Protein Quality.
Protein metabolism in the critically ill.

Olav Rooyackers, professor

Peri-operative Medicine and Intensive Care,
Karolinska Institutet and University Hospital, Stockholm, Sweden

DSKE ÅRSMØDE I KLINISK ERNÆRING

Disclosure

- Payed lectures for Fresenius-Kabi, Baxter, Nestlé and Nutricia
- Consultant Fresenius-Kabi

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CLINICAL NUTRITION

Opinion paper

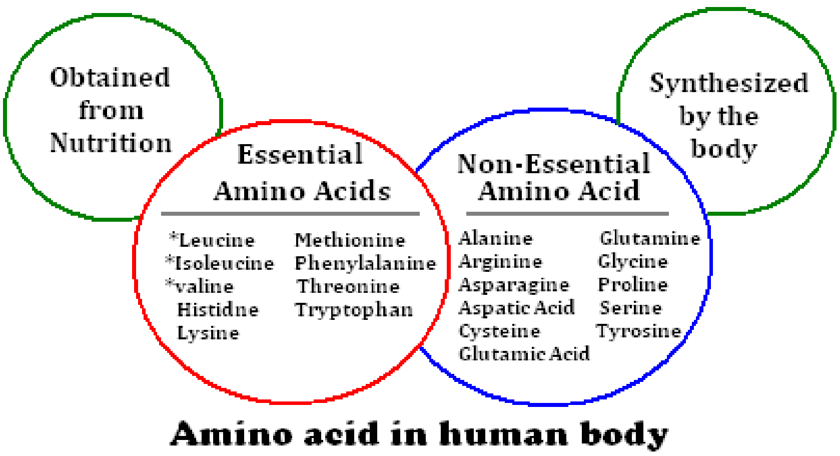
Factors contributing to the selection of dietary protein food sources

Robert R. Wolfe [a,*], Jamie I. Baum [a,b], Carlene Starck [c], Paul J. Moughan [c]

[a] Reynolds Institute on Aging and Department of Geriatrics, University of Arkansas for Medical Sciences, Little Rock, AR, USA
[b] Division of Agriculture, Department of Food Science, University of Arkansas, Fayetteville, AR, USA
[c] Riddet Institute, Massey University, Palmerston North, New Zealand

Biological value protein

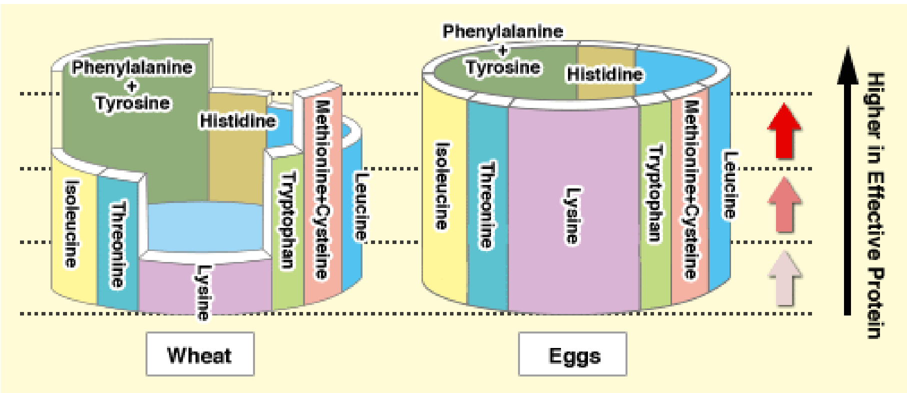
Protein Source	Biological Value
Egg, whole	93.7
Milk	84.5
Fish	76.0
Beef	74.3
Soybeans	72.8
Rice, polished	64.0
Wheat, whole	64.0
Corn	60.0
Beans, dry	58.0



	Plant sources								Animal sources							
	Wheat	Maize	Rice	Oats	Soyabean	Pea	Potato	Quinoa	Whey	Milk	Casein	Beef	Pork	Chicken	Egg	Cod
Essential amino acids																
Histidine	2·1	2·8	2·5	2·3	2·6	2·5	2·0	3·1	1·9	2·7	2·7	3·6	2·6	2·9	2·4	2·8
Isoleucine	4·1	3·8	3·8	4·1	4·7	4·6	4·9	4·7	6·4	5·1	5·0	5·0	5·4	5·9	6·2	4·5
Leucine	6·8	12·9	8·2	7·9	8·0	7·4	7·8	7·8	9·9	9·5	8·9	8·5	8·5	8·2	8·7	8·2
Lysine	1·4	2·8	3·8	4·0	6·6	8·2	6·2	7·2	9·2	6·9	7·6	9·3	9·4	8·8	6·9	9·7
Methionine	1·6	2·0	2·3	1·8	1·3	1·0	1·7	2·6	2·0	2·5	2·6	2·8	2·8	2·8	3·3	3·3
Phenylalanine	5·1	5·0	5·2	5·4	5·1	5·0	5·2	5·3	3·8	4·6	4·9	4·6	4·4	4·4	5·6	4·9
Threonine	2·5	3·7	3·9	3·6	4·0	4·4	4·9	4·5	6·7	4·0	4·3	4·8	4·8	4·4	5·0	5·0
Valine	4·2	5·0	5·5	5·5	4·9	5·1	6·1	5·8	6·3	6·2	6·3	5·2	5·9	5·7	6·7	5·1
Total EAA	27·8	38·1	35·2	34·7	37·1	38·2	38·8	40·9	46·2	41·6	42·4	43·7	43·8	43·2	44·8	43·5
Non-essential amino acids																
Alanine	2·5	7·8	6·0	4·9	4·4	4·4	5·8	6·1	4·8	3·3	2·9	6·1	6·0	3·8	5·8	6·5
Arginine	3·0	4·3	8·3	6·8	7·4	10·3	6·5	9·1	2·5	3·3	3·5	6·6	6·5	6·2	6·0	6·4
Aspartic acid	3·0	6·5	10·3	8·4	12·0	11·9	16·1	9·4	10·2	7·5	6·7	9·4	9·7	10·2	9·5	10·3
Cystine	2·1	1·6	1·1	2·9	1·4	1·2	0·8	0·0	1·7	0·9	0·3	1·3	1·3	1·5	2·4	1·1
Glutamic acid	36·9	19·6	20·6	22·8	19·2	17·5	13·3	15·4	17·8	20·0	20·6	15·9	15·8	16·7	12·5	15·3
Glycine	3·1	3·8	5·0	5·1	4·3	4·4	4·9	6·7	2·2	1·9	1·8	5·1	4·7	5·9	3·3	4·5
Proline	13·0	9·2	4·7	5·6	5·6	4·2	4·9	4·0	6·3	11·3	10·8	3·9	4·2	4·6	4·1	3·8
Serine	4·9	5·1	5·4	5·1	5·3	4·7	5·4	4·8	5·2	5·5	5·6	4·2	4·2	4·3	7·5	4·8
Tyrosine	3·6	4·0	3·5	3·6	3·2	3·0	3·6	3·6	3·0	4·8	5·4	3·8	3·7	3·7	4·1	3·8
Total NEAA	72·2	61·9	64·8	65·3	62·9	61·8	61·2	59·1	53·8	58·4	57·6	56·3	56·2	56·8	55·2	56·5

FAO, 1981

The limiting (essential) amino acid



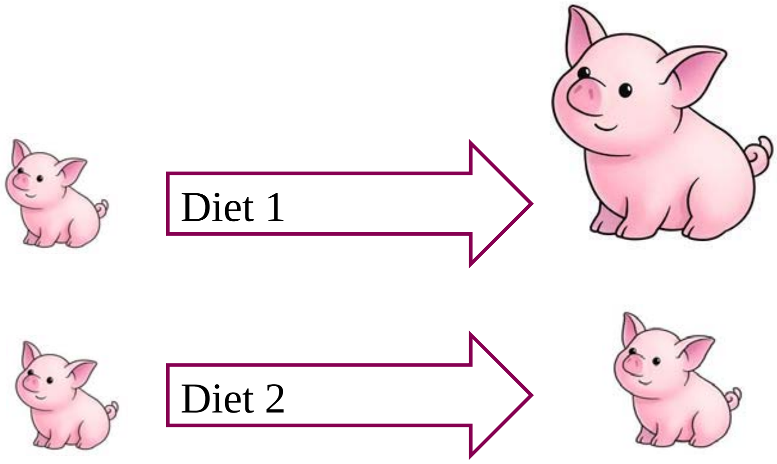


Figure 11
Breakpoint analysis of $^{13}CO_2$ production against dietary lysine intake during infusion of [1-^{13}C]phenylalanine[a]

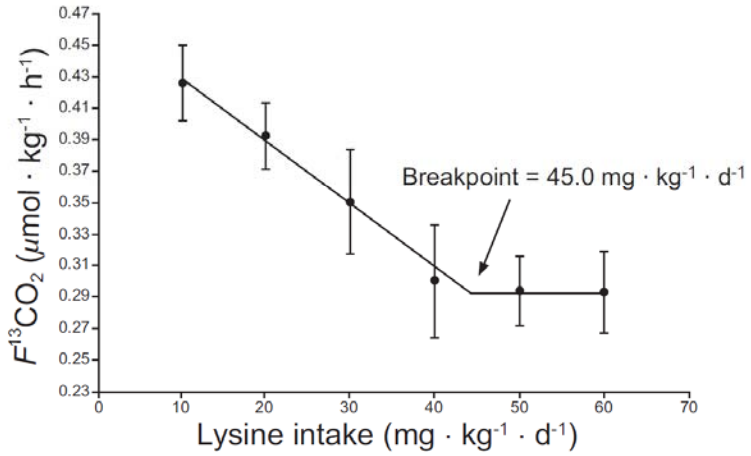


Table 23

Summary of the adult indispensable amino acid requirements

Amino acid protein[b]	Present estimates		1985 FAO/WHO/UNU[a]	
	mg/kg per day	mg/g protein[b]	mg/kg per day	mg/g protein[b]
Histidine	10	15	8–12	15
Isoleucine	20	30	10	15
Leucine	39	59	14	21
Lysine	30	45	12	18
Methionine + cysteine	15	22	13	20
Methionine	*10*	*16*	–	–
Cysteine	*4*	*6*	–	–
Phenylalanine + tyrosine	25	38	14	21
Threonine	15	23	7	11
Tryptophan	4	6	3.5	5
Valine	26	39	10	15
Total indispensable amino acids	**184**	**277**	**93.5**	**141**

[a] From reference *1*.
[b] Mean nitrogen requirement of 105 mg nitrogen/kg per day (0.66 g protein/kg per day).

Biological Value of Some Protein-Rich Foods

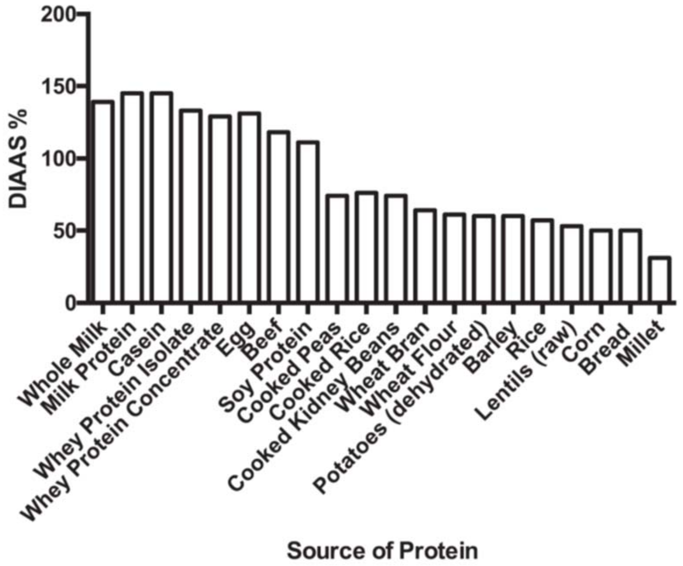
	Ile	Leu	Val	Thr	Met + Cys	Trp	Lys	Phe + Tyr	His	Biological Value
Egg, chicken	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	0,94
Milk, human	1,1	1,4	1,0	1,0	1,1	1,6	1,0	1,0	0,9	0,95
Milk, Cow	1,1	1,3	1,0	0,9	0,7	1,3	1,3	0,9	1,1	0,90
Muscle, beef	0,8	0,9	0,7	0,9	0,9	0,9	1,4	0,7	1,6	0,76
Soybeans	1,0	0,9	0,8	0,8	0,6	1,3	1,1	1,0	1,4	0,75
Rice	0,8	0,9	0,9	0,8	0,9	1,2	0,5	1,2	0,8	0,75
Wheat	0,6	0,8	0,6	0,7	0,8	1,1	0,4	0,8	1,0	0,67
Potatoes	0,6	1,1	0,8	1,3	0,6	1,9	1,4	0,8	1,1	0,67
Oats	0,8	0,8	0,8	0,7	0,6	1,2	0,6	1,0	1,1	0,66
Corn	1,0	1,7	0,8	0,7	1,1	0,5	0,4	1,0	1,0	0,60

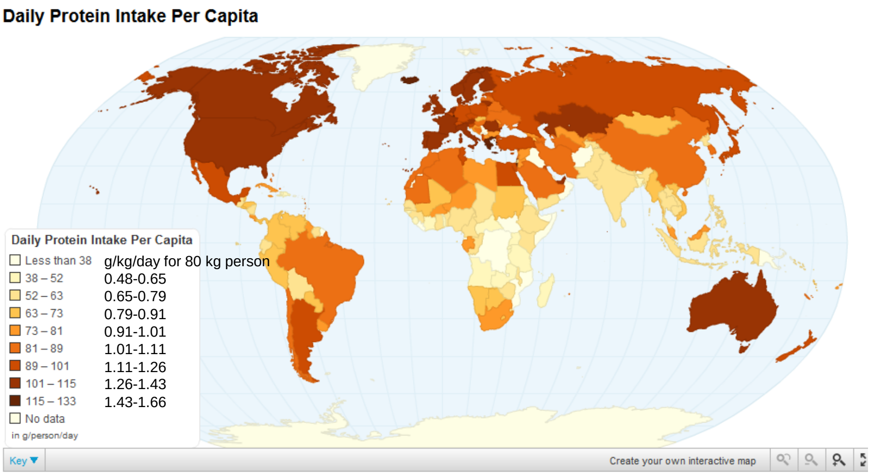
McGilvery, Biochemistry, 1970

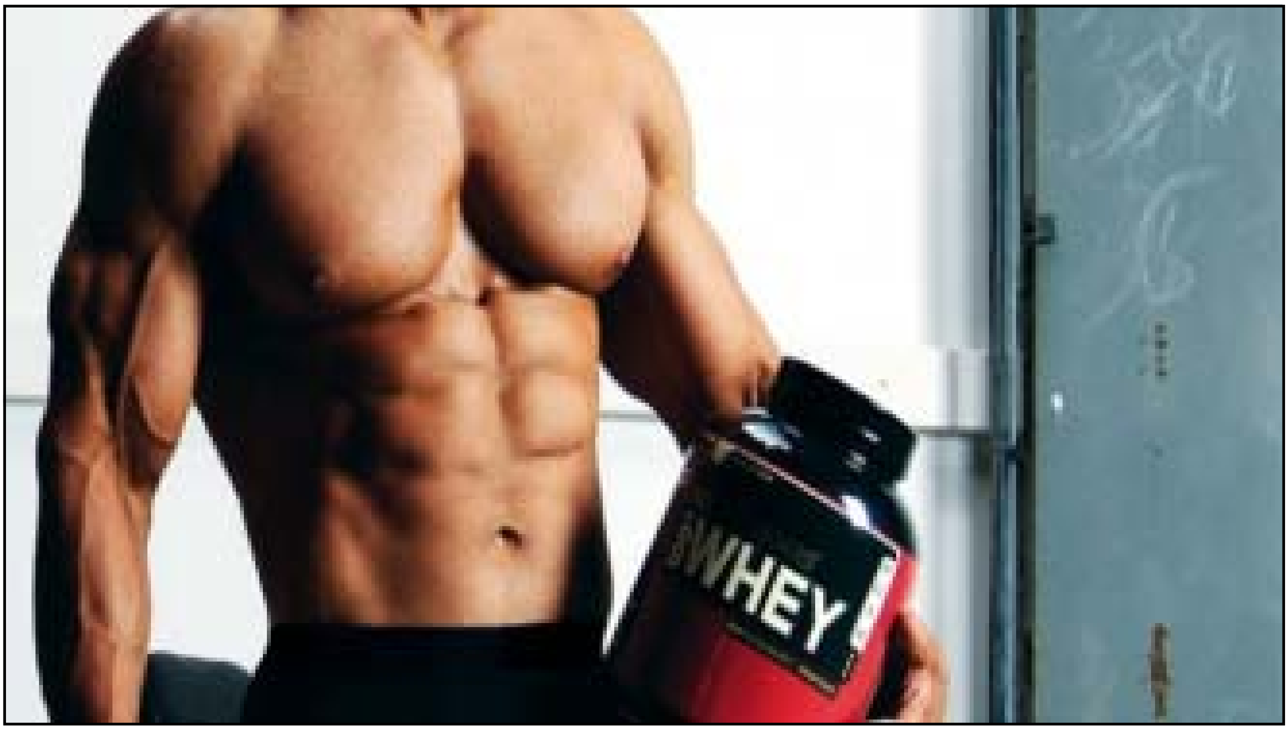
Digestible Indispensible Amino Acid Score

DIAAS (%) = 100[(mg of digestible dietary EAA in 1 g of the dietary test protein /(mg of digestible dietary EAA in 1 g of the reference protein)]

Digestible Indispensible Amino Acid Score




Daily Protein Intake Per Capita
Daily Protein Intake Per Capita
Less than 38
g/kg/day for 80 kg person
38 – 52
0.48-0.65
52 – 63
0.65-0.79
63 – 73
0.79-0.91
73 – 81
0.91-1.01
81 – 89
1.01-1.11
89 – 101
1.11-1.26
101 – 115
1.26-1.43
115 – 133
1.43-1.66
No data
in g/person/day
Key
Create your own interactive map


WHEY

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	Plant sources								Animal sources								Amino acid requirements
	Wheat	Maize	Rice	Oats	Soyabean	Pea	Potato	Quinoa	Whey	Milk	Casein	Beef	Pork	Chicken	Egg	Cod	
Essential amino acids																	
Histidine	2·1	2·8	2·5	2·3	2·6	2·5	2·0	3·1	1·9	2·7	2·7	3·6	2·6	2·9	2·4	2·8	1·5
Isoleucine	4·1	3·8	3·8	4·1	4·7	4·6	4·9	4·7	6·4	5·1	5·0	5·0	5·4	5·9	6·2	4·5	3·0
Leucine	6·8	12·9	8·2	7·9	8·0	7·4	7·8	7·8	9·9	9·5	8·9	8·5	8·5	8·2	8·7	8·2	5·9
Lysine	1·4	2·8	3·8	4·0	6·6	8·2	6·2	7·2	9·2	6·9	7·6	9·3	9·4	8·8	6·9	9·7	4·5
Methionine	1·6	2·0	2·3	1·8	1·3	1·0	1·7	2·6	2·0	2·5	2·6	2·8	2·8	2·8	3·3	3·3	1·6
Phenylalanine	5·1	5·0	5·2	5·4	5·1	5·0	5·2	5·3	3·8	4·6	4·9	4·6	4·4	4·4	5·6	4·9	3·8
Threonine	2·5	3·7	3·9	3·6	4·0	4·4	4·9	4·5	6·7	4·0	4·3	4·8	4·8	4·4	5·0	5·0	2·3
Valine	4·2	5·0	5·5	5·5	4·9	5·1	6·1	5·8	6·3	6·2	6·3	5·2	5·9	5·7	6·7	5·1	3·9
Total EAA	27·8	38·1	35·2	34·7	37·1	38·2	38·8	40·9	46·2	41·6	42·4	43·7	43·8	43·2	44·8	43·5	27·7
Non-essential amino acids																	
Alanine	2·5	7·8	6·0	4·9	4·4	4·4	5·8	6·1	4·8	3·3	2·9	6·1	6·0	3·8	5·8	6·5	
Arginine	3·0	4·3	8·3	6·8	7·4	10·3	6·5	9·1	2·5	3·3	3·5	6·6	6·5	6·2	6·0	6·4	
Aspartic acid	3·0	6·5	10·3	8·4	12·0	11·9	16·1	9·4	10·2	7·5	6·7	9·4	9·7	10·2	9·5	10·3	
Cystine	2·1	1·6	1·1	2·9	1·4	1·2	0·8	0·0	1·7	0·9	0·3	1·3	1·3	1·5	2·4	1·1	
Glutamic acid	36·9	19·6	20·6	22·8	19·2	17·5	13·3	15·4	17·8	20·0	20·6	15·9	15·8	16·7	12·5	15·3	
Glycine	3·1	3·8	5·0	5·1	4·3	4·4	4·9	6·7	2·2	1·9	1·8	5·1	4·7	5·9	3·3	4·5	
Proline	13·0	9·2	4·7	5·6	5·6	4·2	4·9	4·0	6·3	11·3	10·8	3·9	4·2	4·6	4·1	3·8	
Serine	4·9	5·1	5·4	5·1	5·3	4·7	5·4	4·8	5·2	5·5	5·6	4·2	4·2	4·3	7·5	4·8	
Tyrosine	3·6	4·0	3·5	3·6	3·2	3·0	3·6	3·6	3·0	4·8	5·4	3·8	3·7	3·7	4·1	3·8	
Total NEAA	72·2	61·9	64·8	65·3	62·9	61·8	61·2	59·1	53·8	58·4	57·6	56·3	56·2	56·8	55·2	56·5	

FAO, 1981

Leucine

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Clinical Nutrition 32 (2013) 412–419

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Clinical Nutrition

journal homepage: http://www.elsevier.com/locate/clnu

Original article

Leucine co-ingestion improves post-prandial muscle protein accretion in elderly men

Benjamin T. Wall, Henrike M. Hamer, Anneke de Lange, Alexandra Kiskini, Bart B.L. Groen, Joan M.G. Senden, Annemie P. Gijsen, Lex B. Verdijk, Luc J.C. van Loon

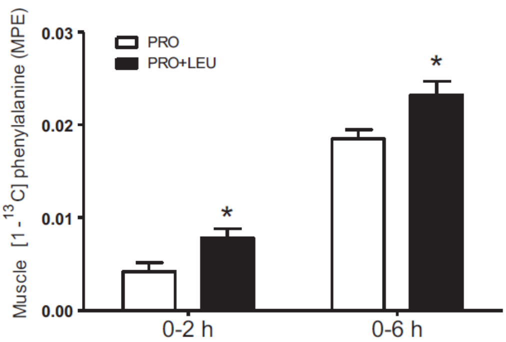

Fig. 4. Mean (±SEM) delta protein-bound L-[1-^{13}C]phenylalanine enrichments (MPE) during a 2 and 6 h incorporation period following the ingestion of 20 g intrinsically L-[1-^{13}C]phenylalanine-labeled casein with (PRO + LEU; $n = 12$) or without (PRO; $n = 12$) 2.5 g crystalline leucine in healthy, elderly men. Data were analyzed with an unpaired, two-tailed Student's *t*-test. *$P < 0.05$ compared with corresponding time point in the PRO group.

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Leucine co-ingestion improves post-prandial muscle protein accretion in elderly men

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Leucine

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TABLE 2 Body composition and muscle strength during 24 wk of leucine or placebo intervention in diabetic men[1]

	Placebo, *n* = 28			Leucine, *n* = 29		
	wk 0	wk 12	wk 24	wk 0	wk 12	wk 24
Body composition						
Body weight, *kg*	84.6 ± 2.0	85.0 ± 2.0	85.1 ± 2.1	83.6 ± 1.8	84.0 ± 1.8	83.9 ± 1.7
Lean mass, *kg*	62.2 ± 1.3	62.2 ± 1.3	62.2 ± 1.3	61.9 ± 1.1	62.2 ± 1.1	62.0 ± 1.0
Fat mass, *kg*	19.6 ± 1.0	20.0 ± 1.1	20.2 ± 1.1	19.0 ± 0.8	19.1 ± 0.9	19.2 ± 0.9
Fat, *%*	22.9 ± 0.8	23.3 ± 0.9	23.4 ± 0.9	22.5 ± 0.6	22.4 ± 0.6	22.6 ± 0.6
Bone mineral content, *kg*	2.7 ± 0.1	2.7 ± 0.1	2.7 ± 0.1	2.7 ± 0.1	2.7 ± 0.1	2.7 ± 0.1
Leg lean mass, *kg*	19.3 ± 0.5	19.4 ± 0.5	19.4 ± 0.4	19.0 ± 0.4	19.1 ± 0.4	19.0 ± 0.4
Leg fat mass, *kg*	5.0 ± 0.3	5.1 ± 0.3	5.2 ± 0.3	4.8 ± 0.2	4.9 ± 0.2	4.9 ± 0.2

Proc. Natl. Acad. Sci. USA
Vol. 94, pp. 14930–14935, December 1997
Physiology

Slow and fast dietary proteins differently modulate postprandial protein accretion

(amino acid turnover/postprandial protein anabolism/milk protein/stable isotopes)

Yves Boirie*, Martial Dangin*†, Pierre Gachon*, Marie-Paule Vasson‡, Jean-Louis Maubois§, and Bernard Beaufrère*¶

*Laboratoire de Nutrition Humaine, Université Clermont Auvergne, Centre de Recherche en Nutrition Humaine, BP 321, 63009 Clermont-Ferrand Cedex 1, France; †Nestec, Ltd., Nestlé Research Center, P.O. Box 44, CH 1000 Lausanne 26, Switzerland; ‡Laboratoire de Biochimie, Biologie Moléculaire et Nutrition, Université Clermont Auvergne, BP 38, 63001 Clermont-Ferrand Cedex 1, France; and §Laboratoire de Technologie Laitière, Institut National de la Recherche Agronomique, 35042 Rennes Cedex, France

Fast or slow proteins

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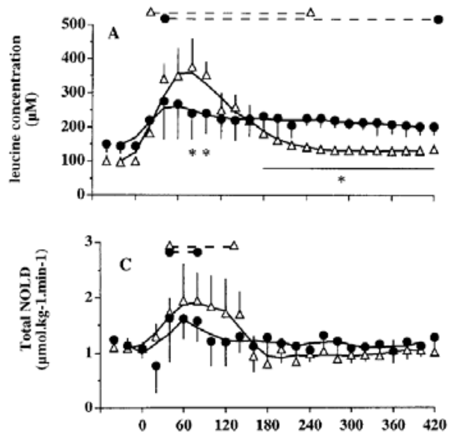


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Original article

Fast-digestive protein supplement for ten days overcomes muscle anabolic resistance in healthy elderly men

Stéphane Walrand [a,b], Céline Gryson [a,b], Jérôme Salles [a,b], Christophe Giraudet [a,b], Carole Migné [a,b], Cécile Bonhomme [d], Pascale Le Ruyet [d], Yves Boirie [a,b,c,*]

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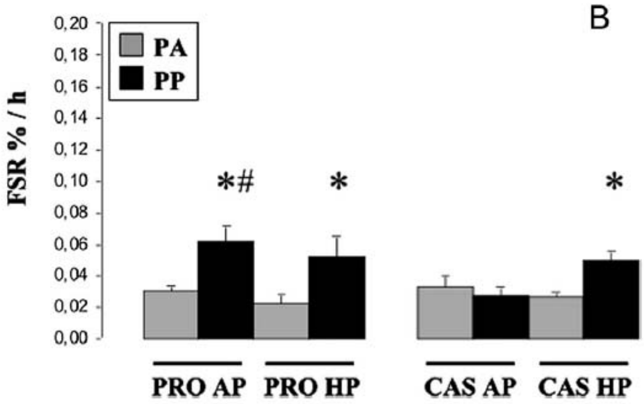
Fast or slow proteins



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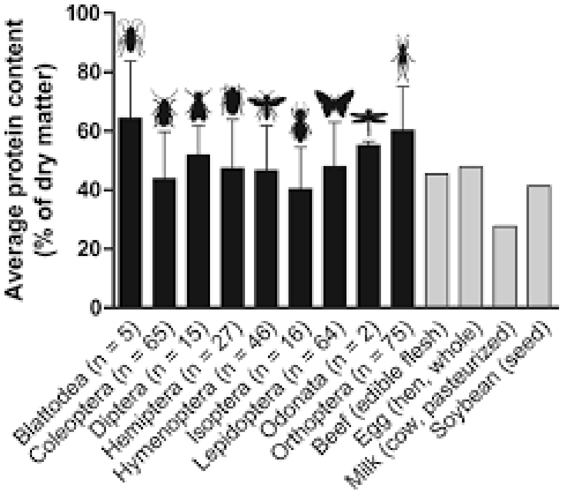

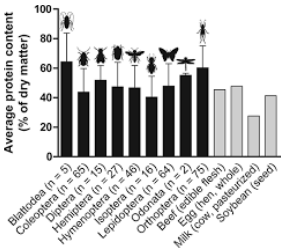

Advances in Analytical Chemistry 2017, 7(2): 31-38
DOI: 10.5923/j.aac.20170702.02

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Amino Acids Profile of Bee Brood, Soldier Termite, Snout Beetle Larva, Silkworm Larva and Pupa: Nutritional Implications

Olaleye Abdul Ademola[1,*], Adubiaro Habibat Omolara[2], Olatoye Rauf Abioye[3]

[1]Department of Chemistry, Faculty of Science, Federal University Dutse, Nigeria
[2]Department of Chemistry, Faculty of Science, Federal University Oye-Ekiti, Nigeria
[3]Department of Chemistry, Faculty of Science, Ekiti State University, Nigeria

Table 4. Essential amino acid scores of the insect samples based on FAO/WHO (1973) standards

Amino acid	BB	ST	SB	SWL	SWP	Mean	SD	CV%	χ^2
Lys	0.983	1.58	0.909	1.58	1.55	1.32	0.343	26.0	0.357
Thr	0.940	0.979	0.919	1.01	1.18	1.01	0.104	10.3	0.043
Val	1.10	0.809	1.12	0.884	0.875	0.958	0.142	14.8	0.066
Leu	1.14	1.10	1.15	1.13	1.11	1.13	0.021	1.86	0.002
Ile	1.91	1.25	1.87	1.34	1.30	1.53	0.327	21.4	0.279
Trp	1.30	1.30	1.38	1.24	1.15	1.27	0.085	6.69	0.023
Met + Cys	1.07	1.24	1.06	1.32	1.13	1.16	0.113	9.74	0.027
Phe + Tyr	1.33	1.15	1.26	1.09	1.13	1.19	0.100	84.0	0.033
Totals	1.20	1.16	1.18	1.19	1.19	1.18	0.015	1.27	0.001

Take home:

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- Biological value of a protein is determined by its essential amino acid content in relation to human requirements
- In general, animal proteins have a higher biological value
- An only vegetarian/vegan diet needs to compensate for this by increasing intake
- Whey protein might have a benificial acute effect in certain situations

Protein metabolism in the critically ill.

Olav Rooyackers, professor

Peri-operative Medicine and Intensive Care,
Karolinska Institutet and University Hospital, Stockholm, Sweden

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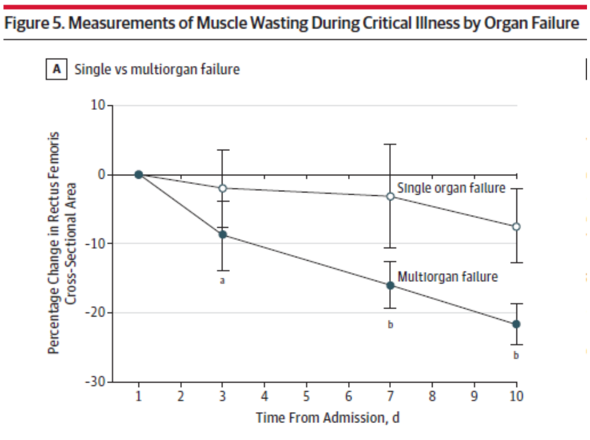
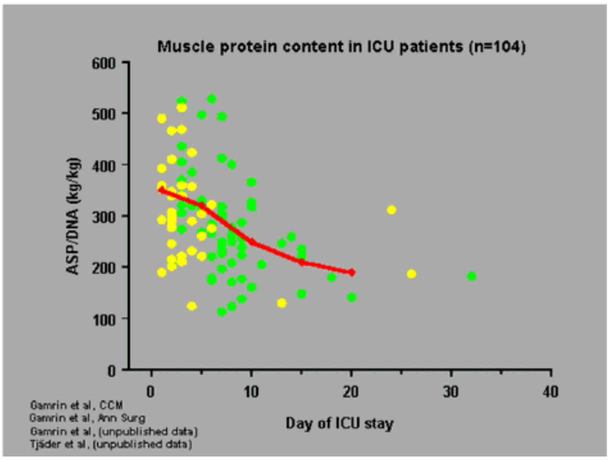
The problem

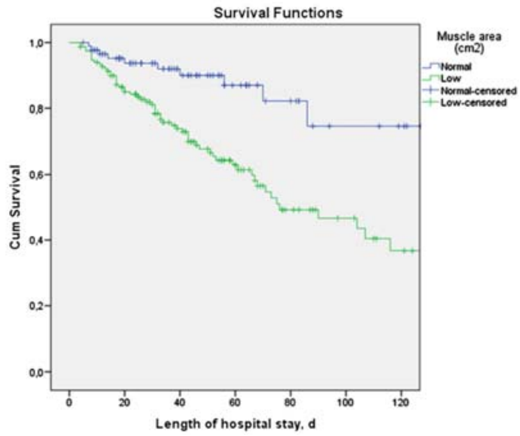


Puthucheary et al, JAMA 2013

The problem

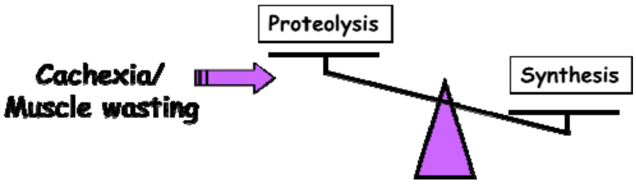


The problem

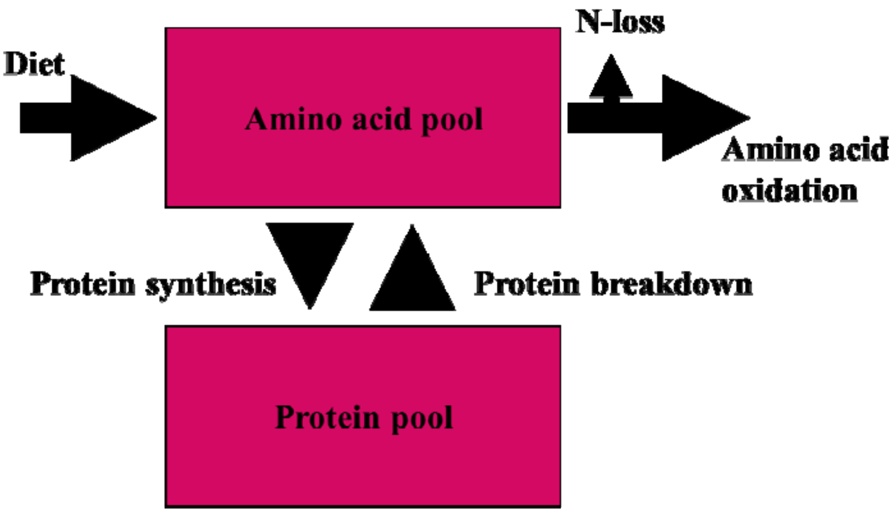


Weijs et al, Crit Care 2014

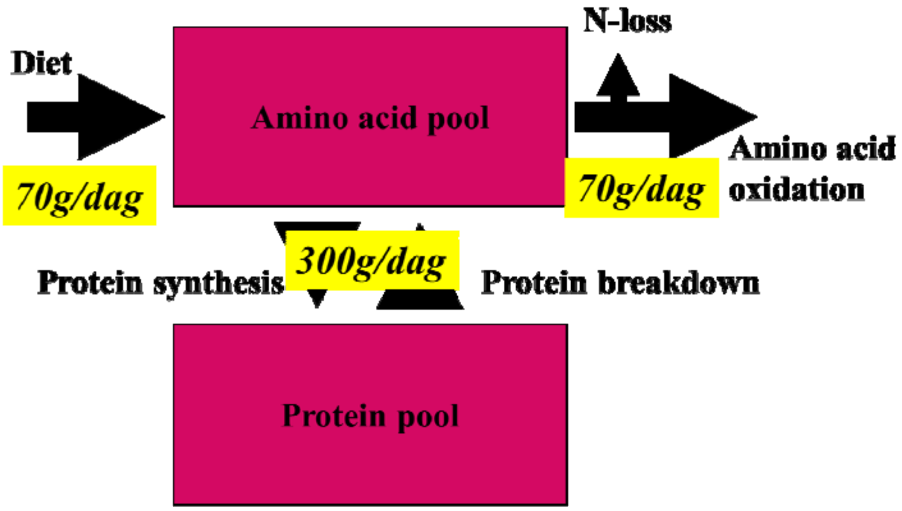
The problem



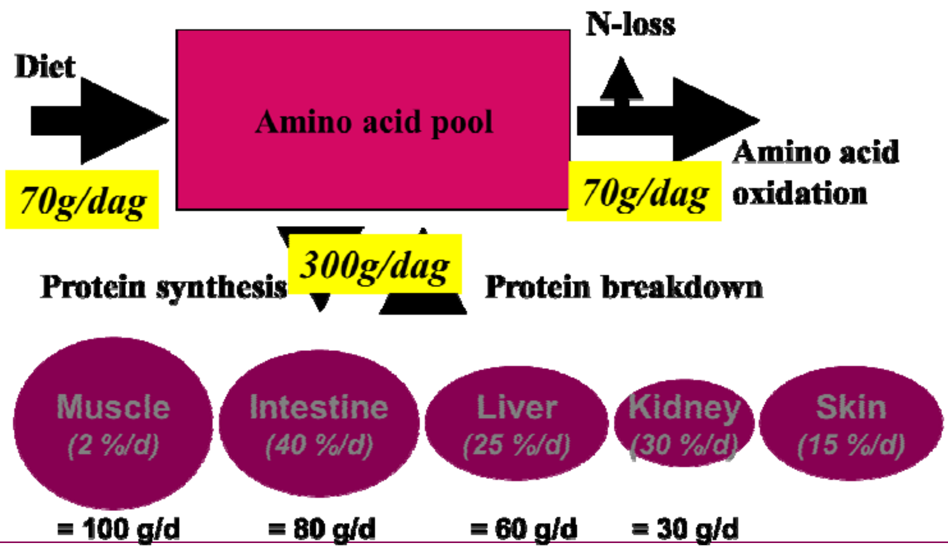
Protein turnover



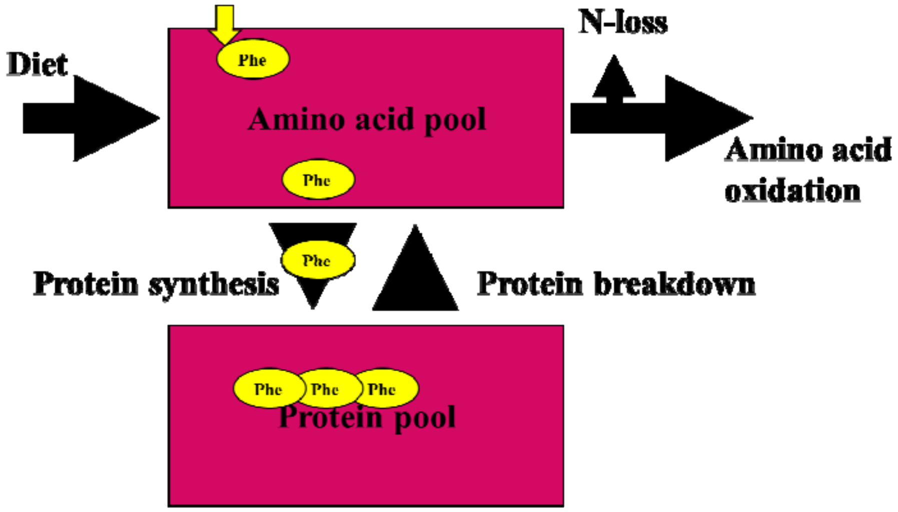
Whole body protein turnover



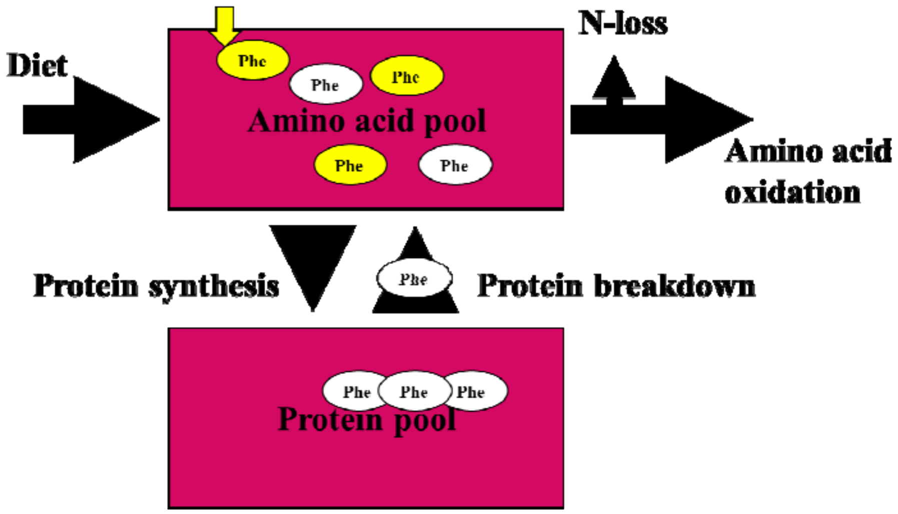
Tissue protein turnover



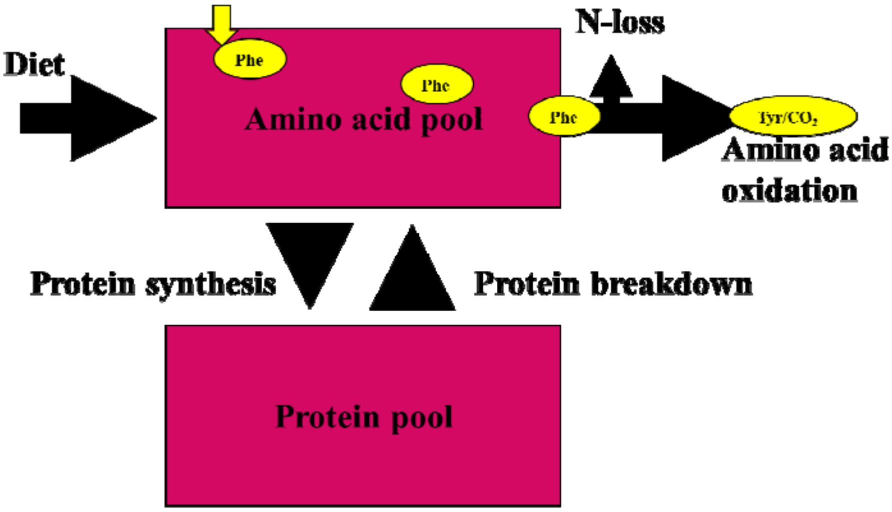
Measuring protein turnover



Measuring protein turnover



Measuring protein turnover



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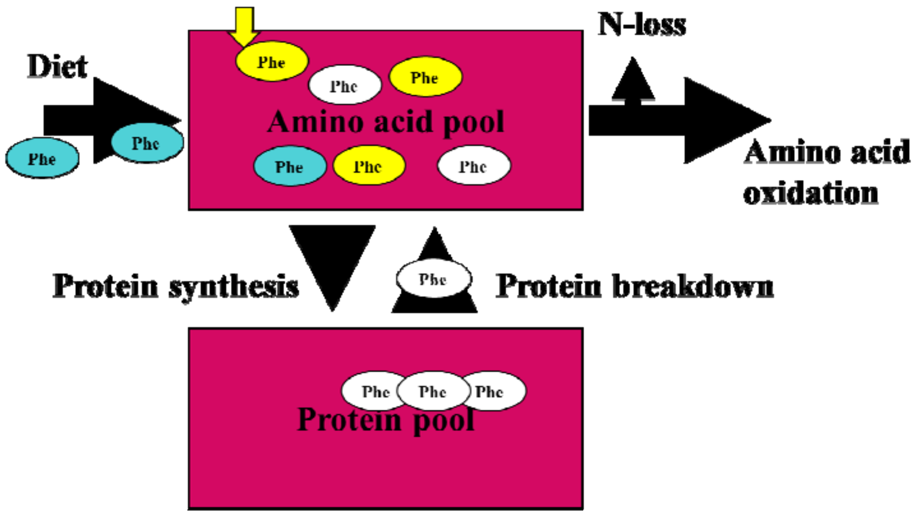
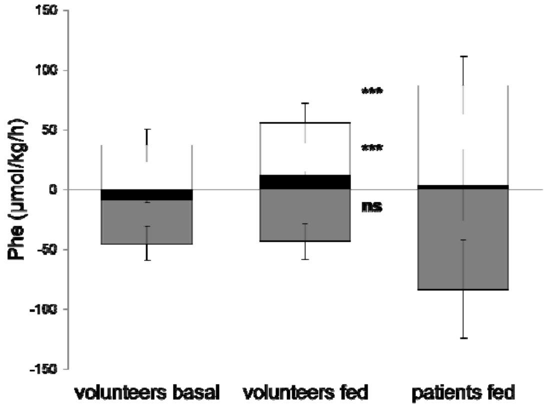
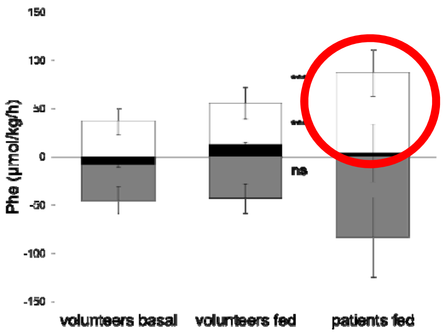


Protein turnover in the critically ill



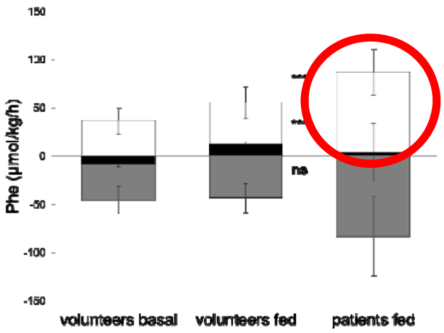
Rooyackers et al, Clin Nutr 2014

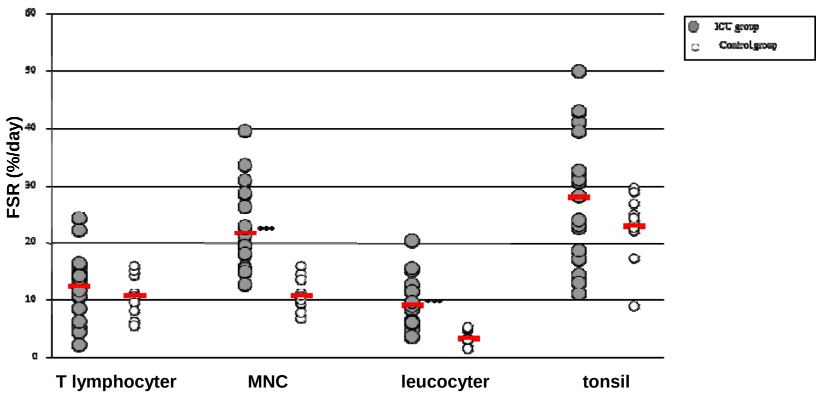
Protein turnover in the critically ill



Rooyackers et al, Clin Nutr 2014

Protein turnover in the critically ill (immune cells)

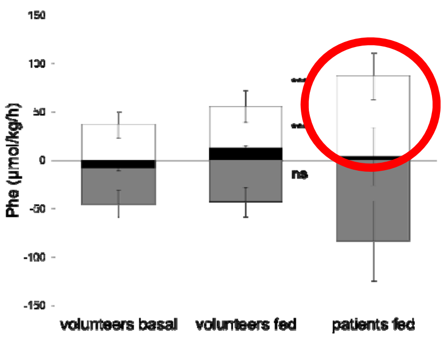


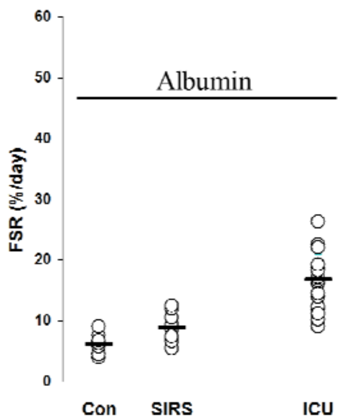


Rooyackers et al, Clin Nutr 2014

Januskiewicz et al, J Clin Immun 2007

Protein turnover in the critically ill (liver)





Rooyackers et al, Clin Nutr 2014

Barle et al, ICM 2001, Cli Sci 2006

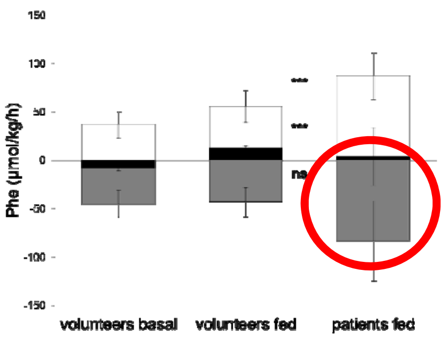
Protein turnover in the critically ill

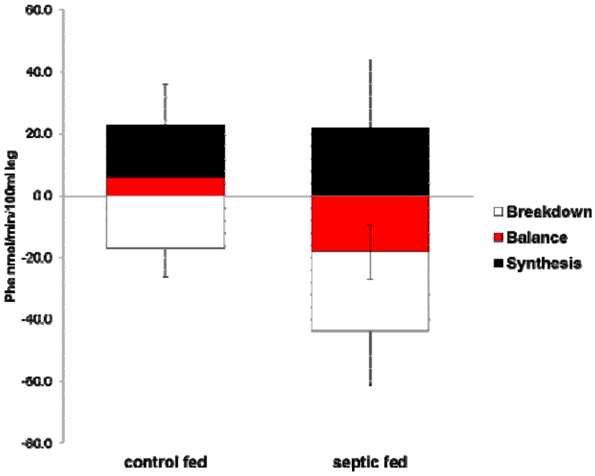
Karolinska Institutet

Rooyackers et al, Clin Nutr 2014

Protein turnover in the critically ill (skeletal muscle)

Karolinska Institutet

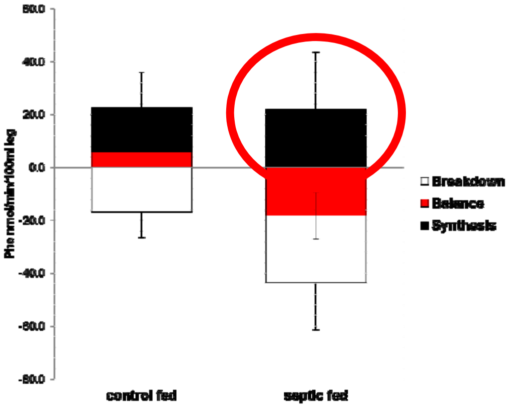


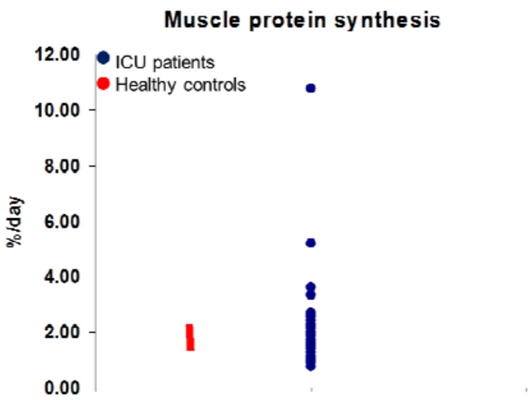


Rooyackers et al, Clin Nutr 2014

Klaude et al. Cli Sci 2011

Protein turnover in the critically ill (skeletal muscle)

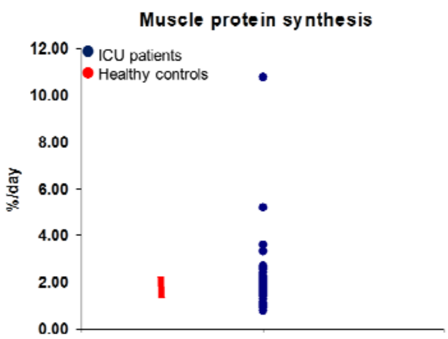


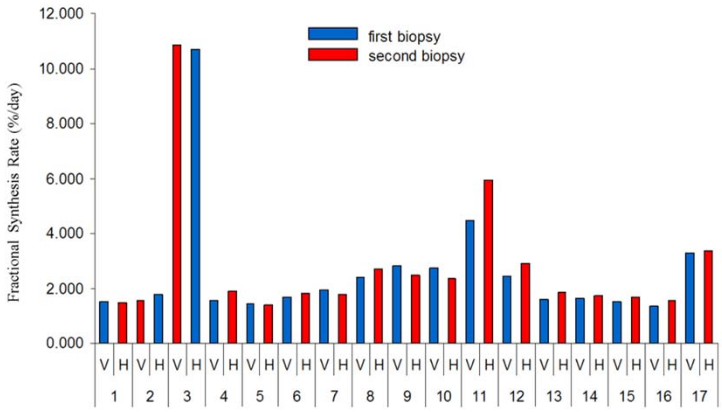


Klaude et al, Clin Sci 2011

Tjäder et al, submitted

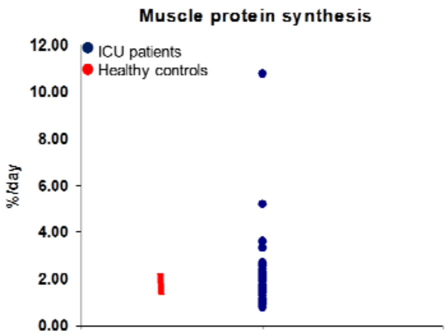
Protein turnover in the critically ill (skeletal muscle)

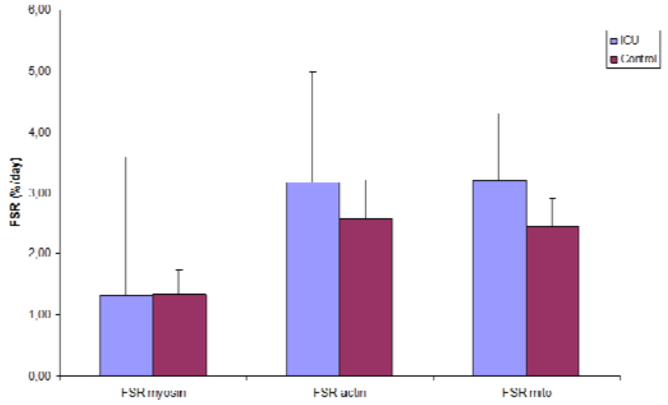




Tjäder et al, submitted

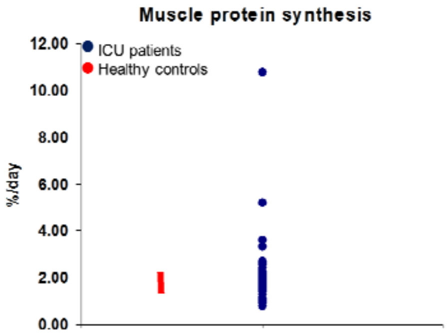
Protein turnover in the critically ill (skeletal muscle)

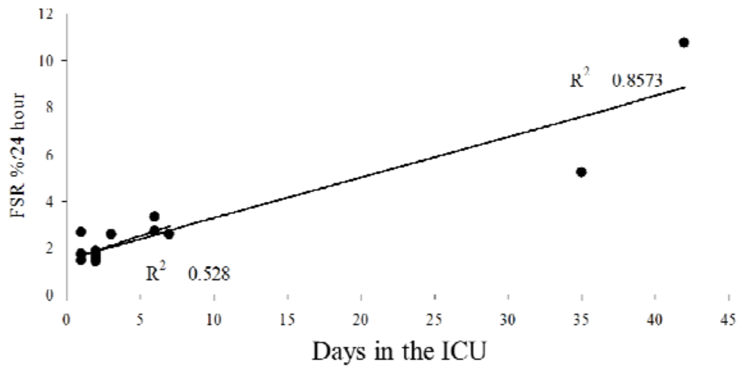




Tjäder et al, submitted

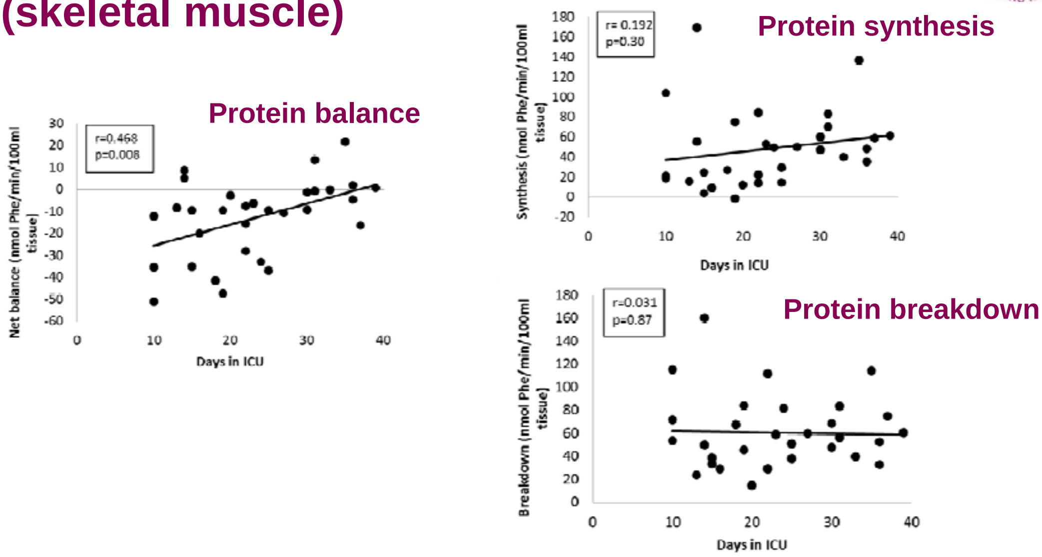
Protein turnover in the critically ill (skeletal muscle)





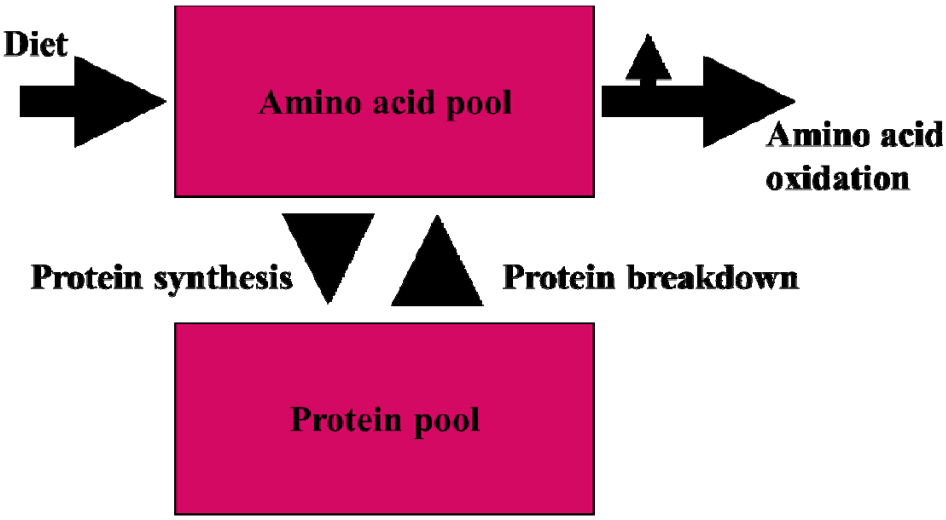
Tjäder et al, submitted

Protein turnover in the critically ill (skeletal muscle)

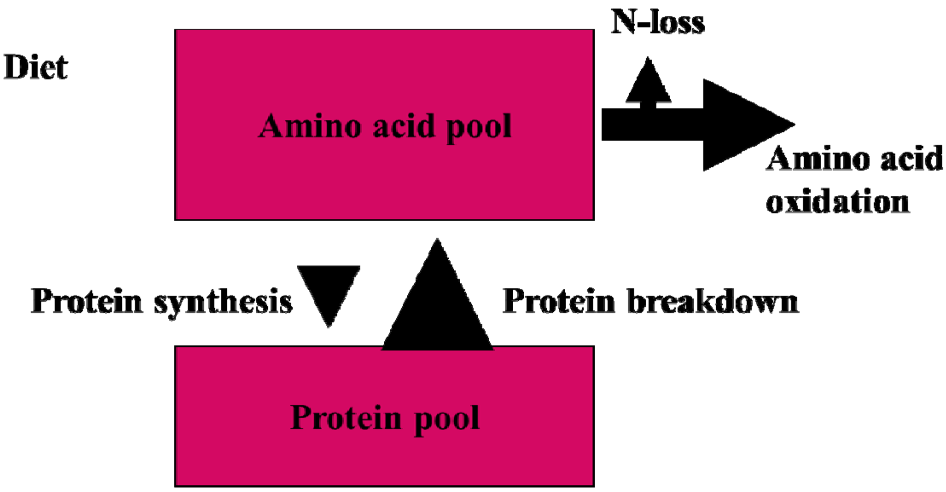


Gamrin et al, Crit Care 2018

Protein utilization in the critically ill



Protein utilization in the critically ill



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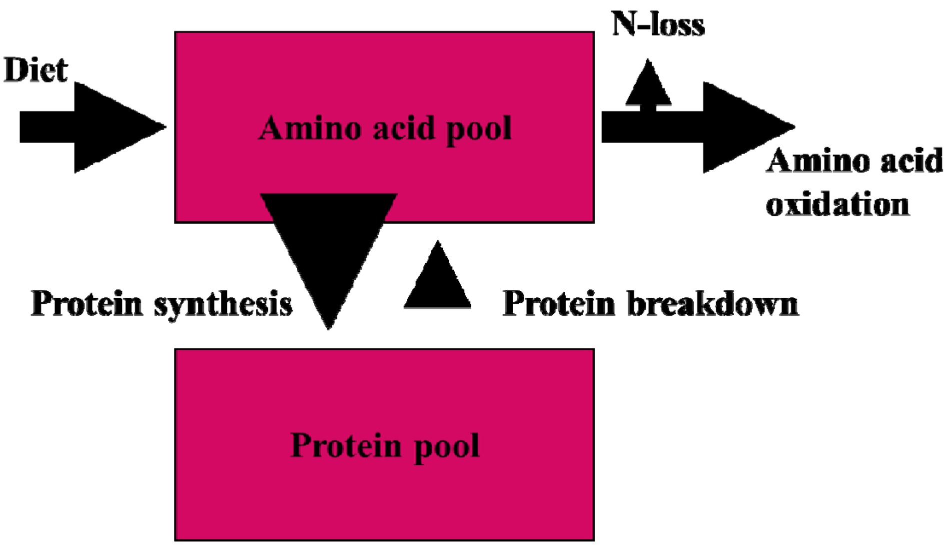

Protein utilization in the critically ill

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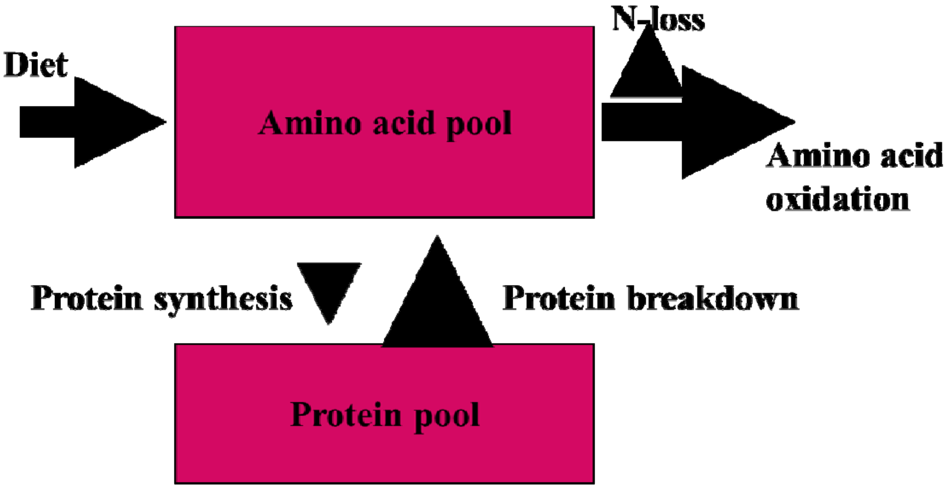

Protein utilization in the critically ill

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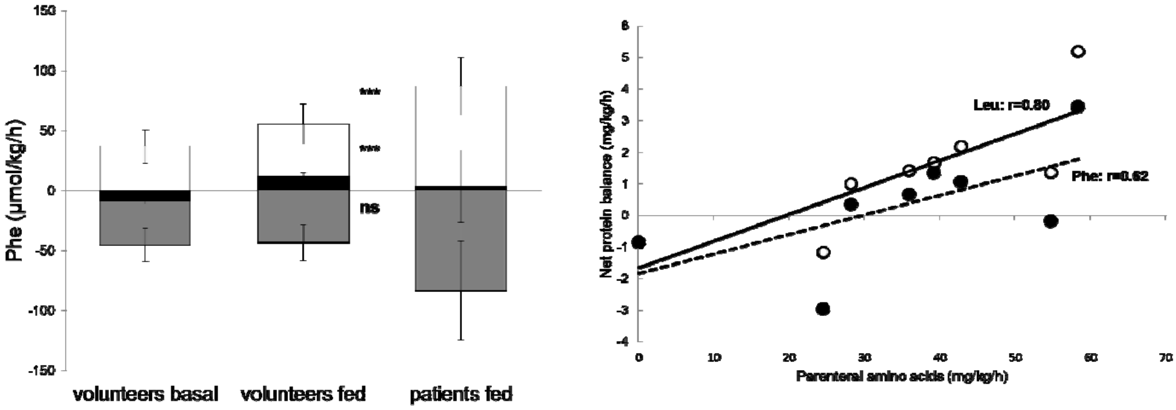

Rooyackers et al, Clin Nutr 2014

Parenteral protein utilization in the critically ill

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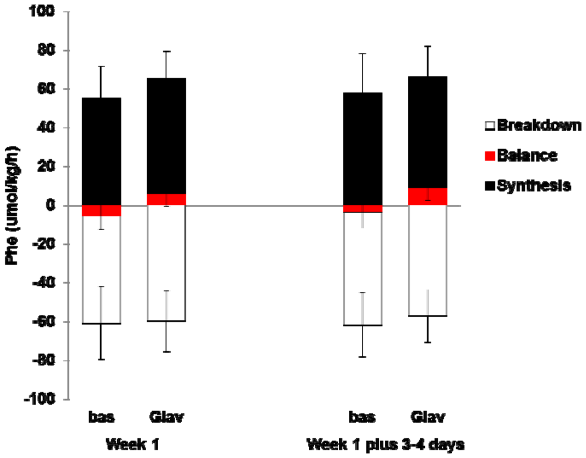

Liebau et al. Crit Care 2015

Parenteral protein utilization in the critically ill

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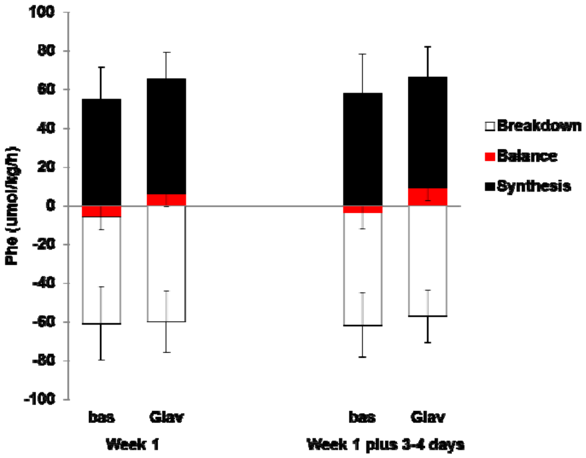

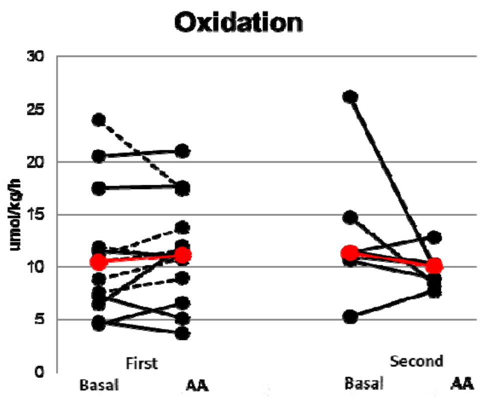

Liebau et al. Crit Care 2015

Parenteral protein utilization in the critically ill

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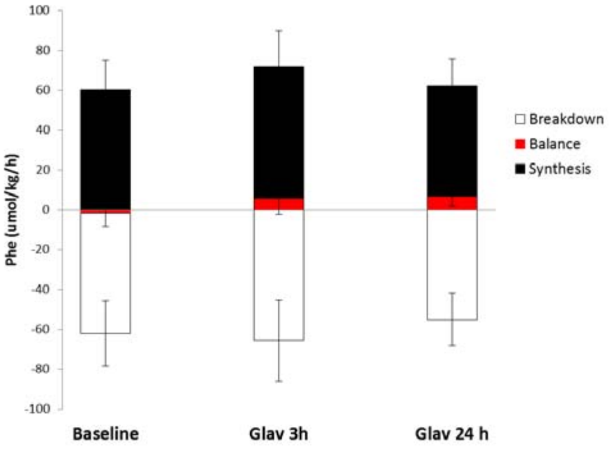

Sundström et al. Unpublished

Parenteral protein utilization in the critically ill

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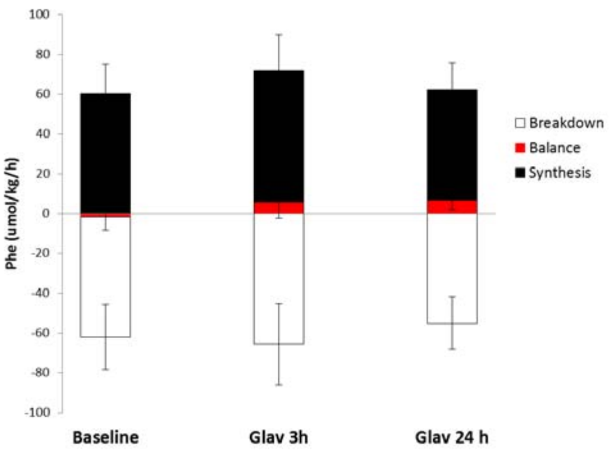
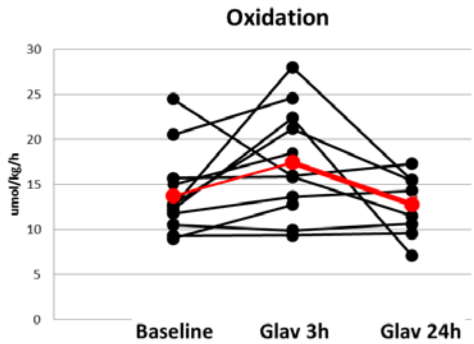
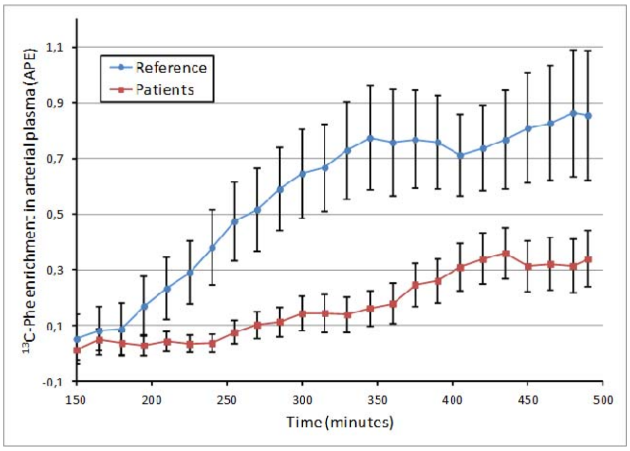




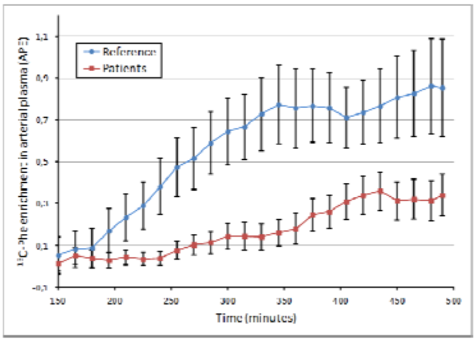
Sundström et al. Unpublished

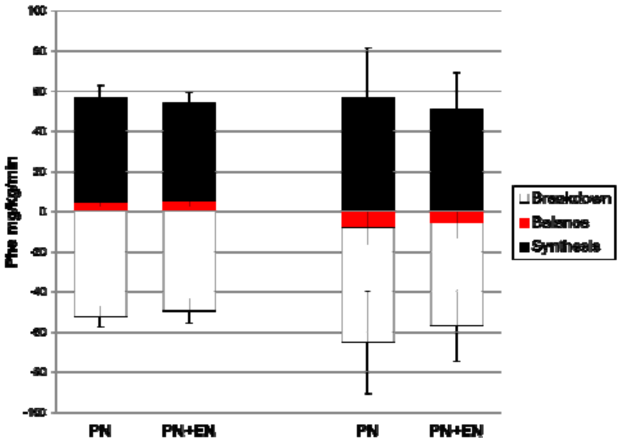
Enteral protein utilization in the critically ill



Liebau et al. AJCN 2015

Enteral protein utilization in the critically ill





Liebau et al. AJCN 2015

Enteral protein utilization in the critically ill

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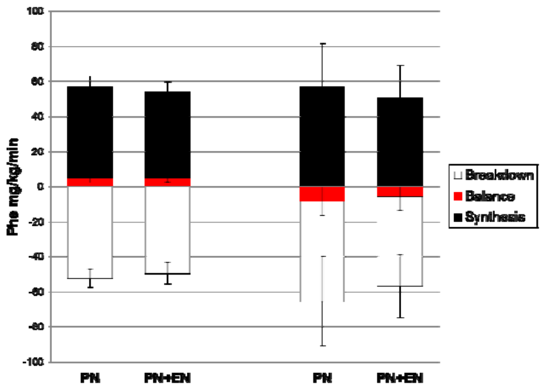

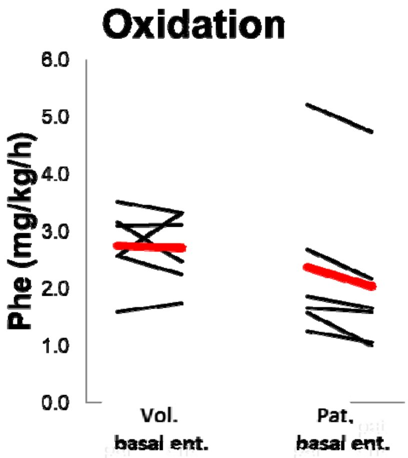

Liebau et al. AJCN 2015

Protein utilization in the critically ill

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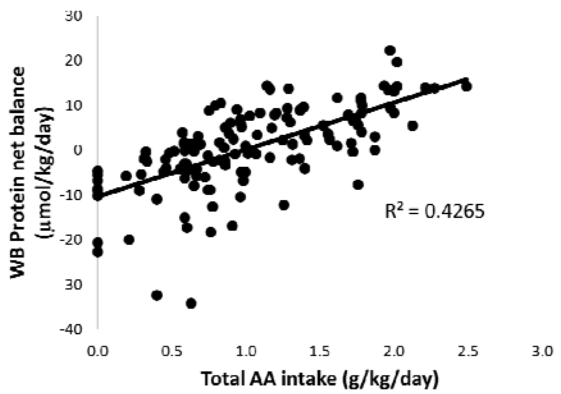

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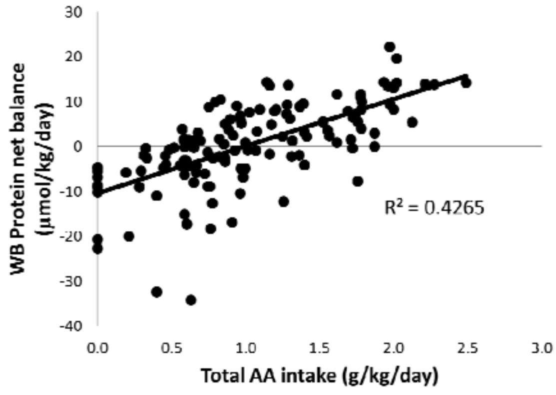
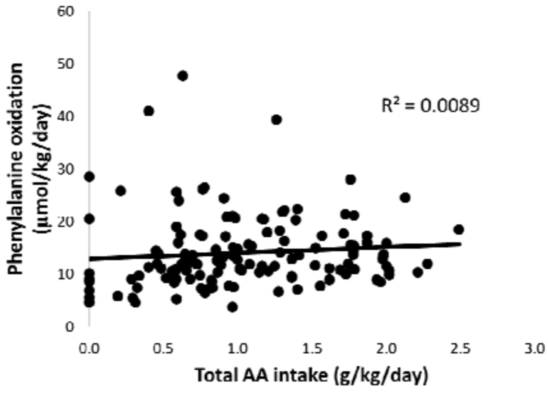
Protein utilization in the critically ill





CC. icu-metabolism.se

What do the guidelines say

	ESPEN (2009)	ASPEN (2016)
Protein	When PN is indicated, a balanced amino acid mixture should be infused at approximately 1.3–1.5 g/kg ideal body weight/day in conjunction with an adequate energy supply. (grade B)	We suggest that sufficient (high-dose) protein should be provided. Protein requirements are expected to be in the range of 1.2–2.0 g/kg actual body weight per day and may likely be even higher in burn or multitrauma patients [Quality of Evidence: Very Low]

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Protein needs

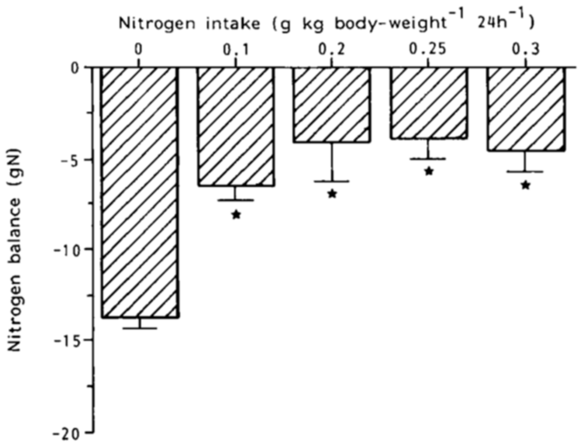

Figure 1 *Mean (s.e.m.) daily nitrogen balance on days 2–8 after severe trauma. The groups receiving nitrogen are compared with the group with no nitrogen intake.* * $P<0.001$

Larsson et al, Br J Surg 1990

Protein needs

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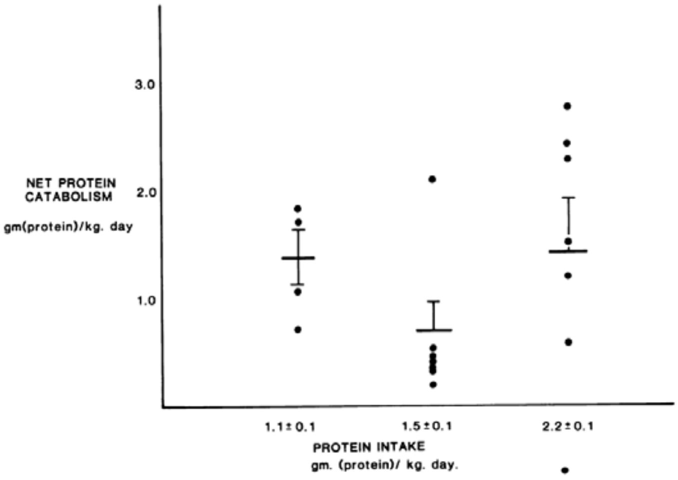

FIG. 3. Rates of NPC in septic patients receiving TPN at three rates of protein intake. ● Individual values for NPC. + Mean rate of NPC with SEM.

Shaw et al, Ann Surg 1987

What do the guidelines say

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Protein needs

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Table 3. Relationship Between Nutrition Therapy and Intensive Care Unit, 28-Day, and Hospital Mortality[a]

	Protein and Energy Target	Energy Target
Model 0[b]		
Intensive care unit	0.91 (0.64–1.31), *P* = .626	1.03 (0.86–1.25), *P* = .733
28 d	**0.59 (0.40–0.88), *P* = .010**	0.90 (0.74–1.09), *P* = .291
Hospital	**0.76 (0.58–0.99), *P* = .041**	0.93 (0.81–1.08), *P* = .339
Model 1[c]		
Intensive care unit	0.79 (0.54–1.17), *P* = .242	0.99 (0.81–1.20), *P* = .886
28 d	**0.51 (0.33–0.78), *P* = .002**	0.84 (0.68–1.03), *P* = .085
Hospital	**0.70 (0.53–0.94), *P* = .017**	0.91 (0.79–1.06), *P* = .233
Model 2[d]		
Intensive care unit	0.72 (0.48–1.09), *P* = .116	0.98 (0.80–1.19), *P* = .834
28 d	**0.40 (0.26–0.64), *P* < .001**	**0.79 (0.64–0.97), *P* = .024**
Hospital	**0.62 (0.46–0.84), *P* = .002**	0.89 (0.77–1.04), *P* = .137

[a]Presented as hazard ratio (95% confidence interval). Bold font indicates significance ($P < .05$).
[b]Unadjusted.
[c]Adjusted for sex, age, body mass index, diagnosis, hyperglycemic index, and Acute Physiology and Chronic Health Evaluation II score.
[d]Additionally adjusted for time to energy target and use of parenteral nutrition.

Weijs et al, JPEN 2012

Protein needs

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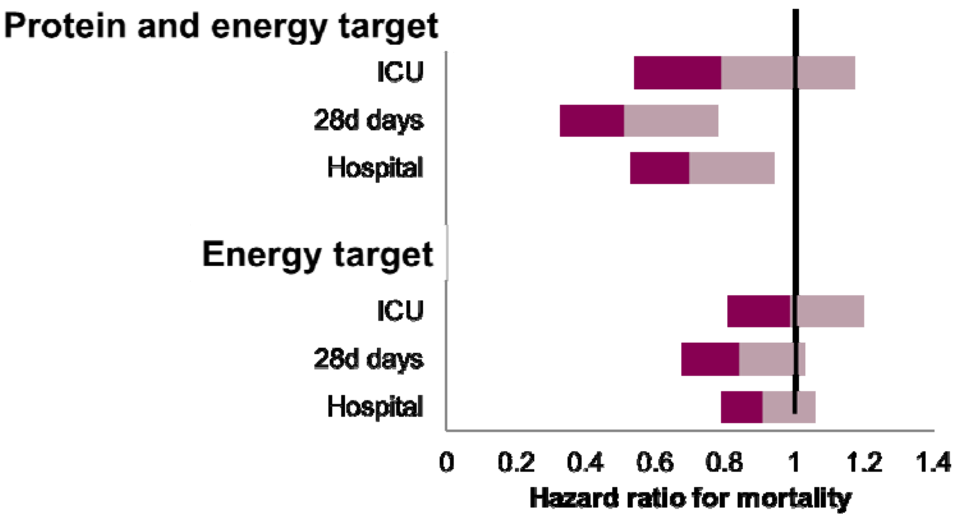

Weijs et al, JPEN 2012

Protein needs

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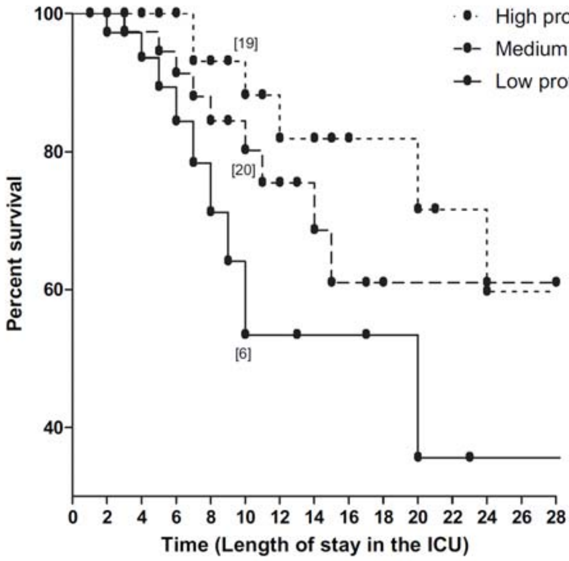

Allingstrup et al, Clin Nutr 2012

Appropriate protein provision in critical illness: a systematic and narrative review[1–3]

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L John Hoffer and Bruce R Bistrian

Am J Clin Nutr 2012;96:591–600. Printed in USA. © 2012 American Society for Nutrition

Total nr studies	13
Randomized	4
Nitrogen balance	12
Turnover	3
Body composition	1
Amino acid profiles	1
Outcome	2

Results: The limited amount and poor quality of the evidence preclude conclusions or clinical recommendations but strongly suggest that 2.0–2.5 g protein substrate · kg normal body weight^{-1} · d^{-1} is safe and could be optimum for most critically ill patients. At the

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Targeted Full Energy and Protein Delivery in Critically Ill Patients: A Pilot Randomized Controlled Trial (FEED Trial)

Kate Fetterplace, APD, BNutrDiet[1,2,3]; Adam M. Deane, MBBS, PhD[3,4]; Audrey Tierney, APD, PhD[2,5]; Lisa J. Beach, PT, MPhty[6]; Laura D. Knight, PT, BPhty, MHSM[6]; Jeffrey Presneill, MBBS, PhD[3,4]; Thomas Rechnitzer, MBBS, FCICM[4]; Adrienne Forsyth, APD, AEP, PhD[2]; Benjamin M. T. Gill, APD, MDiet[1,3]; Marina Mourtzakis, PhD[7]; and Christopher MacIsaac, MBBS, PhD[3,4]

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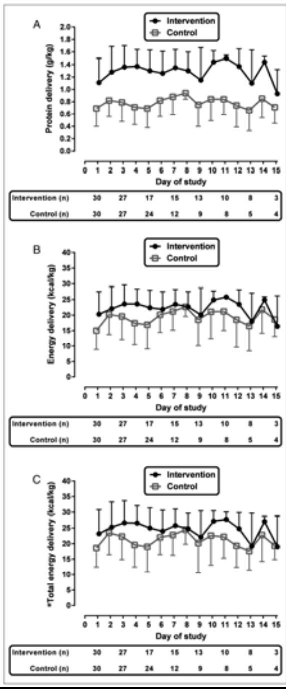

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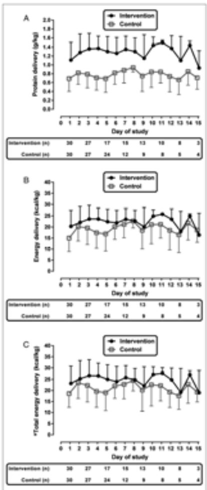

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Table 4. Effect Estimate of Variables on Quadriceps Muscle Layer Thickness (cm) at Intensive Care Unit Discharge Adjusted for Baseline Quadriceps Muscle Layer Thickness (cm).[a]

	Effect Estimate Adjusted for Baseline QMLT				Effect Estimate Adjusted for All Covariants			
Variables	Effect	Robust SE	95% CI	*P*-Value	Effect	Robust SE	95% CI	*P*-Value
Baseline QMLT, cm	0.61	0.11	0.38–0.83	<.001	0.56	0.11	0.33–0.79	<.001
Intervention	0.22	0.08	0.05–0.39	.01	0.22	0.08	0.06–0.38	.01
APACHE III[b]	0.02	0.02	−0.02 to 0.06	.44	0.01	0.02	−0.03 to 0.05	.70
Age,[c] y	0.02	0.03	−0.03 to 0.08	.44	−0.00	0.02	−0.05 to 0.05	.92
Body mass index,[d] kg/m²	0.02	0.09	−0.17 to 0.21	.82	0.03	0.08	−0.14 to 0.19	.73
Admission category[e]								
Elective surgery	−0.44	0.07	−0.58 to −0.30	<.001	−0.57	0.08	−0.73 to −0.41	<.001
Surgical	−0.28	0.08	−0.44 to −0.11	<.01	−0.24	0.09	−0.41 to −0.06	.01

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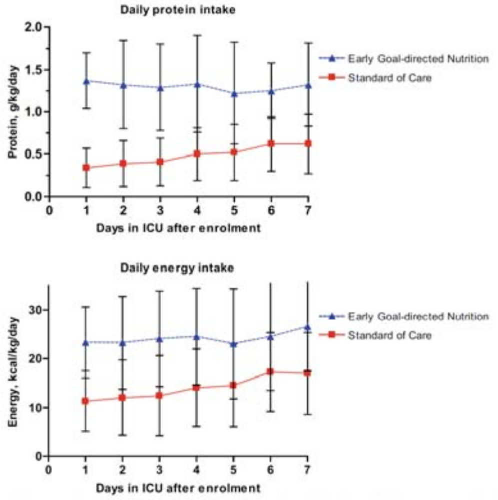

Fig. 2 Mean daily protein and energy intake per trial day 1–7 for the full patient cohort including those who had protein provision reduced because of a plasma urea value above 20 mmol/l. *Error bars* are SD for means in the two groups at each time point

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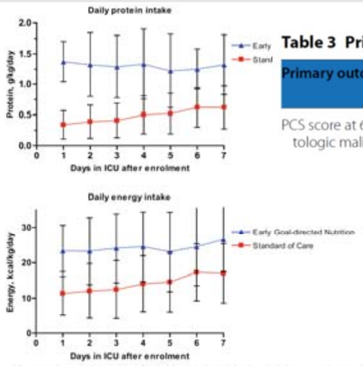

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Table 3 Primary and secondary outcome measures in the two intervention groups

Primary outcome measure	Early goal-directed nutrition ($N = 100$)	Standard of care ($N = 99$)	Adjusted mean difference (95% CI)	p value
PCS score at 6 months adjusted for presence of haematologic malignancy, mean (SD)	22.9 (21.8)	23.0 (22.3)	−0.0[a] (−5.9 to 5.8)	0.99

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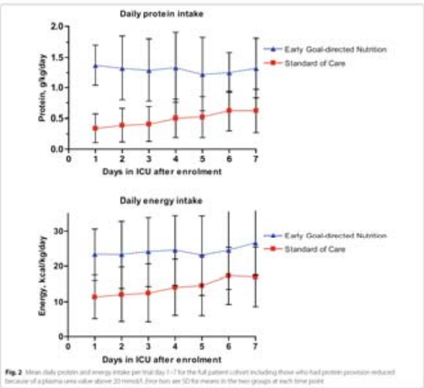
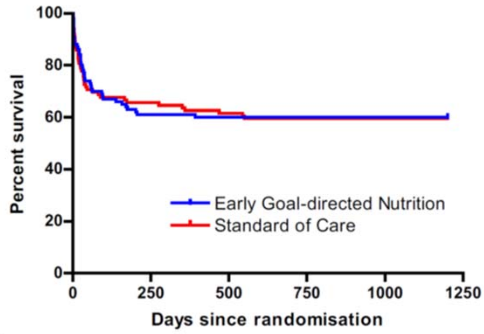
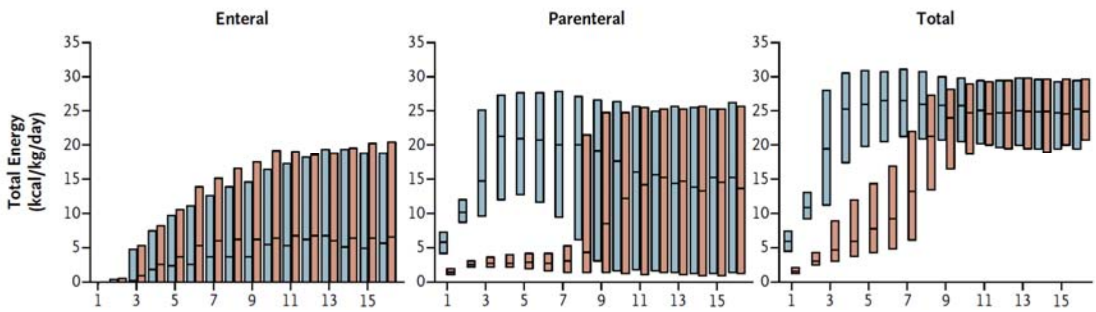




No. at risk			
EGDN	100	38	10
Std. of Care	99	41	8

Fig. 3 Time to death analysis. The figure shows the survival curves for all included patients at 6 months after randomisation of the last patient. Kaplan–Meier analysis showed that survival time did not differ between the EGDN group and the standard of care group. Log rank $p = 0.51$

EPaNIC



Casear et al. NEJM 2011

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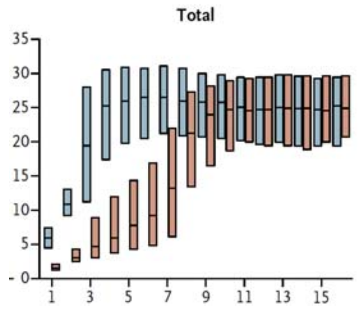

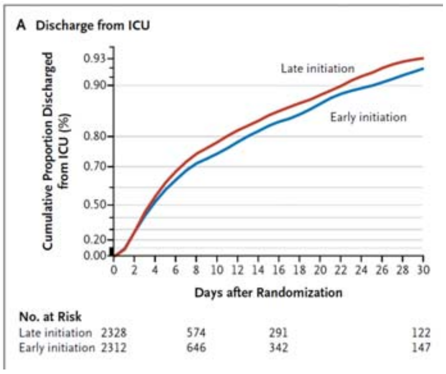

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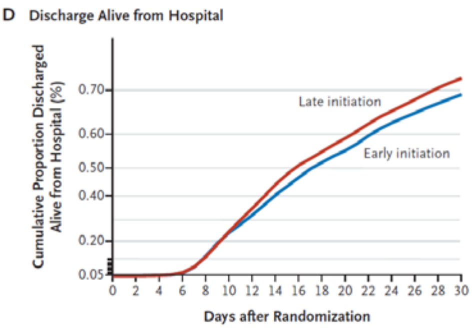

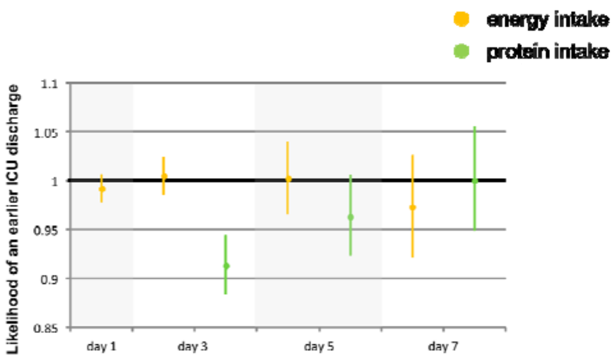

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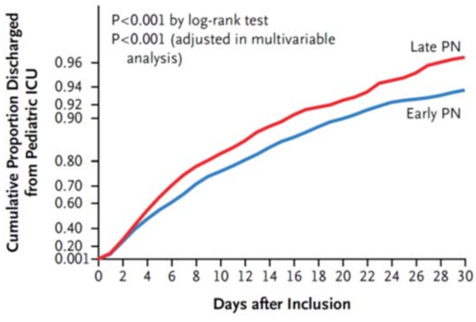

Fivez et al. NEJM 2016

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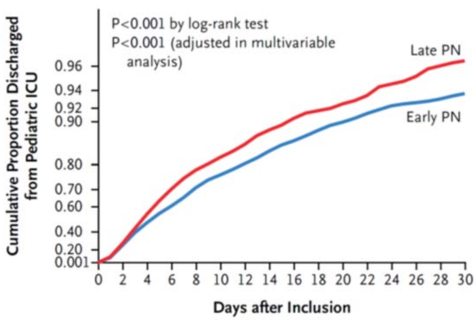
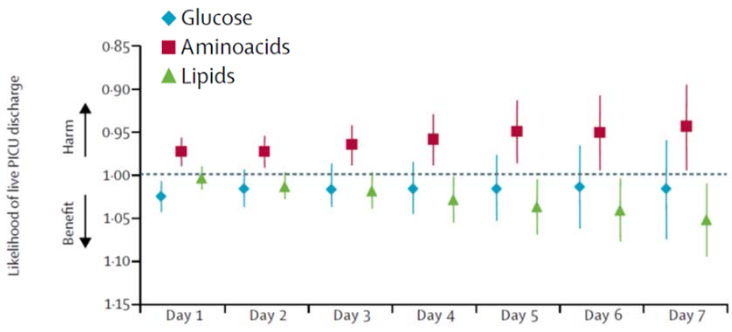


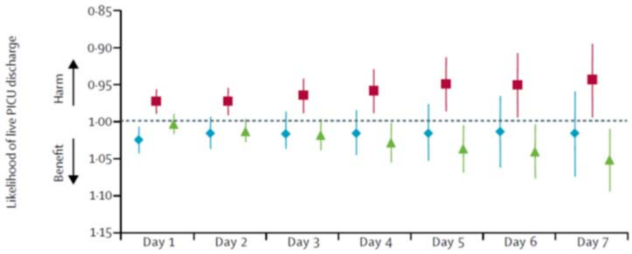


	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
n	1440	1188	924	747	611	517	443
Glucose p value	0·0096	0·19	0·25	0·36	0·48	0·63	0·62
Aminoacids p value	0·0014	0·0032	0·0029	0·0059	0·0067	0·026	0·030
Lipids p value	0·76	0·13	0·10	0·043	0·027	0·035	0·016

Fivez et al. NEJM 2016

Vanhorebeek et al. Lancet res med 2017

PEPaNIC



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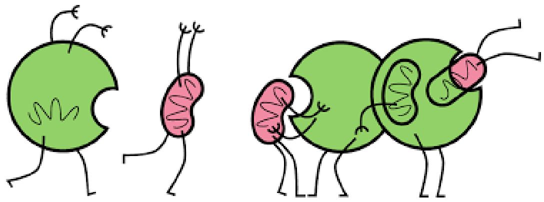

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Take home:

- Critical illness leads to redistrubution of proteins synthesised and degraded
- Muscle wasting is the result of increased breakdown

- The critical ill body is able to utilize parenteral and enteral proteins
- Proteins given up to target seem to have beneficial effects

- ALTHOUGH signal of harm possible during acute/early phase
- BUT this might be individual

- We need to find the signals of harm and monitor these to indivualise nutrition

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