8

Nutrition Facts and Formulas

Adequate nutrition is paramount to optimize survival from critical illness. Many patients in intensive care units cannot or will not take adequate nutrition orally and, thus, supplementation of nutrients via alternative enteral or parenteral routes may be important. The following facts and formulas represent the information necessary for assessment and administration of nutritional support.

1. NUTRITIONAL ASSESSMENT

Total Daily Energy
The *total daily energy* (TDE) requirements for a patient can be calculated using the following formula:

$$\textbf{TDE for men (kcal/day)} = (66.5 + 13.8W + 5H - 6.8A) \times (\text{Activity factor}) \times (\text{Injury factor})$$

$$\textbf{TDE for women (kcal / day)} = (655.10 + 9.6W + 1.9H - 4.7A) \times (\text{Activity factor}) \times (\text{Injury factor})$$

where
W = weight (kg)
H = height (cm)
A = age (years)

The activity factor is derived as shown in Table 8.1:

J. Varon and R.E. Fromm Jr., *Acute and Critical Care Formulas and Laboratory Values*, DOI 10.1007/978-1-4614-7510-1_8,

Table 8.1 Activity factor

Confined to bed	1.2
Out of bed	1.3

Injury Factors
The *injury factors* can be estimated based on the information in Table 8.2:

Table 8.2 Injury factors

Surgery	
Minor	1.0–1.1
Major	1.1–1.3
Infection	
Mild	1.0–1.2
Moderate	1.2–1.4
Severe	1.4–1.8
Trauma	
Skeletal	1.2–1.4
Head injury with steroid therapy	1.6–1.8
Blunt	1.15–1.35
Burns (body surface area)	
Up to 20 %	1.0–1.5
20 % to 40 %	1.5–1.85
Over 40 %	1.85–1.95

Metabolic Rate
The *metabolic rate* (MR) can be calculated in patients with a pulmonary artery catheter as:

$$\mathbf{MR\ (kcal\ /\ h)} = V\mathrm{O}_2(\mathrm{mL\ /\ min}) \times 60\ \mathrm{min/\ h} \times 1\ \mathrm{L}\ /\ 1{,}000\ \mathrm{mL} \times 4.83\ \mathrm{kcal\ /\ L} \times 24\ \mathrm{h\ /\ d}$$

where

$$V\mathbf{O_2}\ \mathbf{(mL\ /\ min)} = \text{Cardiac output (L / min)} \times [\text{arterial oxygen content } (\mathrm{CaO}_2, \mathrm{mL\ /\ L}) - \text{mixed venous oxygen content } (\mathrm{CmO}_2, \mathrm{mL\ /\ L})]$$

Prognostic Nutritional Index
The *prognostic nutritional index* (PNI) allows for nutritional assessment of the critically ill patient and is calculated as:

$$\textbf{PNI (\%risk)} = 158\% - 16.6\,(\text{alb}) - 0.78\,(\text{TSF}) - 0.2\,(\text{tfn}) - 5.8\,(\text{DSH})$$

where

alb = serum albumin (g/dL)
TSF = triceps skin fold (mm)
tfn = serum transferrin (mg/dL)
DSH = delayed skin hypersensitivity (1 = anergy, 2 = reactive)

Probability of Survival
The *probability of survival* (POS) based on the nutritional status of a critically ill patient can be calculated as:

$$\textbf{POS} = 0.91\,(\text{alb}) - 1.0\,(\text{DSH}) - 1.44\,(\text{SEP}) + 0.98\,(\text{DIA}) - 1.09$$

where

alb = serum albumin (g/dL)
DSH = delayed skin hypersensitivity (1 = anergy, 2 = reactive)
SEP = sepsis (1 = no sepsis, 2 = sepsis)
DIA = diagnosis of cancer (1 = no cancer, 2 = cancer)

Index of Undernutrition
Another way to calculate the nutritional deficit is by utilizing the *index of undernutrition* (IOU) (see Table 8.3):

Table 8.3 Index of undernutrition

	Points				
Assay	*0*	*5*	*10*	*15*	*20*
Albumin (g/dL)	>3.5	3.1–3.5	2.6–3.0	2.0–2.5	<2.0
Fat area (%)	>70	56–70	46–55	30–45	<30
Muscle area (%)	>80	76–80	61–75	40–60	<40
Transferrin (g/L)	>2.0	1.76–2.0	1.41–1.75	1.0–1.4	<40
Weight lost (%)	0	0–10	11–14	15–20	>20

Daily Protein Requirements
The calculation of *daily protein requirements* (PR) can be done utilizing the following formula:

$$\textbf{PR (g)} = (\text{Patient weight in kg}) \times (\text{PR for illness in g / kg})$$

Nonprotein Caloric Requirements
In order to determine the nonprotein caloric requirements (NCR):

$$\textbf{NCR} = (\text{Total required calories}) - (\text{Required protein calories})$$

Nitrogen Balance
The *nitrogen balance* (NB) reflects the status of the net protein use:

$$\textbf{NB} = (\text{Dietary protein} \times 0.16) - (\text{UUN} + 2\text{ g stool} + 2\text{ g skin})$$

where

UUN = urine urea nitrogen

In patients with renal failure, the increased blood urea pool and extrarenal urea losses must be accounted for:

$$\textbf{NB} = \text{Nitrogen in} - (\text{UUN} + 2\text{ g stool} + 2\text{ g skin} + \text{BUN change})$$

Catabolic Index
In addition to the above formulas, the *catabolic index* (CI) can be derived from the same variables:

$$\textbf{CI} = \text{UUN} - [(0.5 \times \text{Dietary protein} \times 0.16) + 3\text{ g}]$$

No nutritional stress results in a $CI \leq 0$, in moderate nutritional stress $CI < 5$, and in severe nutritional stress > 5.

Creatinine Height Index
Another index of the loss of lean tissue in malnourished patients is the *creatinine height index* (CHI) and can be calculated as:

$$\textbf{CHI} = \text{Measured creatinine / expected creatinine}$$

Body Mass Index
The *body mass index* (BMI) normalizes for height and allows comparisons among diverse populations:

$$\textbf{BMI} = \text{Body weight (kg)} / (\text{height})^2\text{ (m)}$$

Harris–Benedict Equation
The *Harris–Benedict equation* (HBE) is frequently utilized in assessment of the basal energy expenditure [BEE]:

$$\begin{aligned}\textbf{HBE BEE} &= 66 + [13.7 \times (5 \times H) - 6.8 \times A]\,\text{males} \\ &= 665 + (9.6 \times W) + (1.7 \times H) - (4.7 \times A)\,\text{females}\end{aligned}$$

where

W = weight (kg)
H = height (cm)
A = age (years)

2. FUEL COMPOSITION

The body uses different sources of fuel. Table 8.4 depicts some of them:

Table 8.4 Normal fuel composition of the human body

Fuel	*Amount (kg)*	*Calories (kcal)*
Circulating fuels		
Glucose	0.020	80
Free fatty acids (plasma)	0.0003	3
Triglycerides (plasma)	0.003	30
Ketone bodies	0.0002	0.8
Amino acids	0.006	24
Total		137.8
Tissue		
Fat (adipose triglycerides)	12	110,000
Protein (muscle)	6	24,000
Glycogen (muscle)	0.4	1,600
Glycogen (liver)	0.08	320
Total		135,920

3. OTHER FORMULAS

Body Surface Area
The *body surface area* (BSA) of a patient can be calculated as:

$$\textbf{BSA}\ (\textbf{m}^2) = \frac{(\text{Weight in kg})^{0.425} \times (\text{height in cm})^{0.725} \times 71.84}{10{,}000}$$

Ideal Body Weight
The *ideal body weight* (IBW) for height in males and females can be estimated based on Table 8.5:

Table 8.5 Ideal body weight in males and females

Height in cm	*Males (weight in kg)*	*Females (weight in kg)*
145	51.8	47.5
150	54.5	50.4
155	57.2	53.1
160	60.5	56.2
165	63.5	59.5
175	70.1	66.3
180	74.2	
185	78.1	

Percentage of Ideal Body Weight
The *percentage of ideal body weight* (%IBW) is calculated as:

$$\textbf{\%IBW} = \frac{\text{Actual body weight}}{\text{IBW}} \times 100$$

where

W= actual body weight (kg)