3.1 Nutritional Prescription: Use of Indirect Calorimetry vs. Predictive Equations

There were no new randomized controlled trials since the 2015 update and hence there are no changes to the following summary of evidence.

Question: Does the use of indirect calorimetry vs. a predictive equation for determining energy needs (enteral nutrition) result in better outcomes critically ill adult patients?

Summary of evidence: There were two level 2 studies reviewed. Saffle 1990 compared the effectiveness of indirect calorimetry guided enteral nutrition to enteral nutrition guided by Curreri formula in burn patients, and Singer 2011 compared indirect calorimetry guided enteral nutrition supplemented with parenteral nutrition to enteral nutrition determined by a weight-based formula with attempts to give parenteral nutrition.

Mortality: The Saffle 1990 study found no differences in hospital mortality between the group that received indirect calorimetry guided enteral nutrition and the group that received enteral nutrition guided by Curreri formula (RR 1.33, 95% CI 0.24, 7.26, p=0.74*). On the other hand, the Singer 2011 study found a significant reduction in hospital mortality in patients that received indirect calorimetry guided enteral nutrition compared to patients that received enteral nutrition determined by a weight-based formula (RR 0.59, 95% CI 0.36, 0.97, p=0.04*). However, the use of indirect calorimetry guided enteral nutrition had no effect on either ICU or 60-day mortality.

Infections: Only the Singer study reported data on infections. Indirect calorimetry compared to weight-based predictive equation was associated with a trend towards an increase in ventilator associated pneumonia (RR 2.00, 95% CI 0.98, 4.06, p=0.06*), and was associated with a significant increase in overall infectious complications (RR 1.85, 95% CI 1.24, 2.76, p=0.002*).

LOS: Only the Singer study reported ICU length of stay, finding that the use of indirect calorimetry compared to predictive equations was associated with a significant increase in ICU length of stay (WMD 5.50, 95% CI 1.09, 9.91, p=0.01*). However, in both studies the use of indirect calorimetry had no effect on hospital LOS (Saffle: WMD 0.30, 95% CI -13.15, 13.75, p=0.97; Singer: WMD 2.00, 95% CI -7.33, 11.33, p=0.67*).

Ventilator days: Only the Singer study reported duration of ventilation and found that the use of indirect calorimetry compared to predictive equations was associated with a significant increase in the duration of ventilation (WMD 5.60, 95% CI 1.18, 10.02, p=0.01*).

Nutritional Outcomes: In the Saffle study, diarrhea, hyperglycemia, electrolyte imbalance did not differ between the two groups. Actual protein intake (grams/day) was significantly higher in the groups receiving enteral nutrition via indirect calorimetry in both the Saffle and Singer studies (respectively WMD 37.00, 95% CI 33.13, 40.87, p<0.00001*; and WMD 23, 95% CI 17.07, 28.93, p<0.00001*).

*p-values calculated using Review Manager

Conclusions:

1) The use of indirect calorimetry compared to predictive equations to meet enteral nutrition needs has no effect on mortality.
2) The use of indirect calorimetry compared to predictive equations as a guide to supplement EN with PN is associated with a reduction hospital mortality.
3) The use of indirect calorimetry compared to predictive equations as a guide to supplement EN with PN may be associated with a higher incidence of infections.
4) The use of indirect calorimetry compared to predictive equations as a guide to supplement EN with PN may be associated with a longer ICU length of stay, and duration of ventilation.
5) The use of indirect calorimetry compared to predictive equations may be associated with improved nutritional intake.

Level 1 study: if all of the following are fulfilled: concealed randomization, blinded outcome adjudication and an intention to treat analysis.
Level 2 study: If any one of the above characteristics are unfulfilled.

.1Table 1. Randomized studies evaluating indirect calorimetry vs. predictive equation in critically ill patients

Study	Population	Methods (score)	Intervention	Mortality # (%)†		Infections # (%)	
				Indirect Calorimetry	Predictive Equation	Indirect Calorimetry	Predictive Equation
1) Saffle 1990	Burns 47 % TSBA N=49	C.Random: not sure ITT: yes Blinding: no (7)	EN via Indirect calorimetry (IC) vs. Curreri formula	3/26 (12)	2/23 (9)	NR	NR
2) Singer 2011*	Mechanically ventilated critically ill patients (Mixed medical, surgical, trauma) N=130	C.Random: Yes ITT: No Blinding: No (8)	EN via indirect calorimetry with measurements Q48H supplemented with PN and energy delivery adjusted accordingly vs. EN (using 25kcal/kg/day and not readjusted for 14 days). PN attempted to make up shortfall Non isocaloric/isonitrogenous	ICU 16/56 (29) Hospital 16/56 (29) 60-day 24/56 (58)	ICU 17/56 (30) Hospital 27/56 (48) 60-day 29/56 (48)	VAP 18/56 (32) Total 37/56 (66)	VAP 9/56 (16) Total 20/56 (36)

Table 1. Randomized studies evaluating indirect calorimetry vs. predictive equation in critically ill patients (continued)

Study	LOS days		Ventilator days		Cost		Other	
	Indirect Calorimetry	Predictive Equation	Indirect Calorimetry	Predictive Equation	Indirect Calorimetry	Predictive Equation	Indirect Calorimetry	Predictive Equation
1) Saffle 1990	Hospital 48.8 ± 22.9 (26)	Hospital 48.5 ± 24.9 (23)	NR	NR	NR	NR	Diarrhea 34.6 % Hyperglycemia 38.5 % Nausea 26.9 % Electrolyte imbalance 30.8 % Actual calories intake (kcals/day) 3530 ± 134 Actual protein intake (g/day) 153 ± 7.1	 34.8 % 43.5 % 34.8 % 39.1 % 3490 ± 132 116 ± 6.7

2) Singer 2011	ICU 17.2 ± 14.6 (56) Hospital 33.8 ± 22.9 (56)	ICU 11.7 ± 8.4 (56) Hospital 31.8 ± 27.3 (56)	16.1 ± 14.7 (56)	10.5 ± 8.3 (56)	NR	NR	Energy (kcal/day) 2086 ± 460 1480 ± 356 Protein (g/day) 76 ± 16 53 ± 16

C.Random: concealed randomization
† presumed hospital mortality unless otherwise specified
ITT: intent to treat
NR: not reported
( ): mean ± standard deviation (number)
VAP: ventilator associated pneumonia
ICU: intensive care unit
LOS: length of stay

Table 2. Excluded Articles

#	Reason excluded	Citation
1	Not a RCT	Brandi LS, Bertolini R, Calafa M. Indirect calorimetry in critically ill patients: Clinical applications and practical advice. Nutrition 1997;13(4):349-358.
2	No clinical outcomes	Nataloni S, Gentili N, Marini B, Guidi A et al. Nutritional assessment in head injured patients through the study of rapid turnover visceral proteins. Clin Nutr 1999;18(4):247-51.
3	Not a RCT	Mentec H, Dupont H, Bocchetti M et al. Upper digestive intolerance during enteral nutrition in critically ill patients : Frequency, risk factors, and complications. Crit Care Med 2001;29(10):1955-1961.
4	Not a RCT	Cheng CH, Chen CH, Wong Y et al. Measured versus estimated energy expenditure in mechanically ventilated critically ill patients. Clin Nutr 2002;21(2):165-72.
5	Not mechanically ventilated before study	Lo HC, Lin CH, Tsai LJ. Effects of hypercaloric feeding on nutrition status and carbon dioxide production in patients with long-term mechanical ventilation. JPEN J Parentr Enteral Nutr 2005;29(5):380-397.