UNIVERSITY OF MALAYA

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ENERGY REQUIREMENT USING INDIRECT CALORIMETRY AMONG ICU PATIENTS IN MALAYSIA

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Outline

1) Brief principle of Indirect Calorimetry (IC)

2) The clinical application of IC to optimize energy prescription.

3) Nutritional therapy in COVID-19

Brief Principle Of Indirect Calorimetry

Energy Expenditure: Available Methods

Predictive Equations

Wide range of predictive equations (Harris-Benedict, Mifflin-St. Jeor, Cunningham, Owen, Schofield/WHO) derived according to specific patient population samples

Based on statistical analysis of anthropometric data (age, sex, weight, height, BMI, body composition, etc)

Limited accuracy

Direct Calorimetry

Direct measurement of the heat produced by metabolic processes to quantify total energy expenditure (TEE)

Total body heat production is directly measured via a thermally sealed chamber.

Used in Research settings only

(not practical in clinical applications)

Indirect Calorimetry

Estimating heat production based on the determination of gaseous exchange (oxygen consumed and carbon dioxide produced) at rest

«Indirect» technique because gas exchange does not directly measure heat production

The Gold Standard for clinical applications

Reference Device of 20th Century

- Deltatrac Metabolic Monitor (Datex, Finland)
- Features both canopy and ventilator measurements
- Repeatedly validated (mass spectrometry)
- Existing units are progressively disappearing and the manufacturer no longer offers any support

Indirect Calorimetry (IC) - COSMED

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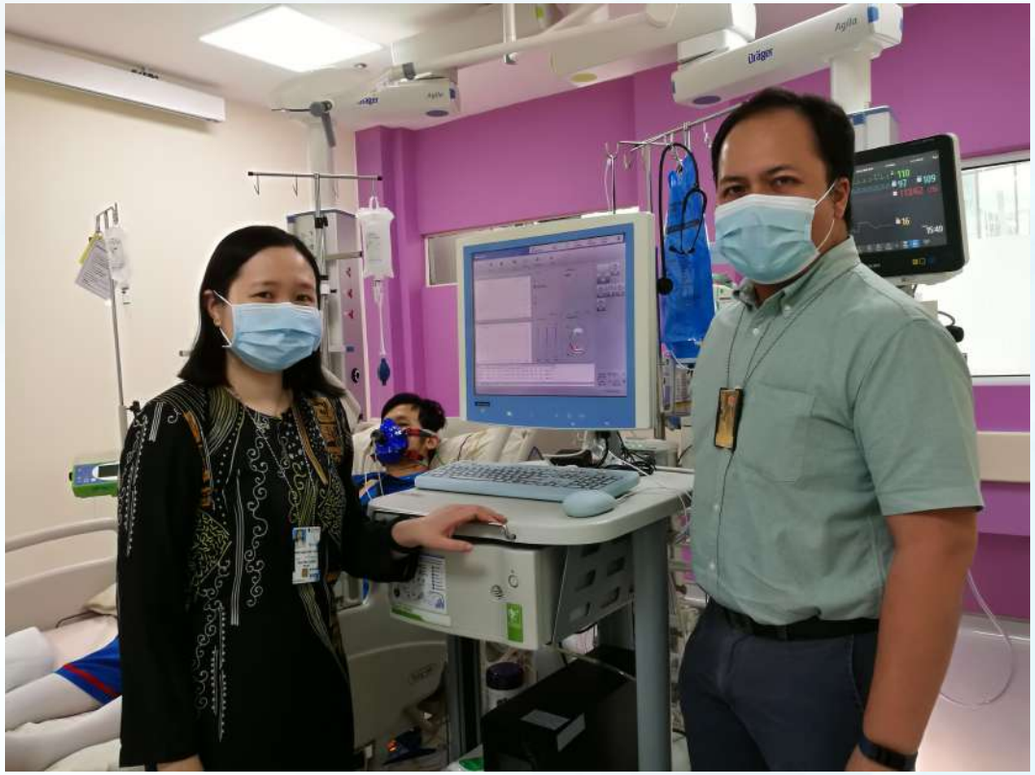
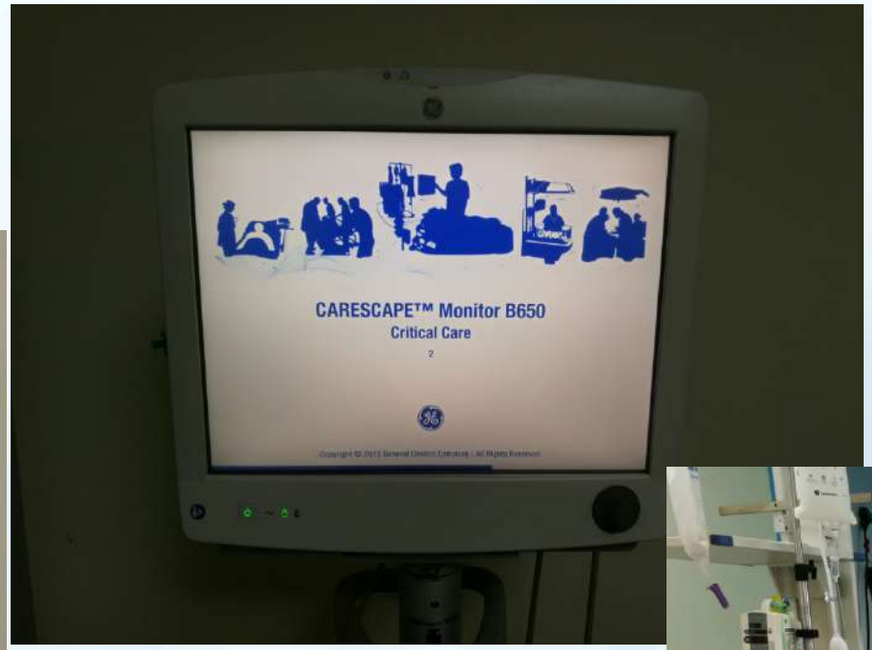


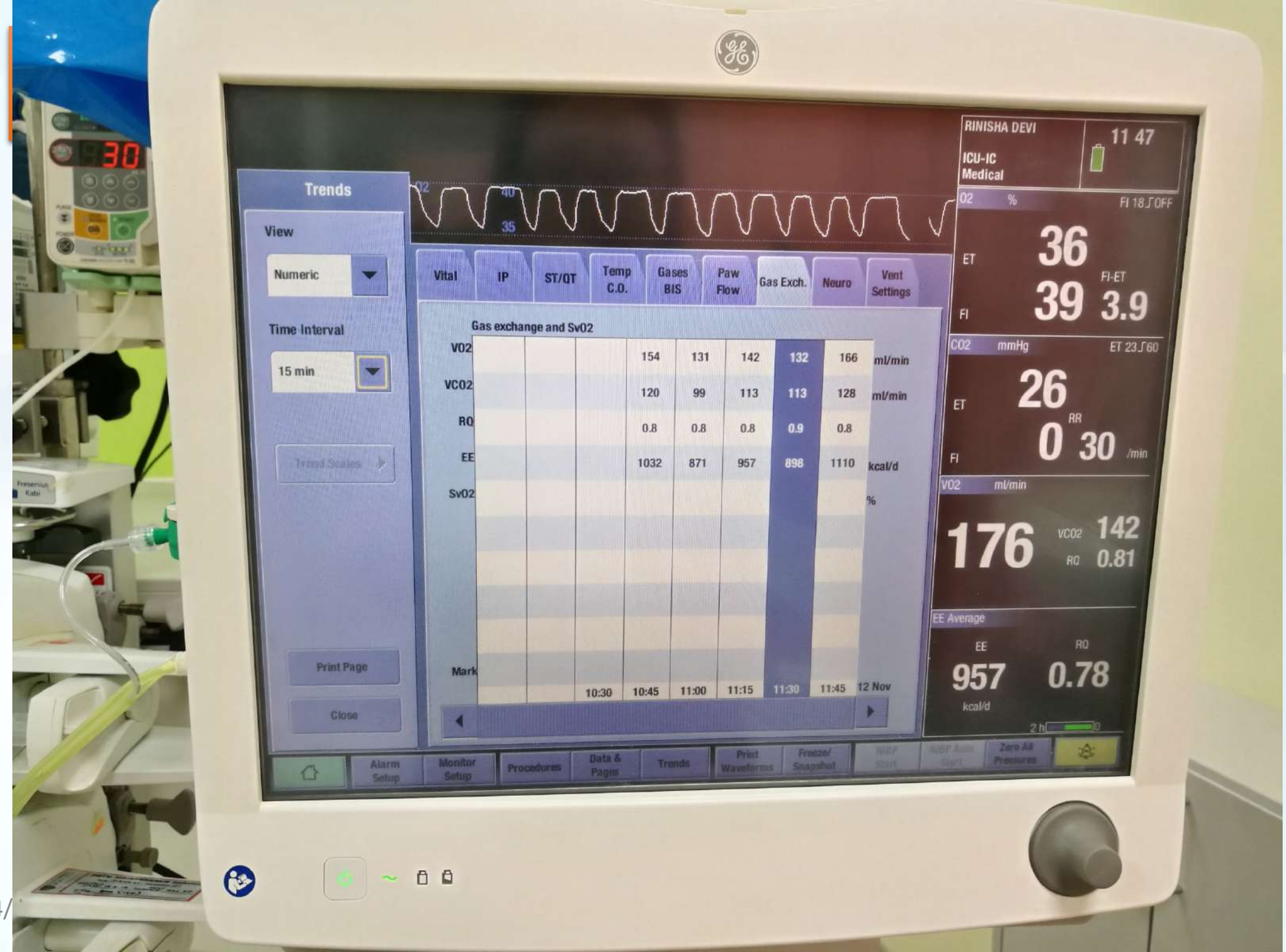
Indirect Calorimetry (IC) - COSMED

Next Generation Indirect Calorimetry (IC) – Q-NRG+ COSMED

- 5 min to measurement
- Easy to clean
- Accuracy +/- 3% or 36 kcal/day, whichever is greater
- Easy to use

Indirect Calorimetry (IC) - GE




Trends
View
Numeric
Time Interval
15 min
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Print Page
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Vital
IP
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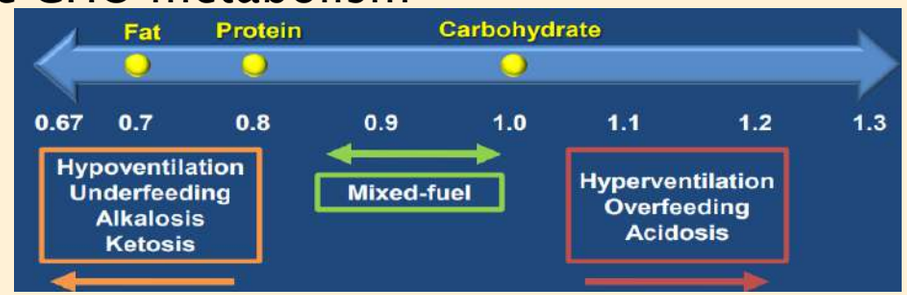
Temp C.O.
Gases BIS
Paw Flow
Gas Exch.
Neuro
Vent Settings
Gas exchange and Sv02
VO2
VCO2
RQ
EE
Sv02
Mark
154 131 142 132 166 ml/min
120 99 113 113 128 ml/min
0.8 0.8 0.8 0.9 0.8
1032 871 957 898 1110 kcal/d
%
10:30 10:45 11:00 11:15 11:30 11:45 12 Nov
RINISHA DEVI
ICU-IC
Medical
11 47
O2 %
FI 18 OFF
ET 36
FI 39
FI-ET 3.9
CO2 mmHg
ET 23 60
ET 26
RR
FI 0 30 /min
VO2 ml/min
176
VCO2 142
RQ 0.81
EE Average
EE 957 kcal/d
RQ 0.78
Alarm Setup
Monitor Setup
Procedures
Data & Pages
Trends
Print Waveforms
Freeze/ Snapshot
Zero All Pressures

INDIRECT CALORIMETRY

- Reference standard in calculation of energy expenditure by measuring 02 consumption and CO2 production
- Reflects the rate of cellular metabolism – food sources (CHO, FAT, PRO) are metabolized to produce energy.
- RESTING ENERGY EXPENDITURE *(Abbreviated Weir Equation, 1949)*
  REE (Kcal/d) = [(VO2 x 3.94) + (VCO2 x 1.11)] x 1,440 min/day
- RESPIRATORY QUOTIENT, $RQ = \frac{VCO2\ (carbon\ dioxide\ production)}{VO2\ (oxygen\ consumption)}$
  - RQ > 1 → overfeeding or pure CHO metabolism
  - RQ < 0.7 → starvation
  - Normal RQ = 0.85



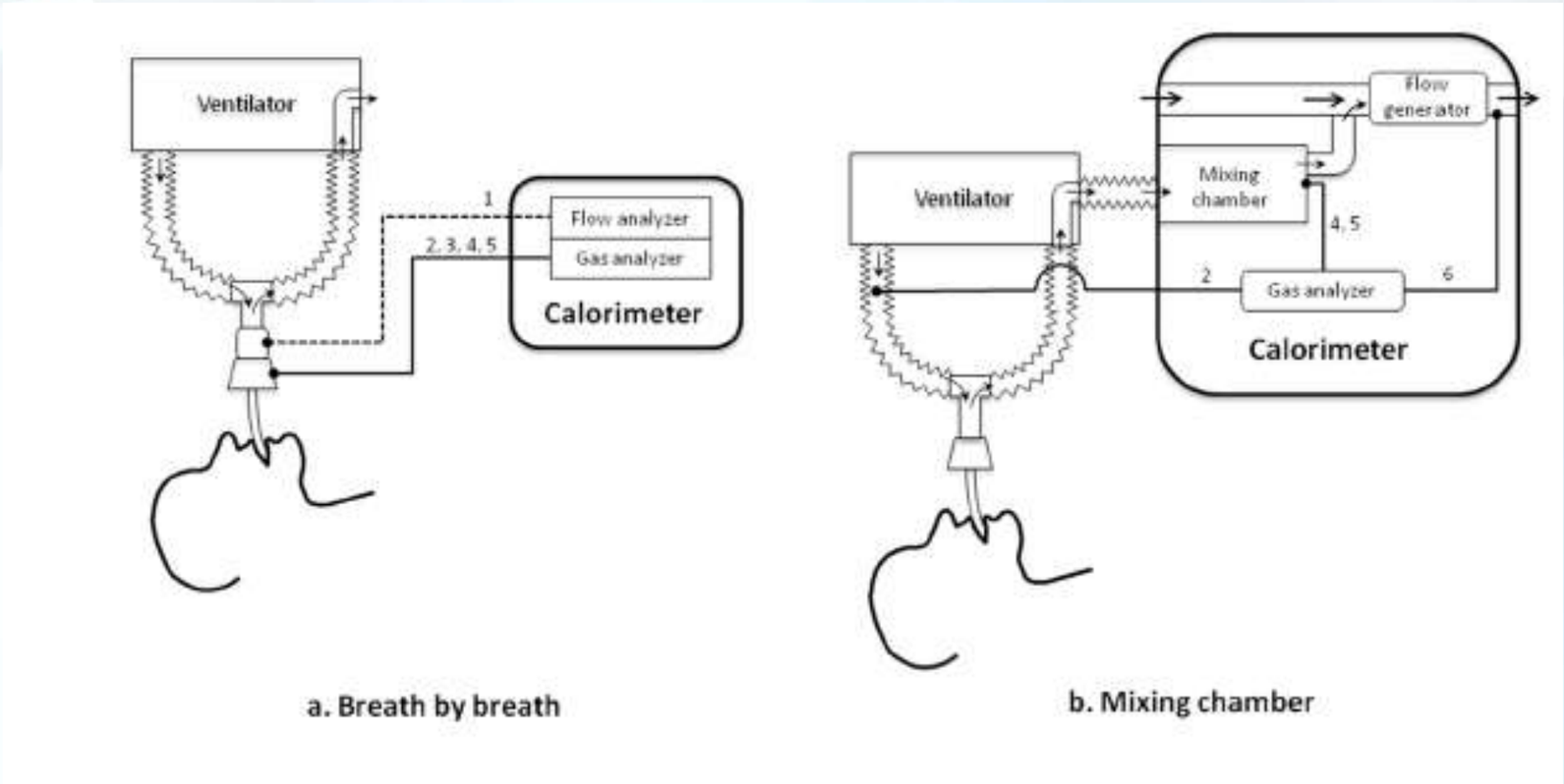
- 2 assumptions are made:

1. The patient is in true steady-state condition
2. All VCO_2 measured reflects substrate utilization

Gupta et al., 2017; Oshima et al., 2016; McClave et. al., 2003

Technical Concepts – Mechanically Ventilated Patients

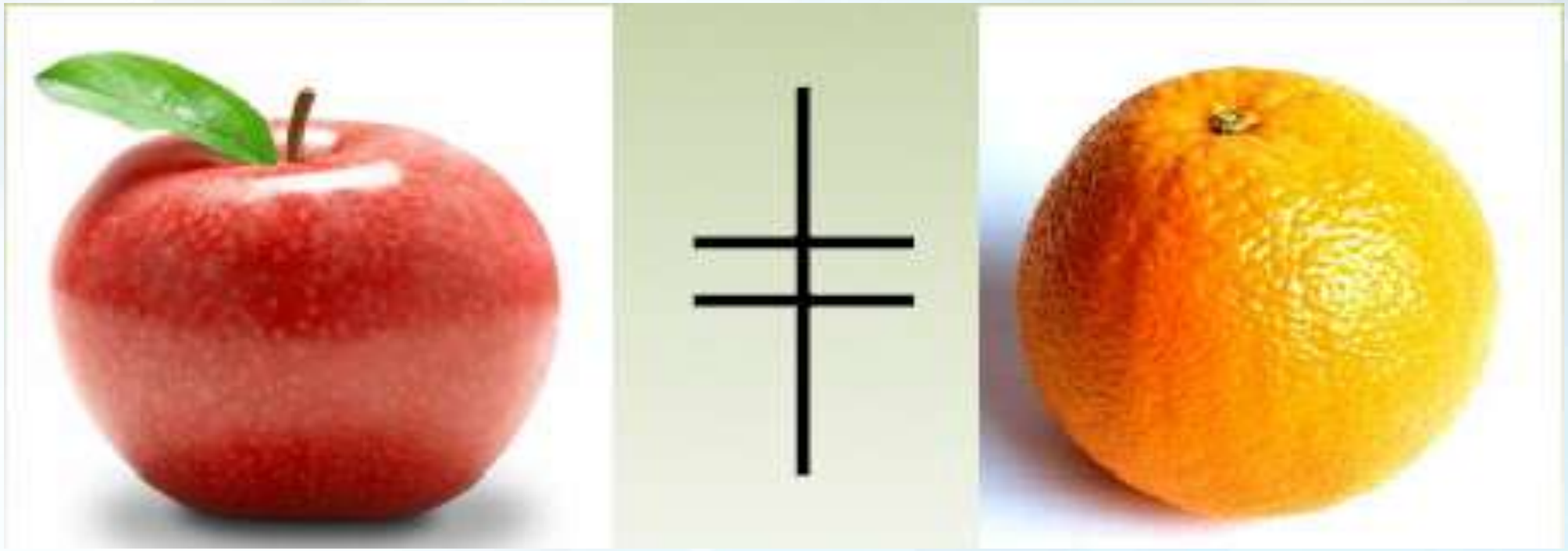
- Gas sampling is obtained from circuit connecting the ETT to ventilator, and measured by using either breath-by-breath analysis or the analysis using a mixed chamber.



Oshima T, et al., Indirect calorimetry in nutritional therapy. A position paper by the ICALIC study group, Clinical Nutrition (2016)

The Clinical Application of Indirect Calorimetry to Optimize Energy Prescription

Are All Critically Ill Patients Same?



Overfeeding or Underfeeding?

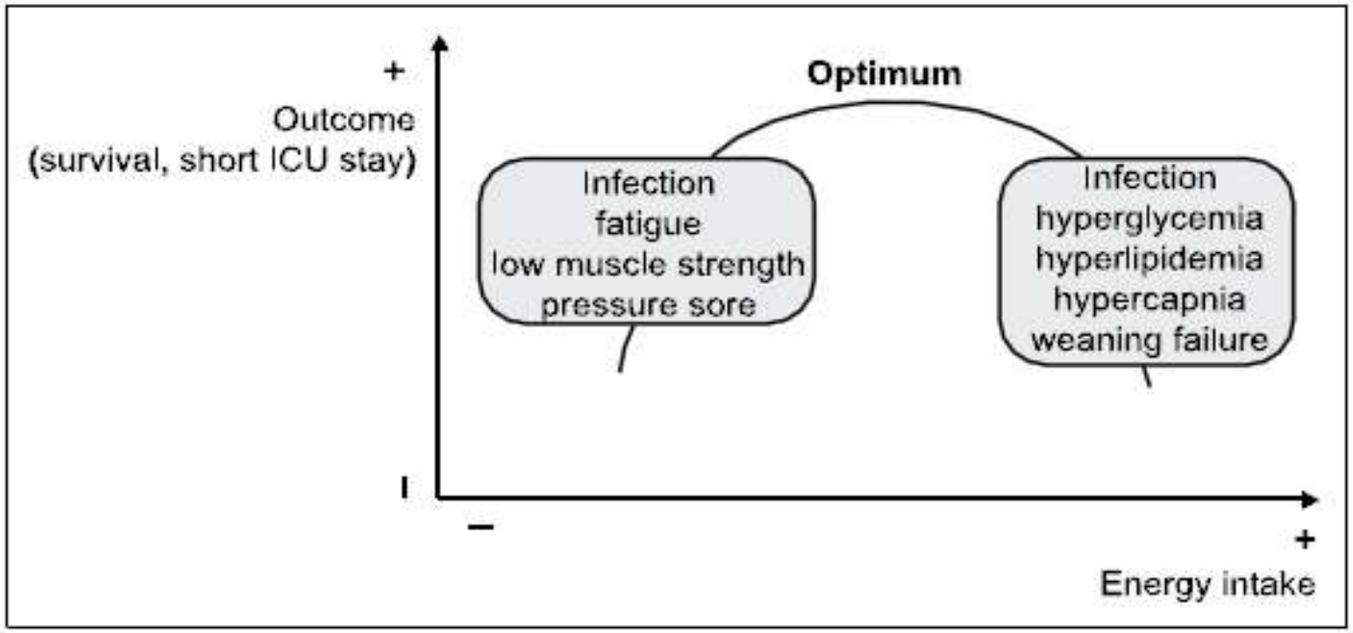


Figure 1. Overnutrition or undernutrition administered to critically patients may induce complications. Therefore, energy intake should be guided by indirect calorimetry. Reprinted with permission from Hiesmayr M. Nutrition risk assessment in the ICU. *Curr Opin Clin Nutr Metab Care*. 2012;15:174-180.

Why Indirect Calorimetry in ICU?

Repeated Indirect Calorimetry (IC) measurements in ICU patients are important as this would **provide accurate energy measurements** to meet individual requirement, especially in **patients who are complicated and at a higher risk for suboptimal feeding.**

The recent **ASPEN 2016 and ESPEN 2019** guidelines recommended IC as the **best method** for determining resting energy expenditure (REE) among ICU patients.

Indirect Calorimetry is not commonly used

Optimal Feeding Strategy In Critical Illness

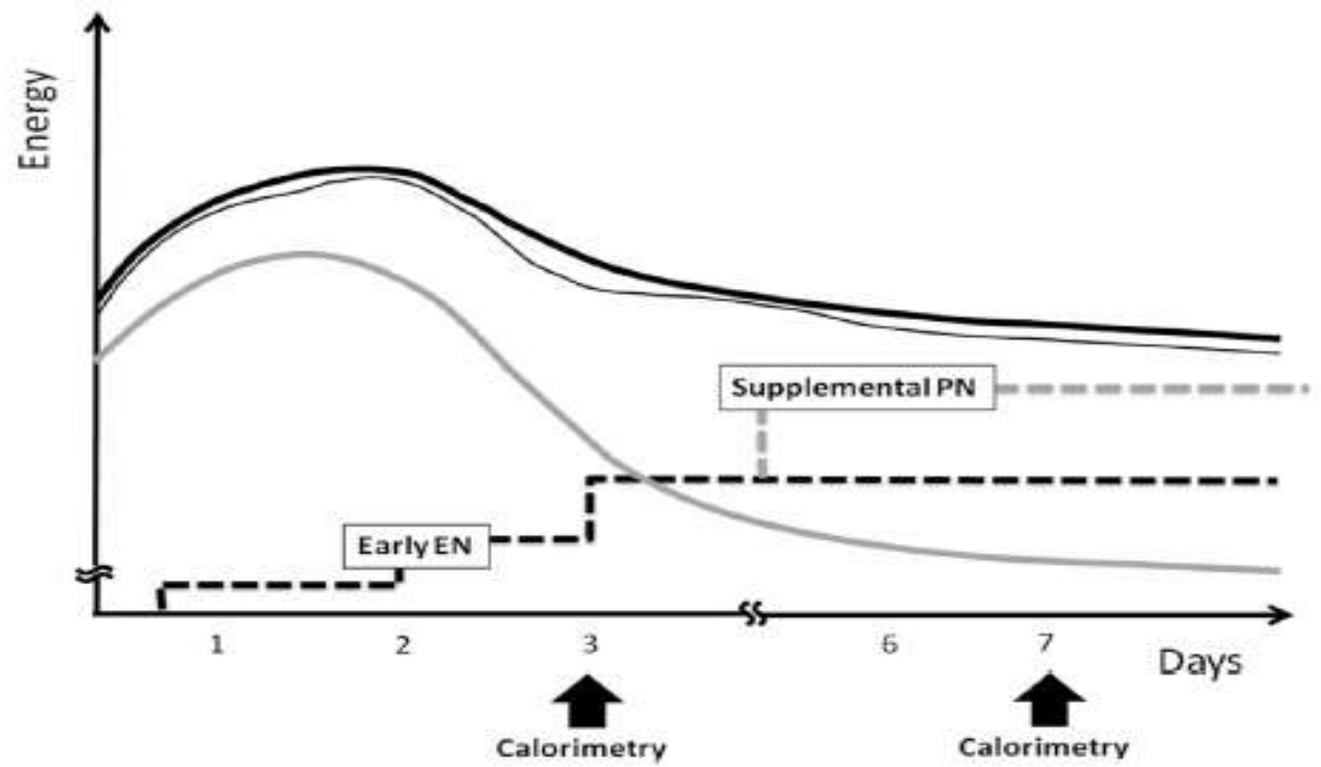


Fig. 5. Conceptual presentation of optimal feeding strategy to avoid both overfeeding and underfeeding in critical illness: Introducing the adequate amount of feeding in proportion to the body's capacity to down-regulate endogenous substrate production avoids both early overfeeding and late underfeeding. 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).

Oshima, T., Berger, M. M., De Waele, E., Guttormsen, A. B., Heidegger, C.-P., Hiesmayr, M., . . . Pichard, C. (2016). Indirect calorimetry in nutritional therapy. A position paper by the ICALIC study group. *Clin Nutr*.

METABOLIC DETERMINANTS THAT MIGHT INFLUENCE RESTING ENERGY EXPENDITURE (REE)

Energy expenditure of a patient is massively influenced by a number of intrinsic and extrinsic factors (Frankenfield & Ashcraft, 2011; Oshima et al. 2016; Frankenfield 2019).

Factors influencing energy expenditure.

- Age, sex, body height, body mass, body temperature Brain activity, endocrine profile, systemic inflammation
- Muscle contractions or paralysis, physical activity
- Fasting or post-absorptive state
- Environmental temperature
- Drugs (e.g. alpha adrenergic stimulant, beta-blockers, sedatives, muscle relaxants)

METABOLIC DETERMINANTS THAT MIGHT INFLUENCE REE IN ACUTE & LATE PHASES

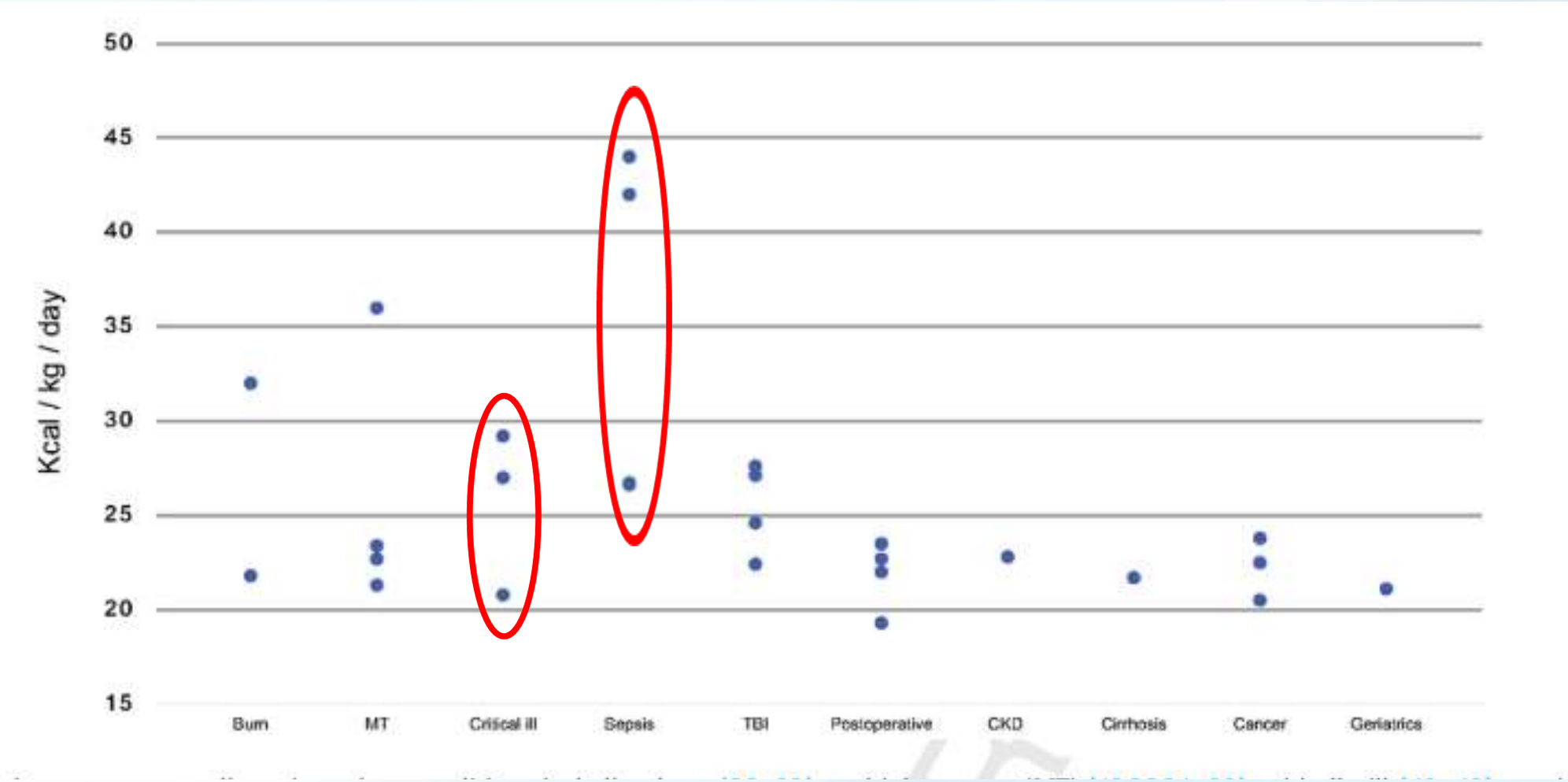
- In the acute phase, metabolic determinants that influence REE were height, weight, age and minute ventilation.

- In the late phase, metabolic determinants that influence REE were weight, age and heart rate.

- Development and validation of specific PEs for critically ill patients is needed especially among Asian population and different phases.

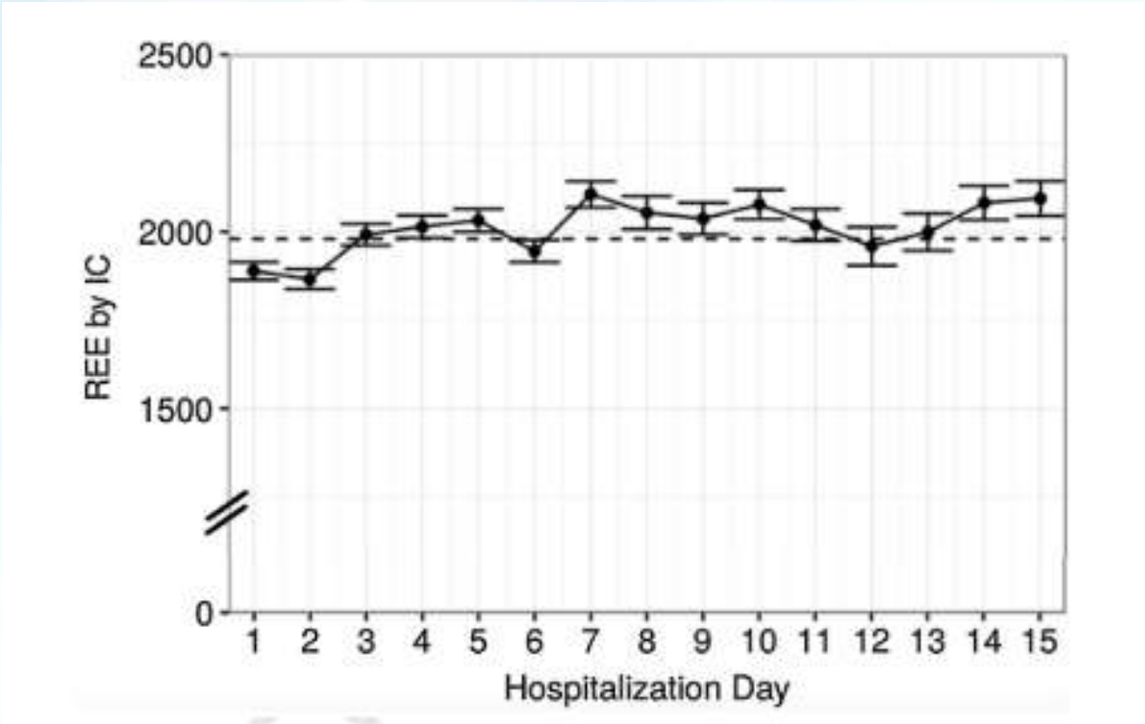
Study completed. Manuscript in preparation.

Variability REE according to Disease



Adapted from Rattanachaiwong S, Singer P, Clinical Nutrition 2019

Variability REE Day by Day and Different Phases



Zusman et al. *Crit Care* 2016,20-367

proposed by Cuthbertson et al.

A Single-Center Prospective Observational Study Comparing Resting Energy Expenditure in Different Phases of Critical Illness: Indirect Calorimetry Versus Predictive Equations

Pei Chien Tah, MSc[1,2]; Zheng-Yii Lee, MSc[1]; Bee Koon Poh, PhD[3]; Hazreen Abdul Majid, PhD, RD[4,5,6]; Vineya-Rai Hakumat-Rai, MBBS, MAnaes[7,8]; Mohd Basri Mat Nor, MBBS, MAnaes[9]; Chee Cheong Kee, MSc[10]; Mazuin Kamarul Zaman, MSc[11]; M. Shahnaz Hasan, MBBS, MAnaes[1]

15 predictive equations (PEs) (34 sub equations) tend to either **over- or under-estimate REE** of critically ill patients at different phases of critical illness.

Incorporation of **"dynamic" variables and respiratory data** into PEs demonstrated **better agreement** with REE-IC compared with PEs developed for healthy adults or PEs based on "static" variables.

Overall, we found **Swinamer (1990)** is the best PE across acute, late and chronic phases of critical illness and could be used to predict REE when IC is not available.

Tah et al. Crit Care Med 2020; 48:e380–e390.

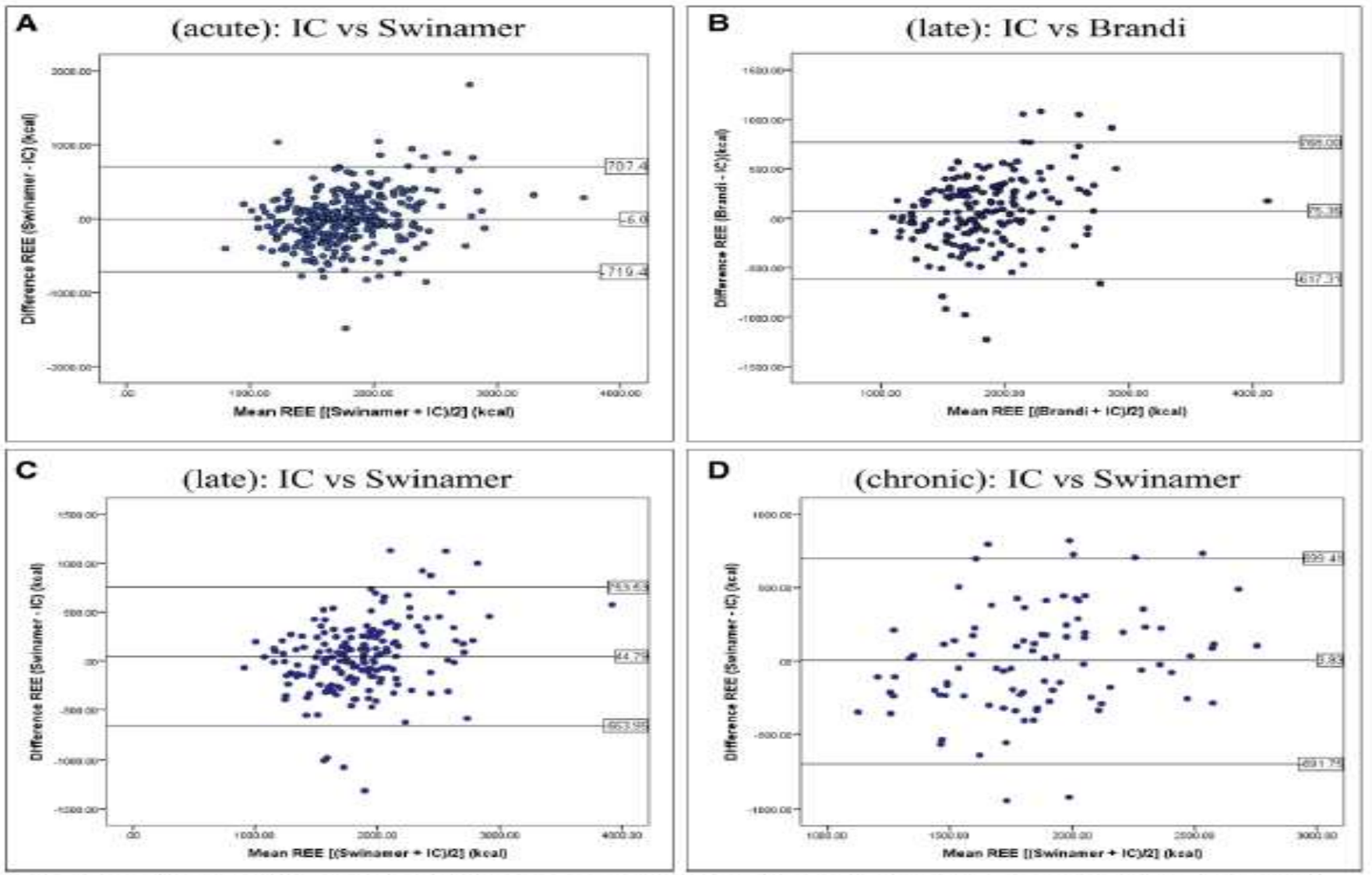
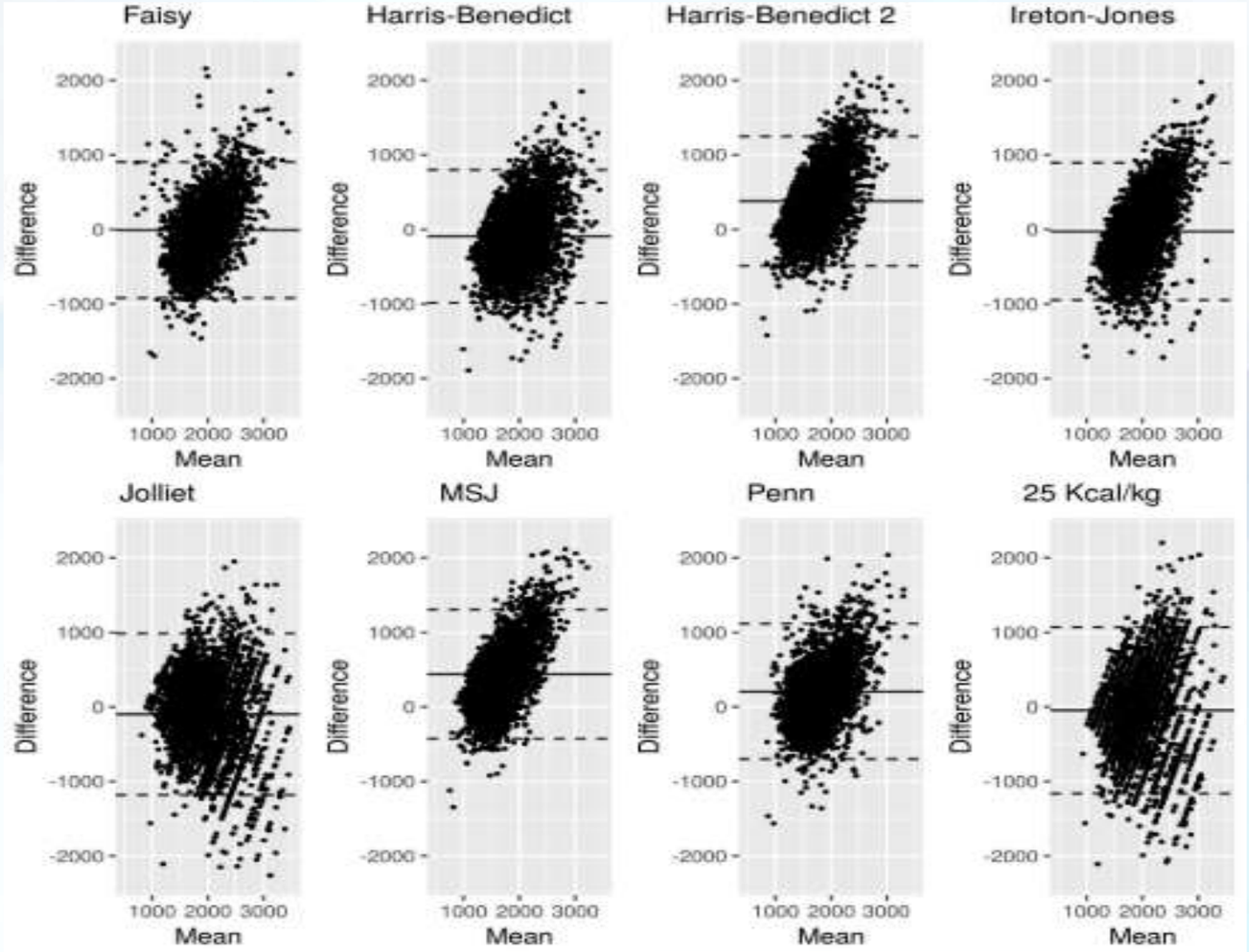


Figure 1. Bland-Altman plots with the highest rank score using score ranking method for the difference between resting energy expenditure (REE) measured by indirect calorimetry (IC) and REE by predictive equations plotted against their mean at acute phase (day 1 to 5), late phase (day 6 to 10), and chronic phase (day ≥ 11).

Tah et al. Crit Care Med 2020; 48:e380–e390.

Bland-Altman Plots - Less Agreement Between Predictive and Measured



Zusman et al. *Clinical Nutrition* 2018

Nutritional Therapy in COVID-19

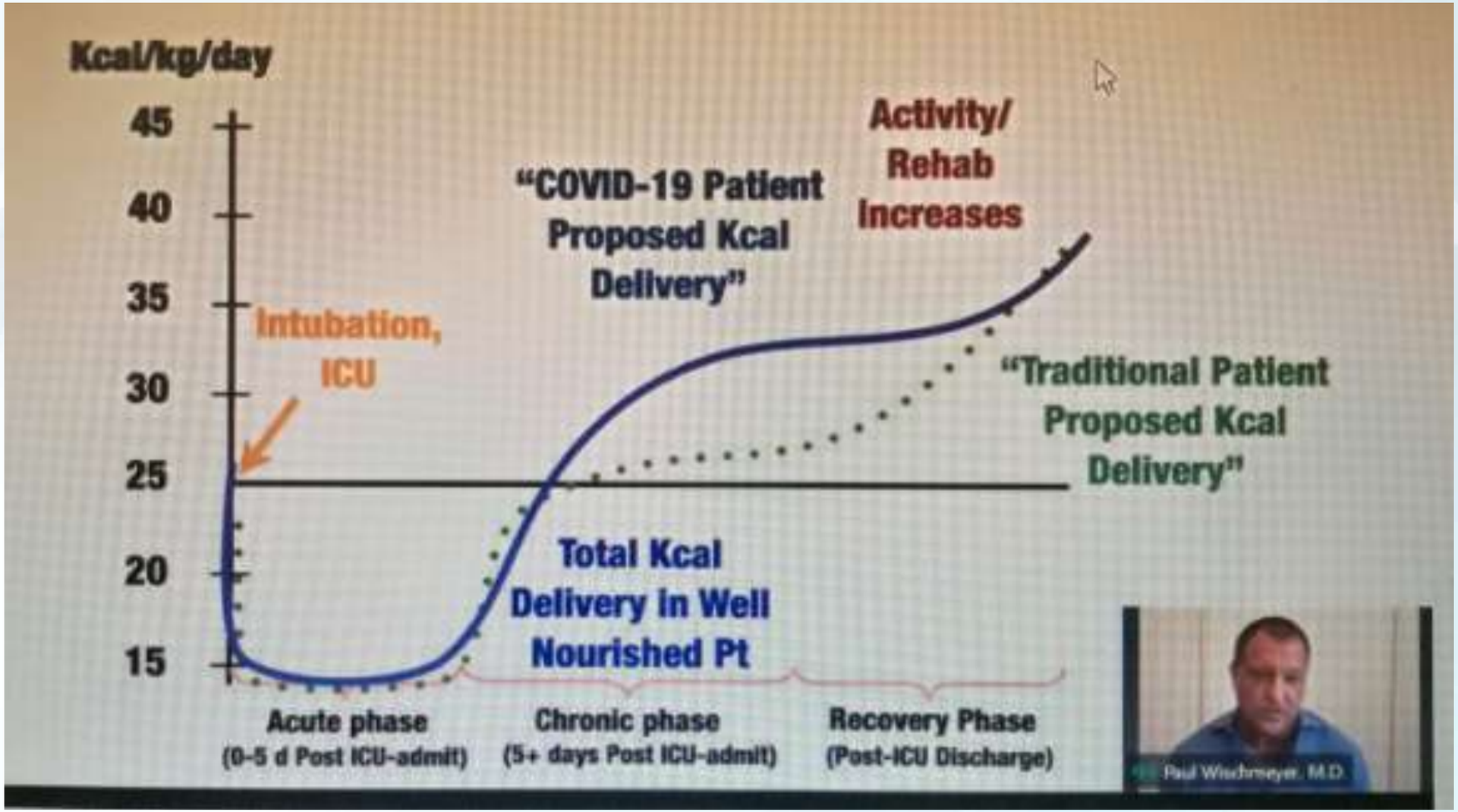
Indirect Calorimetry Data in COVID-19 (Initial LEEP-COVID Data)

- In first 5 days: COVID-19 patients are **HYPOMETABOLIC** (60 – 80% of predicted)

- After day 7: COVID-19 patients are **HYPERMETABOLIC** (160 – 200% of equation predicted even perhaps when paralyzed?)

Study still in the progression and lead by Dr. Paul Wischmeyer

Hypothesized Total Energy Delivery in COVID-19?



Study still in the progression and lead by Dr. Paul Wischmeyer

Use High Standard Nutritional Therapy in COVID-19

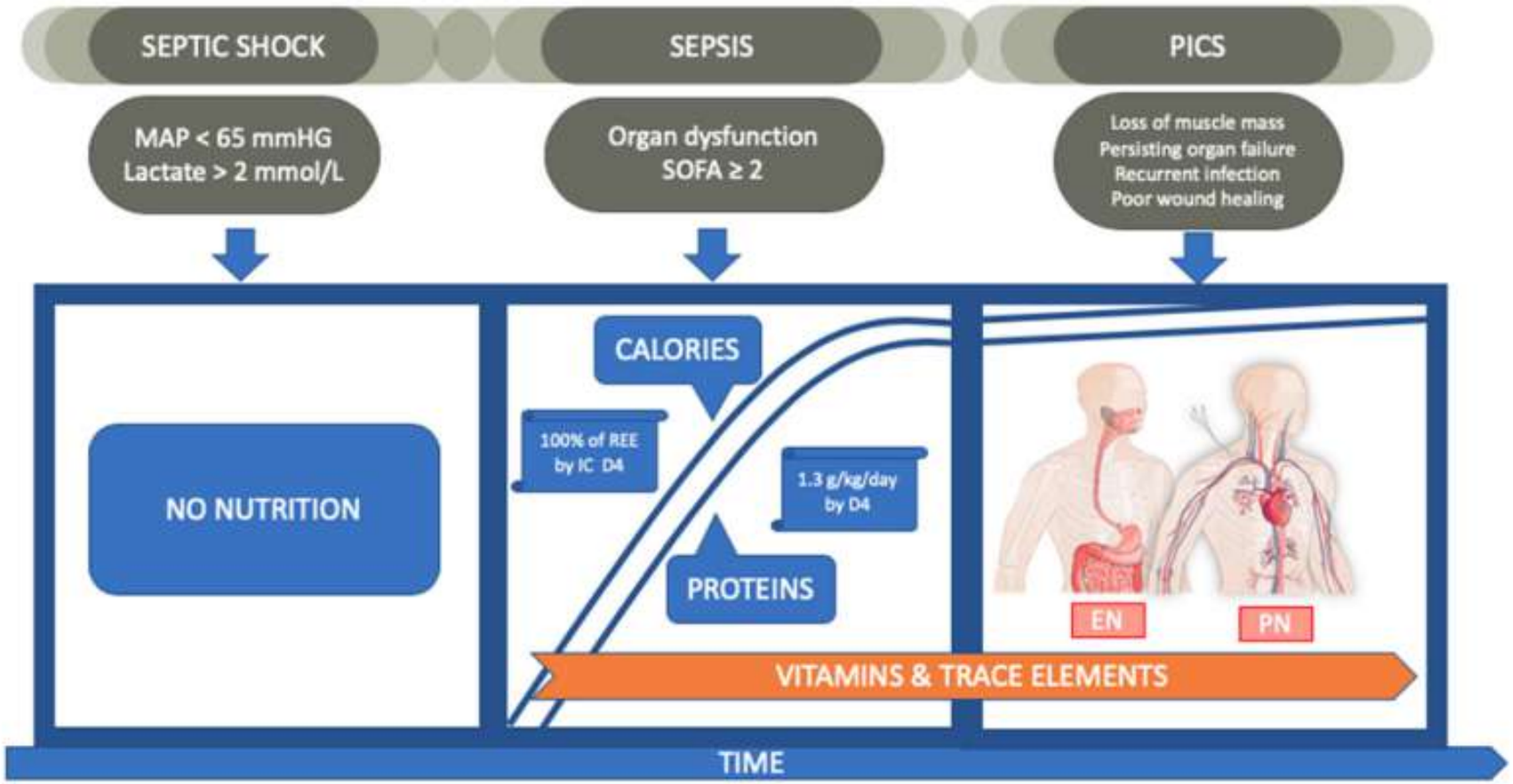
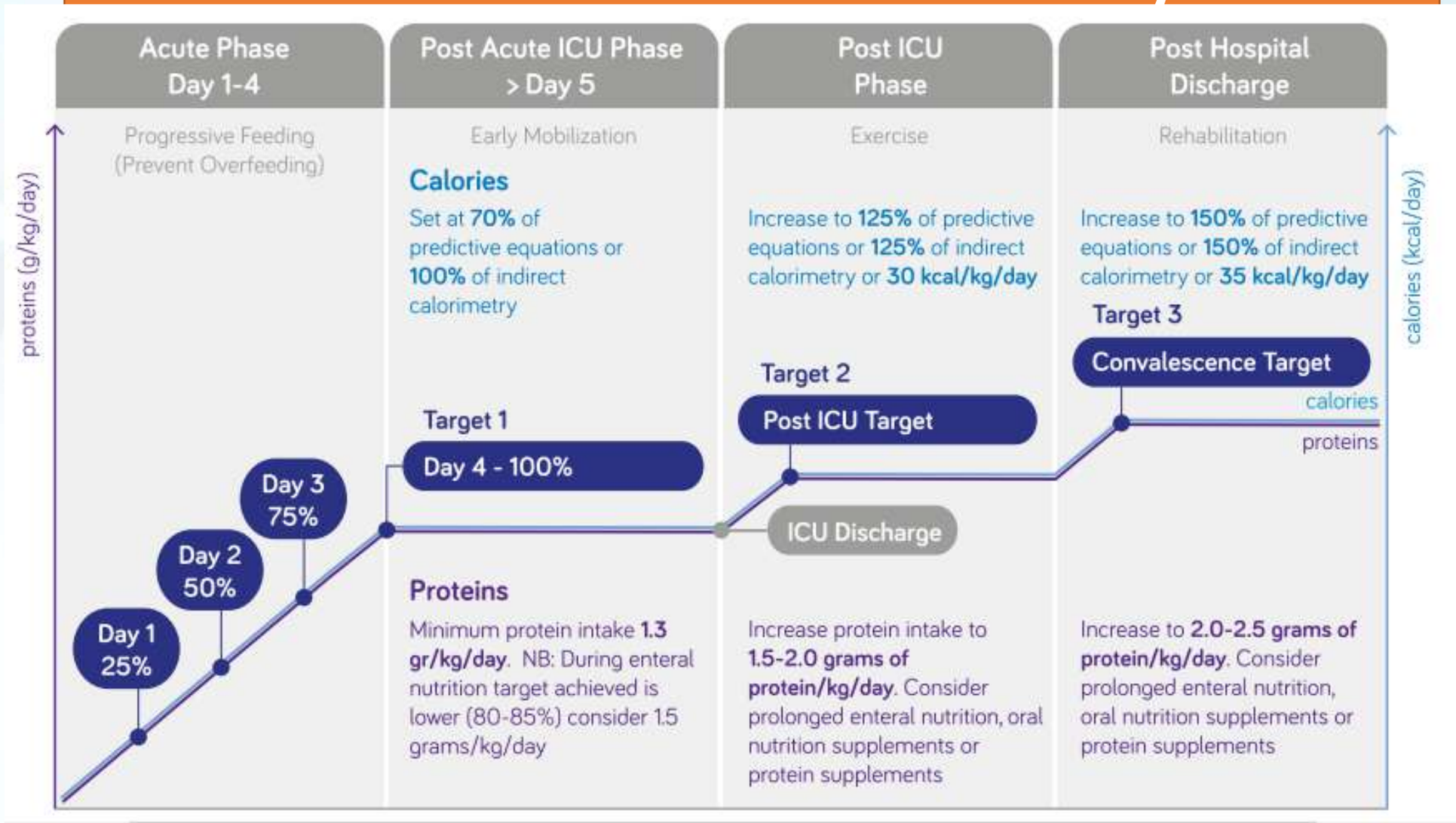


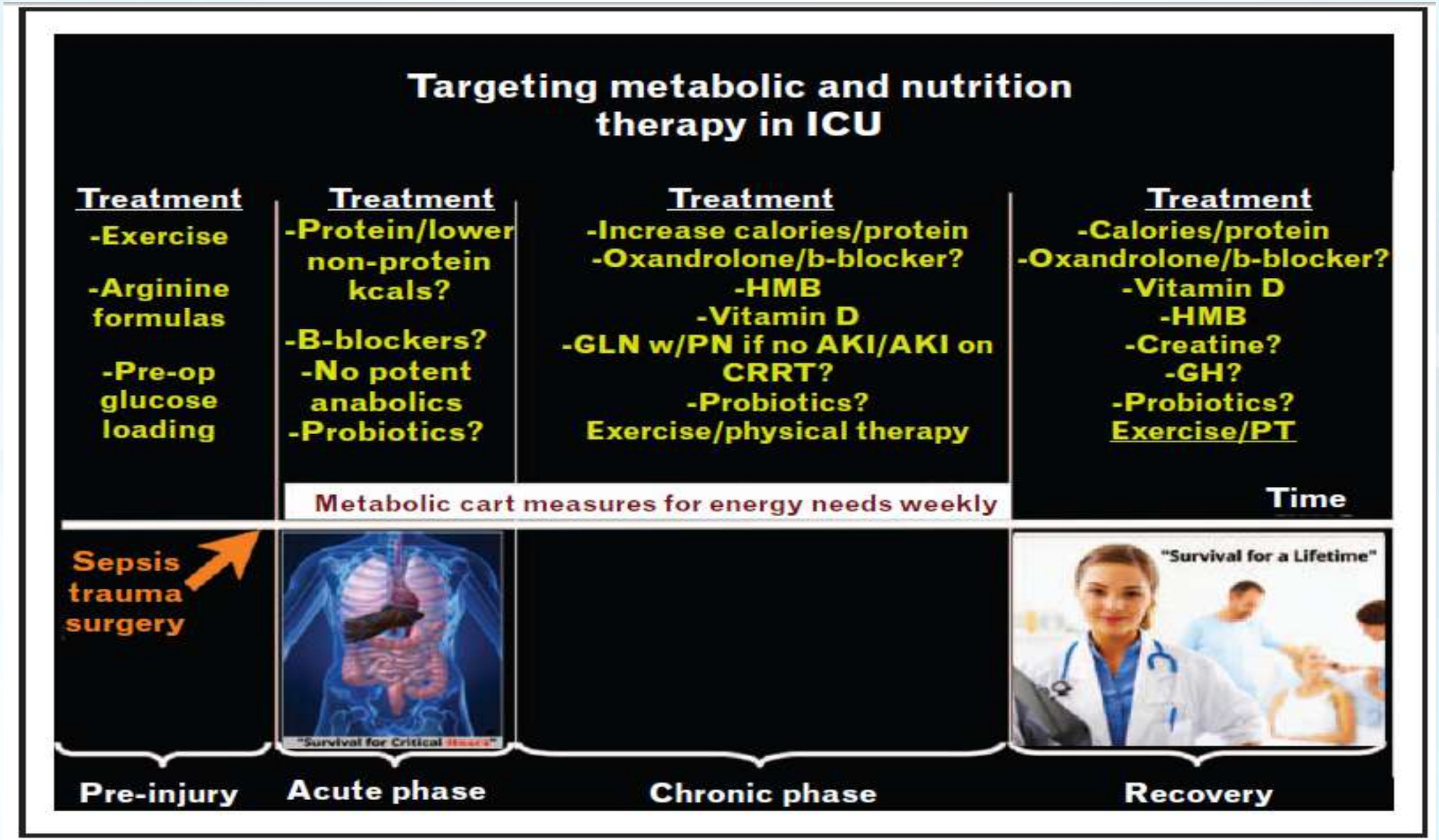
Figure 1. Flow Visual representation of nutritional therapy in sepsis. Mean Arterial Pressure (MAP); Sequential Organ Failure Assessment (SOFA); Post Intensive Care Syndrome (PICS); resting energy expenditure (REE); indirect calorimetry (IC); Day 4 (D4); enteral nutrition (EN); parenteral nutrition (PN).

De Waele et al. Nutrients. 2020

Targeted Nutrition Delivery During The Phases of Critical Illness and Recovery



Van Zanten, De Waele, Wischmeyer. 2019. Critical Care.



Wischmeyer, P. E. (2016). Are we creating survivors… or victims in critical care? Delivering targeted nutrition to improve outcomes. Current opinion in critical care, 22(4), 279-284.

Guidelines

- **ESPEN expert statements and practical guidance for nutritional management of individuals with SARS-CoV-2 infection –** Published in Clinical Nutrition on 24 Mar 2020.
- **Nutrition therapy in the patient with COVID-19 disease requiring ICU care (SCCM/ASPEN) -** Updated 1 April 2020
- **Nutrition management for critically and acutely unwell hospitalized patients with COVID-19 in Australia and New Zealand (AuSPEN) –** Updated 6 April 2020.
- **Practical advice and guidance for management of nutritional support during COVID-19 (NNNG & BAPEN) -** Updated 12 April 2020.
- **Critical Care Specialist Group Guidance on management of nutrition and dietetic services during the COVIC-19 pandemic (BDA)** - Updated 4 May 2020.

Take Home Messages

- Patients with COVID-19 are at significant nutrition risk and should be monitored closely by dietitian.
- Personalized nutrition and point of care IC (POCIC) will allow the clinicians and dietitians to prescribe medical nutrition therapy for critically ill patients in a more accurate and adequate way.
- REE varies with disease, time and population.
- Predictive Equations such as Swinamer equation with highest agreement and accuracy should be applied if IC is not available.
- Future strong clinical evidence and guidelines are needed.

THANK YOU