Clinical Guide for the Use of Metabolic Carts: Indirect Calorimetry—No Longer the Orphan of Energy Estimation

Pierre Singer, MD¹; and Joelle Singer, MD²

Abstract
Critically ill patients often require nutrition support, but accurately determining energy needs in these patients is difficult. Energy expenditure is affected by patient characteristics such as weight, height, age, and sex but is also influenced by factors such as body temperature, nutrition support, sepsis, sedation, and therapies. Using predictive equations to estimate energy needs is known to be inaccurate. Therefore, indirect calorimetry measurement is considered the gold standard to evaluate energy needs in clinical practice. This review defines the indications, limitations, and pitfalls of this technique and gives practice suggestions in various clinical situations. (Nutr Clin Pract. 2016;31:30-38)

Keywords
indirect calorimetry; energy expenditure; calories; energy metabolism; energy intake

Usual Practice: The Predictive Equations
More than 200 equations have been developed to predict resting energy expenditure (REE) of critically ill patients. These equations are generally based on weight, height, age, and sex. In addition, body temperature and minute volume are taken into consideration when the patient is ventilated, while an empiric factor may be added if the patient has multiple trauma, burns, or obesity. It has been demonstrated in many critical analyses that these equations have a low level of accuracy. In addition, the stress factors used to complement the well-known Harris-Benedict equations have been validated for healthy populations. These factors, however, have not improved the accuracy of the equations. The resulting overestimation or underestimation may approach 40%, leading to large errors in the evaluation of energy requirements. It has become clear that energy expenditure during an intensive care unit (ICU) stay are dynamic and influenced by body temperature, level of nutrition support, presence of sepsis, level of sedation, and therapies including physiotherapy or even the visit of relatives. Therefore, it seems clear that only a reliable assessment of energy expenditure using techniques such as indirect calorimetry has the ability to evaluate accurately the energy requirements of critically ill patients during their acute illness. Despite these findings, indirect calorimetry remains the orphan of energy estimation, being used in only 0.8% of the more than...
8000 cases collected by Heyland et al.6 In pediatric intensive care, Kyle et al18 have also shown that of 150 critically ill children who were included in their study, 3 of 4 were candidates for indirect calorimetry per American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.) guidelines. It seems clear, therefore, that indirect calorimetry should not be considered a luxury but rather a necessity.

**Practice Suggestions**

Indirect calorimetry remains the accepted gold standard for determination of caloric needs. Most of the equations predicting energy expenditure in the ICU have a low level of accuracy. Where indirect calorimetry is not available, specific equations elaborated in a specific unit may increase the accuracy of the evaluation of energy expenditure and avoid large errors in calorie prescriptions. Overfeeding or underfeeding may be tolerated for short periods but may adversely affect outcomes in critically ill patients during a prolonged hospital stay.

**Practice Applications of Indirect Calorimetry**

**Intensive Care Patients: The Need for Indirect Calorimetry for Energy Prescription**

The emergence of computerized information systems has led to an increased appreciation of the correlation between energy balance and morbidity and mortality. Dvir et al19 showed that the complication rate of severely critically ill patients doubled if the cumulative energy balance was less than −4000 kcal per ICU stay. Villet et al20 demonstrated that the more negative the energy balance, the higher the rate of infection and the longer the ICU stay. Faisy et al21 even found a survival advantage in patients who had a preserved energy balance compared with those with an energy deficit >1200 kcal/d. These observational findings were the basis for the European Society for Clinical Nutrition and Metabolism (ESPEN) recommendations22: “During acute illness, the aim should be to provide energy as close as possible to the measured energy expenditure in order to decrease negative energy balance (Grade B). In the absence of indirect calorimetry, ICU patients should receive 25 kcal/kg/day increasing to target over the next 2–3 days (Grade C).” A.S.P.E.N.23 recommends that “the target goal of enteral nutrition should be determined and clearly identified at the time of initiation of nutrition support therapy (Grade C). Energy requirements may be calculated by predictive equations or measured by indirect calorimetry. Predictive equations should be used with caution, as they provide a less accurate measure of energy requirements than indirect calorimetry in the individual patient. In the obese patient, the predictive equations are even more problematic without availability of indirect calorimetry.”

The importance of a precise prescription of calorie intake has been stressed more recently by Hiesmayr.24 The primary goal of nutrition care is to avoid nutrition deficits and overnutrition (Figure 1). Observational studies have shown that a nutrition deficit was associated with complications, including decreased muscular force, impairment of immune function, and pressure sores.19–21 Overnutrition has also been associated with complications such as an increase in ventilation requirements, infection rates, and hyperglycemia.25 Timing as well as targeting are both important parameters to define when planning nutrition support. Five recent randomized, prospective studies compared various energy prescriptions (Figure 2), including early vs late parenteral nutrition (PN),26 trophic enteral vs targeted enteral feeding,27 hypocaloric vs “targeted” nutrition support,28 supplemental PN commenced
after day 3,25 and tight caloric control.30 Importantly, the last 2 studies used indirect calorimetry for targeting energy administration and succeeded in showing an improvement in both morbidity and mortality.31 Of the other studies, those administering excessive energy in the study group showed an increase in the infection rate and ICU stay,26 while those targeting or administering low energy in both control and study groups showed no differences in outcome.27,28 These results further support the use of indirect calorimetry in targeting the prescription of energy in critically ill, dynamic, complicated patients.31

**Practice suggestions.** Measure energy expenditure in ventilated patients requiring an ICU stay of >5 days and requiring nutrition support to target the energy prescription and avoid undernutrition or overnutrition.

**The Obese Patient**

Energy requirements are difficult to define in these patients since their lean body mass, which determines the REE, may decrease, increase, or be normal, and fat may also contribute to variability in REE. In a review of the literature including 20 articles, Kee et al32 found that the most common result for REE measured in morbidly obese but not acutely ill patients with a body mass index (BMI) between 40 and 80 kg/m² was between 1800 and 2600 kcal/d. These measurements are in great disparity with those derived from predictive equations.33 Obese patients are more frequently encountered in the ICU than in the past. Regarding their nutrition requirements, a calorie and protein prescription based on weight raises the point about which weight to use: ideal, actual, or adjusted? To date, there is no consensus, and therefore A.S.P.E.N. recommends using indirect calorimetry to better assess their energy requirements.23 A recent retrospective study compared the measured energy expenditure of 33 obese ICU patients with cancer and found a measured energy expenditure of 28.7 ± 5.2 kcal/kg ideal body weight (IBW)/d, significantly higher than the 25 kcal/kg IBW/d recommended by A.S.P.E.N.34 Based on small prospective studies available, a hypocaloric high-protein diet is currently recommended for obese patients. This nutrition therapy also improves insulin resistance.35 The authors suggest that indirect calorimetry should remain the “gold standard” for measuring REE, whereas using actual body weight is likely to overestimate needs, while IBW will underestimate them. Adjusted weight may be the best way to evaluate energy expenditure if indirect calorimetry is not available.36

**Practice suggestions.** Provide calories according to the measured energy requirements using calorimetry. If calorimetry not available, we could suggest the use of adjusted weight.

**The Malnourished Patient**

A new definition of malnutrition has been suggested recently.37 The prevalence of malnutrition approaches 40% in hospitalized patients, and many ICU patients have severe malnutrition. Overfeeding these patients may result in a “refeeding syndrome” and may endanger their lives.24 In these cases, it is recommended to initiate feeding with half of the requirements for the first 24 hours. The estimation of the exact requirements is again very difficult in these complex patients, in view of the association of a decrease in weight, an acute disease superimposed on a probable chronic condition, and usually edema, which impair the justification of using weight as a reliable tool. Indirect calorimetry may be very helpful in these patients and may avoid undernutrition or overnutrition and decrease the risks of refeeding syndrome. Levels of magnesium, phosphorus, and potassium require close surveillance, and guidelines should be followed.38 In these patients, ESPEN ICU guidelines recommend initiating enteral feeding with half the requirements on day 1, increasing to 25 kcal/kg/d after 48 hours.22 These recommendations are similar for A.S.P.E.N., which also encourages starting nutrition support without waiting.25 It is clear that the more malnourished the patient, the more nutrition support becomes important for outcome. Regarding PN, A.S.P.E.N. recommends PN should be initiated after the first 7 days of hospitalization in patients with no evidence of protein-calorie malnutrition,23 while ESPEN recommends22,39,40 PN be started after 48 hours, based on the observational studies presently available.19–21 An observational, prospective study showed the best ICU and hospital survival occurred when patients received nutrition support closest to their measured energy expenditure and in addition received a protein intake of 1.2 g/kg/d.41 This further increases the evidence regarding matching prescription to measured energy expenditure and ensuring its delivery.

**Practice suggestions.** Any patient with a BMI <18.5 kg/m² or having weight loss of >10% of body weight prior to ICU admission should be measured to adapt the “refeeding protocol.” Malnourished patients should receive early protein-energy goal-directed therapy.

**The Septic Patient**

Patients with sepsis may present varying levels of energy expenditure. Thus, patients with sepsis have a higher REE than those with the sepsis syndrome, which is in turn higher than for patients in septic shock.14 During the recovery phase, energy expenditure increases again. This phenomenon reflects the ability of the cell to extract and use O₂. Therefore, oxygen consumption may be a useful tool to assess the evolution of a septic patient. Patients developing multiple organ failure who are unable to produce adequate amounts of adenosine triphosphate (ATP) are at high risk of mortality.**42** Septic patients usually have the highest metabolic rates observed in the ICU and present a particular
The Chronic Obstructive Pulmonary Disease and Ventilated Patient

Ventilated patients have various diseases. These include acute lung injury (ALI) and adult respiratory distress syndrome (ARDS), decompensated pulmonary disorders such as chronic obstructive pulmonary disease (COPD), emphysema, asthma, or idiopathic interstitial pneumonias. Respiratory failure can also occur in the presence of neurological disorders, such as a major stroke, Guillain-Barre syndrome, or myasthenia gravis. Neuromuscular disorders are also frequent, and a new generation of patients, so-called chronically critically ill patients, is increasingly encountered. Mechanically ventilated patients are readily assessed by REE using an open circuit. The measurement will not be accurate when the inspired fraction of oxygen (FIO₂) is >0.6 or if the patient is receiving nitric oxide (NO) inhalation or having an open chest drain. This is based on the fact that the measurement of VCO₂ and VO₂ is computed by the analysis of the respiratory gas exchanged. It is supposed that the inert gas nitrogen (N₂) is constant in both inspired and expired gases (Haldane transformation). If FIO₂ is >0.6, the risk of error on the denominator will increase exponentially. If there is an air leak (eg, chest drain leaking air) or a part of the inspired N₂ air is not equal to the expired air composition, the equation will be not valid and the measurement inaccurate. Recently, a method to assess energy expenditure in patients ventilated with noninvasive ventilatory support has been described. REE can be measured accurately, and the change in sampling air flow does not distort the gas exchange measurement (Figure 3). Even patients supported by extracorporeal membrane oxygenation may be assessed using indirect calorimetry as proposed recently in a pilot study. Brandi et al suggested that indications for measuring energy expenditure in ICU ventilated patients should include those who fail to respond to the estimated nutrition needs, have single-organ or multiorgan failure, need prolonged ICU care and artificial nutrition, or have side effects of artificial nutrition and are in the process of weaning from mechanical ventilation. In a study of 176 chronically ventilated patients admitted to a geriatric rehabilitation center for weaning from mechanical ventilation, Papirov et al found that the Harris-Benedict equation predicted 1385 ± 265 kcal/d, the measured REE was 1473 ± 420 kcal/d, and the actual amount of enteral feeding administered was excessive, reaching 1649 ± 257 kcal/d. Length of ventilation is increased in patients with significant overnutrition or undernutrition, and length of ventilation could be reduced by reduction of the calorie intake in stable patients with elevated VCO₂.

Practice suggestions. In the weaning process, administer 85% of the REE if the patient is stable and VCO₂ is elevated. In long-term ventilation, indirect calorimetry could be proposed to guide the nutrition support required to reach successful weaning.
The Cardiothoracic Patient

Ratzlaff et al\textsuperscript{62} recently showed a 556 \pm 543-calorie/d difference between that measured by indirect calorimetry and that predicted by the Penn State formula in 71 patients, including those following coronary arterial bypass graft (CABG), multiple or single valve replacement, redo valve of some vascular thoracic surgery, and those treated with a left ventricular assist device. The higher energy expenditure observed was associated with changes in the nutrition prescription in 66\% of patients. The mean REE was 2406 \pm 587 kcal/d, while the predicted energy expenditure was 1850 \pm 323 kcal/d with a 95\% confidence interval (CI) of 428–685. Interestingly, after cardiac arrest, reduced body temperature decreases REE by 20\% compared with 36°C, and substrate utilization was different between survivors and nonsurvivors.\textsuperscript{63}

Medications

Medications such as analgesics, antihypertensives, and anesthetics may affect energy expenditure.\textsuperscript{3} Adrenergic blockade decreases metabolism\textsuperscript{64} while epinephrine increases energy demand.\textsuperscript{65,66} Muscle relaxants, opiates, and barbiturates given to patients with severe head trauma reduce energy expenditure.\textsuperscript{67,68} Swinamer et al\textsuperscript{69} described a decrease in energy expenditure when sedatives were administered to ventilated patients. Antipyretics also decrease energy expenditure by reducing fever.\textsuperscript{70}

When to Measure REE in the ICU

Significant variability of measured REE has been observed in numerous studies. In the Tight Calorie Control Study (TICACOS),\textsuperscript{30} a significant daily variation (P < .05) was observed in all patients in the first 10 days, resulting in changes in the calorie prescription of the study group.\textsuperscript{30} This variability has been described in the past,\textsuperscript{43} and we thus recommend measuring REE once in ICU patients staying \leq 5 days but between 2 and 3 times a week in patients staying \geq 7 days. In these patients, energy deficit has been associated with increased morbidity and mortality.\textsuperscript{19–21} The measurement may be performed once a day with enough accuracy and reflects the energy expenditure of the entire day.\textsuperscript{71} It can also be performed with a continuous measurement device giving 24-hour energy expenditure and detecting minute-by-minute variations related to fever, activity, medications, physiotherapy, and visit of relatives.\textsuperscript{17,72}

Pitfalls and Limitations

There are limitations to the use of indirect calorimetry in clinical practice in the ICU. The cost (expensive devices, requirement of experienced personnel) but also the labor may be limiting factors in many centers that are reluctant to invest in this technique. In addition, the measurement may be inaccurate depending on the instrument used.\textsuperscript{73–75} In a recent prospective study of complementary PN to patients unable to reach energy target with enteral feeding,\textsuperscript{29} only 67\% of the patients were eligible for a measurement. The reasons for ineligibility may be a high FIO\textsubscript{2},\textsuperscript{52,76} which increases exponentially the error of measurement of oxygen consumption; an air leak in the system or originating from chest drains; extracorporeal circulation removing CO\textsubscript{2} such as extracorporeal membrane oxygenation or CO\textsubscript{2} removal\textsuperscript{77} or the use of NO; instability of the patient; and recent ventilator modifications or disconnection (loss of positive end-expiratory pressure [PEEP]).\textsuperscript{78} Large bias flow ventilators, especially ventilators set in the flow-triggered mode, create a special problem if the calorimeter is unable to separate inspired and expired gases related to the bias flow.\textsuperscript{17} Correct calibration, avoidance of extreme circuit flow rates, and appropriate length of measurement are also of great importance to ensure the validity of the measurements. Table 1 gives 10 recommendations before performing indirect calorimetry in an ICU patient and should be adhered to in order to avoid errors that could affect the results.\textsuperscript{17} Clearly, the hemodynamic and respiratory stability of the patient prior to and during the measurement should be respected. Analysis of the results on a screen or a printed result will confirm this stability. Any result showing stability of REE, VO\textsubscript{2}, and VCO\textsubscript{2} should be questionable. In addition, any result showing a respiratory quotient (RQ) of >1.3 or <0.64 should also not be accepted, since these reflect technical problems.\textsuperscript{79} Either an air leak or poor calibration is often the origin of these deviations.

| Table 1. Recommendations to Improve Indirect Calorimetry Measurements. |
|-------------------------|-------------------------------|
| Step | Recommendation |
| 1.  | Adequate warmup of the calorimeter for some of the devices |
| 2.  | Precise calibration |
| 3.  | Eliminate patients with chest tubes, air fistulas, or other leaks |
| 4.  | Partial fraction of oxygen should be below \(0.60\) (~0.70 if using M-COVX; GE Healthcare, Helsinki, Finland) |
| 5.  | Patient should be stable without recent fluctuations in respiratory status |
| 6.  | Nitric oxide administration should preclude measurement |
| 7.  | No recent change in the setting 1–2 hours before the indirect calorimetry measurement |
| 8.  | Measurements are allowed if the patient is hemodynamically stable |
| 9.  | Measurements are allowed if temperature is stable |
| 10. | Avoid measurements if the patient is ventilated with positive end-expiratory pressure \(>12\). |

Targeting Energy Prescription in Hospitalized Patients and Outpatients

Barak et al\textsuperscript{80} have described a large population of hospitalized patients who underwent indirect calorimetry measurements in an internal medicine department over 10 years. The REE was
pancreatic tumors, patients had a measured preoperative REE under- going pancreatoduodenectomy for bile duct cancer or teers and 31.2 kcal/kg/d in patients. In another population cohorts was higher, being 35.6 ± 4.3 kcal/kg/d. Estimated or measured total energy expenditure in 6 conditions was much broader, with 65% having an REE >25 kcal/kg/d, while the distribution for patients with pathological have a narrow distribution with a peak (46%) around 23–25 kcal/kg/d in healthy subjects. Figure 4 shows the distribution of energy expenditure in healthy individuals (light gray) and patients with various pathologies (dark). Reprinted with permission from Kreymann G, DeLegge MH, Luft G, Hise ME, Zaloga GP. The ratio of energy expenditure to nitrogen loss in diverse patient groups—a systematic review. Clin Nutr. 2012;31:168-175.

The authors found that the average stress factor for these hospitalized patients was 1.25, and using an adjusted body weight equal to IBW plus 50% of the difference between ideal and actual body weight was acceptable for obese patients. Recent feeding, fever, and restlessness increased the measured energy expenditure. In a comparable study, Boullata et al. retrospectively evaluated the accuracy of various predictive equations compared with indirect calorimetry in 395 patients measured over 1 year. Measured energy expenditure was 1617 ± 355 kcal/d for the entire group and 1790 ± 397 kcal/d in the obese group. Sixty-one percent of all the patients had significant overprediction or underprediction when the various predictive equations were used. These errors were judged clinically unacceptable by the authors. No equation accurately predicted REE in a majority of hospitalized patients. In the absence of a reliable predictive equation, only indirect calorimetry can provide accurate assessment of energy needs. Kreymann et al. recently reviewed all the studies measuring energy expenditure and nitrogen loss in hospitalized patients. The mean REE of 881 patients with a variety of pathological conditions was 28.1 ± 6.5 kcal/kg/d (median, 26.9 kcal/kg/d) compared with 23.7 ± 2.0 kcal/kg/d (median, 23.6 kcal/kg/d) in healthy subjects. Figure 4 shows the relative frequencies of classes of REE. Healthy individuals have a narrow distribution with a peak (46%) around 23–25 kcal/kg/d, while the distribution for patients with pathological conditions was much broader, with 65% having an REE >25 kcal/kg/d. Estimated or measured total energy expenditure in 6 cohorts was higher, being 35.6 ± 4.3 kcal/kg/d in healthy volunteers and 31.2 kcal/kg/d in patients. In another population undergoing pancreatectoduodenectomy for bile duct cancer or pancreatic tumors, patients had a measured preoperative REE of 22.4 ± 3.9 kcal/kg/d, and this REE increased to 25.7 ± 3.5 kcal/kg/d at day 7 and 25.4 ± 4.9 kcal/kg/d at day 14. Guiding nutrition management based on 30 kcal/kg/d. An impressive study in patients with cancer showed that when REE was clinically estimated or calculated with the Harris-Benedict equation, underfeeding and overfeeding occurred in >70% of the patients when predictive equations were used. The authors concluded that precise measurement of caloric need is crucial. Lawinski et al. published a model of personalized nutrition in a large home PN population, showing that measured REE was more accurate than that obtained from the predicted equations currently available in the literature, again supporting the need for measuring energy expenditure for this specific population.

Several studies targeting energy prescription according to REE have been published recently. An observational study demonstrated that critically ill patients who were fed close to their REE requirements and in addition received a high-protein intake had better survival rates than those receiving lower energy loads. Two other studies used indirect calorimetry to target the administration of calories in the intensive care. The TICACOS study showed that while morbidity was increased (longer ICU and ventilation days) in the group receiving energy requirements according to REE, mortality was significantly lower in the per protocol group (P < .05), suggesting a better outcome with more personalized nutrition support. Another study measured REE at day 3 in patients failing to receive adequate enteral feeding who then received supplemental PN. In comparison to the control group that received a prescribed 25 kcal/kg/d, significantly fewer infections were noted in the study group who also had a shorter ICU stay. Petros et al. compared patients fed according to their REE (eucaloric group) with patients fed with a hypocaloric regimen and found that the eucaloric group had significantly less infectious complications.

In a hospitalized group of geriatric patients recovering from hip replacement, patients who received oral supplementation according to the measured REE had significantly fewer infectious complications (mainly pulmonary) compared with the control group. The TICACOS pilot study showed that patients with cancer treated according to their REE had significantly fewer hospitalizations and better survival compared with a control group.

**Tool for Research: The Utilization of Substrates**

From the measurement of oxygen consumption, carbon dioxide production, and nitrogen excretion, not only REE but also utilization of substrates such as carbohydrates and fat can be calculated.

Carbohydrate use equals $4.45 \text{ VCO}_2 - 3.21 \text{ VO}_2 - 2.87 \text{ NM}$

Fat use equals $1.67 \text{ VO}_2 - 1.67 \text{ VCO}_2 - 1.92 \text{ NM}$.
These equations are useful for research to determine if the administered nutrients are being used by the whole body. This added value of indirect calorimetry is not well known since it requires the precise measurement of urinary nitrogen excretion. Without this measurement, substrate calculation is very inaccurate.\textsuperscript{89} Jeevanandam et al.\textsuperscript{90} administered PN according to measured energy expenditure and nitrogen output to 8 patients with severe trauma. Calculating the substrate utilization, the authors concluded that positive energy balance could be achieved and that PN did not reverse negative nitrogen balance but decreased net fat oxidation and increased carbohydrate and protein oxidation. Another application could be to explore the effects of new nutrients to critically ill patients. In a recent study, PN enriched with \( \omega-3 \) polyunsaturated fatty acids in critically ill patients did not modify glucose oxidation, lipid oxidation, glucose production, or gluconeogenesis but did decrease energy expenditure significantly (0.015 vs 0.019 kcal/kg/min with soybean lipids, \( P < .05 \)).\textsuperscript{91} Indirect calorimetry can also be used in combination with the euglycemic hyperinsulinemic clamp technique to assess whole-body glucose and lipid metabolism in various clinical settings.\textsuperscript{92,93}

Conclusions

It is increasingly recognized that bedside indirect calorimetry provides the most accurate assessment of energy requirements available in most clinical conditions. It improves the accuracy of the energy prescription by \( >40\% \), thus avoiding undernutrition and overnutrition. This seems to be of increasing importance, since in addition to observational studies showing that a calorie deficit is associated with worse outcomes, prospective, randomized studies using indirect calorimetry to target energy goals have succeeded in improving clinical outcomes. Recent recommendations from large European nutrition societies recommend the use of indirect calorimetry when available. When used appropriately, this practice may improve the nutrition support of critically ill patients.

Statement of Authorship

P. Singer and J. Singer equally contributed to the conception and design of the manuscript. Both authors contributed to the analysis of the data, drafted the manuscript, critically revised the manuscript, agree to be fully accountable for ensuring the integrity and accuracy of the work, and read and approved the final manuscript.

References

**A.S.P.E.N. Journal-based Continuing Education (CE) Activity**

### Journal Article Title and Citation:
Prevalence of Sarcopenia and Associated Outcomes in the Clinical Setting, NCP, February 2016

### Journal-based CE Activity Overall Goal:
The NCP Editor, in concurrence with A.S.P.E.N.'s Education and Professional Development Committee, selected this article to be offered for CE credit to fill an observed learning need in the arena of clinical nutrition and metabolism. This CE activity serves to promote the process of life-long learning for physicians, dietitians, pharmacists, and nurses by providing peer-reviewed journal articles that fully qualify for continuing education credits.

### Goal and Target Audience:
This educational activity is directed toward clinical nutrition and metabolism professionals and others who wish to update their knowledge of clinical nutrition and metabolism. By participating in this educational activity, the reader may expect to:
- Acquire knowledge in the area of clinical nutrition and metabolism research.
- Update or confirm your understanding of appropriate clinical nutrition and metabolism practices.
- Identify further learning needs as they relate to the subject matter.

### Learning Objectives:
1. Distinguish between similarities and differences in current sarcopenia definitions
2. Recognize risk factors associated with decreased muscle mass
3. Describe the prevalence of sarcopenia among general medical/surgical and critically ill patients
4. Assess outcomes linked with sarcopenia in the clinical setting

### Successful Completion:
To obtain CE credit for this activity, attendees must read the journal article in its entirety, complete an online assessment for each article and achieve a score of 100%, and complete an online activity evaluation. All are located in A.S.P.E.N.’s eLearning Center – www.nutritioncare.org/elearning.

### Accreditation Statements/Continuing Education Credit:
**Nurses, Pharmacists and Physicians**
The American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.) is accredited by the American Nurses Credentialing Center (ANCC), the Accreditation Council for Pharmacy Education (ACPE), and the Accreditation Council for Continuing Medical Education (ACCME), to provide continuing education for the healthcare team.

This activity is for a maximum of 1 contact hour (0.1 CEU) per journal article and is a knowledge activity.

A.S.P.E.N. designates this journal-based CME activity for a maximum of 1 AMA PRA Category 1 Credit™ per article. Physicians should only claim credit commensurate with the extent of their participation in the activity.

A.S.P.E.N. is approved by the California Board of Registered Nursing, Provider CEP 3970.

ACPE UAN: 0216-0000-16-070-H04-P.

### Policies/Information:
- **Non-Commercialism:** A.S.P.E.N. subscribes to the ACCME Standards for Commercial Support. A.S.P.E.N. does not provide programs that constitute advertisement or include promotional materials. A.S.P.E.N. does not endorse any products.
- **Computer Requirements and Technical Support:** Participants will need a computer with internet connection to access the online assessment and evaluation for each journal article. If the journal article is read electronically, then the ability to read a PDF document is also necessary. Users should enable pop-ups if attempting to read article electronically. For technical difficulties please contact Digitell Inc. Customer Support at: 1-800-679-3646. Office hours are between 9 AM to 5 PM ET, Monday through Friday.
- **Privacy and Confidentiality:** A.S.P.E.N. respects the privacy of its members and website visitors. Companies that receive personal information from A.S.P.E.N. in order to execute the business of A.S.P.E.N. may use personal information only for that purpose.
- **Refund Policy:** Refunds are not available.
- **Grievances:** Grievances must be submitted in writing to Director of Education and Research at A.S.P.E.N. 8630 Fenton Street. Suite 412. Silver Spring, MD 20910.

### Commercial Support and Sponsorship:
No commercial support or sponsorship has been received for this continuing education activity.

### Commercial Relationships Disclosures and Conflicts of Interest (COI) of Authors and Journal Editors
The following authors have nothing to disclose as related to the content of this article: Sarah Peterson and Carol Braunschweig.

NCP Associate Editors, Elizabeth Krzywda, Mary Marian, Gerard Mullin, and Jayshil Patel have nothing to disclose.

Todd Canada has served in a consultant role for Baxter Healthcare and NPS Pharmaceuticals and has received honoraria.

Ryan Hurt has served in a consultant role for Nestlé Nutrition and has received honorarium.

**NCP Editor-in-Chief** Jeannette Hasse has nothing to disclose.

No conflicts related to disclosure information present and subsequently no need for resolution. Standard journal peer review process also in place as another layer of review to ensure no conflicts to resolve.