Nutrition in Critically illness

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Nutrition care in ICU

Physiologic changes during critically illness

Increased Nutritional Requirements:

Critical illness often leads to **increased metabolic rate**, inflammation, and tissue breakdown, resulting in increased energy and nutrient requirements

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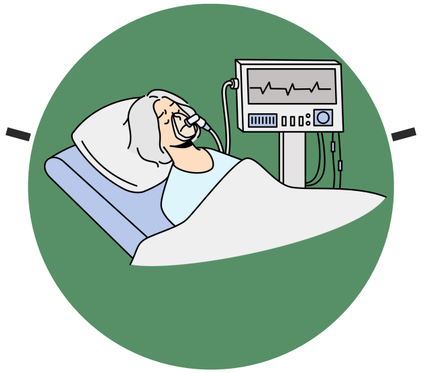
ACUTE AND LATE PHASE FOLLOWING INFECTION/STRESS/INJURY

Acute Phase
Early period



Acute Phase
Late period

Late Phase
Rehabilitation or
Chronic phase

Day 1-2	Day 3-7	After day 7
Catabolism	Catabolism	Anabolism

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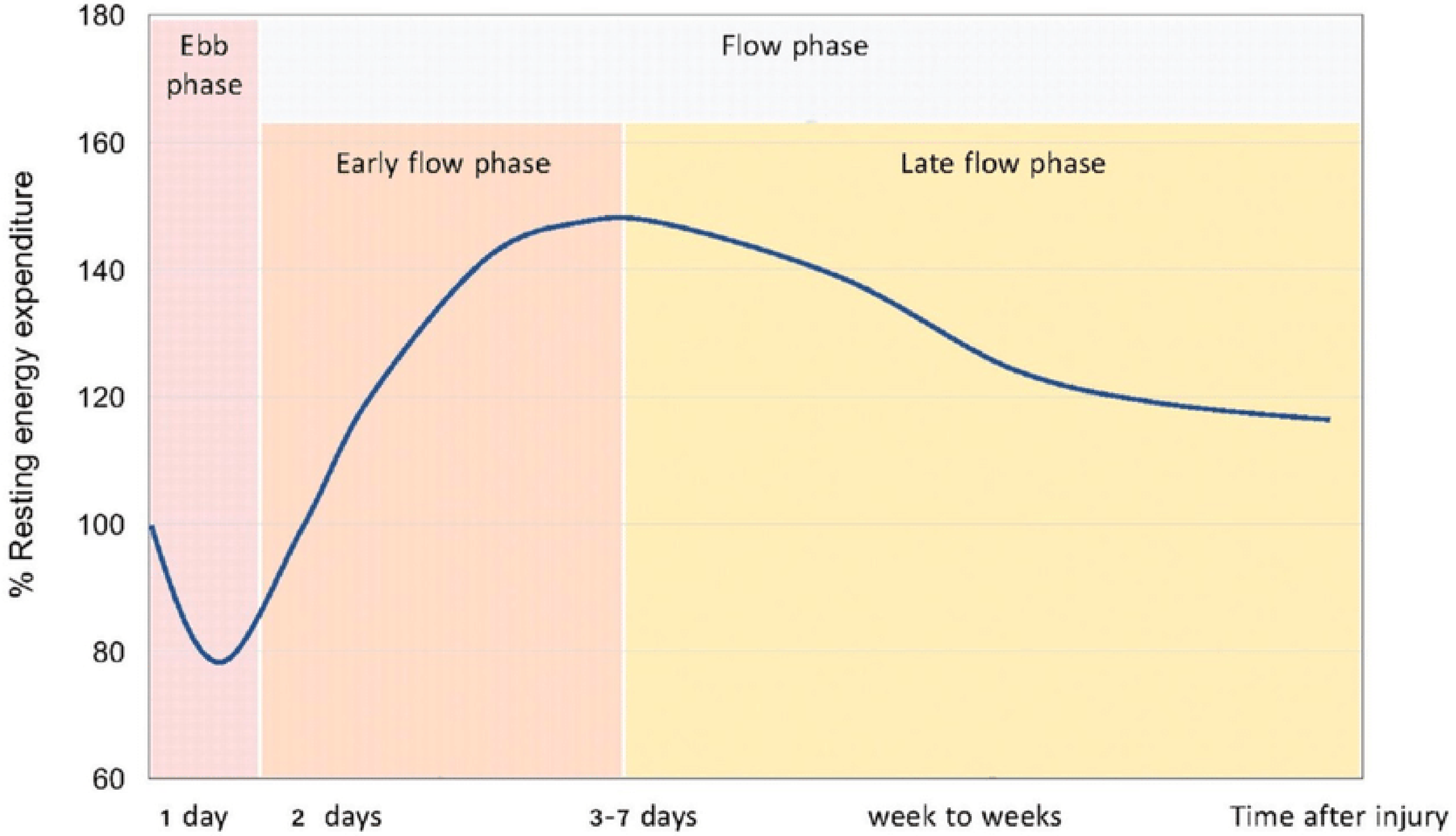
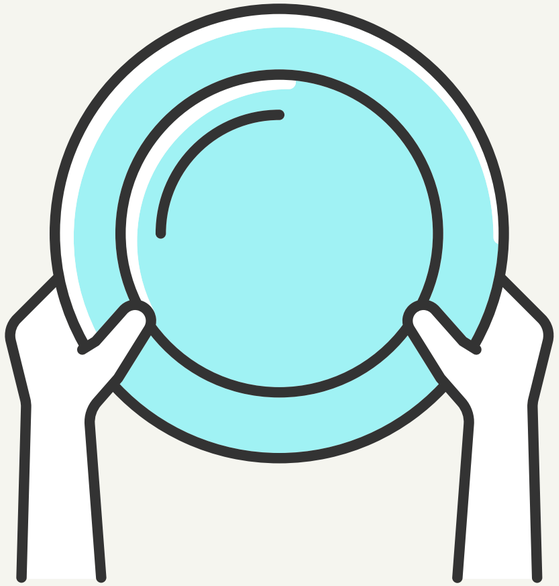

180
160
140
120
100
80
60
% Resting energy expenditure
Ebb phase
Flow phase
Early flow phase
Late flow phase
1 day
2 days
3-7 days
week to weeks
Time after injury

Reduced Food Intake:

- Critical illness can cause loss of appetite, early satiety, difficulty swallowing, and other eating challenges.

- Factors such as nausea, vomiting, pain, sedation, mechanical ventilation, and gastrointestinal dysfunction can all contribute to reduced food intake during critical illness.



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Altered Nutrient Absorption:

Gut dysfunction, decreased blood flow to the intestines, and increased gut permeability can all impair nutrient absorption

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Increased Nutrient Losses:

Critical illness can also result in increased nutrient losses due to factors such as increased urine output, drainage from wounds or tubes, and increased gastrointestinal losses.

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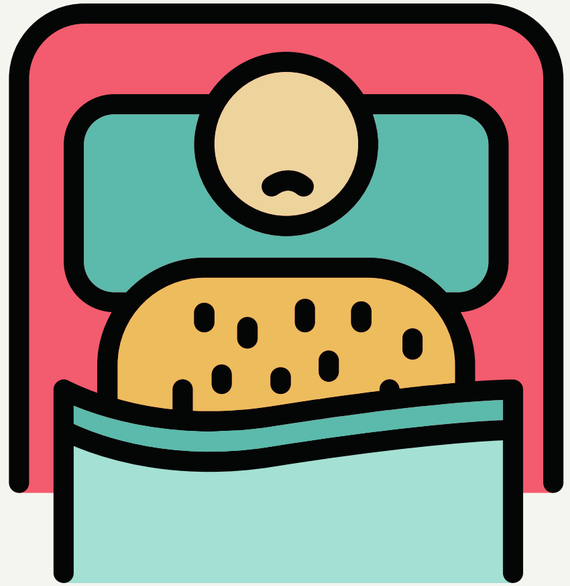
Inflammatory Response:

Critical illness triggers a systemic inflammatory response, which can increase nutrient requirements, alter nutrient metabolism, and affect nutrient utilization



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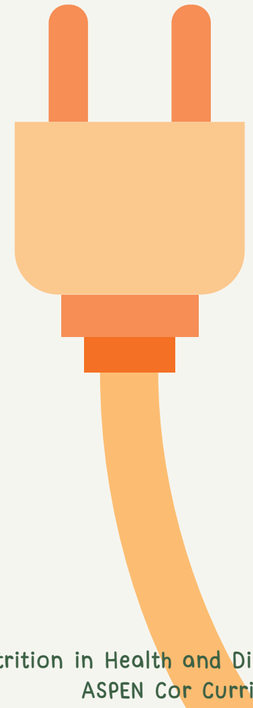
Nutrition care in ICU

Why Nutrition support is important in critically-ill patients

Energy support

- Increased energy needs due to the stress response and metabolic changes associated with their condition
- Prevents malnutrition, and promotes recovery



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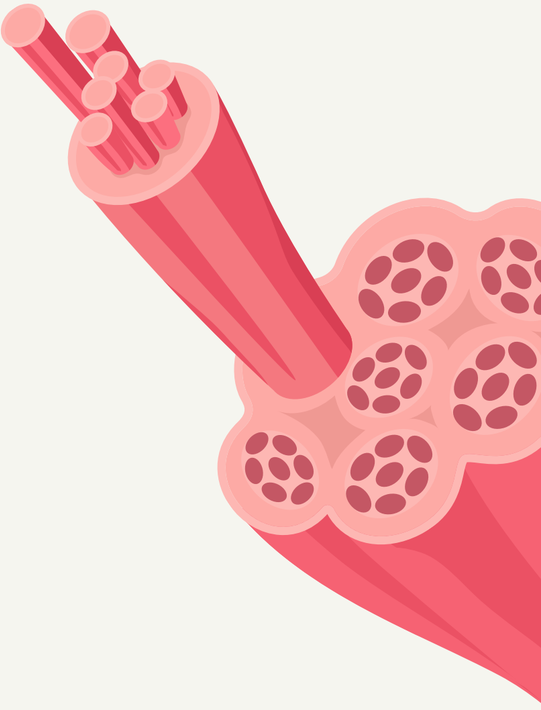
Maintenance of Lean Body Mass



- Stress response associated with critical illness
- Adequate nutrition, particularly protein, is essential to help prevent muscle wasting, maintain muscle strength, and preserve organ function

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Support of Immune Function

- Critically ill patients often experience impaired immune function due to their illness or injury, making them more susceptible to infections.

- Proper nutrition, including adequate protein, vitamins, and minerals, is essential for maintaining immune function and supporting the body's ability to fight infections

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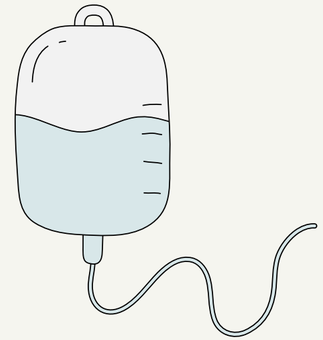
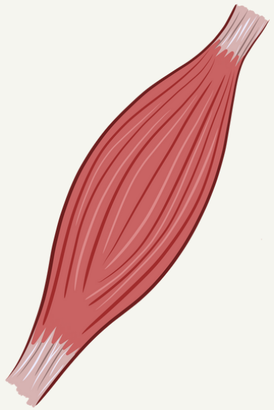
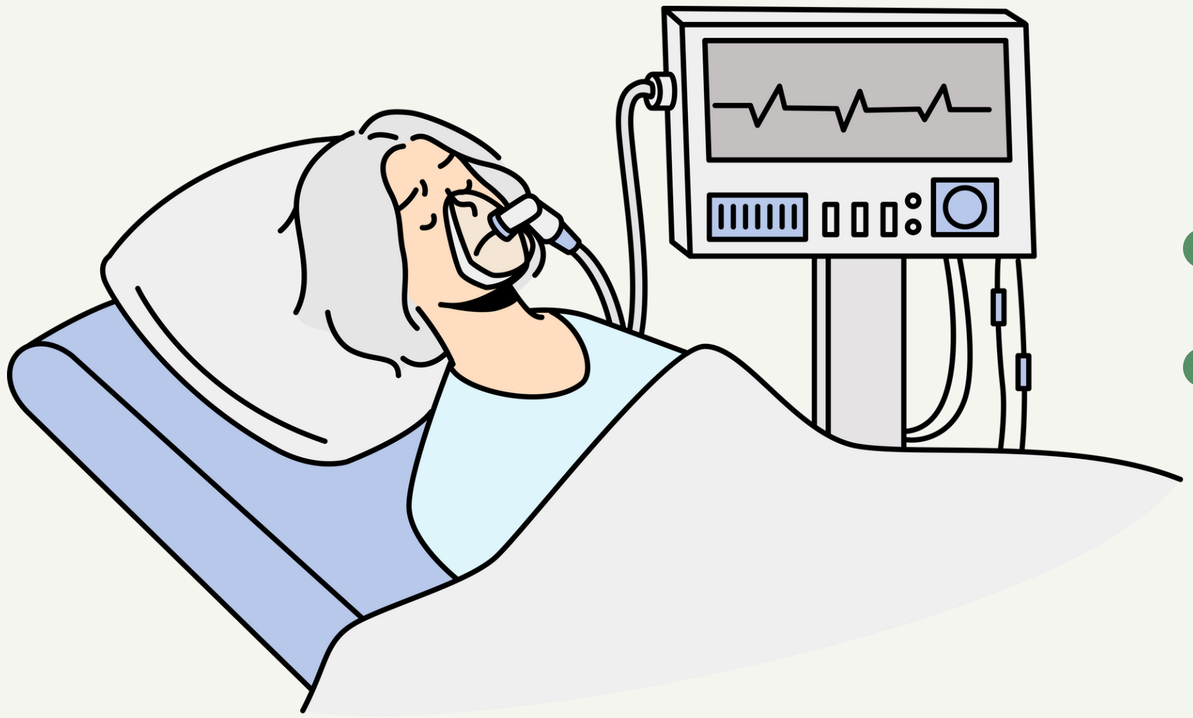
How to assess nutrition status ?

- Fluid administration



- Rapid wasting of lean tissue





- Decrease in muscle mass, strength, endurance and mobility

Hypoalbuminemia

- Marker of severity
- Low value being a response to inflammation

- Elevated C-Reactive protein

Nutrition Screening

Not-at-risk

Rescreen at:
- Regularly specified intervals or
- When nutritional/ clinical status changes

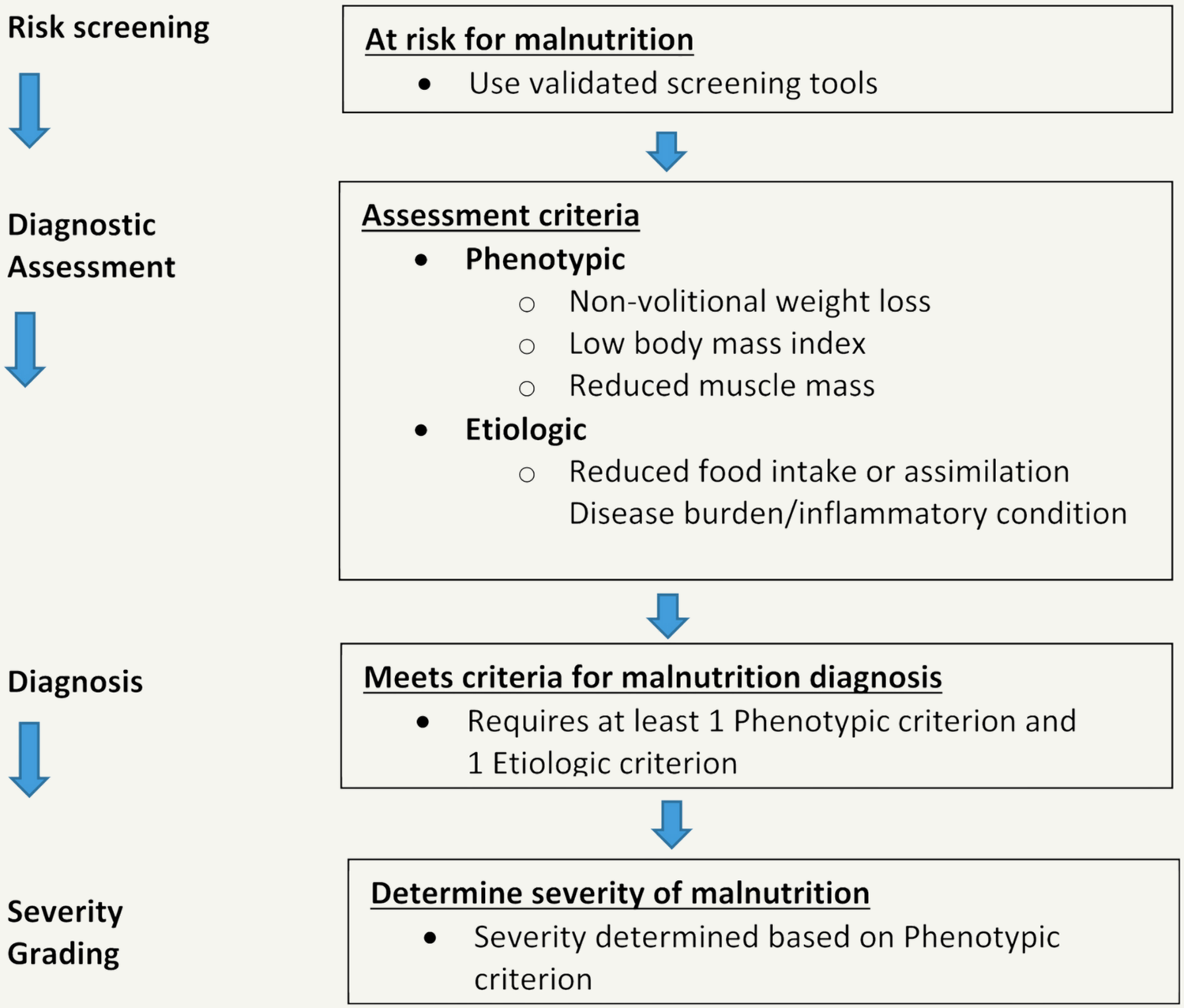
At-Risk or Malnourished

Nutrition Assessment

At-Risk or Malnourished

Nutrition Therapy

GLIM DIAGNOSTIC SCHEME FOR SCREENING, ASSESSMENT AND DIAGNOSIS



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VALIDATED SCREENING TOOLS

Table 1
Survey of existing approaches used in screening and assessment of malnutrition and cachexia.

	NRS-2002 [12] [a]	MNA-SF [21] [a,b]	MUST [22] [a]	ESPEN 2015 [8] [a]	ASPEN/AND [7] [a]	SGA [4] [a]	Evans 2008 [5] [c]	PEW 2008 [23] [d]	Fearon 2011 [6] [c]
Etiologies									
Reduced food intake	X	X	X	X	X	X		X	X
Disease burden/inflammation	X	X	X	X	X	X	X	X	X
Symptoms									
Anorexia		X				X	X		X
Weakness		X				X	X		
Signs/Phenotype									
Weight loss	X	X	X	X	X	X	X	X	X
Body mass index	X	X	X	X			X	X	X
Lean/fat free/muscle mass		X		X	X	X	X	X	X
Fat mass					X	X		X	
Fluid retention/ascites					X	X			
Muscle function; e.g. grip strength					X	X	X		
Biochemistry							X	X	

NRS-2002: Nutritional Risk Screening-2002, MNA-SF = Mini Nutritional Assessment-Short Form, MUST = Malnutrition Universal Screening Tool, ESPEN = European Society for Clinical Nutrition and Metabolism, ASPEN = American Society of Parenteral and Enteral Nutrition, AND = Academy of Nutritiona and Dietetics, SGA=Subjective Global Assessment, PEW=Protein Energy Wasting.

[a] Malnutrition approach.
[b] Adapted for older adults.
[c] Cachexia approach.
[d] Adapted for chronic kidney disease.

GLIM RECOMMENDATIONS

	Phenotype criteria		
	Weight loss (%)	Body mass index (kg/m^2)	Muscle mass[a]
Stage 1/Moderate Malnutrition (Requires 1 phenotypic and 1 etiologic criterion)	5–10% within the past 6 mo, or 10–20% beyond 6 mo	<20 if <70 yr, <22 if ≥70 yr Asia:<18.5 if <70 yr, <20 if ≥70 yr	Mild to moderate deficit (per validated assessment methods – see below)
Stage 2/Severe Malnutrition (Requires 1 phenotypic and 1 etiologic criterion)	>10% within the past 6 mo, or >20% beyond 6 mo	<18.5 if <70 yr, <20 if ≥70 yr Asia: TBD	Severe deficit (per validated assessment methods – see below)

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GLIM RECOMMENDATIONS

Table 2
Examples of recommended thresholds for reduced muscle mass.

	Males	Females
Appendicular Skeletal Muscle Index (ASMI, kg/m^2) [15]	<7.26	<5.25
ASMI, kg/m^2 [24][a]	<7	<6
ASMI, kg/m^2 [17][b]		
DXA	<7	<5.4
BIA	<7	<5.7
Fat free mass index (FFMI, kg/m^2) [8]	<17	<15
Appendicular lean mass (ALM, kg) [25]	<21.4	<14.1
Appendicular lean mass adjusted for BMI = ALM/BMI [26]	<0.725	<0.591

DXA = dual energy x-ray absorptiometry, BIA = bioelectrical impedance analysis. BMI = body mass index.

[a] Recommendations from European Working Group on Sarcopenia in Older People 2 (EWGSOP2); personal communication Alfonso Cruz- Jentoft.

[b] Recommendations from Asian Working Group for Sarcopenia (AWGS) for Asians.

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GLIM RECOMMENDATIONS

	Etiology criteria	
	Food intake, malabsorption or GI symptoms	Disease burden/ inflammation
Stage 1/Moderate Malnutrition (Requires 1 phenotypic and 1 etiologic criterion)	Any reduction of intake below ER for >2 weeks, or moderate mal-absorption/GI symptoms[b]	Acute disease/injury[d], or chronic disease-related[e]
Stage 2/Severe Malnutrition (Requires 1 phenotypic and 1 etiologic criterion)	≤50% intake of ER for >1 week, or severe mal-absorption/GI symptoms[c]	Acute disease/injury[d], or chronic disease-related[e]

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NUTRIC SCORE

Variable	Range	Points
Age	<50	0
	50 - <75	1
	≥75	2
APACHE II	<15	0
	15 - <20	1
	20-28	2
	≥28	3
SOFA	<6	0
	6 - <10	1
	≥10	2
Number of Co-morbidities	0-1	0
	≥2	1
Days from hospital to ICU admission	0 - <1	0
	≥1	1
IL-6	0 - <400	0
	≥ 400	1

NUTRIC SCORE WITH IL-6

Sum of points	Category	Explanation
6-10	High Score	➢ Associated with worse clinical outcomes (mortality, ventilation). ➢ These patients are the most likely to benefit from aggressive nutrition therapy.
0-5	Low Score	➢ These patients have a low malnutrition risk.

NUTRIC SCORE WITHOUT IL-6

Sum of points	Category	Explanation
5-9	High Score	➢ Associated with worse clinical outcomes (mortality, ventilation). ➢ These patients are the most likely to benefit from aggressive nutrition therapy.
0-4	Low Score	➢ These patients have a low malnutrition risk.

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Nutrition care in ICU

How to prescribe nutrition therapy in critically illness ?

How much ?

Macronutrients	ESPEN 2018	ASPEN 2021
Energy	• Indirect calorimetry • VO2 or VCO2 • Predictive equation	• Weight based equation: 12-25 kcal/kg in the first 7-10 day of ICU

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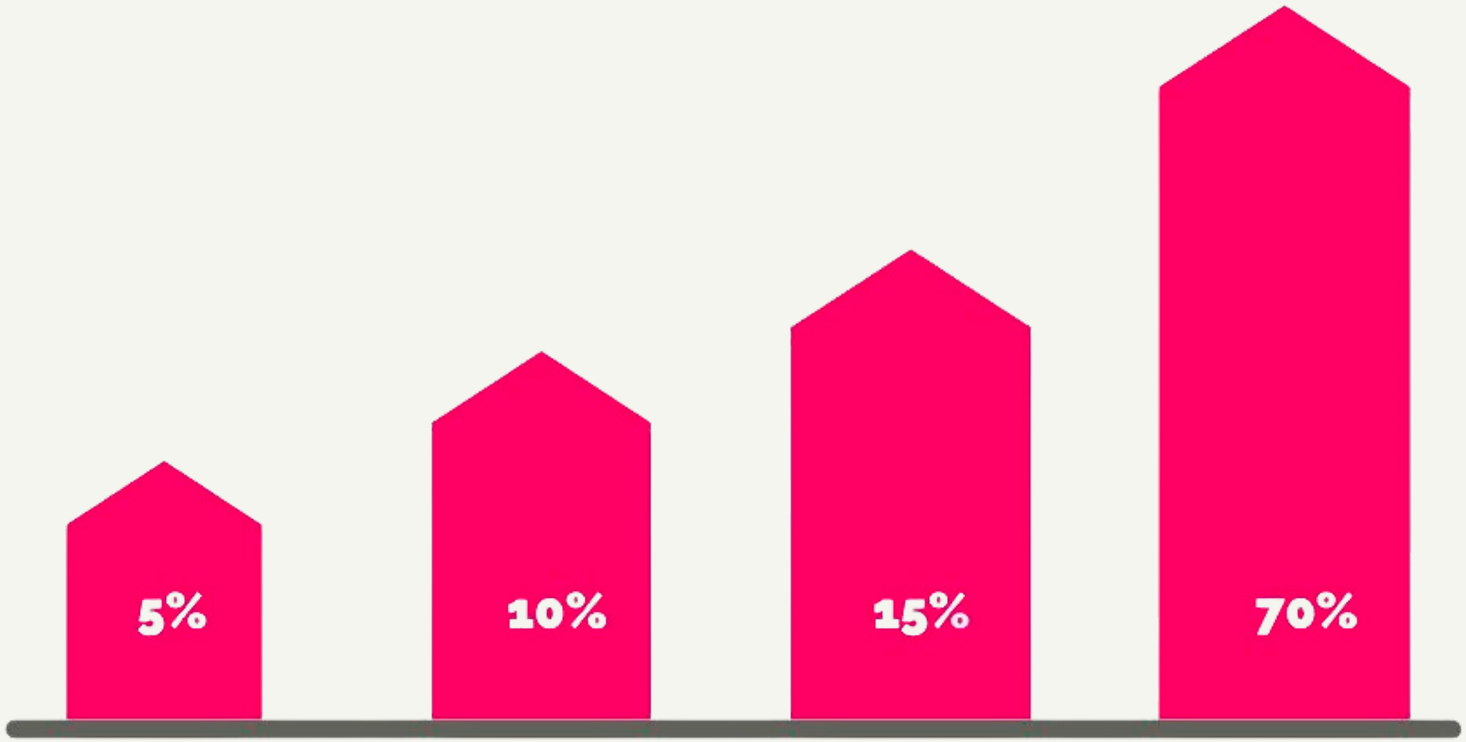
TDEE

Total Daily Energy Expenditure

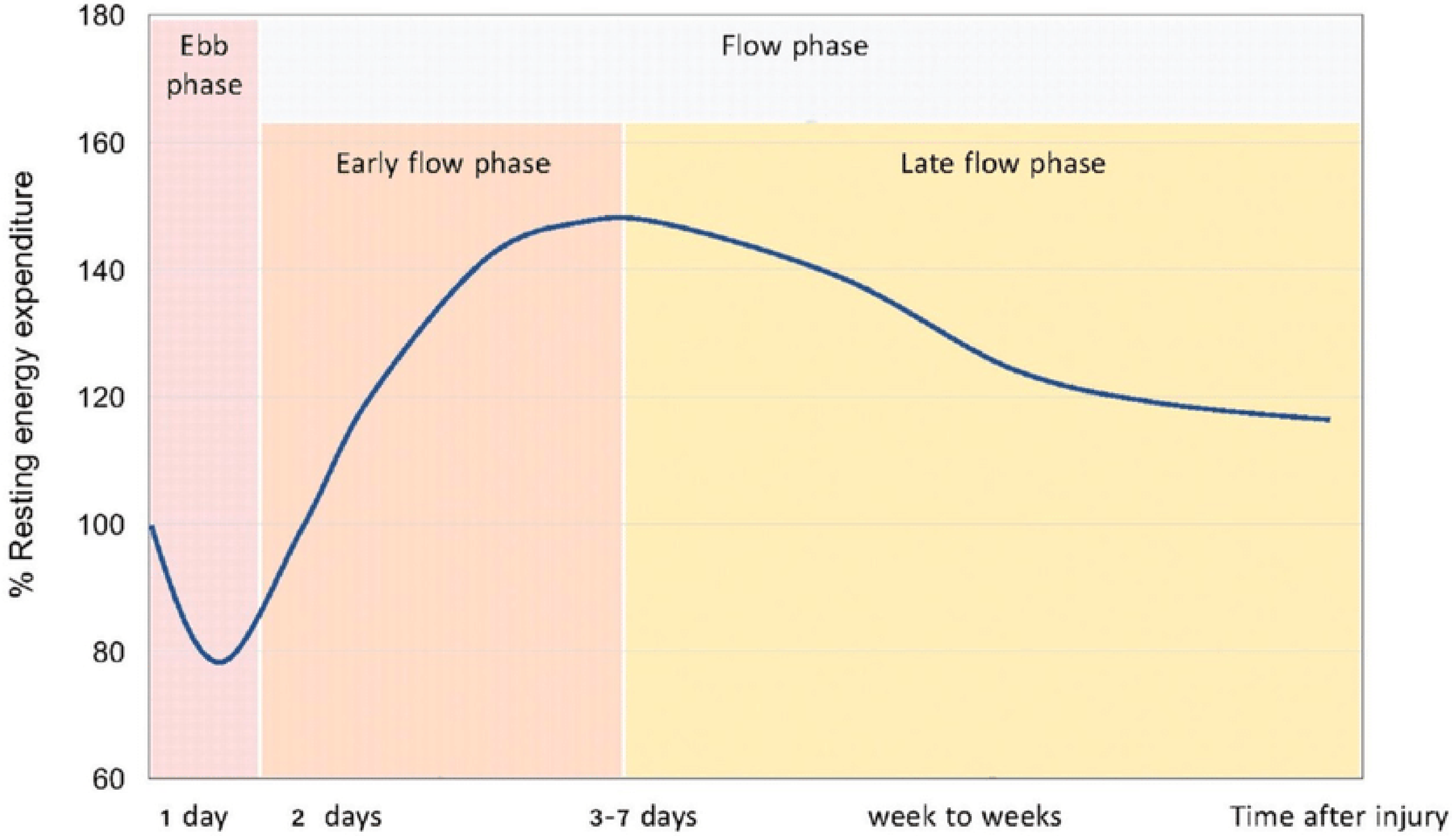


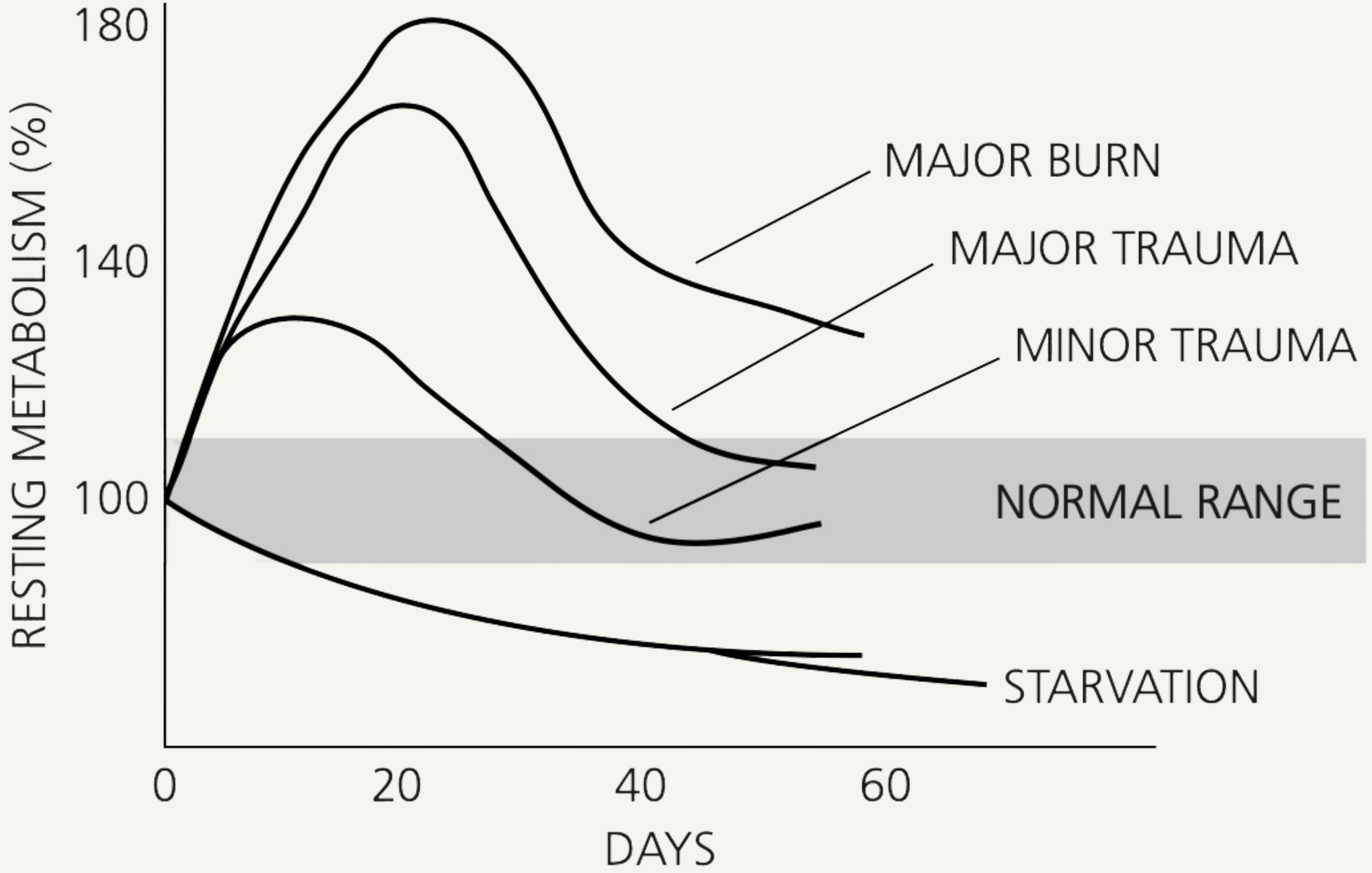
EAT
Exercise Activity Thermogenesis

TEF
Thermic effect of food

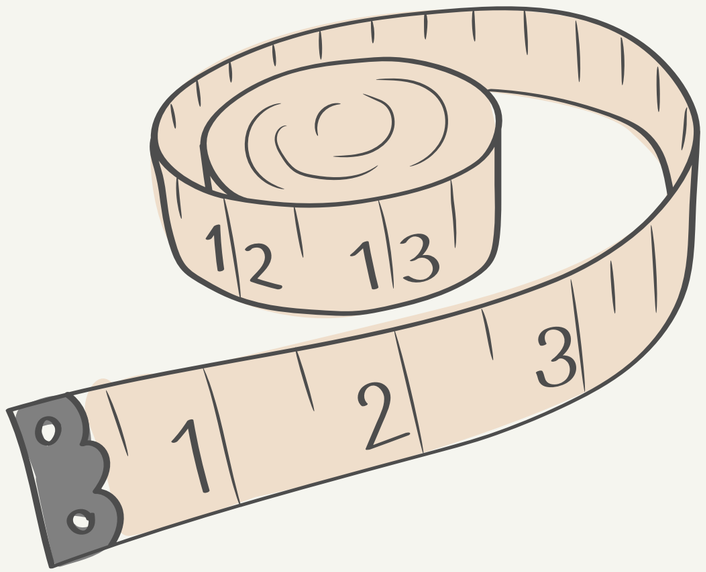
NEAT
Non-Exercise Activity Thermogenesis

BMR
Basal Metabolic Rate


180
160
140
120
100
80
60
% Resting energy expenditure
Ebb phase
Flow phase
Early flow phase
Late flow phase
1 day
2 days
3-7 days
week to weeks
Time after injury

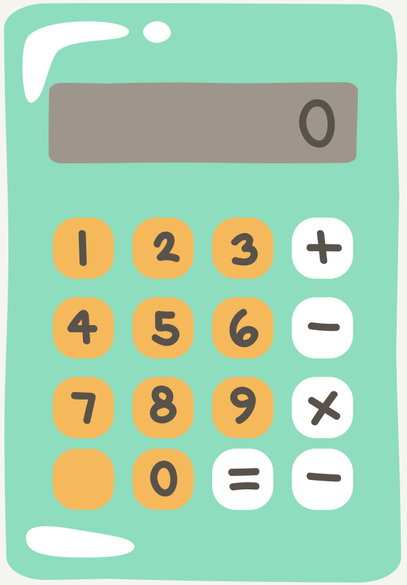

180
140
100
RESTING METABOLISM (%)
MAJOR BURN
MAJOR TRAUMA
MINOR TRAUMA
NORMAL RANGE
STARVATION
0
20
40
60
DAYS

How can we get energy expenditure ?



Measure

(direct, indirect calorimetry)



Estimate (calculate)

(predictive equation, weight-based equation)

Indirect calorimetry

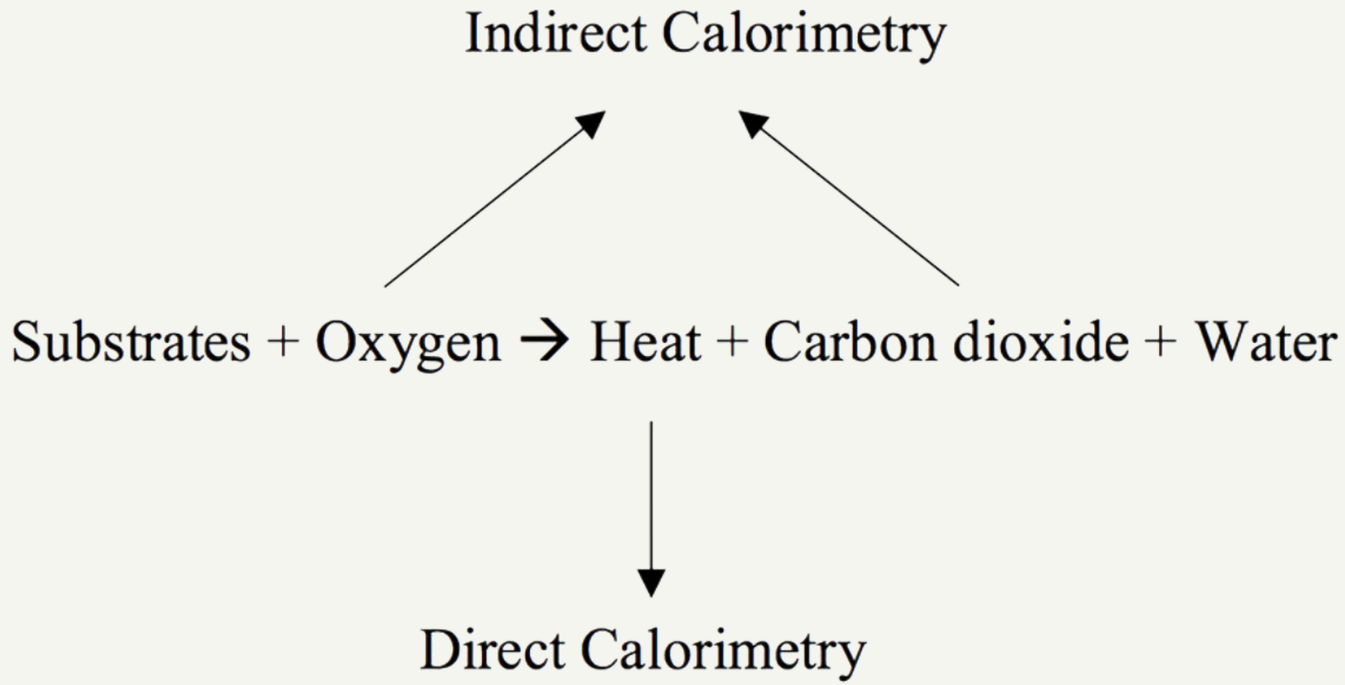


FIGURE 1 | Direct calorimetry measures heat production and indirect calorimetry measures gas exchange: oxygen consumption and carbon dioxide production.

Predictive equations

Description of predictive equations.

Equation name	Calculation of resting energy expenditure
Harris-Benedict equation [25]	Males: [66.5 + (13.8 × AdjBW) + (5 × Ht) – (6.8 × Age)] × 1.5
	Females: [655 + (9.6 × AdjBW) + (1.8 × Ht) – 4.7 × Age)] × 1.5
Owen equation [35]	Males: 879 + (10.2 × ActBW)
	Females: 795 + (7.2 × ActBW)
Mifflin equation [26]	Males: 5 + (10 × ActBW) + (6.25 × Ht) – (5 × Age)
	Females: 161 + (10 × ActBW) + (6.25 × Ht) – (5 × Age)
Ireton-Jones equation for obesity [27, 36, 37]	Males: 606 + (9 × ActBW) – (12 × Age) + 400 (if ventilated) + 1400
	Females: ActBW – (12 × Age) + 400 (if ventilated) + 1444
American College of Chest Physicians (ACCP) guidelines [17]	BMI < 25: ActBW × 25 BMI ≥ 25: IBW × 25

AdjBW = Adjusted body weight = Ideal body weight + 0.25 (Actual body weight – Ideal body weight)

IBW = Ideal body weight = 50 + 2.3 per inch > 60 inches (men); 45.5 + 2.3 per inch > 60 inches (women)

ActBW = Actual body weight = weight on admission (kg)

Ht = Height (cm)

Energy expenditure	%Precise
Harris-Benedict	31.3
Mifflin	17.8
Ireton-Jones	22.2
25 kcal/kg	12.0

A Comparison of Predictive Equations of Energy Expenditure and Measured Energy Expenditure in Critically Ill Patients. Journal of Critical Care 27, no. 3 (June 2012): 321.e5-12.

How much ?

Macronutrients	ESPEN 2018	ASPEN 2021
Energy	• Indirect calorimetry • VO2 or VCO2 • Predictive equation	• Weight based equation: 12-25 kcal/kg in the first 7-10 day of ICU
Protein	• 1.3 g/kg/day (progressively)	• 1.2-2.0 g/kg/day
Carbohydrate	• Glucose infusion rate (GIR) < 5 mg/kg/min	• NA
Fat (Intravenous lipid emulsion; ILE)	• < 1.5 g/kg/day	• Either mixed-oil ILE or 100% SO ILE • Either FO or non-FO containing ILE

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How to ? (step up calorie)

Energy expenditure	ESPEN 2018	ASPEN 2021
How to... ?	• IC ◦ Hypocaloric (< 70% of EE) in the early phase ◦ Isocaloric nutrition can be progressively implemented after the early phase	NA
	• Predicitive equatioin ◦ Hypocaloric (< 70% of EE) over the 1st week of ICU	

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How to ? (route selection)

Route	ESPEN 2018	ASPEN 2021
EN vs PN in the 1st week of ICU	• Oral diet first • Early EN with in 48 hr • If contraindicated to oral or EN + start PN within 3-7 day • If contraindicated to oral or EN = servere maln. : early and progressive PN	• Early EN within 24-48 hr* • Either EN or PN is accpetable
Supplemental PN in the 1st week in ICU	• SPN should not be started until all strategies to maximize EN tolerance have been attempted	• Not initiating PN prior to day 7 of ICU admission

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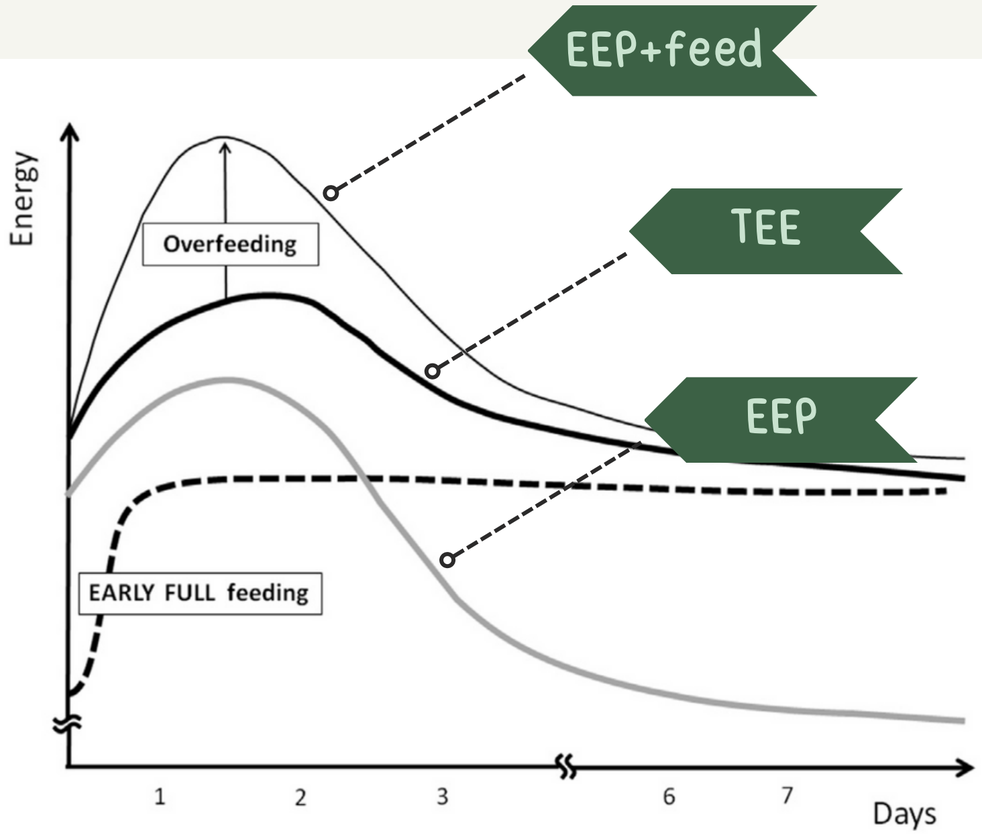

Fig. 4. Conceptual presentation of the relative overfeeding frequently related to parenteral nutrition during the early phase of critical illness. During the acute phase of the critical illness, the release of endogenous energy substrates is increased and meets total energy expenditure (TEE), and administering energy does not immediately terminate this response. Introducing full feeding in this early phase usually results in overfeeding, as the endogenous energy production is not attenuated by energy administration thus creates an excessive energy source above TEE. (Solid bold line: Total energy expenditure; grey bold line: adapted endogenous energy production; dotted bold line: early energy administration; thin line: combined endogenous and exogenous energy administration).

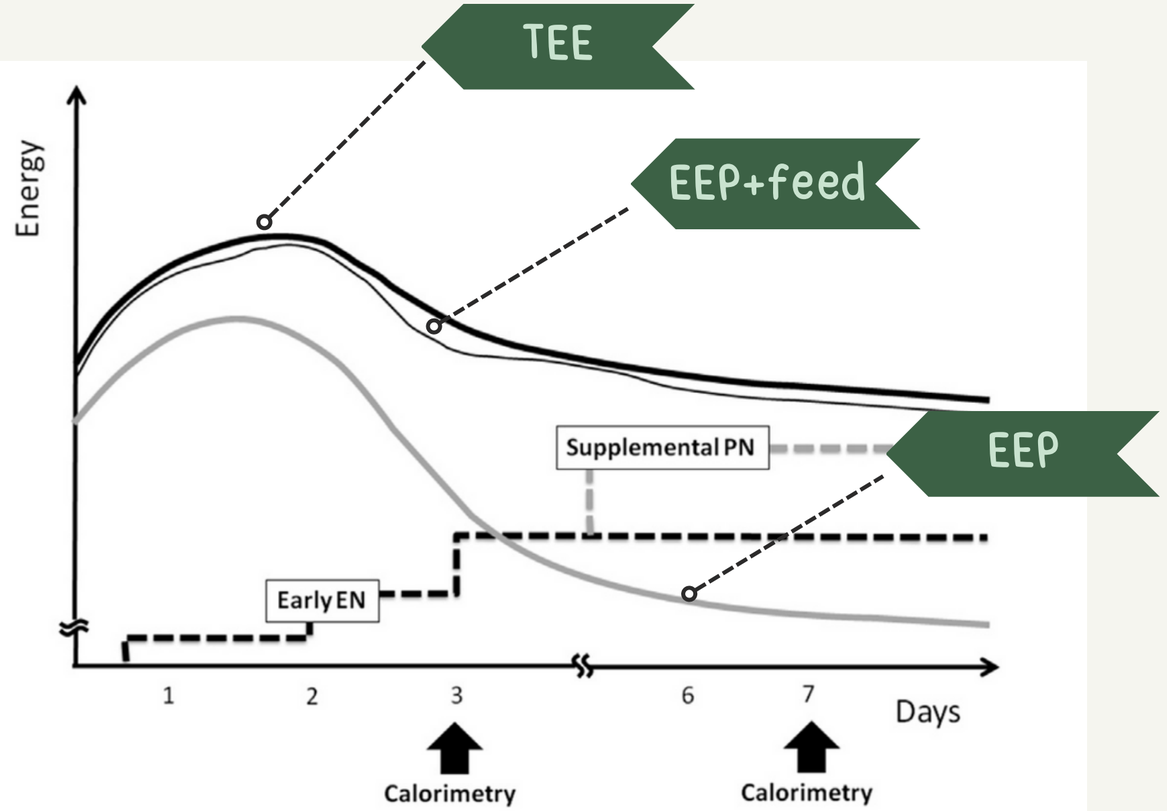

Fig. 5. Conceptual presentation of optimal feeding strategy to avoid both overfeeding and underfeeding in critical illness: Introducing the adequate amount of feeding in proportion to the body's capacity to down-regulate endogenous substrate production avoids both early overfeeding and late underfeeding. Repeated calorimetry is needed to monitor the dynamic changes of energy expenditure, however, providing the optimal amount of energy still requires special attention to avoid both underfeeding and overfeeding. (Solid bold line: Total energy expenditure; grey bold line: adapted endogenous energy production; dotted bold line: energy administration by EN; grey dotted bold line: energy administration by PN; thin line: combined endogenous and exogenous energy administration).

Indirect Calorimetry in Nutritional Therapy. A Position Paper by the ICALIC Study Group. Clinical Nutrition (Edinburgh, Scotland) 36, no. 3 (June 2017): 651–62.

EN	ESPEN 2018	ASPEN 2021
EN technique	• Continuous feeding rather than bolus feeding	• Either EN or PN is accpetable
Feeding intolerance	• Prokinetic: IV erythromycin, IV metoclopramide • Post-pyloric feeding	• Not initiating PN prior to day 7 of ICU admission

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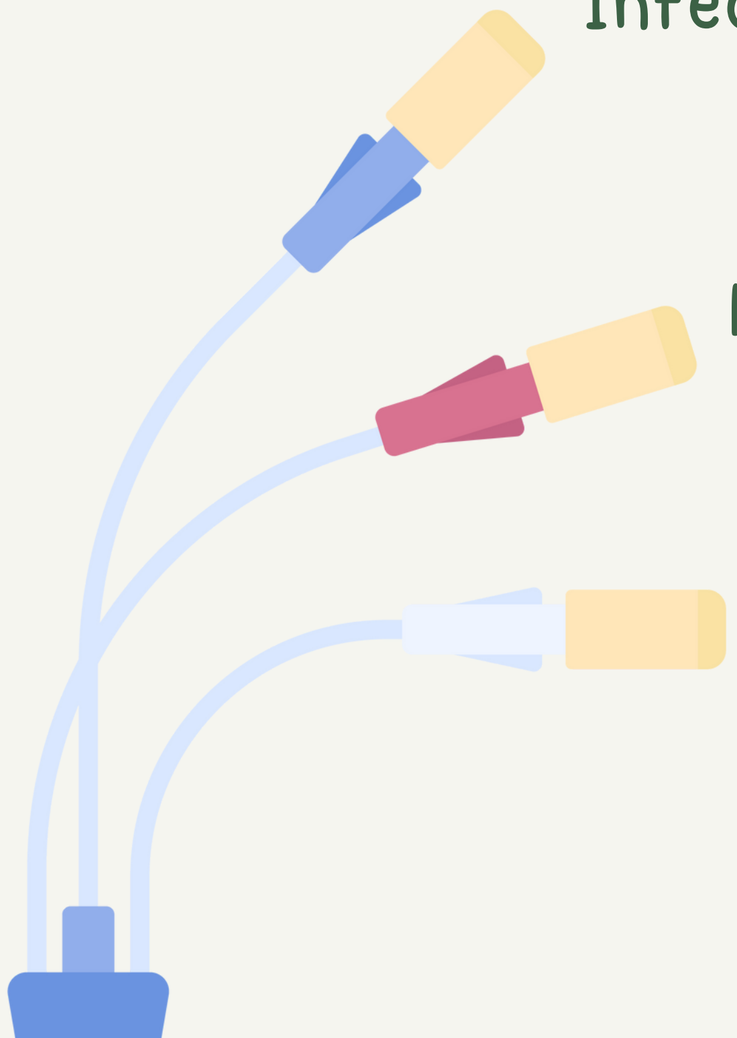
How to ? (monitoring)

Route	ASPEN 2016
EN	• Monitoring daily for tolerance of EN • Avoid inappropriated NPO • GRV not be used as part of routine care ○ **where GRVs are still utilized, holding EN when GRV < 500 mL in the absence of signs of intolerance should be avoided** • Post-pyloric feeding in high risk of aspiration
PN	• Target blood glucose : 140 or 150 - 180 mg/dL • Discontinue PN when achieved EN > 60% target calorie

Guidelines for the Provision and Assessment of Nutrition Support Therapy in the Adult Critically Ill Patient." Journal of Parenteral and Enteral Nutrition 40, no. 2 (2016): 159-211.

How to ? (monitoring)



Infection, CRBSI

Metabolic complications

- Hyperglycemia
- Hypertriglyceridemia
- PN-associated liver diseases

Mechanical complications

- Pneumothorax
- Thrombosis

Glutamine

Burn patients: > 20% of BSA

- Enteral glutmine : 0.3-0.5 g/kg/day in first 10-15 days

Trauma patients:

- Enteral glutmine : 0.2-0.3 g/kg/day in first 5 days

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Omega-3 fatty acid

EN enriched with omega-3 FA within nutritional doses can be administered.

High doses omega-3 enriched enteral formulas should not be given on a routine basis.

ILE enriched with EPA+DHA (Fish oil dose 0.1-0.2 g/kg/d) can be provided in patients receiving PN

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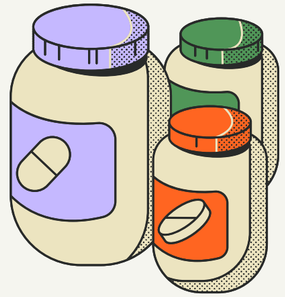

To enable substrate metabolism, micronutrients (i.e. trace elements and vitamins) should be provided daily with PN.

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Antioxidants as high dose monotherapy should not be administered without proven deficiency.

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- In critically ill patients with measured low plasma levels (25-hydroxy-vitamin D < 12.5 ng/ml, or 50 nmol/l) vitamin D3 can be supplemented.

- A high dose of vitamin D3 (500,000 UI) as a single dose can be administered within a week after admission.

ESPEN Guideline on Clinical Nutrition in the Intensive Care Unit. Clinical Nutrition 38, no. 1 (February 2019): 48-79.