Factors affecting energy expenditure measurement by indirect calorimetry among critically ill patients with acute kidney injury

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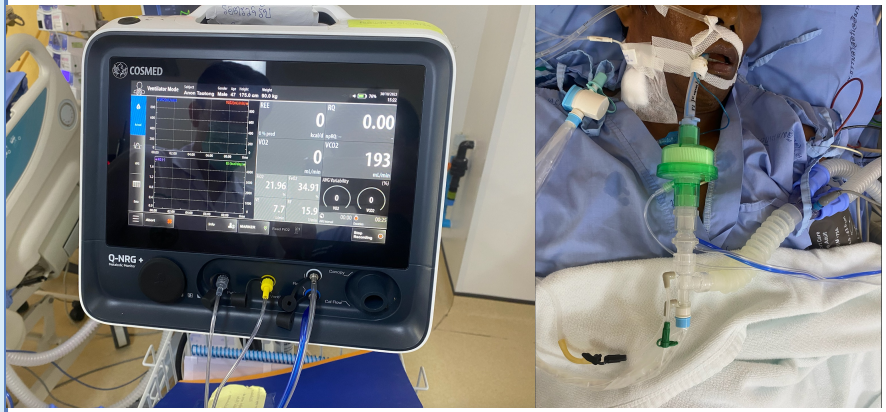
Introduction

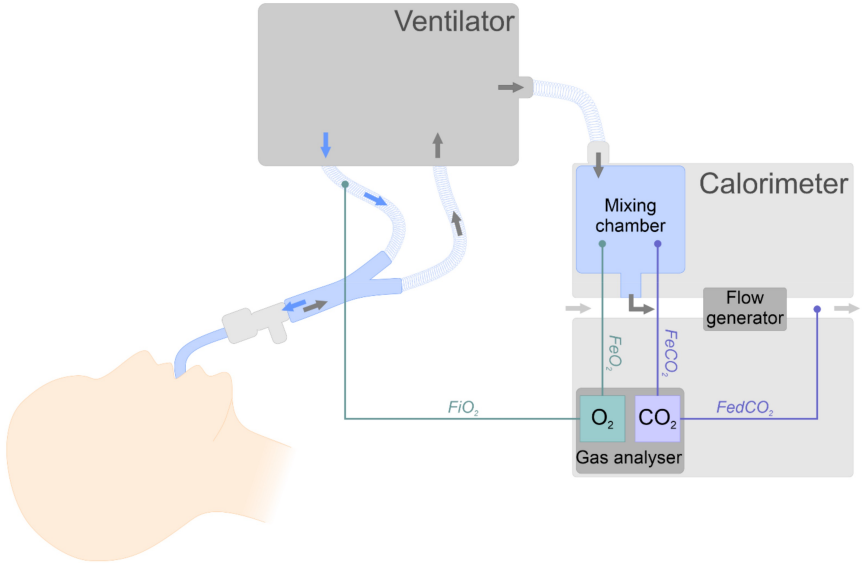
- Adequate nutritional support has been associated with reduced mortality rates and increased efficiency in patient care

- Energy expenditure measurement in critical ill patient
  - Indirect calorimetry
  - VCO2
  - Estimate energy requirements based on body weight

ESPEN guideline on clinical nutrition in hospitalized patients with acute or chronic kidney disease

Indirect calorimetry





Oxygen consumption and carbon dioxide production

Gold standard : Indirect calorimetry

- Gold standard
- High accuracy
- Decrease mortality rate

- High cost (45 USD/set)
- Limited tools

ESPEN
The European Society for Clinical Nutrition and Metabolism

Expert opinion

- Critical ill : 20-25 Kcal/kg/day
- AKI : 25-35 Kcal/kg/day

Limited tools + Limited study in Critically ill with AKI

Research Question

Limited study in Critically ill with AKI

What factors influence energy expenditure in critically ill patients with AKI?

New predictive equation for energy expenditure (kcal/day)

Objective

This study aimed to investigate factors influencing energy requirements and establish an equation to guide energy expenditure in critically ill patients with acute kidney injury (AKI).

Study design

Study design : Cross-sectional study

The study was approved by The Human Research Ethics Committee of Thammasat University (Medicine) (IRB No. MTU-EC-IM-0-100/66).

Exclusion criteria

- End-stage chronic kidney disease stages 4 and 5 or receiving kidney replacement therapy before enrollment in the study.
- Cardiac or thoracic surgery.
- limitations in using indirect calorimetry, including:
    1. FiO2 > 0.6.
    2. Pregnant patients.
    3. BMI < 17 or > 35 kg/m2.
    4. Severe liver disease, such as cirrhosis with Child-Pugh Score C.

Clinical information and laboratory data collection.

Measure energy expenditure between 48-72 hours after admission by indirect calorimetry.

Explore Parameters influencing energy requirements.

Energy expenditure equation by regression analysis.

Statistical Analysis

Sample size

N > 50 + 8m

- N is the number of participants
- m is the number of independent variables of interest.

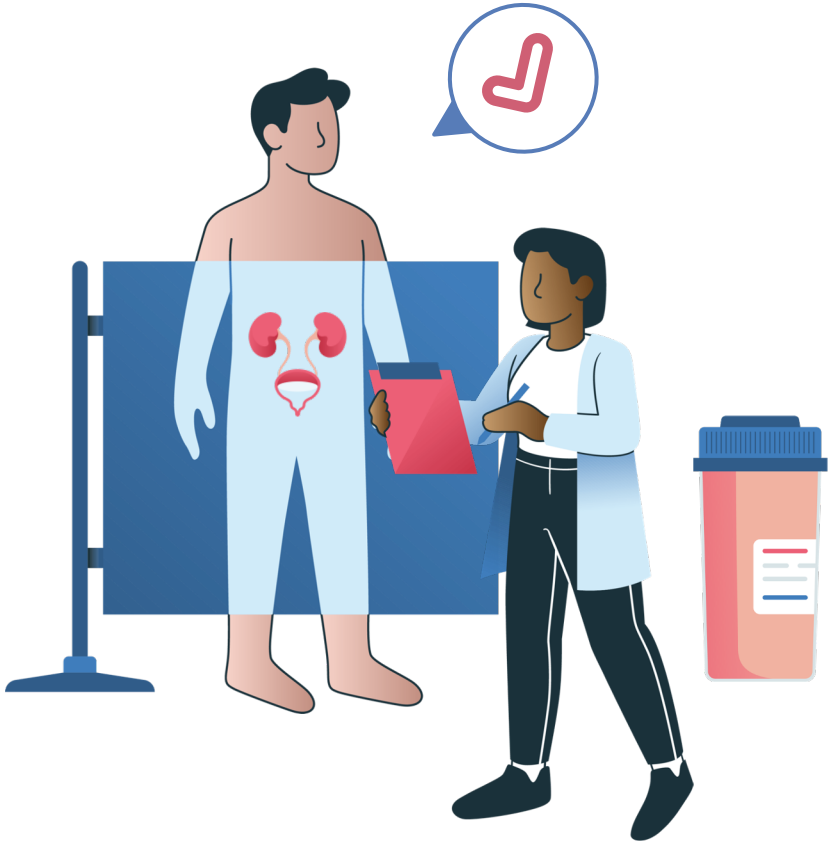
In this study, 3 anticipated independent variables will be established; therefore, N > 74 is obtained

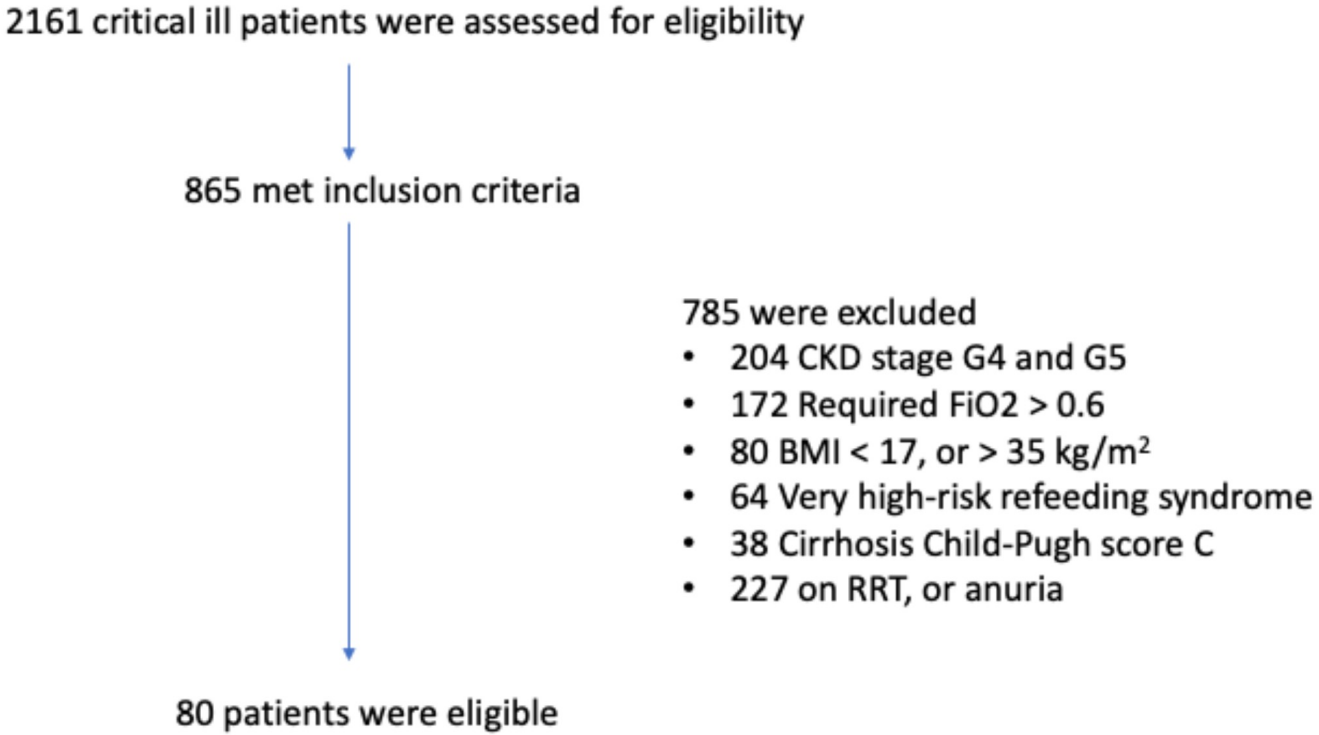
*From Tabachnick, B.G., & Fidell, L. S. (1996). Using multivariate statistics (3rd ed.). New York: HarperCollins

Statistical Analysis

- Normally distributed data: means and standard deviations or as medians and interquartile ranges
- Non-normally distributed data : medians and interquartile range
- Factors influencing energy expenditure and the relationship between energy expenditure
    - Regression analysis > univariate and multivariate analyses.
    - Correlation coefficients

Results





A study flow for enrolled participants

Baseline characteristic

Characteristic	All N=80 (100%)	Male N=47 (58.75%)	Female N=33 (41.25%)
Age, mean (SD), y	69.8(15.14)	66.8(16.39)	73.9(12.21)
Body weight, mean(SD),kg	63.33	67.31(11.35)	57.65(12.61)
Height, mean(SD),m	1.61	1.67(0.065)	1.53(0.067)
BMI,mean(SD),kg/m^2	24.31	24.17(3.69)	24.51(5.22)

Baseline characteristic

Clinical data	All(N=80)
Cause of AKI	
- **Pre renal**	46(57.5)
- **Ischemic ATN**	29(36.25)
- **Nephrotoxic ATN**	2(2.5)
- **AIN**	0
- **Post renal**	0
- **Mixed**	3(3.75)
Stage of AKI(%)	
- **Stage 1**	36(45)
- **Stage 2**	29(36.25)
- **Stage 3**	15(18.75)

Baseline characteristic

	Severity	Mean(SD)
In-hospital mortality rates 40%	**APACHE II score**	20.61(6.60)
	SOFA score	6.65 (3.56)

Baseline characteristic **

Lab investigation	- Mean(SD)
Complete blood count and coagulogram	
- Hb(g/dl)	10.59(3.17)
- WBC	12,486.55(9084.71)
- Platelet	246,526.3(141,207.5)
- INR	1.64(1.50)
Renal function test	
- BUN(mg/dl)	42.73(26.42)
- Cr(mg/dl)	2.44(1.57)
- Na(mmol/L)	134.91(6.43)
- K(mmol/L)	4.29(0.79)
- Cl(mmol/L)	101.45(6.13)
- HCO3(mmol/L)	19.97(6.13)

Lab investigation	- Mean(SD)
Liver function test	
- Albumin	3.02(0.56)
- AST	205.83(752.17)
- ALT	108.61(306.33)
- TB	1.14(0.98)
- DB	0.44(0.52)
Lactate	4.95(3.64)
ABG	
- pH	7.36(0.12)
- PaCO2	34.98(17.05)
- PaO2	159.17(101.95)

Factors affecting energy expenditure in critical ill with AKI

Factors	Coefficients	95% CI	P-value
Gender (female=0,male=1)	-149.44	-352.73 to 53.84	0.147
Age(year)	-10.35	-16.68 to -4.03	0.002
Body weight(Kg)	14.84	7.56 to 22.11	<0.001
Height(meters)	889.52	-190.29 to 1969.33	0.105
BMI(kg/m2)	35.80	13.82 to 57.78	0.002
Body temperature	45.87	-64.90 to 156.63	0.412
SBP (mmHg)	1.99	-0.82 to 4.80	0.163
PR (/min)	-0.03	-3.99 to 3.93	0.988
RR (/min)	-4.04	-21.25 to 13.16	0.641

Factors affecting energy expenditure in critical ill with AKI

Factors	Coefficients	95% CI	P-value
BUN (mg/dl)	2.27	-1.56 to 6.10	0.241
Current Cr (mg/dl)	90.58	29.14 to 152.02	0.004
Na (mmol/l)	3.99	-11.86 to 19.84	0.617
K (mmol/l)	-89.24	-216.91 to 38.43	0.168
Cl (mmol/l)	-9.05	-25.58 to 7.47	0.279
HCO_3(mmol/l)	8.52	-8.00 to 25.04	0.308
Lactate (mmol/l)	-27.95	-55.27 to -0.63	0.045

Factors affecting energy expenditure in critical ill with AKI

Factors	Coefficients	95% CI	P-value
pH	101.46	-717.87 to 920.80	0.806
PaCO2 (mmHg)	6.40	-0.59 to 12.21	0.031
PaO2 (mmHg)	-1.13	-2.10 to -0.16	0.022
P/F ratio	-0.20	-0.58 to 0.17	0.281
FiO2 (%)	-506.07	-1341.37 to 329.2	0.231
PEEP (mmHg)	15.417	-63.57 to 94.40	0.699

Primary outcome

Factors significant associated with EE:

- Age
- Body weight
- Current creatinine
- lactate
- PaCO2
- PaO2

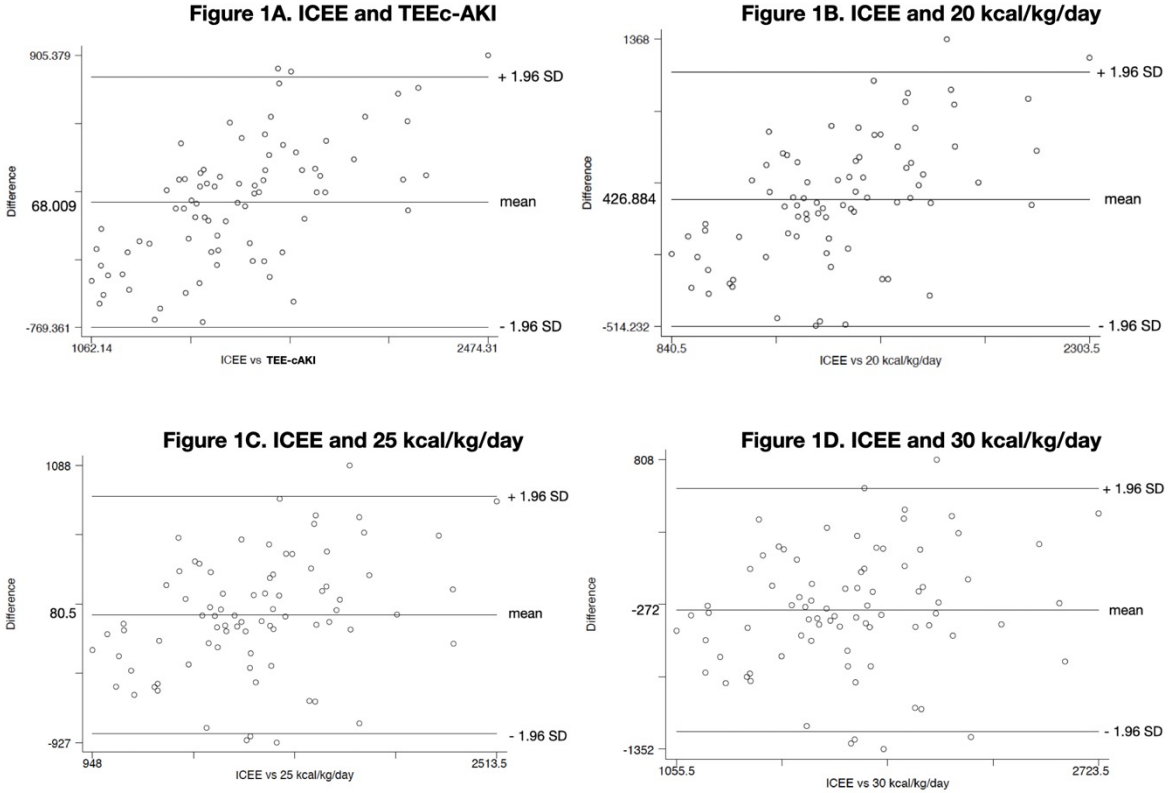
A stepwise forward selected regression analysis was conducted

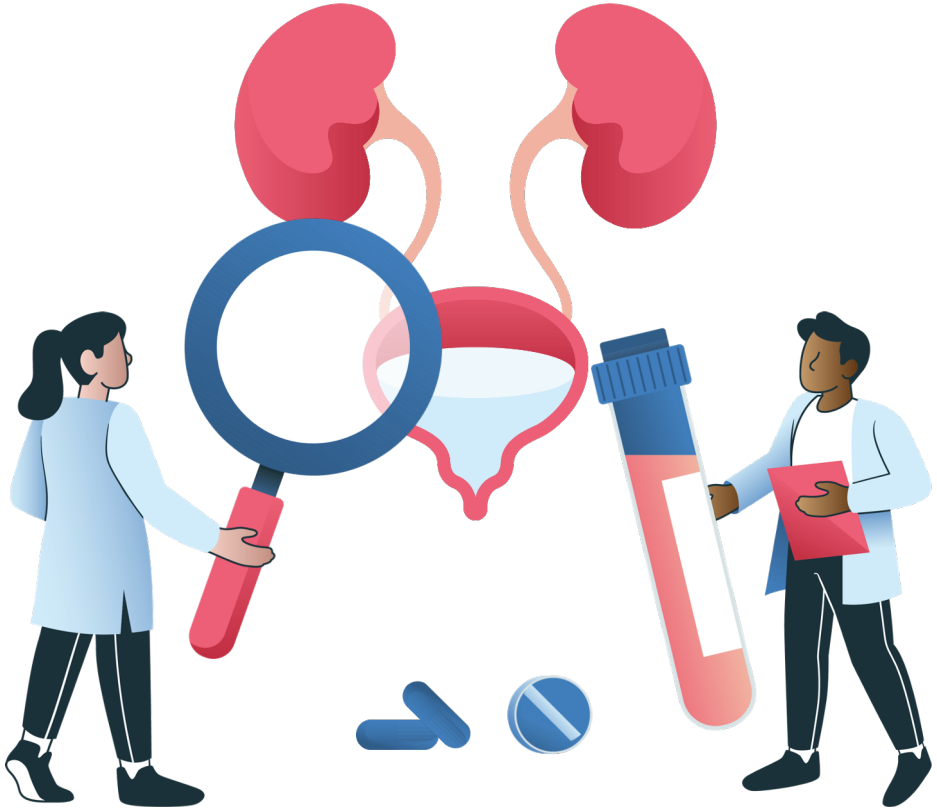
- Age
- Body weight
- Current creatinine

Common variables were selected to use in pragmatic predictive equation

The predictive EE (kcal/day): 1232.38 + 77.43 (Cr) + 9.81 (BW) – 6.56 (Age) Adjusted R^2 23.96%, $p<0.001$

Figure 1. Bland-Altman plots between IC derived energy expenditure (ICEE) and other predictive methods.





Discussion

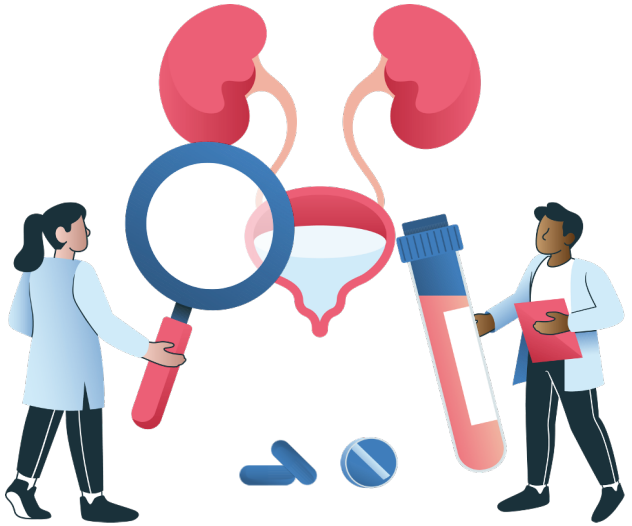
Discussion

- The **first study** investigating factors influencing energy expenditures in such patients
- Establish an **equation for estimating** dietary energy intake

Discussion

Limitation

- Advanced age
- Severe stage of AKI
- Lack of internal validation



Conclusion

Most critically ill AKI patients energy expenditure primarily influenced by age, body weight, current creatinine.

The formula for energy expenditure appeared practical, cost-effective, and may complement or replace indirect calorimetry, offering valuable guidance for managing energy expenditure in critically ill AKI patients.

Thanks