Nutrition Requirements in the Adult Burn Population

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1

Disclosures

- The views and opinions expressed in this presentation are mine and do not necessarily represent official policy or position of Massachusetts Academy of Nutrition and Dietetics, the Academy of Nutrition and Dietetics, and Massachusetts General Hospital
- I have no financial interest in any products or research described in this presentation

2

Learning Objectives

1. The participant will be able to describe the metabolic changes after burn injury.
2. The participant will be able to determine appropriate calorie and protein needs in severe burn injury
3. The participant will be able to identify common vitamins and minerals required for wound healing

3

Agenda

- Overview of patient population
- Introduction to the skin and thermal injury
- Metabolic changes in response to burn
- Nutrition Care Process
- Case Study

4

Massachusetts Fire Facts 2020

- 369 burn injuries required medical treatment
  - 76% occurred at home or surrounding yard
  - 51% of injuries were scald, 18% of these from cooking liquid
  - 5% (11) of home related injuries resulted in death
- Children under 5 years old accounted for 48% of 162 scald injuries
- Campfires or bonfires caused 52% of all burn injuries from fire

2012 https://www.mass.gov/doc/2020-m-birs-annual-report/downloadM-BIRS Annual Report (mass.gov)

5

Burn injury by age

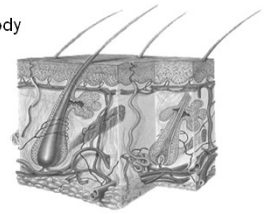
- < 4 y/o — Residential
  - *scald, contact*
- 5-14 y/o — Residential
  - *cooking, risk taking*
- 15-65 y/o — Work related
  - *risk taking, SUD*
- > 65 y/o — Residential
  - *scalds, cooking, accidents, comorbidities*

6

Function of the Skin

The largest organ of the human body

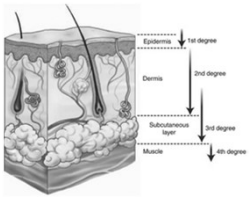
- Protection
- Temperature regulation
- Sensation
- Absorption
- Secretion



7

Basics of Burn Classification

- 1st degree
  - Only involves epidermis
  - Heal on their own in 3 to 4 days
- 2nd degree
  - Involve epidermis and dermis
  - Take +/-3 weeks to heal
  - Deep 2nd degree burns will require grafting
- Full thickness
  - Require excision and grafting



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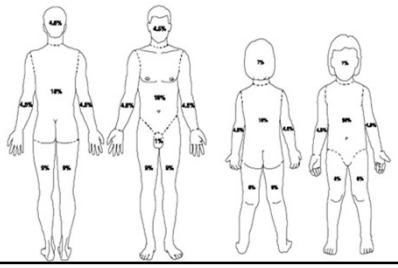
Lund Browder Burn Diagram TBSA% -The Rule of Nine's



9

Burn Management Goals

- Effective, timely wound healing
  - *Early excision and grafting*
- Prevention of infection
- Prevention of drying
- Patient comfort
- Ease of dressing changes
- Nutrition
  - *PO*
  - *Enteral*
  - *TPN*

10

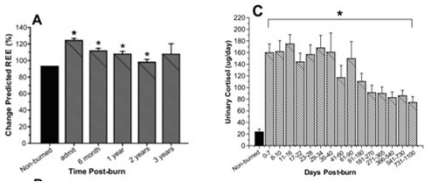
Burn Management: Nutrition

- Primary goal of burn management is to reduce the metabolic rate to preserve lean body mass and reduce risk of death
- Major (greater than 15 to 20% TBSA) burn injury initiates a cascade of hormones that increase metabolic rate
- The metabolic response occurs in 2 phases
  - *Ebb occurs within first 72hours of burn injury*
    - Notable for decrease in metabolic rate, impaired glucose intolerance
  - *Flow occurs more than 72hours post burn, peaks in 5-7 days, lasts up to 12months*
    - Notable for increased metabolic rate, increased cardiac output, insulin resistance, increased catabolism
- 10 to 50 fold increase in catecholamines and corticosteroids can last from 9 months to 3 years post burn

11

Prolonged stress response

- Large prospective study
- 977 children with thermal injury, average 50% TBSA
- Compared to healthy cohort

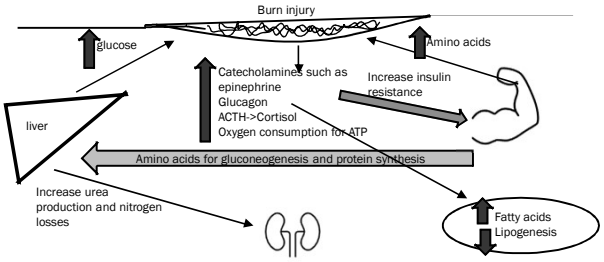


Jeschke et al. (2011) PLoS ONE 6(7): e21245. doi:10.1371/journal.pone.0021245

12

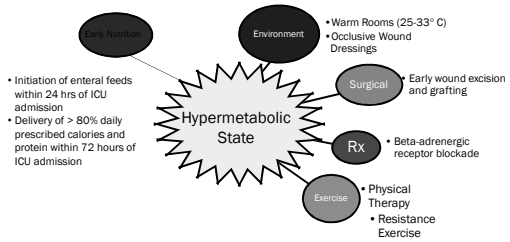
Metabolic response to burn

Primary fuel source is glucose



13

Mitigators of Hypermetabolism



14

Nutrition Care Process

15

Nutrition Screen and Assessment

- All burn patients are at nutritional risk. Of greatest concern are:
  - Burns exceeding 25% TBSA
  - Concomitant injury (trauma, inhalation injury)
  - Presence of chronic disease
  - Elderly
  - Malnourished
- Consider circumstances that impact nutrition status on admission
  - -Recent weight loss, poor calorie intake
  - -Food allergies, intolerances or restricted diets
  - -Food insecurity

16

Nutrition Prescription: Estimating Calorie Needs

- Gold standard for estimating energy needs is indirect calorimetry (IC).
- Indirect calorimetry is measurement of oxygen consumption and carbon dioxide production to calculate resting energy expenditure and RQ.
- Data collected is used in the abbreviated Weir equation:
  - REE=[3.0(VO2)+1.1(VCO2)]x1.44
- Determine RQ to assess validity of study VCO2/VO2
  - Ethanol 0.67
  - Fat oxidation 0.71
  - Protein oxidation 0.82
  - Mixed substrate oxidation 0.85
  - Carbohydrate oxidation 1.0
  - Lipogenesis 1.0 - 1.2

17

Indirect Calorimetry

- Obtain measurement when patient is in a steady state before nursing/wound care.
- Consider factors that affect steady state and accurate measurement
  - Leaks in the sampling system, chest tube, broncho-pleural fistula
  - Hyperventilation
  - FiO2 over 60, or unstable FiO2
  - CVVH (although may only account for 3% difference, Jonckheer et al. 2020)
- Apply activity factor to REE to determine total energy expenditure

Matarese, 1997.

18

Estimating Calorie Needs in Burns

- Nutrition Care Manual recommends 15 to 20% activity factor
- Royall et al, Critical Care Medicine (1994).
  - *Cohort study in Toronto*
  - *20 adult patients, average 36% TBSA*
  - *IC measured for 24h*
  - *Activities tracked and REE measured*

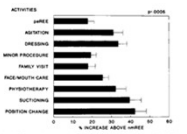


Figure 2. Percent increase in energy expenditure above baseline (night and morning) resting energy expenditure (mREE) during activities. Postevent resting energy expenditure (peREE) and all activities produced a significantly increased energy expenditure compared with mREE ($p < .0005$). Data are mean ± SEM.

Table 1. Energy expenditure during activities (mean ± SEM)

Activity	$\dot{V}O_2$ (mL/min)	$\dot{V}CO_2$ (mL/min)	Respiratory Quotient	Energy Expenditure (kcal/day)	Duration (hr)
Total	359 ± 18	320 ± 14	0.90 ± 0.03	2492 ± 120	19 ± 6
Total REE	335 ± 17	299 ± 14	0.90 ± 0.03	2319 ± 118	9.8 ± 0.4
Postevent REE	403 ± 22	327 ± 14	0.92 ± 0.03	2500 ± 116	3.1 ± 0.2
Agitation	393 ± 26	347 ± 21	0.90 ± 0.04	2716 ± 177	1.8 ± 0.2
Dressing	408 ± 21	355 ± 16	0.88 ± 0.03	2814 ± 142	1.0 ± 0.2

19

Estimating Calorie Needs

- In absence of IC, ESPEN recommends the Toronto Formula
- Allard et al 1990 JPEN
- Prospective study of 10 adult patients, average 49% TBSA burn injury

Table II
Estimated and measured energy expenditures

	Estimated EE (EEE) (kcal/day)	Measured EE (MEE) (kcal/day)	p value <	EEE/MEE %
EBEE	1608 ± 55	2627 ± 65	0.001	61 ± 4
Mod. Curreri	3542 ± 41	2627 ± 65	0.001	135 ± 2
TF	2542 ± 57	2537 ± 86	NS	100 ± 3
2 × EBEE	3260 ± 45	2765 ± 101	0.001	124 ± 2

- There is no consensus on how to feed the critically ill obese adult with a burn

20

Pediatric Equations in absence of IC

- ESPEN recommends using Schoffield equation

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

Suggest stress factor: 1.2 for less than 10% TBSA, 1.3 for 10-20% TBSA, 1.5 for 20-40% TBSA, 1.7 for 40-60% TBSA, and 2 for >60% TBSA

Rousseau et al. 2013. Clinical Nutrition. 32 (497-502).

21

Protein Requirement

- Aim for 20% of calories from protein, range 1.5g to 2g/kg for adults, 3g/kg for children (Rousseau, 2013)
- Based on INS data, 14 burn centers surveyed
- Average prescribed target of 1.8g/kg, mean intake 1.2g/kg per patient days (67% of goal)

Table 4
Prescribed (goal) versus received energy and protein.

	Targeted, mean (SD) n = 283 patients	Received, mean (SD) n=2849 patient-days	Site average n=14 sites	Best site	Worst site
Energy requirements, kcal/d	2648.4 (738.8)	1717.9 (1149.0)	1657.9	2418.4	1145.1
Protein requirements, g/d	149.1 (52.1)	98.0 (72.7)	92.7	159.5	68.5
Energy per kg of BW, kcal/kg/d	32.3 (9.2)	21.1 (14.5)	20.7	29.0	14.1
Protein per kg of BW, kcal/kg/d	1.81 (0.61)	1.2 (0.86)	1.15	1.79	0.85
Nutritional adequacy for energy, %	N/A	64.9 (40.0)	65.3	80.2	42.0
Nutritional adequacy for protein, %	N/A	65.6 (42.1)	65.4	87.3	43.6

BW: Body Weight; SD: Standard Deviation.

Chourdakis, M et al (2020). Nutritional therapy among burn injured patients in the critical care setting: An international multicenter observational study on "best achievable" practices. *Clinical Nutrition*, *39*(12). 3813-3820.

22

Fluid Requirement for Resuscitation Parkland Formula

- Typically > 20 % TBSA
- Ringer's lactate
- 2-4ml / kg / % TBSA
- 24 hours
- ½ in 1st 8 hours
- ½ in next 16 hours
- Second and third degree only
- May need adjustment for inhalation injury

23

Micronutrients in burn injury

- Decreased levels of Vitamin A, C, D, Fe, Cu, Se, Zn have been shown to impair wound healing
- Remember that plasma nutrient values are measuring circulating levels and may be influenced by inflammatory state so may not reflect true nutrient status and functional capacity
- ESPEN recommends considering supplementation with zinc, copper, selenium, Vitamin B1, C, D, E (Grade C evidence, strong agreement)

Rousseau et al. 2013. Clinical Nutrition. 32 (497-502).

24

Trace element supplementation

- Berger et al. Critical Care. 2006
- Double blinded supplementation, total 41 patients, mean age 40, mean 46% TBSA burn
- Intervention consisted of intravenous trace element supplements (copper 2.5 to 3.1 mg/day, selenium 315 to 380 µg/day, and zinc 26.2 to 31.4 mg/day) for 8 to 21 days versus placebo
- Reduction of infectious complications

Table 4

Infectious complications

Type of infection	Supplemented group (n = 21) Number of patients per number of episodes (mean episodes ± SD per patient)	Placebo group (n = 20) Number of patients per number of episodes (mean episodes ± SD per patient)	P value*
Any infection	21/43 (2.0 ± 1.0)	20/69 (3.5 ± 1.2)	<0.001
Pneumonia			
Any	11/13 (0.6 ± 0.7)	20/35 (1.7 ± 1.1)	0.001
Early (0 to 48 hours)	6/6 (0.3 ± 0.5)	4/4 (0.2 ± 0.5)	ns to 0.220
Nosocomial (>48 hours)	7/7 (0.33 ± 0.5)	16/31 (1.55 ± 1.0)	<0.001
VAP*	6/6 (0.33 ± 0.5)	13/13 (0.65 ± 0.5)	0.023
Recurrent*	2/2 (0.1 ± 0.3)	13/19 (0.95 ± 0.8)	<0.001

25

Nutrition Intervention: Minor Burns

- Oral diet
  - Small/frequent meals and snacks with protein
  - Oral nutrition supplements as needed
  - Varied diet with fruits and vegetables to provide a variety of vitamin and minerals
  - Fiber (whole grains, fruits/vegetables) to support bowel function
  - Calorie counts to monitor for adequate intake
- In major burns, oral diet alone is difficult to sustain because of the large and often intolerable amounts of food necessary to manage severe catabolism

26

Nutrition Intervention of MAJOR BURNS (greater than 20% TBSA)

- Fluid resuscitation is thought to cause gut edema and a paralytic ileus if the GI tract is not used early
- Very early enteral feeding initiated within 6-12 hrs after injury by the gastric route can help with:
  - Reduction of the stress hormone levels of the hypermetabolic response
  - Increased immunoglobulin production
  - Reduction in intestinal permeability
  - Reduction of Curling ulcers (type of stress ulcer)
  - Reduces the risk of malnutrition and energy deficit
- Parenteral Nutrition only if enteral fails

Rousseau AF et al. Clin Nutr. 2013 Aug;32(4):497-502.

27

Maximize Calorie Intake: Volume Based Feeding

- Volume-based feeding (VBF)
  - When tube feeds are held for the OR, the RNs will adjust hourly rate to gradually make up for interrupted enteral nutrition.
  - The intention is to deliver > 80% of prescribed nutrition.
- Wang et al, in 2023 performed meta-analysis and systemic review
  - 16 studies with 2896 critically ill patients
  - Showed significant improvement in energy (15% increase) and protein delivery (22% increase) with VBF
  - VBF had shorter ICU stay
  - No increase in risk of death, mechanical ventilation days
  - No increase in EN complications

28

Maximize Calorie Intake: Limit Fasting

- Carmichael et al. 2019
  - Retrospective study of EN delivery in ventilated burn patients to assess impact on calorie intake
  - 45 adult patients, mean TBSA 44%, mean ventilated days 13
  - 86% of patients had gastric feeds throughout the study period
  - No aspiration events occurred
  - Patients who had TF held for majority of procedures met only 69% of caloric goals vs those who received TF through majority of procedures met 81% of goal ($p<0.002$)

29

Anesthesiology Practice Guidelines 2017

*A. Fasting Recommendations**

Ingested Material	Minimum Fasting Period†
• Clear liquids‡	2h
• Breast milk	4h
• Infant formula	6h
• Nonhuman milk§	6h
• Light meal**	6h
• Fried foods, fatty foods, or meat	Additional fasting time (*e.g.*, 8 or more hours) may be needed

*Guidelines intended for healthy patients of all ages undergoing elective procedures
**Light meal is toast/crackers
2023 update allows for consumption of clear liquids containing carbohydrates until 2h pre-op

30

Nutrition Therapy-Parenteral Nutrition (TPN)

- Indications: prolonged high dose vasopressor support complicating enteral tolerance, bowel trauma, ileus, inability to meet needs enterally
- Possible complications, especially with burn patients:
  - Infection (bacterial translocation, line-related)
    - *Use dedicated central lumen for TPN*
  - Hyperglycemia
    - *Avoid exceeding glucose infusion rate of 5mg/kg/min*
    - *Use TPN alongside insulin therapy*
  - Overfeeding
  - Hyperlipidemia

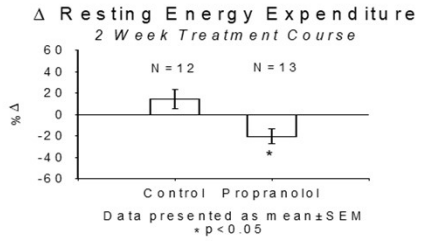
31

Drug therapy to modulate metabolism

- Propranolol (beta blocker)
  - Anti-catabolic
  - Reduces heart rate, prevents bone loss, reduces insulin resistance, skeletal muscle wasting and increases lean body mass post-burn
  - May not be well tolerated when on pressors
- Oxandrolone
  - *Previously used because of anabolic effects, but no longer approved by FDA 2/2 risk of liver failure and blood lipid changes*
- For children only: recombinant human growth hormone
  - Give 0.05 to 0.2mg/kg/day
  - Enhances donor site healing, reduces hypermetabolism and reduces growth deficit
  - Not beneficial for adults

32

Herndon et al. NEJM (2001). 345 (17).
- Randomized trial
- 25 children with burns greater than 40% TBSA



33

Nutrition Monitoring and Evaluation

- Monitor calorie and protein intake from TF and calorie counts
- Weights twice a week
  - Keep in mind that soaked bandages, fluid resuscitation, and other hardware will impact weight trends
- Monitor for changes in nutrition focused physical exam
- Monitor for clinical improvement via wound granulation, graft take and loss, and donor site healing as described by surgery
- Monitor for feeding adequacy
  - Overfeeding: azotemia, hyperglycemia, elevated LFTs, GI symptoms
  - Underfeeding: weight loss, graft loss

34

What about prealbumin and crp?

- Prealbumin
  - Negative acute phase reactant
  - Maximal decrease in PAB will happen between days 6-8 in all burned patients, but persistent low levels are associated with decreased likelihood of survival. Jeschke et al. (2011) PLoS ONE 6(7): e21245.
- C-reactive protein (CRP)
  - Positive acute phase reactant
  - Elevated in setting of inflammation and stress
  - Used to interpret prealbumin trends

35

Summary

- Minimize hypermetabolism
- Enteral nutrition within 12h, goal intake by 48h
- Clinical monitoring for ongoing caloric needs
- Adult protein needs 1.5-2.0 g/kg, children - 3.0 g/kg
- Micronutrient replacement

36

Case Study

- 68 yo F who presented for evaluation after a house fire caused by unattended incense.
- 20% mixed superficial and partial thickness burn
- Patient had worsening facial edema and required intubation for airway protection.
- Initial course complicated by fungal infection seen during excisional debridement, post burn day 4
- Social history: daily wine cooler and recent crack cocaine use

37

Chart review

Labs

- Glucose 400
- Prealbumin 16
- Crp 2
- WBC 12.43

Medications

- LR at 200ml/h
- Bowel regimen
- Folic acid, thiamine, Vitamin C, zinc, MVI with minerals
- Levophed 2mcg/min, propofol 30mcg/kg/min

38

Nutrition Assessment

- Anthropometrics: Height 144.8cm, Weight 68.9kg, BMI 32.9kg/m2
  - Ideal body weight (IBW): 46kg
- Estimated calorie needs
  - 30 to 35kcal/kg of IBW= 1388kcal to 1619kcal/day
- Estimated protein needs
  - 2 to 2.5g/kg of IBW= 93 to 116g/day
- TF recommendations, started within 12hours of admission:
  - TF and protein supplement provided1320kcal, 105g protein. Propofol provided 300kcal/day
- Micronutrient recommendations: 100mg thiamine, 1mg folic acid, multivitamin with minerals, 220mg zinc sulfate daily x 14 days, 500mg vitamin C twice a day x 14 days

39

Nutrition follow up

- Oxandrolone started post burn day 2 with 10mg twice a day
- Calorie provision maintained at 1400 to 1550kcal per day, 100g of protein.
- On post burn day 15, she remained intubated, sedated, on propofol (10-30mcg/kg/min), insulin drip (56units required in 24h).
  - REE measured as 1359kcal (Toronto equation 1388kcal)
  - Prealbumin of 3, crp 123.6

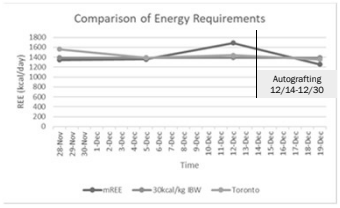
40

Surgery summary

- Excision and debridement post burn day 5, 7, 12
  - *Invasive fungal infection delayed autografting*
- Trach placed post burn day 21, **first autografting** to bilateral arms, chest
- Excisional debridement with allograft bilateral hands, right forearm day 26
- Excisional dermal graft of bilateral hands, excision of face day 34
- Excision and autografting of bilateral hands, forehead day 37 (mostly closed!)
- Gastrostomy placement, post burn day 58

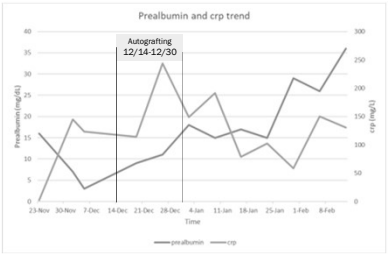
41

Nutrition Needs



Tolerated trach mask by 12/28 so unable to measure REE
Calorie goal was then titrated based on clinical course.

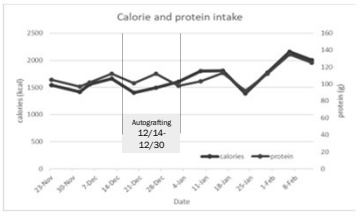
42



Timely grafting helps to reduce inflammation, hypermetabolism, and allow for recovery

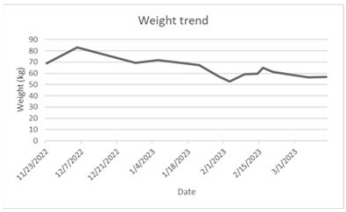
43

Nutrition delivery



We fed about 30 to 35 kcal/kg and 2.2g protein/kg, then increased to 40 to 45kcal/kg, 2.5g protein/kg with increasing activity and infectious complications

44



Her weight remained higher than admission weight until 1/30. Weight loss was obscured by volume overload. Overall, she lost about 18% of usual weight, which may have contributed to infectious complications.

45

Case study conclusions

- The nutrition plan requires ongoing reassessment and adjustment to meet the needs of the patient
- Obese patients with burns present a unique challenge for calorie estimation and delivery
- Difficult to prevent weight loss in setting of severe burns. Nutrition goal is to minimize weight loss, support wound healing and clinical progress.
- Prealbumin is heavily influenced by inflammation and open wounds

46

Conclusion

- There is a dramatic increase and sustained metabolic demand with major burns
- Initiate nutrition support early to reduce metabolic demand and prevent muscle catabolism
- Use indirect calorimetry for best estimate of energy needs
- Titrate TF and protein goal to promote wound healing and recovery
- Likely need to provide daily multivitamin with minerals and may need additional others as indicated

47

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48

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49

50