Mass General Brigham

Considerations in the Management of Critically Ill Patients with Obesity

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November 9, 2024

Disclosures

Dr. Apovian has participated on advisory boards for:

- Orexigen
- Gelesis
- Allergan
- Abbott Nutrition
- EnteroMedics
- Zafgen
- Real Appeal
- Nutrisystem
- Tivity
- Novo Nordisk
- Scientific Intake
- Bariatrix Nutrition
- SetPoint Health
- Xeno Biosciences
- Rhythm
- Janssen
- Tivity Health
- Roman Health Ventures
- Jazz

Dr. Apovian has received research funding from:

- Gelesis
- Novo Nordisk

Obesity in the ICU

- >106,000 ICU beds in US hospitals, with 80% filled, 2021
- > 42% of US older adults have obesity
- **~50% of U.S. ICU patients have obesity**
- Sarcopenic obesity (combination of low skeletal muscle mass and high obesity) can be found in older, critically ill patients
  - Should be viewed as at risk for malnutrition due to higher fat stores and stigma/bias associated with obesity
  - These patients may not receive early nutrition support

American Hospital Association. Fast Facts on U.S. Hospitals, 2021. https://wwwaha.org/statistics/fast-facts-us-hospitals.
McKendry J, Thomas ACQ, Phillips SM. Nutr Clin Pract. 2020 Aug;35(4):607-616.

BMI and Excess Body Fat

Waist circumference (WC) and waist-hip ratio (WHR) are tools to assess fat distribution and contribute to risk stratification

- **BMI: poor marker of excess body fat** in patients with either increased or low muscle mass (sarcopenic obesity)
- Patients with similar BMI may have different obesity-related complications depending on the distribution of excess fat (visceral and ectopic versus subcutaneous fat)
- Adipose tissue is highly metabolically active
- Visceral adipose tissue has a more deleterious adipocyte secretory profile resulting in insulin resistance and a chronic low-grade inflammatory and procoagulant state
- Subcutaneous fat in the lower body may act as a metabolic sink for excess fat and protect other tissues/organs from lipotoxicity

		Disease risk: Waist Circumference (WC)	
Diagnosis	**BMI WHO classification [weight (kg)/height m^2]**	**MALES $\leq$ 94 cm FEMALES $\leq$ 80 cm**	**MALES > 94 cm FEMALES > 80 cm**
Underweight	< 18.5		
Normal weight	18.5–24.9		
Overweight	25–29.9	Increased	High
Obesity class I (moderate obesity)	30–34.9	High	Very high
Obesity class II (severe obesity)	35–39.9	Very high	Very high
Obesity class III (very severe obesity)	≥ 40	Extremely high	Extremely high

Schetz M, et al. *Intensive Care Med*. 2019 Jun;45(6):757-769.

GUIDELINES

for the Provision and Assessment of Nutrition Support Therapy in the Adult Critically Ill Patient

Section Q.

Obesity in Critical Illness

Pages 196 - 199

Clinical Guidelines

Journal of Parenteral and Enteral Nutrition
Volume 40 Number 2
February 2016 159–211

DOI: 10.1177/0148607115621863
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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 Enteral Nutrition (A.S.P.E.N.)

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Keywords
nutrition; critical care; intensive care unit; enteral; parenteral; evidence-based medicine; Grading of Recommendations, Assessment, Development, and Evaluation criteria; guidelines

Preliminary Remarks (Intent of Guidelines)

A.S.P.E.N. and SCCM are both nonprofit organizations composed of multidisciplinary healthcare professionals. The mission of A.S.P.E.N. is to improve patient care by advancing the science and practice of clinical nutrition and metabolism. The mission of SCCM is to secure the highest-quality care for all critically ill and injured patients.

Guideline Limitations

These A.S.P.E.N.-SCCM Clinical Guidelines are based on general conclusions of health professionals who, in developing such guidelines, have balanced potential benefits to be derived from a particular mode of medical therapy against certain risks inherent with such therapy. However, practice guidelines are not intended as absolute requirements. The use of these practice guidelines does not in any way project or guarantee any specific benefit in outcome or survival.

The judgment of the healthcare professional based on individual circumstances of the patient must always take precedence over the recommendations in these guidelines.

The guidelines offer basic recommendations that are supported by review and analysis of the current literature, other national and international guidelines, and a blend of expert opinion and clinical practicality. The population of critically ill patients in an intensive care unit (ICU) is not homogeneous. Many of the studies on which the guidelines are based are limited by sample size, patient heterogeneity, variability in disease severity, lack of baseline nutrition status, and insufficient statistical power for analysis.

Periodic Guideline Review and Update

This particular report is an update and expansion of guidelines published by A.S.P.E.N. and SCCM in 2009.[1] Governing bodies of both A.S.P.E.N. and SCCM have mandated that these guidelines be updated every 3–5 years. The database of randomized controlled trials (RCTs) that served as the platform for the analysis of the literature was assembled in a joint "harmonization process" with the Canadian Clinical Guidelines group. Once completed, each group operated separately in its interpretation of the studies and derivation of guideline recommendations.[2] The current A.S.P.E.N. and SCCM guidelines included in this paper were derived from data obtained via literature searches by the authors through December 31, 2013. Although the committee was aware of landmark studies published after this date, these data were not included in this manuscript. The process by which the literature was evaluated necessitated a common end date for the search review. Adding a last-minute landmark trial would have introduced bias unless a formalized literature search was reconducted for all sections of the manuscript.

Target Patient Population for Guideline

The target of these guidelines is intended to be the adult (≥18 years) critically ill patient expected to require a length of stay (LOS) greater than 2 or 3 days in a medical ICU (MICU) or surgical ICU (SICU). The current guidelines were expanded to include a number of additional subsets of patients who met the above criteria but were not included in the previous 2009 guidelines. Specific patient populations addressed by these expanded and updated guidelines include organ failure (pulmonary, renal, and liver), acute pancreatitis, surgical subsets (trauma, traumatic brain injury [TBI], open abdomen [OA],

McClave SA, et al. JPEN J Parenter Enteral Nutr. 2016 Feb;40(2):159-211. (page 196)

Target Patient Population for Guideline

- Adult (≥18 years) critically ill patient expected to require a length of stay (LOS) greater than 2 or 3 days in a medical ICU (MICU) or surgical ICU (SICU)
- Current guidelines were expanded to include additional subsets of patients who met the above criteria and not included in the previous 2009 guidelines
- Specific patient populations addressed by these expanded and updated guidelines include:
  - Organ failure (pulmonary, renal, and liver)
  - Acute pancreatitis
  - Surgical subsets (trauma, traumatic brain injury, open abdomen, burns)
  - Sepsis
  - Postoperative major surgery
  - Chronic critically ill
  - **Critically ill obese**
- The addition of PN or the use of total PN (in the acute phase) needs to be considered on a case-by-case basis

McClave SA, et al. *JPEN J Parenter Enteral Nutr*. 2016 Feb;40(2):159-211. (pages 159-160)
Hill A, Elke G, Weimann A. *Nutrients*. 2021 Aug 19;13(8):2851.

Nutrition Assessment: Tools

- There are **no validated and recommended tools** to estimate the nutritional status of a critically ill patient
- In (semi-) elective admissions, a screening for malnutrition in standard care before major surgery may be practical and is recommended
- Several tools to estimate nutrition risk are the:
  - Nutrition Risk Score (NRS 2002)
  - NUTRIC (Nutrition Risk in the Critically Ill) Score
  - Subjective Global Assessment (SGA)
  - Malnutrition Universal Screening Tool (MUST)
- Many of these tools include some of the following factors:
  - Medical history: age, comorbidities, loss of physical function
  - Nutrition history: weight loss, reduced food intake, loss of appetite
  - Physical examination: BMI, edema, body composition
  - Severity of disease: critically ill patients are severely ill by definition

Hill A, Elke G, Weimann A. *Nutrients.* 2021 Aug 19;13(8):2851.

Obesity in Critical Illness

- **Patients with a BMI >30 have an OR of 1.5 for having malnutrition** (P = .02)
- Reasons for the surprisingly high rate of malnutrition in patients with obesity may stem in part from:
  - Unintentional weight loss early after admission to the ICU
  - Lack of attention from clinicians who misinterpret the high BMI to represent additional nutrition reserves that protect the patient from insult

McClave SA, et al. *JPEN J Parenter Enteral Nutr*. 2016 Feb;40(2):159-211. (page 196)

Obesity in Critical Illness

- ICU patients with obesity are more likely than lean subjects to have problems with fuel utilization, predisposing them to greater loss of lean body mass
- Patients with obesity are at greater risk for insulin resistance and futile fuel cycling of lipid metabolism (increases in both lipolysis and lipogenesis)
- In an early study of trauma patients with obesity in a SICU derived only 39% of their REE from fat metabolism vs. 61% in their lean counterparts[1]
- These patients derived a higher percentage of energy needs from protein metabolism, indicating greater potential for erosion of lean body mass

1. Jeevanandam M, Young DH, Schiller WR. *J Clin Invest*. 1991; 87(1): 262- 269.
2. McClave SA, et al. *JPEN J Parenter Enteral Nutr.* 2016 Feb;40(2):159-211. (page 196)

The Obesity Paradox

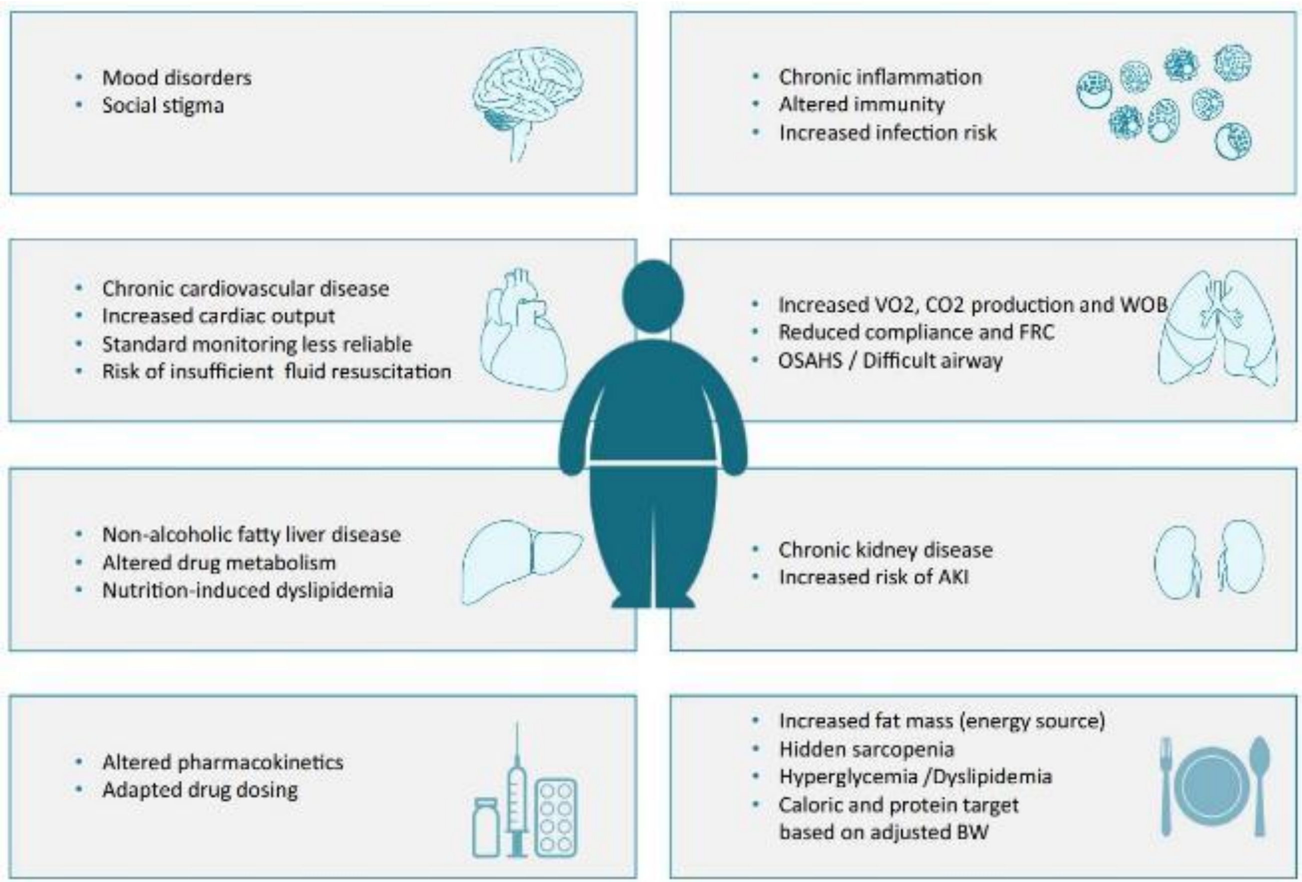
Obesity increases the risk of obesity-related disease but paradoxically is associated with increased survival in patients with these diagnoses is called "obesity paradox"

- Large cohort studies in the general population have demonstrated an increased mortality risk in both overweight and obese individuals[1]
- Recent data in hospitalized **patients or patients with chronic illnesses showed a relationship between BMI and mortality**, with ***overweight and moderate obesity being associated with lower mortality*** compared with a normal BMI or more severe obesity
  - Observed in heart failure, coronary artery disease, end-stage kidney disease, pneumonia, sepsis, acute respiratory distress syndrome (ARDS), general critical illness

1. Heymsfield SB, Wadden TA. *N Engl J Med.* 2017 Jan 19;376(3):254-266.
2. Schetz M, et al. *Intensive Care Med.* 2019 Jun;45(6):757-769.

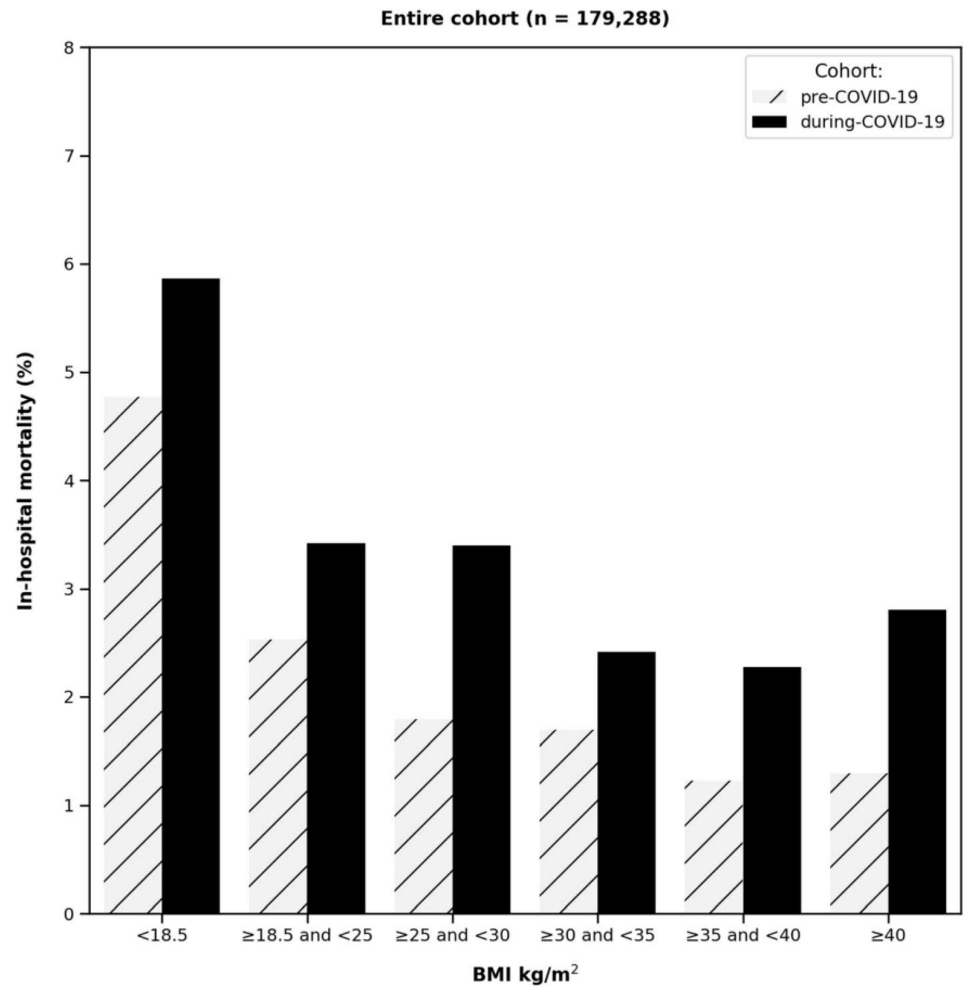
Impact of obesity on organ systems and their management during critical illness

Although moderate obesity may paradoxically decrease mortality in ICU patients, increased adipose tissue has an impact on several organ systems, increases morbidity and requires an adapted ICU management



Schetz M, et al. *Intensive Care Med*. 2019 Jun;45(6):757-769.

Mortality Rates Higher During COVID-19 Pandemic



Medical ward patients with severe obesity have a lower risk for mortality vs. normal BMI

Does not apply during COVID-19, where obesity was a leading risk factor for mortality in the medical wards

Mount Sinai Health System, NYC
N = 179,288
(149,098 admitted before Covid; 30,190 during covid)

Soffer S, et al. *BMC Endocr Disord*. 2022 Jan 6;22(1):13.

The Obesity Paradox in Critical Illness

- The obesity paradox may contribute to clinicians' illusion that patients with obesity do not need nutrition therapy early in their ICU stay
  - The mortality curve for BMI is U-shaped, with mortality **highest** in patients with class III severe obesity with BMI >40 and in people with BMI <25
  - **Mortality is *lowest* in subjects with BMI in the range of 30–40 (class I and II obesity); this protective effect of moderate obesity is the OBESITY PARADOX**
- Raises question of whether BMI in this range is the best indicator of risk- ??

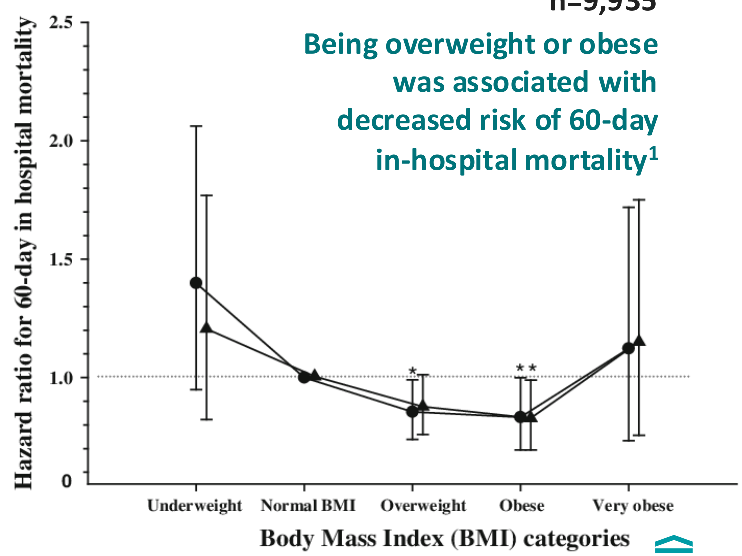
OBESITY PARADOX
in ICU Patients with Obesity:

Should not be used as rationale to withhold feeding

Should not stop clinicians from considering early administration of nutrition therapy

n=9,935

Being overweight or obese was associated with decreased risk of 60-day in-hospital mortality[1]



1. Hutagalung R, et al. *Intensive Care Med*. 2011 Nov;37(11):1793-9.
2. McClave SA, et al. *JPEN J Parenter Enteral Nutr*. 2016 Feb;40(2):159-211. (page 196)

Principles and Goals for Feeding the Critically Ill Patient with Obesity

- Support lean body mass
- Promote anabolism and positive nitrogen balance
- Avoid overfeeding and worsening co-morbid conditions (i.e. hyperglycemia, increased CO2 production, fluid overload)
- Promote glycemic control and wound healing
- Include an exercise program to optimize lean muscle mass

McKendry J, Thomas ACQ, Phillips SM. *Nutr Clin Pract*. 2020 Aug;35(4):607-616.
McClave SA, et al. *JPEN J Parenter Enteral Nutr*. 2016 Feb;40(2):159-211.

ASPEN/SCCM Expert Consensus

For Feeding the Critically Ill Patient with Obesity

- Early start within 24-48 hours of ICU admission for patients with obesity who cannot sustain volitional intake
- Nutritional assessment to include: metabolic syndrome biomarkers, comorbidities evaluation, inflammation/SIRS, central adiposity, sarcopenia, BMI>40
- High –protein feeding to preserve lean body mass, mobilize adipose stores, minimize overfeeding
- For all classes of obesity, the EN regimen should not exceed 65-70% of target energy requirements as measured by indirect calorimetry; if IC is unavailable:
  - BMI 30-50: use 11-14 kcal/kg actual body weight/day
  - BMI >50: use 22-25 kcal/kg actual body weight/day

https://www.nutritioncare.org/Guidelines_and_Clinical_Resources/Resources_for_Critical_Care_Clinicians/

ASPEN/SCCM Expert Consensus

For Feeding the Critically Ill Patient with Obesity

- Protein should be provided in the range from:
  - BMI 30-40: 2.0 g/kg ideal body weight/day
  - BMI $\geq$40: 2.5 g/kg ideal body weight/day

TARGET: 154 – 193 gms/day

- If available, use an enteral formula with low caloric density and reduced NPC:N
  - Additional monitoring is needed to assess worsening of hyperglycemia, hyperlipidemia, hypercapnia, fluid overload, hepatic fat accumulation
- For patients with a history of bariatric surgery to receive supplemental thiamine prior to dextrose-containing IV fluids or nutrition therapy
  - Additionally, evaluate for micronutrient deficiencies

https://www.nutritioncare.org/Guidelines_and_Clinical_Resources/Resources_for_Critical_Care_Clinicians/

Clinical Guidelines Informing Nutrition Provision in Critically Ill Adults with Obesity

- 650,000 million adults worldwide had obesity, 2016
- In the largest analysis of international nutrition provision during critical illness (n=17,154) **≥ 50% of patients were overweight or had obesity**

KEY POINTS

- Obesity is associated with increased morbidity in the general population, but the impact of obesity in critical illness on clinical outcomes is more complex
- Clinical **guidelines recommend hypocaloric energy provision with high protein** intake for hospitalized and critically ill obese patients
- Commonly used predictive equations are less accurate in overweight and obese patients vs. normal weight, and **indirect calorimetry is preferred to calculate energy expenditure**
- Clinicians should **manage the nutrition of the obese critically ill patient as any other patient**; conservatively in the first week of ICU stay, with an aim to meet energy and protein requirements after this time

Lambell K, Peake S, Ridley E. *Clin Nutr*. 2019 Aug;38(4):1957.

Minimal high-quality research exists investigating the impact of nutrition on clinical and functional outcomes in critically ill patients with obesity

Randomised trials informing recommendations for nutrition in obese critically ill patients

Paper	Trial details			Intervention			Control			Outcomes
	Population	n	Study aim and details	Energy	Protein	Actual intake Mean (SD)	Energy	Protein	Actual intake Mean (SD)	
Choban et al, 1997	Obese adult patient referred for PN (13 patients in ICU)	30	To assess the efficacy of hypocaloric vs eucaloric PN with protein at 2 g/kg IBW Double blind	Hypocaloric Aim for kcal/ nitrogen ratio of 75:1	High protein	1293 (299) kcal and 120 (27)g protein	Eucaloric Aim 150:1 kcal/ nitrogen ratio	High protein	1936 (198) kcal and 108 (14) g protein (1.2 g/kg actual weight, 2 g/kg IBW)	Weight change; 0 (6.3) kg (Hypocaloric) vs 2.7 (7) kg (Eucaloric)
Burge et al, 1994	Hospitalised obese patients referred to nutrition service for PN	16	To determine if nitrogen balance could be maintained in patients receiving hypocaloric, high protein PN Double blind	Hypocaloric 50% REE; kcal/ nitrogen ratio of 75:1	High protein	1285 (374) kcal (14 kcal/ABW) and 111 (32) g protein (1.3 g/ kg ABW, 2 g/kg IBW)	Eucaloric 100% of REE; aim 150:1 kcal/ nitrogen ratio	High protein	2492 (298) kcal (25 kcal/kg/ actual weight) and 130 (15) g protein (1.2 g/kg or 2 g/kg IBW)	No clinical outcomes reported Weight change; - 4.1 (6)) kg (Hypocaloric) vs – 7.4 (8.4) kg ((Eucaloric)

ICU: Intensive Care Unit; IBW: Ideal body weight PN: parenteral nutrition; SD: standard deviation

More research is needed

Lambell K, Peake S, Ridley E. Clin Nutr. 2019 Aug;38(4):1957.

The Respiratory System

- One of the main objectives of the critical care management of obese patients is prevention of respiratory complications
- Respiratory management of ICU patients with obesity may differ between patients with healthy lungs and those with ARDS at ICU admission

Schetz M, et al. *Intensive Care Med.* 2019 Jun;45(6):757-769.

Airway Management
ICU Patients with Obesity

- Obesity is a risk factor for difficult intubation and difficult mask ventilation
- Elevated Mallampati score, limited mouth opening, reduced cervical mobility, presence of an obstructive apnea syndrome, coma and severe hypoxemia are associated with difficult intubation in obese patients

Schetz M, et al. *Intensive Care Med.* 2019 Jun;45(6):757-769.

Airway Management
ICU Patients with Obesity

- To limit desaturation during the intubation procedure, preoxygenation must be optimized.
- A preoxygenation of 5 min with noninvasive ventilation (NIV) in a sitting position, associating pressure support and positive end-expiratory pressure (PEEP) permits reaching an exhaled fraction in oxygen>90% more quickly than standard bag valve mask ventilation in patients with obesity
- Te OPTINIV preoxygenation technique [associating a high-flow nasal cannula (HFNC) with NIV] was more effective at reducing oxygen desaturation vs. the reference method using NIV alone in a randomized controlled trial including obese and nonobese patients with severe acute respiratory failure

Schetz M, et al. *Intensive Care Med.* 2019 Jun;45(6):757-769.

Invasive mechanical ventilation in non-ARDS

ICU Patients with Obesity

- Protective ventilation should be applied in obese patients, using low tidal volume [set according to ideal body weight (IBW)], moderate-to-high PEEP and recruitment maneuvers
- Te respiratory mechanics, alveolar recruitment and gas exchanges are significantly improved by application of PEEP ≥ 10 cmH2O (improvement of respiratory compliance and decrease of inspiratory resistance)
- Commonly used PEEP by clinicians (11.6±2.9 cmH2O) was shown inadequate for minimizing atelectasis and "optimizing" ventilation
- A recruitment maneuver followed by PEEP titration significantly improved lung volumes, respiratory system elastance and oxygenation
- Optimal PEEP levels were around 20 cmH20; 12 cmH2O was found effective

Schetz M, et al. *Intensive Care Med.* 2019 Jun;45(6):757-769.

Invasive mechanical ventilation in ARDS

ICU Patients with Obesity

- High PEEP has been reported to be associated with better survival in obese patients with ARDS
- Contrary to non-obese patients, driving pressure might not be appropriate to assess the severity and prognosis of obese ARDS patients
- Low-to-negative values of transpulmonary pressure predict lung collapse and intratidal recruitment/derecruitment
  - These results further support the monitoring of transpulmonary pressure using esophageal pressure even if future studies are needed to demonstrate its safety and efficiency
- Prone position is a therapy of choice
- Reverse Trendelenburg position and optimal abdominal fat positioning can help to avoid complications of increased abdominal pressure as bowel ischemia after failure or impossibility of using prone positioning
- Neuromuscular blockers, veno-venous extracorporeal membrane oxygenation (ECMO) can also be safely used

Schetz M, et al. *Intensive Care Med.* 2019 Jun;45(6):757-769.

Europe vs. US Guidelines

Suggestions	ESPEN guidelines	ASPEN guidelines
For calculating the energy target if measurement of REE is not possible		
In general	20–25 kcal/kg actual BW/day Below 70% of REE should be given during 'early' acute phase	25–30 kcal/kg actual BW/day
In obese	Same as above, but calculated according to adjusted BW[a] If REE measured, set target to 80–100% of REE after the early acute phase (within days 3–7)	11–14 kcal/kg actual BW/day if BMI 30–50 kg/m^2 22–25 kcal/kg ideal BW[b]/day if BMI > 50 kg/m^2 If REE measured, set target to 65–70% of REE
For calculating protein target		
In general	1.3 g/kg actual BW/day	1.2–2.0 g/kg actual BW/day
In obese	Same as above, but calculated with adjusted BW[a]	2.0–2.5 g/kg ideal BW[b]/day
For adjustment of nutritional therapy according to serum markers[c]		
Glucose	Below 10 mmol/l (180 g/l) Consider lowering carbohydrate administration when > 6 U insulin/h is needed for > 24 h	Below 10 mmol/l (180 g/l)
Urea	Consider lowering protein administration if > 30 mmol/l: Probably only justified if protein administration > 1.5 g/kg BW/day	–
Triglycerids	Investigate and consider lowering fat administration if > 5.6 mmol/l	–

Schetz M, et al. *Intensive Care Med*. 2019 Jun;45(6):757-769.

Europe vs. US Guidelines

Suggestions	ESPEN guidelines	ASPEN guidelines
Examples for calculating energy and protein targets in obese[d]		
Example 1: male 120 kg, 185 cm ≥ BMI = 35.1 kg/m^2 Ideal BW[b] = 77 kg[b] and adjusted BW[a] 86–88 kg		
Energy target	Calculated with adjusted BW[a] 25 kcal × 86–88 kg Target = 2150–2200 kcal/day	Calculated with actual BW 14 kcal × 120 kg Target = 1680 kcal/day
Protein target	Calculated with adjusted BW[a] 1.3 g × 92–96 kg[a] Target = 120–125 g/day	Calculated with ideal BW[b] 2.0–2.5 g × 77 kg[b] Target = 154–193 g/day
Example 2: female 140 kg, 165 cm ≥ BMI = 51.5 kg/m^2 Ideal BW[b]: 53 kg and adjusted BW[a] = 70–75 kg		
Energy target	Calculated with adjusted BW[a] 25 kcal × 70–75 kg Target = 1750–1875 kcal/day	Calculated with ideal BW[b] 25 kcal × 53 kg Target = 1325 kcal/day
Protein target	Calculated with adjusted BW[a] 1.3 g × 70–75 kg Target = 91–98 g/day	Calculated with ideal BW[b] 2.0–2.5 g × 53 kg Target = 106–133 g/day

REE resting energy expenditure, BW body weight a Adjusted BW=ideal BW+20–25% of difference between actual and ideal BW (actual BW−ideal BW) b Ideal BW: for males: 0.9×(height in cm−100); for females: 0.9×(height in cm−106) suggested in ESPEN guidelines, no specific suggestion for calculating ideal BW in ASPEN guidelines c No difference in guideline targets regardless of whether applied to normal weight or obese individuals d The upper level of suggested energy targets in kcal/BW/day is taken as a basis for calculations

Schetz M, et al. *Intensive Care Med*. 2019 Jun;45(6):757-769.

QUESTION

What is the amount of protein recommended per day by ASPEN for ICU patients with obesity?

1. 130 – 140 gms/day
2. 154 – 193 gms/day
3. 99 – 110 gms/day
4. 120 – 125 gms/day

How Obesity Affects the Practice of Medicine

Caroline M. Apovian, MD, FACN, FACP, FTOS, DABOM

- Bias of Clinicians
- Inappropriate Medical Equipment
- Diagnostic Imaging Issues

“Our culture has enormous negativity toward overweight people, and doctors aren't immune.

If doctors have negative feelings toward patients, they're more dismissive, they're less patient, and it can cloud their judgment, making them prone to diagnostic errors."

Jerome Groopman, MD
Chief, Division of Experimental Medicine
Beth Israel Deaconess Medical Center

Professor of Medicine
Harvard Medical School

Book author and staff writer for *The New Yorker*

Obesity Bias of Clinicians

As patient BMI increases, **physicians** report:

- Having less patience
- Less desire to help the patient
- Seeing obese patients was a waste of their time
- Having less respect for patients

Nurses

- 31% "would prefer not to care for obese patients"
- 12% "would prefer not to touch obese patients"
- 24% agreed that obese patients "repulsed them"

Views on Patients with Obesity:

Physicians

- Less self-disciplined
- Less compliant
- More annoying

Nurses

- Lazy
- Lacking in self-control/willpower
- Non-compliant

Medical Students

- Poor in self-control
- Less likely to adhere
- Sloppy
- Awkward
- Unpleasant
- Unsuccessful
- Responsible for symptoms

Hebl & Xu, 2001; Huizinga et al., 2009. Poon & Tarrant, 2009; Brown, 2006; Bagley, 1989; Hoppe & Ogden, 1997; Maroney & Golub, 1992. Blumberg & Mellis, 1980; Keane, 1990; Persky & Eccleston, 2011; Wigton & McGaghie, 2001.

Weight Discrimination is a Real Problem

- The prevalence of weight discrimination in the U.S. is increasing **and is comparable to that of race and gender discrimination**[1]
- There are few other medical diseases in our society that are as stigmatized and shunned as obesity[2]
- The societal stigma often associated with excess **weight is perpetuated with focus on personal responsibility for obesity**[1]

Nurse in a bariatric surgery unit tries on a padded suit to simulate the experience of her patients

1. Andreyeva T, Puhl RM, Brownell KD. Obesity (Silver Spring). 2008 May;16(5):1129-34.
2. Puhl RM, Heuer CA. Obesity (Silver Spring). 2009 May;17(5):941-64.

Gaps Between 2013 Obesity Treatment Guidelines and Actual Practice

Guideline Recommendations

1. **Use BMI** to identify risk; advise patients of their risk
2. **Use waist circumference** to identify risk; advise patients of their risk
3. 3%-5% sustained weight loss reduces risk factors and risk of diabetes
4. Prescribe set # of calories per day
5. There is no ideal diet
6. Advise adults with obesity who meet criteria: **surgery may be an option**

J Am Coll Cardiol. 2014 Jul 1;63(25 Pt B):2985-3023.
2013 AHA/ACC/TOS Guideline for the Management of Overweight and Obesity in Adults

Actual Practice

- **Clinicians often fail to diagnose overweight and obesity or discuss weight management with patients**

<1% of US adults with severe obesity undergo bariatric surgery annually; low MD referrals are due to:

- Biggest reason at VA: lack of training
- Provider attitudes
- Costs/lack of reimbursement
- Fear of complications
- Lack of time to counsel patients

Barriers to effective treatment

- **Lack of training for clinicians**
- **Lack of time to counsel**
- **Cynicism about treatment effectiveness**
- **Lack of patient motivation to lose weight**
- **Lack of reimbursement**
- **Inadequate resources to care for patients over time**

Bleich SN, et al.BMJ Open. 2012 Dec 20;2(6).

Extra Body Fat Can Literally Obscure Some Illnesses

“The more tissue between the palpating hand and what you're trying to feel, the harder it is to detect a mass."

Jeffrey C. King, MD
Professor and Director of Maternal-and-Fetal Medicine
University of Louisville School of Medicine

“Ultrasound is the approach that's the most limited by body fat, because the beams can't penetrate the tissue if you have more than 8 centimeters of subcutaneous fat.”

Dr. Raul Uppot, radiologist

"It's more difficult to hear heart and lung sounds in heavy people. I use an **electronic stethoscope**, which works well, but I'm very aware of the issues that can crop up in overweight patients. Not all doctors have these stethoscopes - or are aware they need one."

Mary Margaret Huizinga, MD, MPH
Director, Johns Hopkins Digestive Weight Loss Center

Extra Body Fat Can Literally Obscure Some Illnesses

"The vaginal walls become lax and collapse into the middle, obscuring the cervix."

Jeffrey C. King, MD
Professor and Director of Maternal-and-Fetal Medicine
University of Louisville School of Medicine

"Larger or modified speculums can help, but not all docs have them and they can make the exam more uncomfortable."

Lynda Wolf, MD
Reproductive Endocrinologist
Reproductive Medicine Associates of Michigan

Obese women are less likely to get Pap smears than normal-weight women.
Doctors may be partly to blame for the screening lapse, too:

83% of 1,300 physicians were reluctant to do pelvic exams on obese women[1]

Assessing Blood Pressure in Patients with Severe Obesity

- RESULTS:
  Correlation between intra-arterial and forearm measures was 0.90 (P < 0.001) for the 2570 data (systolic and diastolic)

Compared to intra-arterial,

- **Forearm method**
  overestimated systolic (**6** ± 16 mm Hg, P < 0.001)
  underestimated diastolic (**2** ± 11 mm Hg, P = 0.03)

- **Upper-arm**
  underestimated systolic (**8** ± 16 mm Hg, P < 0.01)
  overestimated diastolic (**9** ± 7 mm Hg, P < 0.001)

CONCLUSION:

- **Our results suggest that forearm method may be a more accurate alternative to upper-arm measurement to assess blood pressure in severely obese patients**

1285 measures of intra-arterial
and forearm BP taken in 51 severely obese patients in a supine position in the operating and the recovery room

Subset of 352 upper-arm measures were taken in the recovery room and compared to the intra-arterial and the forearm methods.

Leblanc ME, et al. Obesity (Silver Spring). 2013 Dec;21(12):E533-41.

Diagnostic Imaging and Obesity

- **Radiography**
- Limited by X-ray beam attenuation resulting in decreased image contract and amplification of noise, and increase in exposure time resulting in motion artifacts
  - Raising kilovolt (peak) and milliampere second helps improve image quality

- **Ultrasound image**
- **Quality is affected by fat more than any other imaging modality**
  - Ultrasound beams are attenuated by fat at a rate of 0.63 dB/cm
  - Use of lowest frequency transducer (1.5-2.0 MHz) may partially overcome increased image attenuation

https://acphospitalist.org/archives/2011/10/obesity.htm

90% of US Hospitals without Large Capacity Imaging
(>450 lb limit)

Many people cannot fit in scanners, typical weight limit of 350 to 450 pounds

Medical Centers	**Own Large Weight Capacity CT**	**Own Large Weight Capacity MRI**
Hospitals with Emergency Departments	**10%**	8%
Academic Hospitals	28%	10%
Rural Hospitals	5%	-
Critical-access Hospitals	3%	-
Trauma Centers	34%	-
Stroke Centers	23%	-
Bariatric Surgery Centers	21%	-

Ginde AA, et al. Obesity (Silver Spring). 2008 Nov;16(11):2549-51.

Metabolic Response to Critical Illness and Obesity

Metabolic Response to Critical Illness

- **There is a common hypermetabolic, inflammatory response to physiologic stress, directed at promoting acute survival, which affects macronutrient** (protein, lipid, and carb) **utilization throughout the body[1-5]**
- **Obesity is a proinflammatory state and probably lowers the threshold at which these mechanisms become overwhelmed or exaggerated during critical illness**

1. Mizock BA. Best Pract Res Clin Endocrinol Metab 2001; 15:533–551.
2. Dungan KM, Braithwaite SS, Preiser JC. Lancet 2009;373:1798–1807.
3. Honiden S, McArdle JR. Clin Chest Med 2009; 30:581–599.
4. Jeevanandam M, Young DH, Schiller WR. J Clin Invest 1991; 87:262–269.
5. Leonidou L, Michalaki M, Gogos CA, et al. Am J Med Sci 2008; 336:467–471.

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Carbohydrate Metabolism and (Stress-induced) Hyperglycemia

- **Frequent complication of critical illness and the end-product of increased counter-regulatory hormone production** (glucagon, glucocorticoids, and catecholamines) **and inflammatory cytokine release, leading to accelerated hepatic gluconeogenesis, lipolysis, and peripheral insulin resistance**[1,2,3]

- **Associated with poorer outcomes in both diabetic and nondiabetic individuals during critical illness**[4,5]

1. Mizock BA. Best Pract Res Clin Endocrinol Metab 2001; 15:533–551.
2. Dungan KM, Braithwaite SS, Preiser JC. Lancet 2009; 373:1798–1807.
3. Honiden S, McArdle JR. Clin Chest Med 2009; 30:581–599.
4. Leonidou L, Michalaki M, Gogos CA, et al. Am J Med Sci 2008; 336:467–471.
5. Van den Berghe G, Wilmer A, Hermans G, et al. NEJM 2006; 354:449–461.

Carbohydrate Metabolism and Hyperglycemia

- **Include glycemic control in nutrition support plan**
  - **Given prevalence of diabetes and insulin resistance among the obese patients**
- **Avoid iatrogenic hyperglycemia from overfeeding**
  - **Administration of excess glucose (calorie) loads can lead to increased lipogenesis, hepatic steatosis, and increased CO2 production, which in turn increases work of breathing [23,25].**
- **Insulin infusion is preferable method to achieve normoglycemia in the ICU, especially as insulin absorption may vary in obese patients with substantial amounts of subcutaneous adipose tissue [29].**
- **Alternatively, regular insulin can also be added directly to TPN solution once requirements are stable**

1. Mizock BA. Best Pract Res Clin Endocrinol Metab 2001; 15:533–551.
2. Honiden S, McArdle JR. Clin Chest Med 2009; 30:581–599.
3. Moghissi ES, Korytkowski MT, DiNardo M, et al. AACE and ADA Endocrine Practice 2009; 15:353–369.

Fatty Acid Oxidation and Protein Utilization

- **At fasting baseline, obese persons have increased blood levels of hormones and substrate, including amino acids and free fatty acids (FFAs)**
- **FFA elevation usually signifies insulin resistance**
  - **Causes increased lipolysis, impaired skeletal muscle FFA oxidation, and reduced suppression of plasma FFA by insulin[1]**
- **Despite abundance of serum FFAs and triglyceride-rich adipose stores, obese individuals are ineffective at mobilizing or using these energy sources during critical illness[1,2,3]**

1. Abdul-Ghani MA, Muller FL, DeFronzo RA, et al AmJ Physiol Endocrinol Metab 2008; 295:E678–E685.
2. Schiffelers SL, Saris WH, van Baak MA. Int J Obes Relat Metab Disord 2001; 25:33–38.
3. Jeevanandam M, Young DH, Schiller WR. J Clin Invest 1991; 87:262–269.

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Fatty Acid Oxidation and Protein Utilization

- **Jeevanandam et al. showed major differences in utilization of endogenous fuel sources between starved obese and nonobese trauma patients**
- **Lean patients relied largely on fatty acid oxidation for energy [about 61% of resting energy expenditure (REE)]**
- **Obese patients derived most energy from catabolism of lean mass (only 39% of energy from FFA)**

1. Jeevanandam M, Young DH, Schiller WR. J Clin Invest 1991; 87:262–269.

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Fatty Acid Oxidation and Protein Utilization

- **Muscle protein catabolism is a hallmark feature of critical illness, regardless of BMI, with studies showing losses of up to 10–20% of skeletal muscle after 1 week in the ICU[1,2]**
- **Obese persons have increased amounts of fat-free mass (FFM) over their height-matched lean counterparts, but more likely to use as fuel during critical illness when fasted, accelerating rate of protein losses[3]**
- **FFM (protein) catabolism typically persists despite provision of nutrition support**
  - **Administration of either greater total calories or protein calories has been shown to mitigate its rate and improve nitrogen balance**

1. Stevens RD, Dowdy DW, Michaels RK, et al. Intensive Care Med 2007;33:1876–1891.
2. Reid CL, Campbell IT, Little RA. Clin Nutr 2004; 23:273–280.
3. Jeevanandam M, Young DH, Schiller WR. J Clin Invest 1991; 87:262–269.

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Fatty Acid Oxidation and Protein Utilization

- **Hypocaloric, high-protein nutrition is preferable approach in obese patients**
  - **Promotes endogenous fat oxidation and shifts obese patients away from utilization of FFM as the predominant fuel source, while simultaneously inducing favorable changes in body composition[1,2]**
- **Avoidance of overfeeding is critical**
  - **Excess caloric load is associated with increased protein turnover and fat storage[3]**

1. Dickerson RN, Boschert KJ, Kudsk KA. Nutrition 2002; 18:241–246.
2. Dickerson RN. Curr Opin Nutr Metab Care 2005; 8:189–196.
3. Biolo G, Agostini F, Simunic B, et al. Am J Clin Nutr 2008; 88:950–958...

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Patient Evaluation

Dietary and Weight History

- **Significant gain or loss of weight** *Intentional?*
- **Changes in gastrointestinal function, prior abdominal or bariatric surgeries**
- **Mechanical limitations to eating**

These key elements should reveal:

- Baseline nutritional status
- Level of risk for refeeding syndrome
- Weight maintenance *or* weight loss

when determining best approach to nutrition support in the obese ICU patient

Physical Exam

- **Cardiopulmonary assessment**
- **Abdominal examination**
- **Determination of volume status**
- **Identification of muscle wasting indicative of chronic protein-calorie malnutrition**
- **Whole-body skin surface, including folds and surgical sites***
  integrity and presence of wounds)
- **Accurate weight and height**
  - **Monitor weight daily**
- **Monitor 24-h fluid balance**
  (intake-output)

* May require additional staff or specialized lifting equipment

Determining Energy Needs

Injury-induced Stress in Traumatized Obese Patients

- **Stressed obese patients BMI >30**
- **Obese patients had net fat oxidation that accounted for only 39% of REE compared with net fat oxidation accounting for 61% in nonobese**
- **Net carb and protein oxidation rates higher in the obese**
- **Conclusion: under stress, obese patients cannot take advantage of abundant fat stores**

Jeevanandam M, Young DH, Schiller WR. J Clin Invest 1991;87:262-269.

Energy Needs in the Obese

Actual Body Weight	Overestimates energy needs
Adjusted Body Weight	Lacks rigorous validation
Ideal Body Weight	Underestimates energy needs
Predictive Equations	No consensus

Energy Expenditure Assessment

Name	Equation
Hamwi Equation for Ideal Body Weight (IBW)	Male (lbs): 106+6 (Height in inches - 60) Female (lbs): 100+5 (Height in inches - 60)
Adjusted Body Weight (ABW)	[(actual body weight - IBW) x (0.25 to 0.5)] + IBW
Weir Equation for REE	From metabolic cart: kcal/d = 1.44 x [3.9(O_2 consumption) + 1.1(CO_2 production)]
Harris–Benedict Equation (HBE)	Men: kcal/d = 66.47 + 13.75 (w) +5 (h) -6.75 (a) Women: kcal/d= 655.1 + 9.56 (w) +1.85 (h) 4.68 (a) Adjusted: kcal/d=HBE(injury factor)(activity factor)
Mifflin–St. Jeor (MSJ)	Men: kcal/d = 10 (w) +6.25 (h) -5 (a) +5 Women: kcal/d = 10 (w) +6.25 (h) -5 (a) -161
Ireton–Jones	Ventilator-dependant: kcal/d = 1784 + 5 (w) -11 (a) + 244 (if men) + 239 (if trauma) + 804 (if burn) Spontaneously breathing: kcal/d = 629 - 11 (a) + 25 (w) - 609 (if BMI >27 kg/m2)
Penn State	Harris–Benedict: kcal/d = 0.85 (HBE) +175 (Tmax) +33 (Ve) - 6344 Mifflin: kcal/d = 0.96 (MSJ) +167 (Tmax) +31 (Ve) - 6212
Cunningham	kcal/d = 370+21.6 (kg of fat-free mass)
Diabetes *modified*	kcal/d = 71.761 -2.34 (a)+10 (w)+146 (if diabetic) +257.3 (if men)
American College of Chest Physicians (ACCP)	25–30 kcal/kg of actual weight or 21 kcal/kg IBW

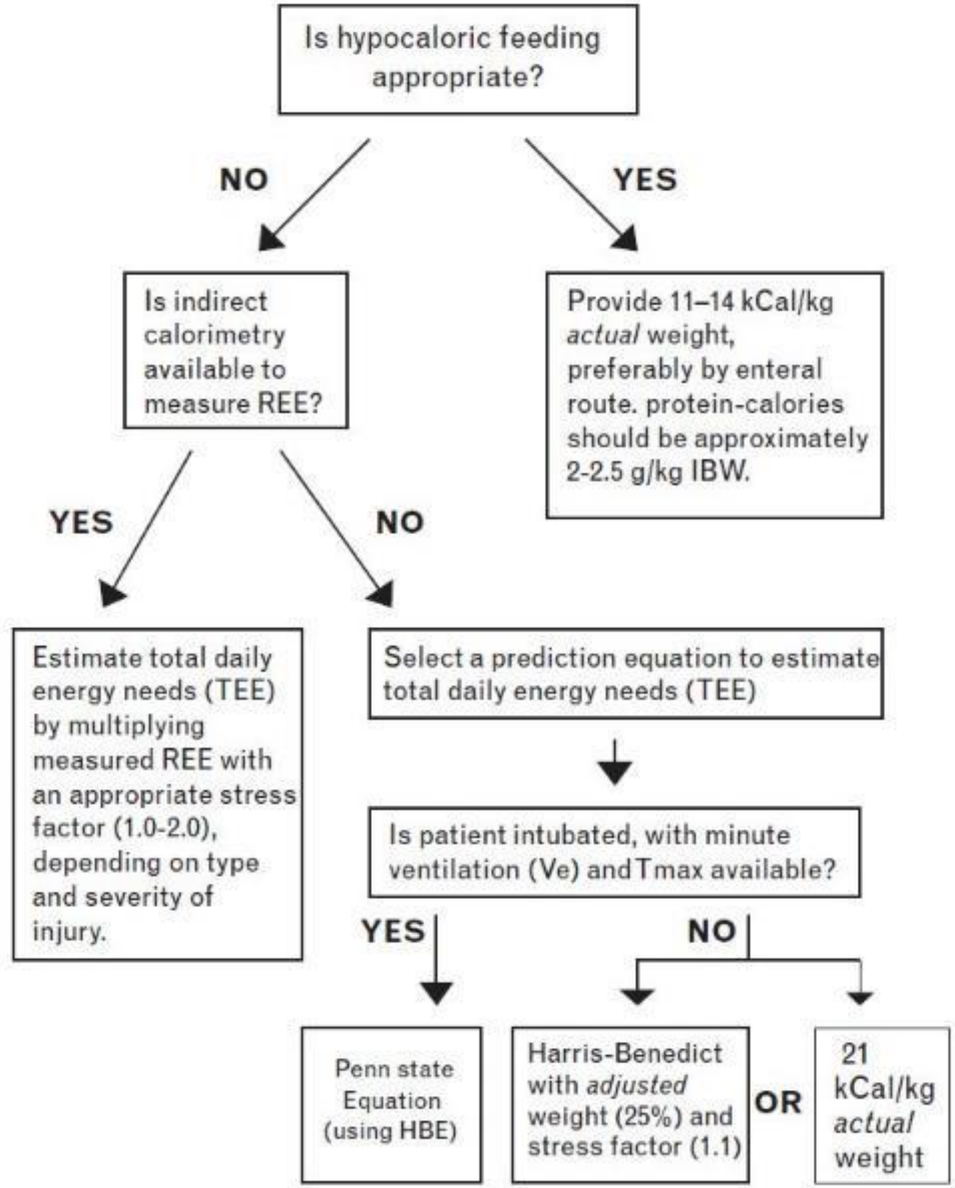
Indirect Calorimetry

'Gold Standard'

No available equation reliably estimates REE, though Penn State and HBEs have strongest evidence in obese ICU patients

a = age; h = height (cm); Tmax = maximum temperature in a 24 h period; Ve = minute ventilation; w = actual weight (kg)

Algorithm for Determining Feeding Needs in Critically Ill Obese Patients



Quick Method

Not Validated

- Use 25-35 kcal/kg in hospitalized non-obese patients[1]

- Use 20-21 kcal/kg actual body weight in obese patients (BMI>30)[2]

1. FAO-WHO. Energy and protein requirements. Geneva: WHO, 1985. Technical report series 724.
2. Amato P, Keating KP, Querica RA, et al. Nutr Clin Pract 1995; 10:229-230.

Hypocaloric Feeding in Obese Patients

Definition

- **Permissive underfeeding of a patient**
- **Derived from protein-sparing modified fast**
- **Premise: hypocalorically feed the obese critically ill so that they can use their fat stores – overfeeding exacerbates complications**
- **How to do it?**
- **How many calories and protein is adequate?**

Features and Benefits

- **No standard method**
- **Generally involves:**
  - **30-70% of estimated daily calories**
  - **Protein: 50-60% of total calories**
    - **Minimizes glucose loads while sparing lean body mass from catabolism**

- **Benefits:**
  - **Improve insulin sensitivity**
  - **Improve glycemic control**
  - **Prevent metabolic consequences of overfeeding** *(hypercapnea, fluid retention, and hypertriglyceridemia)*
  - **Weight loss and reduced fat mass**
  - *(should never be primary objective in critical illness)*

ASPEN/SCCM Guidelines

2009 Consensus Statement

- **Endorses hypocaloric feeding of critically ill obese patients with enteral feeds**
- **Provide no more than 60–70% of target energy requirements or 11–14 kcal/kg actual body weight/day**
- **Protein in the range of at least 2.0 g/ kg IBW/day for class I and II obese patients**
- **Protein at least 2.5 g/kg IBW/day for class III obesity**
- **Contraindications:**
  - **Conditions precluding the use of high-protein nutrition, such as progressive renal failure or hepatic encephalopathy**
  - **Conditions in which full caloric (dextrose) loads are preferred, including history of hypoglycemia, diabetic ketoacidosis, or severe immunocompromised state**

SCCM = Society of Critical Care Medicine, ASPEN = American Society for Parenteral and Enteral Nutrition
McClave SA, Martindale RG, Vanek VW, et al. JPEN 2009: 277–316.

Critical Care Challenges in Obesity

Respira-tory	• Mechanics of breathing • CO_2 retention • Obstructive Sleep apnea • Aspiration pneumonia • Pulmonary embolism/deep vein thrombosis
Cardiac	• ↑ Blood volume, cardiac output, stoke volume • ↓ Left ventricular contraction, ejection fraction
Medical Dosing	• Lipophilicity of medicine • ↓ Hepatic clearance of some medications • Creatinine clearance for renal dosing
Vascular Access	• Difficulty placing and finding anatomical "landmarks"

Critical Care Challenges in Obesity

Enteral Access	• Difficulty placing at bedside and difficulty confirming location • Weight limits for fluoroscopy tables and endoscopy suites
Imaging	• Weight limits for computed tomography scans, magnetic resonance imaging, fluoroscopy, and interventional radiology • Radiography of poor quality
General Patient Care	• Changing bed linens, bathing, bowel movements • Clean skin/wound care • Transporting patient out of ICU • Lack of equipment designed for obese pts • Number of staff required to move pt in bed • Injuries to nursing and other staff from moving/lifting patient

Published Studies on Nutrition Support in Obese Patients

Author	Study Design/ Route of Feeding	Hypo-caloric control (n)	Protein (g./kg.day) H/C	Total (g./kg.day) H/C
Dickerson, 2002 (23)	Retrospective/ Enteral	28/12	1.3/1.6 IBW -2.0 adj BW	18.6/27.2 IBW
Liu, 2000 (22)	Retrospective/ Parenteral	30/0	0.74/1.0 ABW 1.64 adj BW	-18/24 ABW
Choban, 1997 (21)	Prospective/ Randomized DB	16/14	2.0/2.0 IBW 1.2/1.2 ABW	-22/36 IBW 13.5/22.4 ABW
Burge, 1994 (20)	Prospective/ Randomized DB	9/7	2.0/2.2 IBW 1.2/1.3 ABW	22/42 IBW 14/25 IBW
Dickerson, 1986 (19)	Prospective/ Parenteral	13/0	2.1 IBW 1.2 ABW	N/A (Provide 51.5% of REE as nonprotein kcal.)

Summary: Obesity in the ICU

- **Presents unique challenges**
- **Determining REE**
  - **Prediction equations - highly unreliable**
  - **Indirect calorimetry - preferred method**
  - **Penn State equation and adjusted HBE - good choices**
  - **21 kcal/kg of actual body weight – quick method (not validated)**
- **Hypocaloric feeding containing at least 2.0 g/kg**
- **IBW per day protein (1.3–1.5 g/kg actual weight) prevents complications of overfeeding, such as hyperglycemia and fluid retention, while preserving FFM and promoting steady weight loss**
- **Excess body mass may have a protective effect in mild-moderately obese patients**

Summary

- ~50% of U.S. ICU patients have obesity
- Waist circumference (WC) and waist-hip ratio (WHR) are better tools than BMI alone to assess fat distribution and contribute to risk stratification
- Obesity increases the risk of obesity-related disease but paradoxically is associated with increased survival in patients with these diagnoses is called "obesity paradox"
- RESOURCE: 2016 GUIDELINES for the Provision and Assessment of Nutrition Support Therapy in the Adult Critically Ill Patient