3) | 0.42[e] |
| Ryan score[b] | 1 (1) | 1 (1) | 1 (1) | 1 (0) | 1 (1) | 0.91[e] |
| Length of stay (days)[b] | 31 (35) | 34 (14) | 31 (37) | 29 (34) | 30 (35) | 0.72[c] |
| Ventilation time (days)[b] | 12 (19) | 14 (15) | 11 (14) | 9 (20) | 20 (23) | 0.06[c] |
| Number of infections per patient during 21 days[h] | 2.0 (1.2) | 2.3 (1.6) | 2.6[g] (1.3) | 1.7[g] (1.1) | 2.0 (1.2) | <0.05[c] |
| CRP medians (mg/l)[b] | 168 (125) | 180 (108) | 169 (145) | 161[g] (114) | 172[g] (139) | 0.001[e] |
| Number of patients requiring CRRT[a] | 17 (12%) | 1 (9%) | 1 (3%) | 3 (5%) | 12 (29%) | <0.05[f] |
| Mortality[a] | 16 (12%) | 2 (18%) | 2 (7%) | 5 (9%) | 7 (17%) | 0.44[f] |

[a] Numbers of patients (%).
[b] Medians (interquartile range): CRP is expressed as the median of all values of the first 21 days.
[c] Kruskal–Wallis.
[d] Chi-squared.
[e] ANOVA.
[f] Fisher's exact.
[g] Bonferroni.
[h] Mean (standard deviation).

Pantet, O., Stoecklin, P., Charrière, M., Voirol, P., Vernay, A., & Berger, M. M. (2019). Trace element repletion following severe burn injury: a dose-finding cohort study. Clinical nutrition, 38(1), 246-251.

# Minerals

Nutrients. 2022 Oct; 14(20): 4248.
Published online 2022 Oct 12. doi: 10.3390/nu14204248
PMCID: PM
PMID:

**The Extent of Burn Injury Significantly Affects Serum Micro- and Macroelement Concentrations in Patients on the First Day of Hospitalisation**

Izabela Gutowska,[1,*] Wojciech Żwierełło,[1] Krzysztof Piorun,[2] Marta Skórka-Majewicz,[1] Dominika Maciejewska-Markiewicz,[3] Patrycja Kupnicka,[4] Irena Baranowska-Bosiacka,[4] Bartosz Dalewski,[5] a Dariusz Chlubek[4]

## Findings:

- ✓ As per Gosling's study hypocupremia in one of the patients, whose burns covered 78% of TBSA, resolved on day 75, after wounds have healed → Monitor **Copper** status over the **long term.**
- ✓ **Early sufficient supplementation** of **Selenium** can restore plasma levels but with constant **monitoring** due to the high risk of **overloading**.
- ✓ The increase in **Chromium** concentration on 1st day after burn might be part of the stress response to **prevent lean body mass loss** in initial phase.

Gutowska, I., Żwierełło, W., Piorun, K., Skórka-Majewicz, M., Maciejewska-Markiewicz, D., Kupnicka, P., Baranowska-Bosiacka, I., Dalewski, B., & Chlubek, D. (2022, October 12 *extent of burn injury significantly affects serum micro- and Macroelement concentrations in patients on the first day of hospitalisation*. Nutrients. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9

# Minerals


Clinical Nutrition 32 (2013) 497–502

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journal homepage: http://www.elsevier.com/locate/clnu

ESPEN endorsed recommendations: Nutritional therapy in major burns☆

Copper, Selenium & Zinc are lost in large amounts in exudative losses.

→ Substitution should be done as follows for:

- ✓ 7-8 days for burns 20-40% TBSA
- ✓ 2 weeks for burns 40-60% TBSA
- ✓ 30 days for burns >60% TBSA

**Competition between Copper and Zinc for intestinal absorption → adminstration of enteral nutrition substitutio doses is inefficient**

usseau, A.-F., Losser, M.-R., Ichai, C., & Berger, M. M. (n.d.). *ESPEN endorsed recommendations: Nutritional therapy in major Burns*. Clinical nutrition (Edinburgh, Scotland)(2013)
ps://pubmed.ncbi.nlm.nih.gov/23582468/

# Nutrition Intervention

# Timing for Achieving Nutritional Goals

## SCCM/ASPEN:

80% of Energy and Protein goals should be met within 48 – 72 hours

## ESPEN:

NO specific timing

Chourdakis, M., Bouras, E., Shields, B. A., Stoppe, C., Rousseau, A.-F., & Heyland, D. K. (n.d.). *Nutritional therapy injured patients in the critical care setting: An international multicenter observational study on "best achievable" practices*. Clinic (Edinburgh, Scotland)(2020). https://pubmed.ncbi.nlm.nih.gov/32336526/

# Fluids and Fibers

**Fluids**

- All patients with burns covering >10% of TBSA require fluid resuscitation as per Parkland formula (Baxter, 1974)

**Fiber**

- Recommended from the start as these patients are exposed to an increased risk of constipation due to:
  - ✓ Important fluid movements
  - ✓ ↑ Doses of sedatives and opioids

Rousseau, A.-F., Losser, M.-R., Ichai, C., & Berger, M. M. (n.d.). *ESPEN endorsed recommendations: therapy in major Burns.* Clinical nutrition (Edinburgh, Scotl https://pubmed.ncbi.nlm.nih.gov/23582468/

# Route of Feeding

**Give priority to the Enteral route!**

- Early Initiation:
  - ✓ **SCCM/ASPEN**: within the first 6 hours from injury
  - ✓ **ESPEN:** within 12 hours from injury
- Early EN has shown to:

↓
- Circulating catecholamines, cortisol and glucagon
- Risk of Curling ulcer formation
- LOS
- Risk of diarrhea
- Caloric deficits

↑
- Preserve intestinal mucosal integrity, motility and blood flow
- Muscle mass maintenance, wound healing
- Insulin secretion
- Protein retention

Chourdakis, M., Bouras, E., Shields, B. A., Stoppe, C., Rousseau, A.-F., & Heyland, D. K. (n.d.). *Nutritional therapy among burn injured patients in the critical care setting: An international multicenter observat "best achievable" practices*. Clinical nutrition (Edinburgh, Scotland)(2020). https://pubmed.ncbi.nlm.nih.gov/32336526/

McClave, S. A. et al.(n.d.). *Guidelines for the provision and assessment of Nutrition Support Therapy in the adult critically ill patient: Society of Critical Care Medicine (SCCM) and American Society for Parenteral and Ent (A.S.P.E.N.)*. JPEN. Journal of parenteral and enteral nutrition. https://pubmed.ncbi.nlm.nih.gov/26773077/

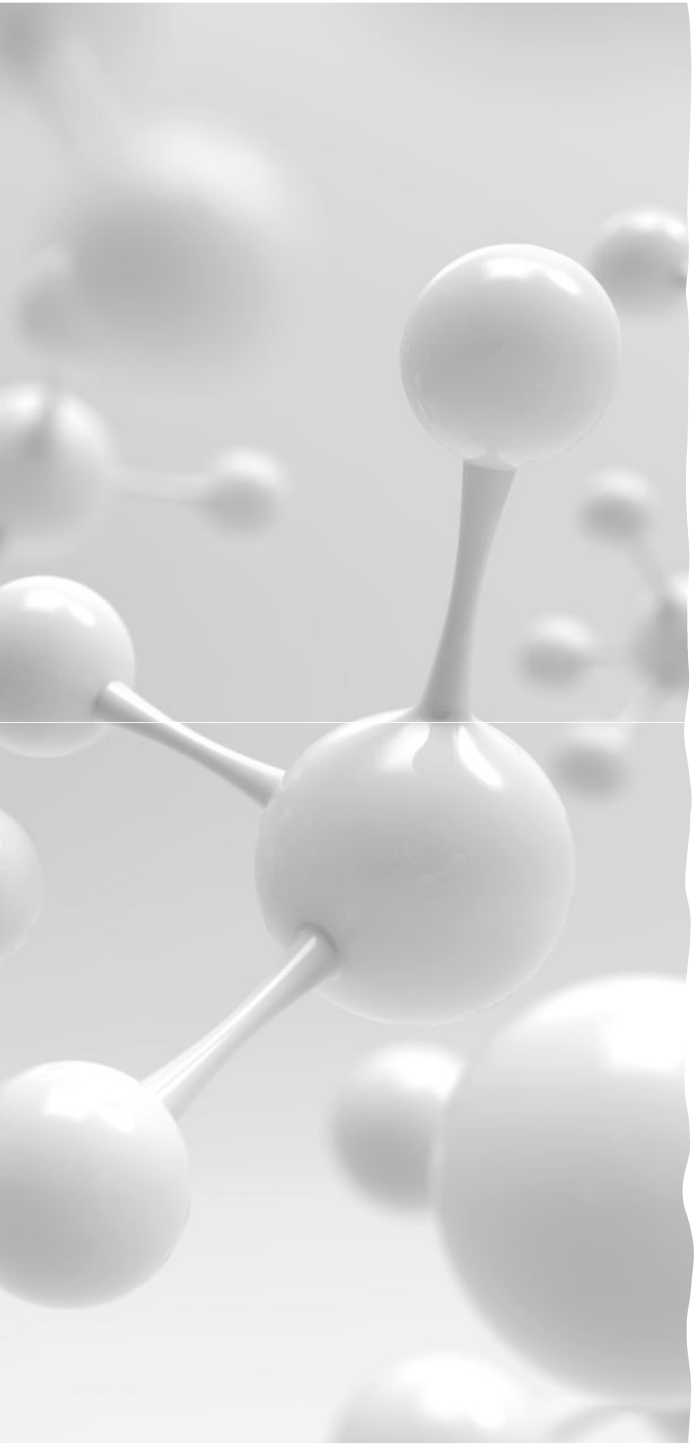
# Nutrition Support

- Volume-based feedings as recently presented by the PEPuP protocol, seems to increase the probability of meeting the nutritional goals in a safe way, also related to less episodes of hyperglycemia and lower use of PN (Prest PJ, 2019)

- Consider supplemental PN if patients are **unable** to consume more than 60% of energy and protein through enteral route or PO within 7-10 days (ASPEN, 2016)


, P. J., Justice, J., Bell, N., McCarroll, R., & Watson, C. M. (n.d.). *A volume-based feeding protocol improves nutrient delivery and glycemic control in a Surgical Trauma Intensive Care Unit.* JPEN. Jour
nteral and enteral nutrition. https://pubmed.ncbi.nlm.nih.gov/31529520/

lave, S. A. et al.(n.d.). *Guidelines for the provision and assessment of Nutrition Support Therapy in the adult critically ill patient: Society of Critical Care Medicine (SCCM) and American Society for Parenter*
*al Nutrition (A.S.P.E.N.).* JPEN. Journal of parenteral and enteral nutrition. https://pubmed.ncbi.nlm.nih.gov/26773077/



# Immune-Enhancing Formulas

Some of the specific nutrients utilized in the nutrition support of burn patients are as follows:

- Glutamine
- Arginine
- Omega-3 fatty acids

Nutrition Care Manual. (n.d.-b). https://www.nutritioncaremanual.org/

REENERGIZE

# Glutamine

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

## A Randomized Trial of Enteral Glutamine for Treatment of Burn Injuries

Daren K. Heyland, M.D., Lucy Wibbenmeyer, M.D., Jonathan A. Pollack, M.D., Bruce Friedman, M.D., Alexis F. Turgeon, M.D., Niknam Eshraghi, M.D., Marc G. Jeschke, M.D., Sylvain Bélisle, M.D., Daisy Grau, M.D., Samuel Mandell, M.D., M.P.H., Sai R. Velamuri, M.D., Gabriel Hundeshagen, M.D., M.M.S., Naiem Moiemen, M.D., Kayvan Shokrollahi, F.R.C.S.(Plast.), Kevin Foster, M.D., Fredrik Huss, M.D., Declan Collins, M.D., Alisa Savetamal, M.D., Jennifer M. Gurney, M.D., Nadia Depetris, M.D., Christian Stoppe, M.D., Luis Ortiz-Reyes, M.Sc., Dominique Garrel, M.D., and Andrew G. Day, M.Sc., for the RE-ENERGIZE Trial Team*

The largest international, multicenter, double-blind, pragmatic, rando controlled trial:

Aim: Clarify the effects of glutamine in burn patients

Inclusion criteria: deep 2nd or 3rd degree burns (>10-20% TBSA)

Method:

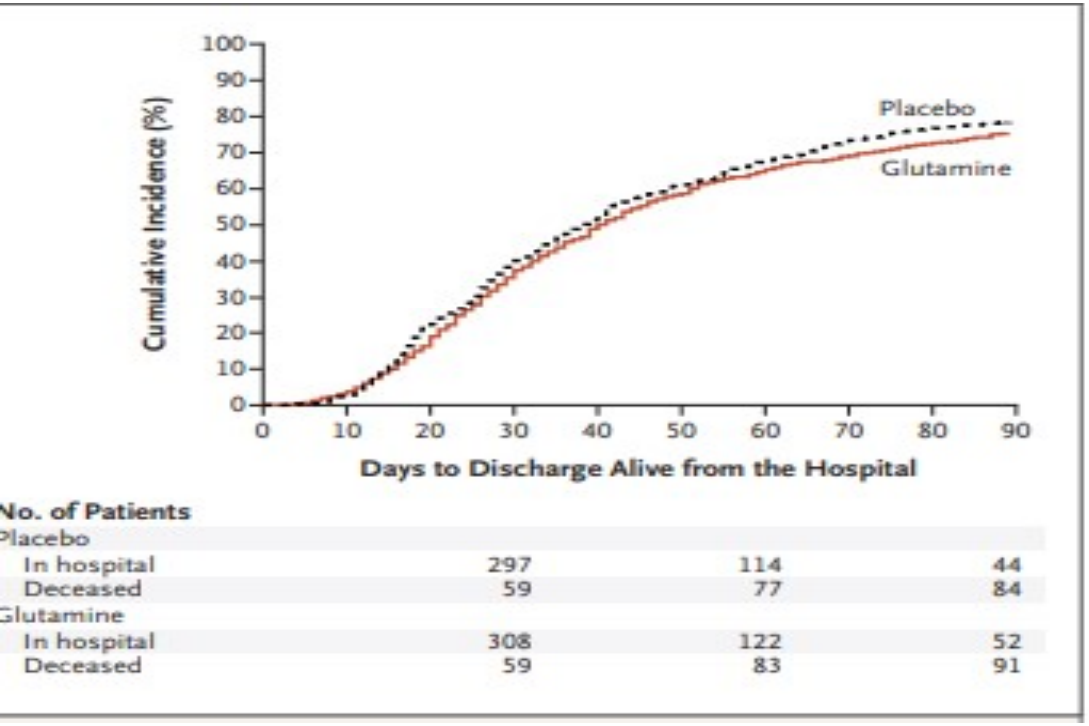
- Administration within 72 hours after hospital admission 0.5g/l enterally delivered glutamine or placebo
- Given Q4h through a feeding tube or 3-4 times/day by mouth, unti
  - 7 days after the last skin grafting procedure
  - 7 days after discharge from the acute care unit
  - 3 months after admission
- Primary outcome: Time to discharge alive from the hospital

Heyland et al., 2022 (n.d.). *A randomized trial of enteral glutamine for treatment of burn injuries*. The New England journal of medicine. https://pubmed.ncbi.nlm.nih.gov/36082909/

# Results

1209 patients with severe burns (mean burn size 33% of TBSA)

1200 patients included in the analysis




| No. of Patients | | | |
|---|---|---|---|
| Placebo | | | |
| In hospital | 297 | 114 | 44 |
| Deceased | 59 | 77 | 84 |
| Glutamine | | | |
| In hospital | 308 | 122 | 52 |
| Deceased | 59 | 83 | 91 |

| Analysis | Glutamine (N=596) | Placebo (N=604) | Subdistribution Hazard Ratio (95% CI)* | P Val |
|---|---|---|---|---|
| Primary analysis: median no. of days to discharge alive from the hospital (IQR) | 40 (24–87) | 38 (22–75) | 0.91 (0.80–1.04)† | 0.1 |
| Secondary analysis stratified according to site | | | 0.89 (0.78–1.02) | 0.0 |
| Secondary analysis with site as a random effect | | | 0.88 (0.77–1.00) | 0.0 |
| Secondary analysis with site as a random effect and with adjustment for age, APACHE II score, baseline SOFA score, burn size, Charlson co-morbidity index score, and geographic region | | | 0.92 (0.81–1.05) | 0.2 |

**In patients with severe burns, supplemental glutamine did not reduce the time to discharge from the hospital**

Heyland et al., 2022 (n.d.). *A randomized trial of enteral glutamine for treatment of burn injuries*. The New England journal of medicine. https://pubmed.ncbi.nlm.nih.gov/36082909/

# Glutamine

- Conditionally essential for burn patients
- The favorite substrate for lymphocytes & entercocytes preserve small bowel integrity & gut-associated immu function
- ESPEN:
  - ✓ Till now, no precise dose, route, or duration adminstration (inconclusive studies)
  - ✓ Dose for other critical patients: 0.3 g/kg/day during 5- days
  - ✓ Ornithine alpha-ketoglutarate (precursor of glutamir can be used as an alternative to glutamine
    - Dose: 30g divided into 2 to 3 boluses daily
- ASPEN:

**✗ Recommends against glutamine supplementation**

Rousseau, A.-F., Losser, M.-R., Ichai, C., & Berger, M. M. (n.d.). *ESPEN endorsed recommendations: Nutritional therapy in major Burns*. Clinical nutrition (Edinburgh, Scotland). https://pubmed.ncbi.nlm.nih.gov/23582468/

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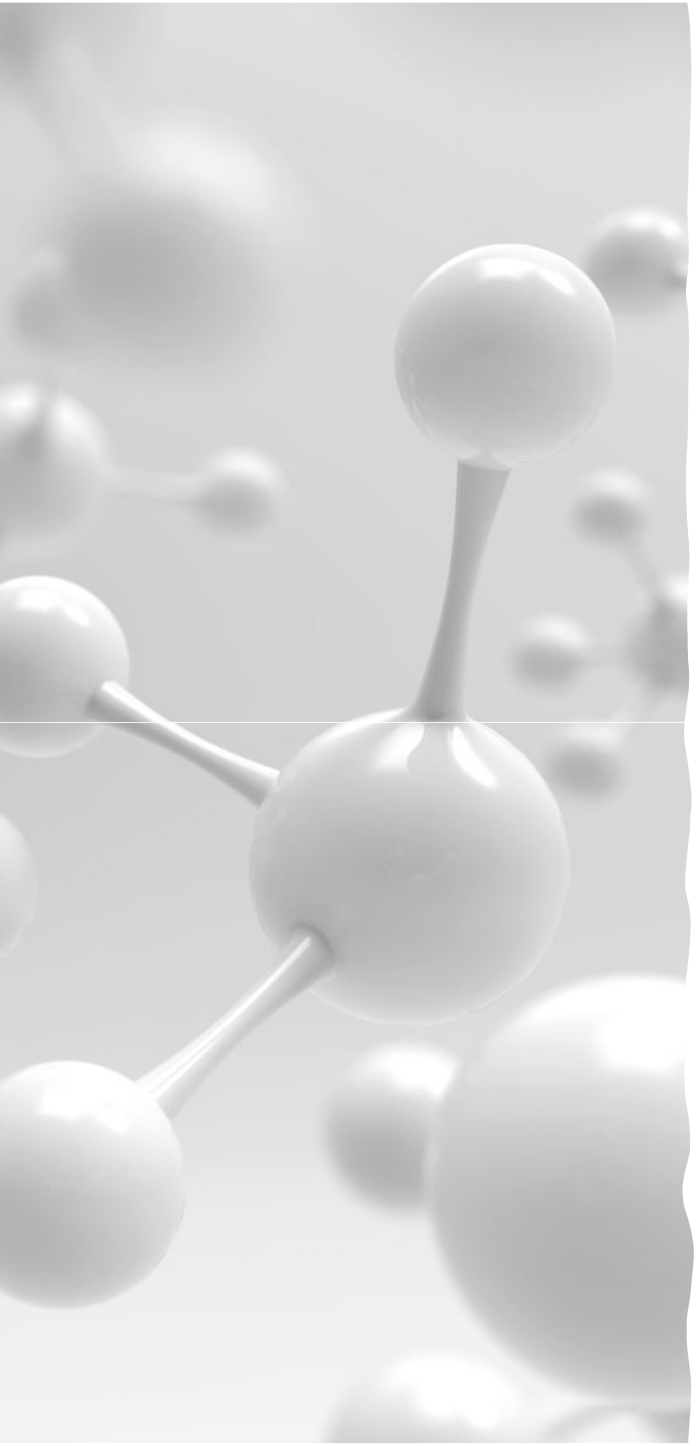

# Immune-Enhancing Formulas

- The addition of arginine, glutamine, and omega-3 fatty acids to enteral formulas has been evaluated in clinical trials, but it remains controversial (Gottschlich, 1990b; Saffle, 1997).

- The benefits of arginine supplementation have not been clearly elucidated, though they appear to be beneficial in trauma and surgical patients but may be harmful in septic patients (Zaloga, 2004; McClave, 2016).

McClave, S. A. et al.(n.d.). *Guidelines for the provision and assessment of Nutrition Support Therapy in the adult critically ill patient: Soc Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.).* JPEN. Journal of parentera enteral nutrition(2016). https://pubmed.ncbi.nlm.nih.gov/26773077/

# Non-Nutritional Management of Hypermetabolism

# Non-nutritional Management of Hypermetabolism

- Maintenance of nursing environmental temperature at 28-30℃ (warm ambient temperature)
- Early excision & coverage of deep burn wounds
- Pain control
- Early institution of exercise therapy
- Adminstration of agents stimulating protein synthesis such as
  - Non-selective beta-blockers (Propranolol)
  - Oxandrolone

ousseau, A.-F., Losser, M.-R., Ichai, C., & Berger, M. M. (n.d.). *ESPEN endorsed recommendations: Nutritional therapy in major Burns*. Clinical nutrition (Edinburgh, Scotlan
tps://pubmed.ncbi.nlm.nih.gov/23582468/

# Oxandrolone

- A synthetic androgen, at a dose of 10 mg/12 hours for adults and 0.1 mg/kg/12 hours for children, resulted in:

  - ↓ Mortality
  - ↓ Length of stay
  - ↓ Weight loss
  - ↓ Healing time

  - ↑ Bone metabolism
  - ↑ Protein synthesis efficiency

- However, its adminstration require close monitoring of liver function

ousseau, A.-F., Losser, M.-R., Ichai, C., & Berger, M. M. (n.d.). *ESPEN endorsed recommendations: Nutritional therapy in major Burns*. Clinical nutrition (Edinburgh, Scotland
tps://pubmed.ncbi.nlm.nih.gov/23582468/

# Propranolol

- Non-selective beta-blockers; best results in children but less significant in adults
- Benefits:
  - ↓ HR & metabolic rate
  - ↓ Cytokines
  - ↓ Release of stress hormones
  - ↓ Both hypermetabolism & hypercatabolism
  - ↑Peripheral lean body mass accumulation

<u>Recommendation:</u> Start adminstration after resuscitation phase,

1. Propranolol at the end of the first week
2. Oxandrolone a little later for

Rousseau, A.-F., Losser, M.-R., Ichai, C., & Berger, M. M. (n.d.). *ESPEN endorsed recommendations: Nutritional therapy in major Burns*. Clinical nutrition (Edinburgh, Scotl
https://pubmed.ncbi.nlm.nih.gov/23582468/

# Recombinant Human Growth Hormone (rhGH)

- Its adminstration is **not** recommended in adults (increased mortality) but in children it is effective
- At a dose of 0.05-0.2 mg/kg/d it showed to:
  - ↑ Donor site healing
  - ↑ Lean body mass accretion
  - ↓ Hypermetabolism & growth deficit

**BUT** duration of treatment is still to be determined (as per some studies, treatment up to 1 year has shown to be safe)

ousseau, A.-F., Losser, M.-R., Ichai, C., & Berger, M. M. (n.d.). *ESPEN endorsed recommendations: Nutritional therapy in major Burns*. Clinical nutrition (Edinburgh, Scotland
tps://pubmed.ncbi.nlm.nih.gov/23582468/

# Take Home Message!

- ✓ Energy requirements are **elevated** by the burn injury
- ✓ Protein requirements are substantially **increased**

} associated with **healing and immune function**

- ✓ Wound healing process can be used to assess protein adequacy
- ✓ Maintain **weight within 5 % - 10 %** of pre-burn weight
- ✓ Prevent signs and symptoms of **micronutrient deficiency**
- ✓ Minimize **hyperglycemia** and **hypertriglyceridemia**
- ✓ Provide nutrition support via **enteral route** as early as possible, within 6 - 18 hours post burn injury, through a high–protein, high–carbohydrate formula





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