Nutritional Immunomodulation in Critical Illness

Prof Jonathan Asprer, MD

University of Santo Tomas

Manila, Philippines

University of Santo Tomas

Established in 1611, celebrating 400 years in 2011

From nutrition support to therapy

- ***Traditional role of nutrition support:***

  To provide calories, protein, vitamins, minerals, trace elements

- ***Current role of nutrition therapy:***

  Modulate immune response in the cascade from SIRS- MOD- MOF

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IMMUNOMODULATION

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Goals of nutrition support

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- *Prevention of starvation-induced complications*
- *Improvement of nutritional status*
- *Improvement of metabolic status*
- *Reduction in LOS and ICU stay*

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- *Improvement of nutritional status*
- *Improvement of metabolic status*
- *Reduction in LOS and ICU stay*

Goals of nutrition therapy

- *Decreasing local and systemic infections*
- *Modulation of SIRS, and the cascade to MOD and MOF*
- *Metabolic support of individual organs*
- *Reduction in morbidity & mortality*

Nutritional immunomodulation

- ***Early enteral feeding (EN) can stimulate gut immunity & gut function***
- ***Early PN for critically ill patients with poor EN tolerance avoids the infections and other complications associated with caloric deficits***
- ***Hyperglycemia in critical illness is associated with increased mortality and must be controlled***
- ***Pharmacologic effects of glutamine & fish oils directly modulate immune responses***

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2009 Guidelines: ASPEN-SCCM, ESPEN

aspen
Clinical Guidelines

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Guidelines for the Provision and Assessment of Nutrition Support Therapy in the Adult Critically Ill Patient:

Society of Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.)

ELSEVIER

ESPEN Guidelines on Parenteral Nutrition: Intensive care

Pierre Singer [a], Mette M. Berger [b], Greet Van den Berghe [c], Gianni Biolo [d], Philip Calder [e], Alastair Forbes [f], Richard Griffiths [g], Georg Kreyman [h], Xavier Leverve [i], Claude Pichard [j]

ASPEN-SCCM ICU Guidelines, JPEN, May-June 2009
ESPEN ICU Guidelines, Clinical Nutrition, Aug 2009

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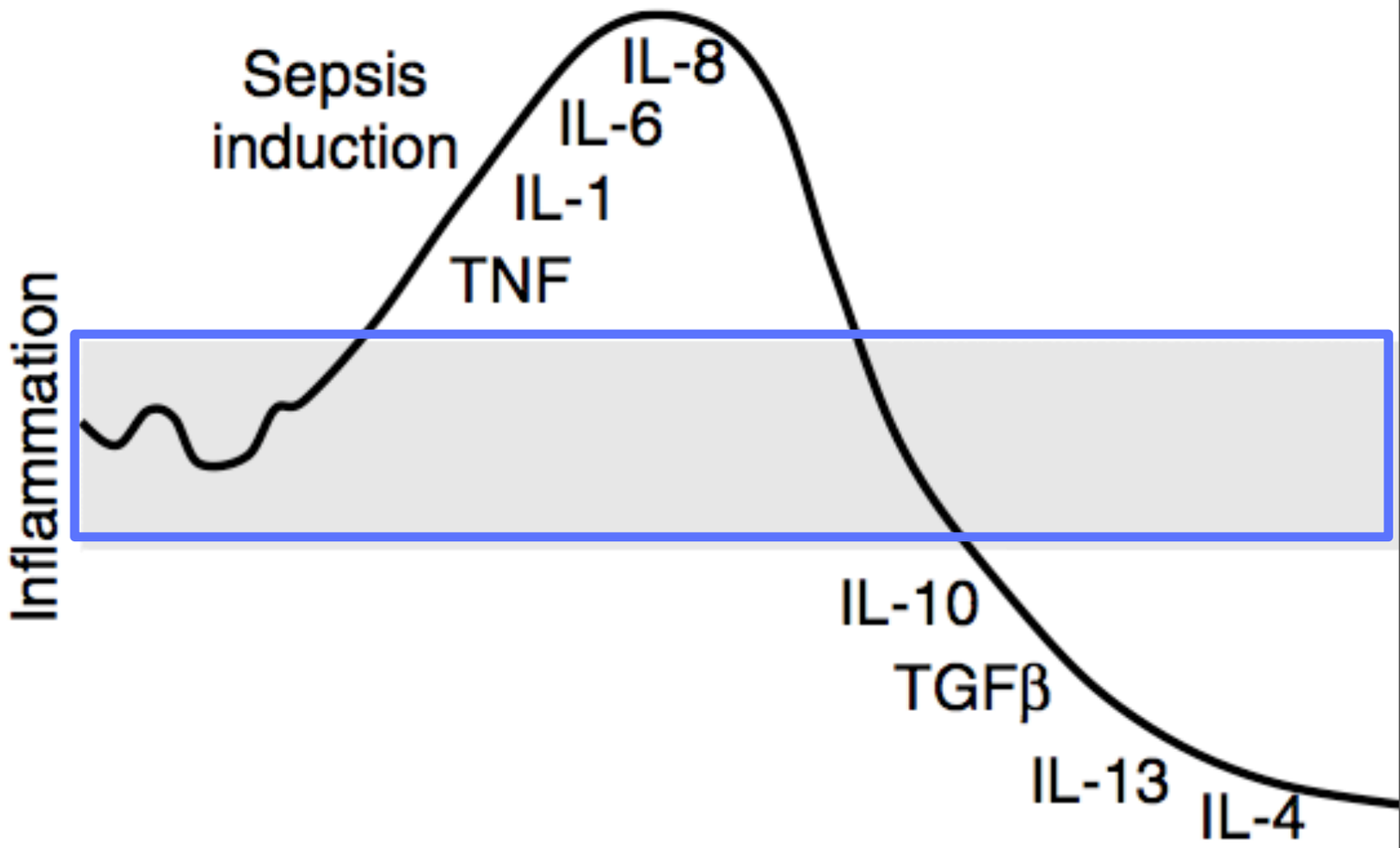

Calder, ESPEN, 9/2007

Dysfunctional inflammatory response in ICU-

Initially in SIRS phase:

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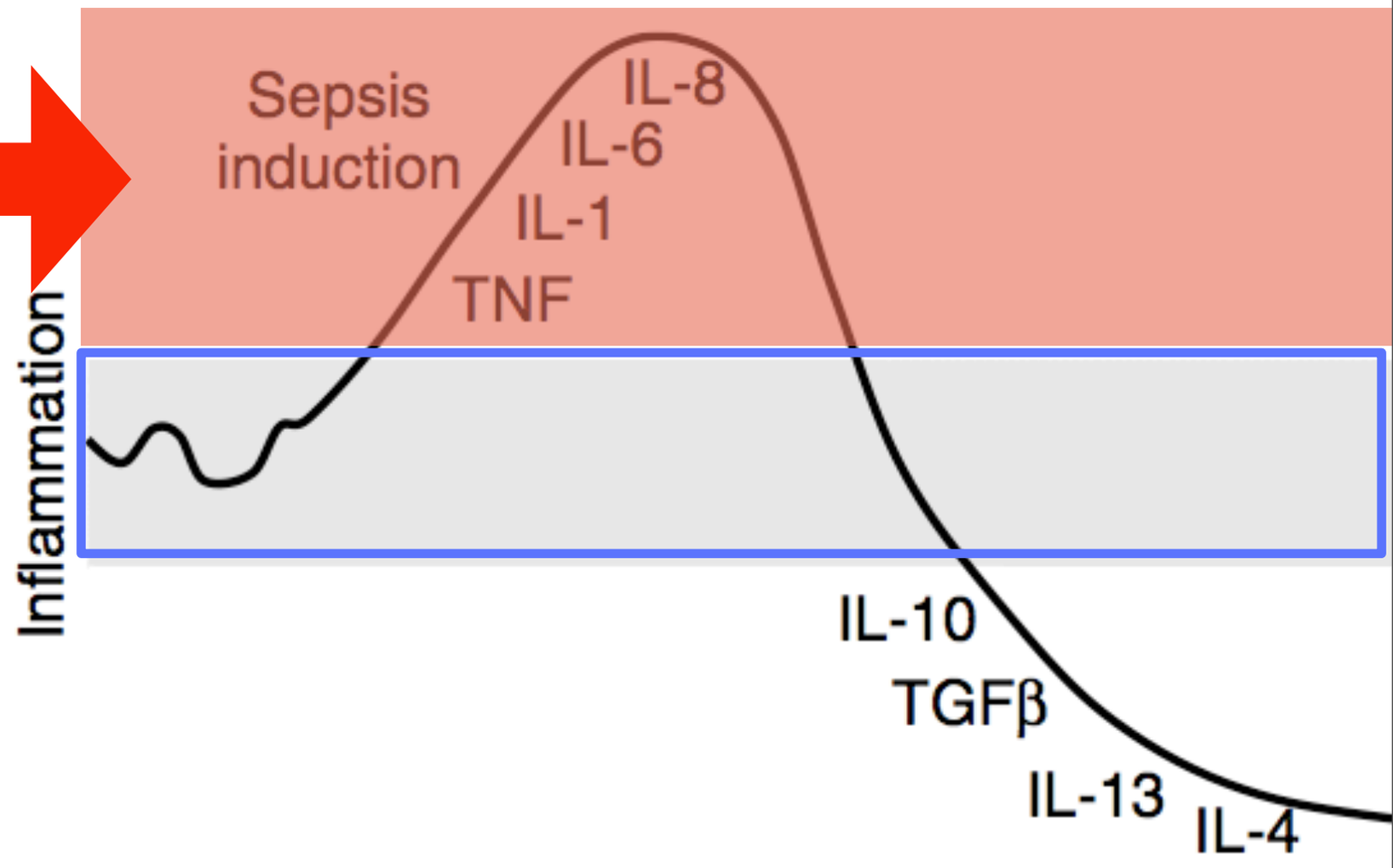
Increased generation of inflammatory mediators



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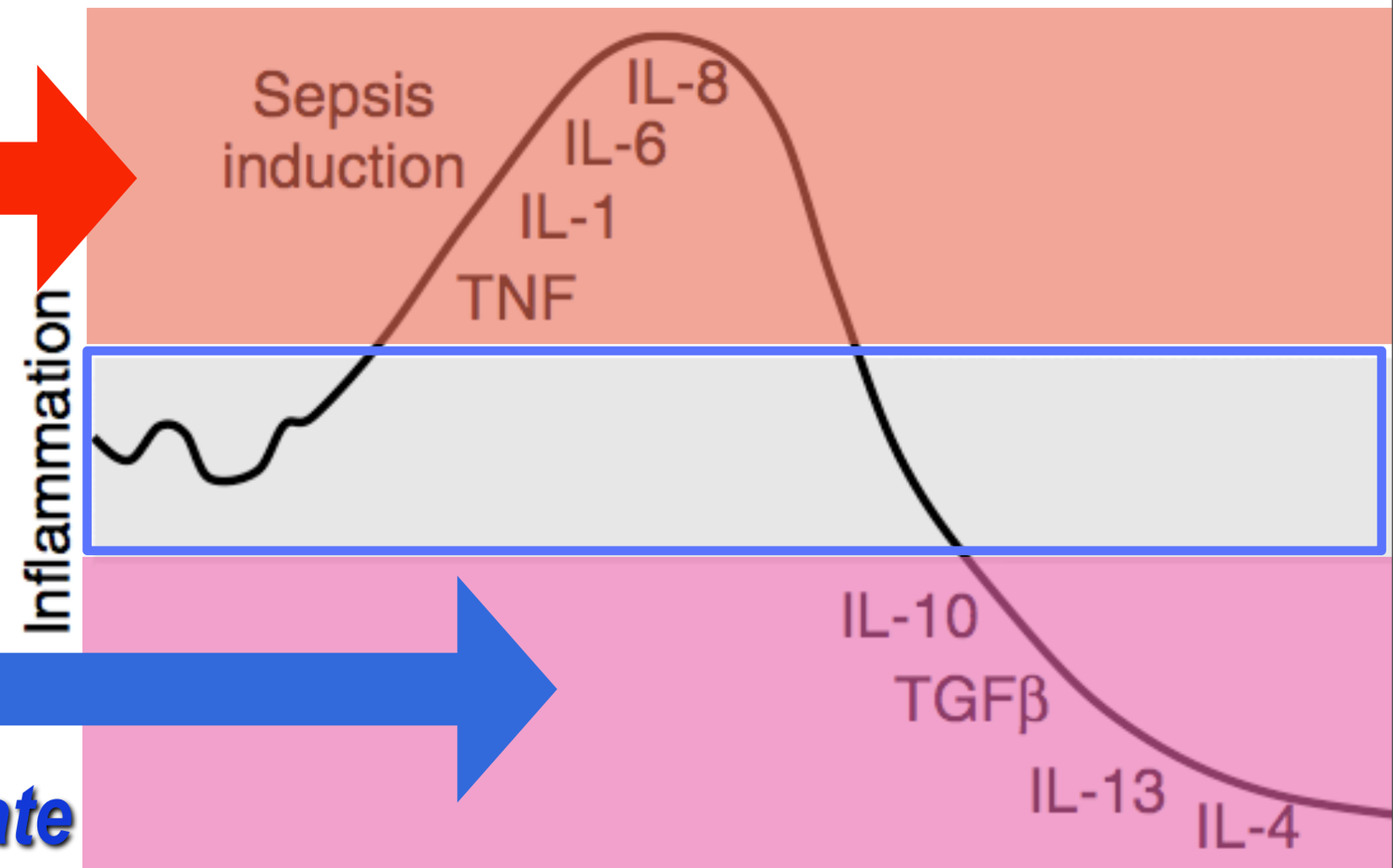

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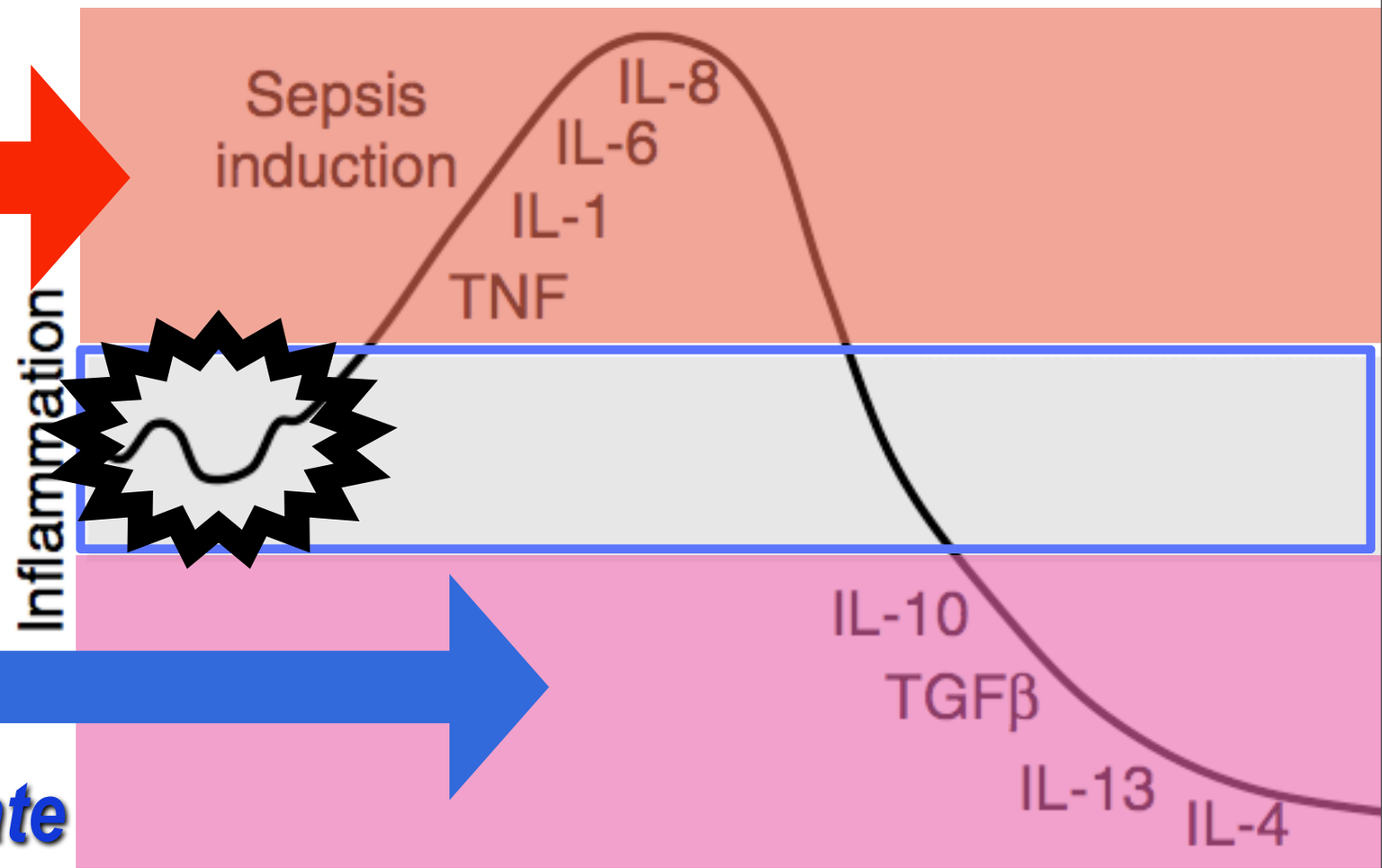

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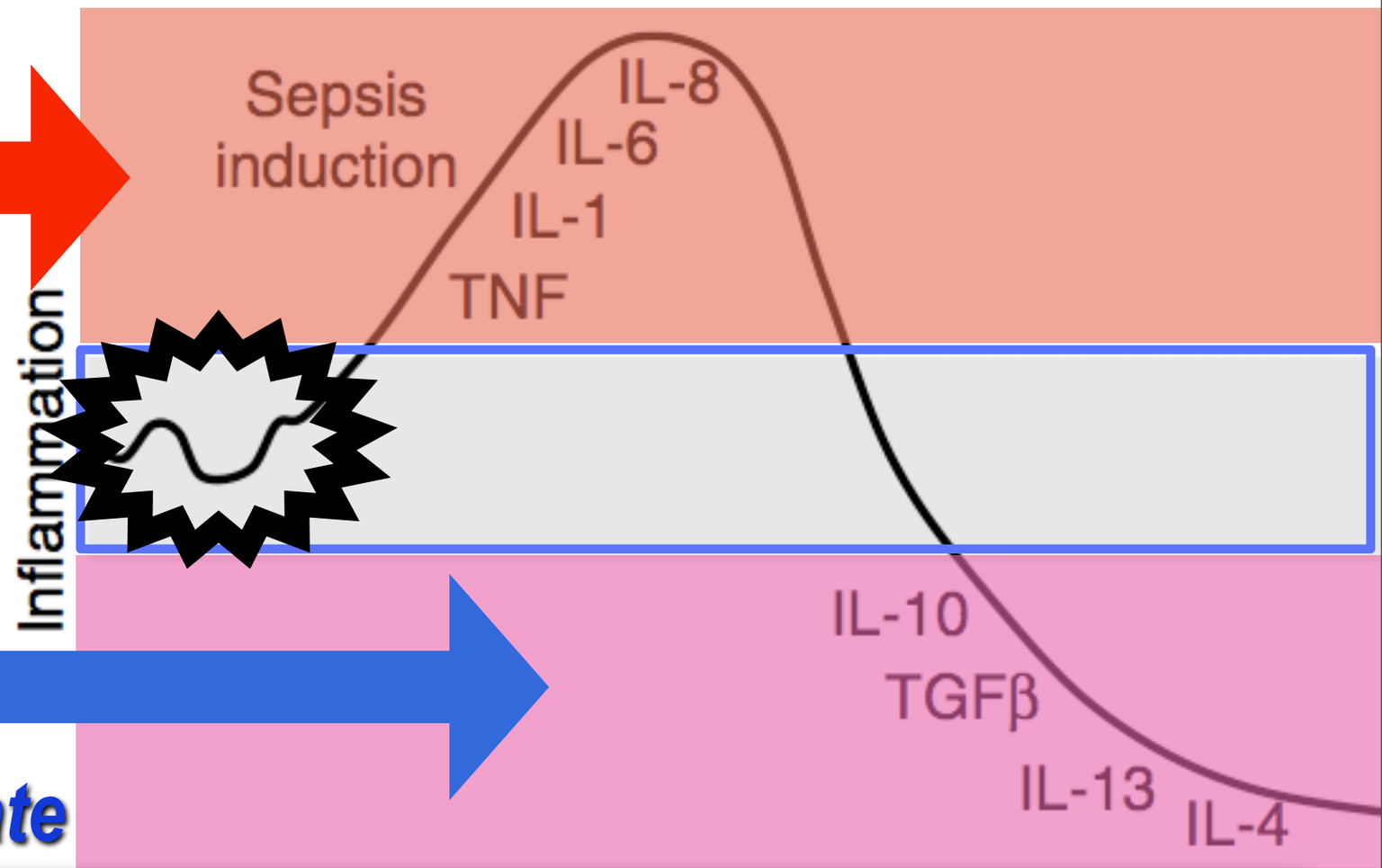

Early feeding can stimulate gut function & gut immunity within 24 – 48 hrs after the critical event (surgery, ICU, etc)

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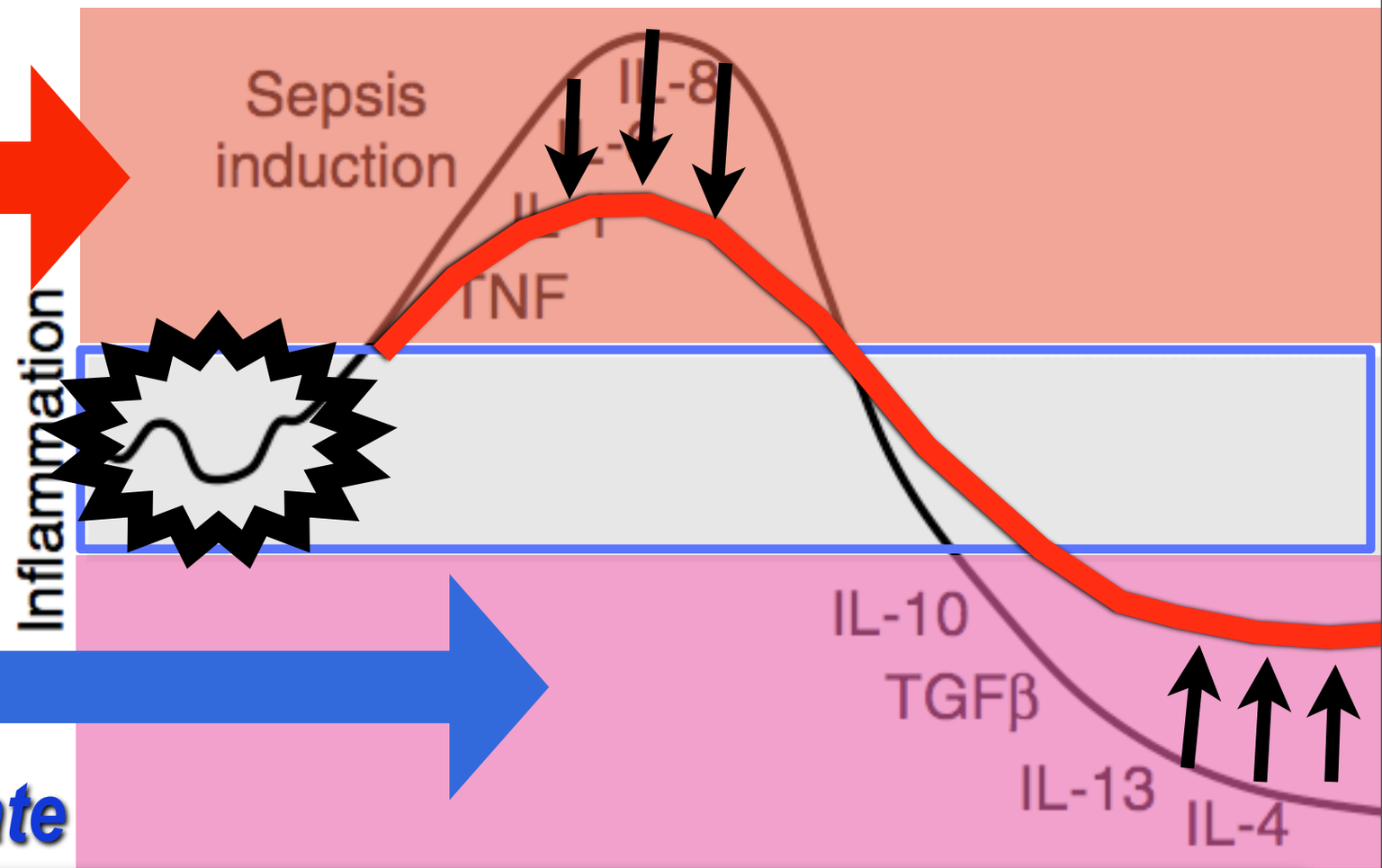

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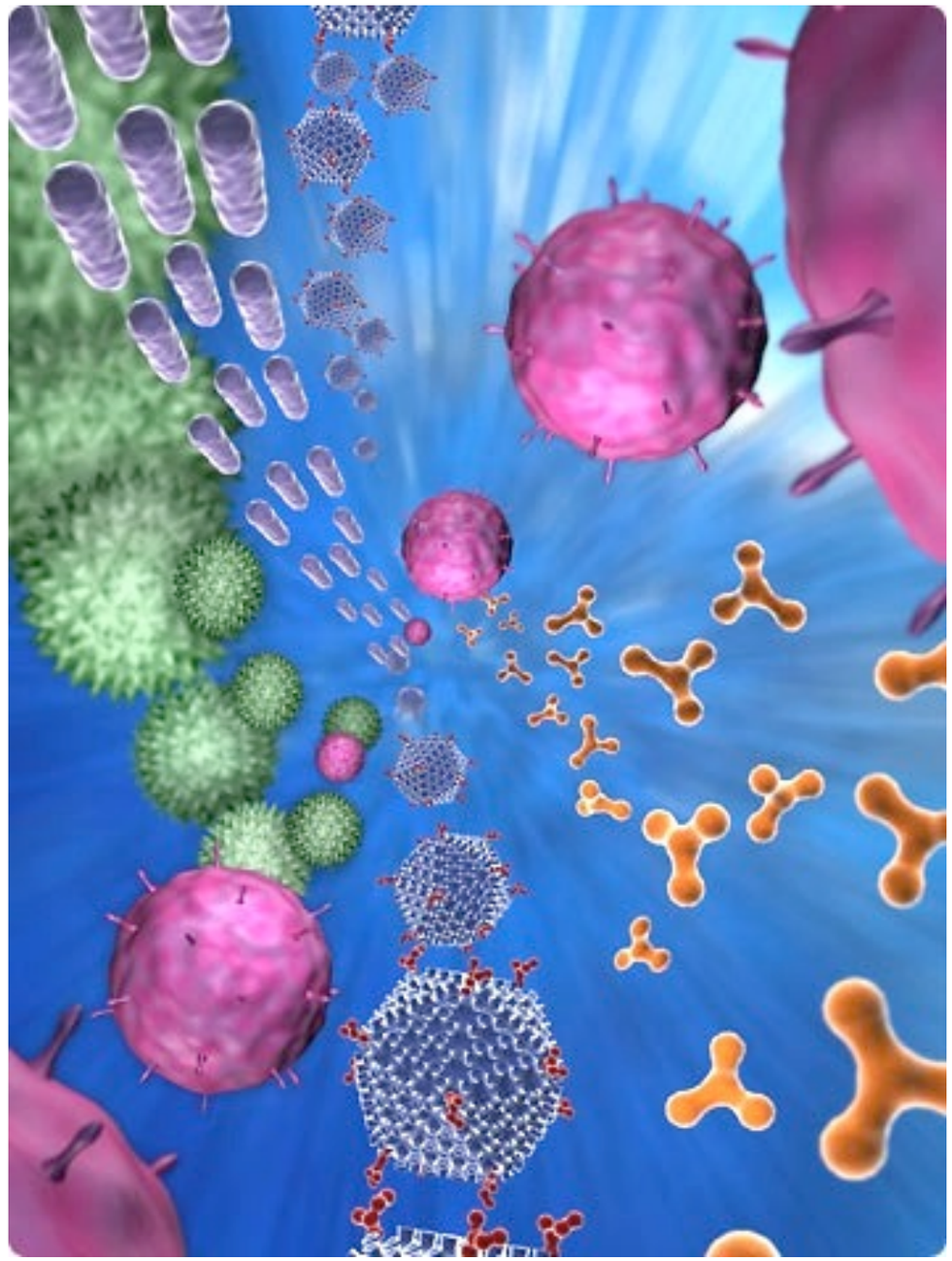

Kudsk, JPEN, Vol 32, No. 4. July- Aug 2008

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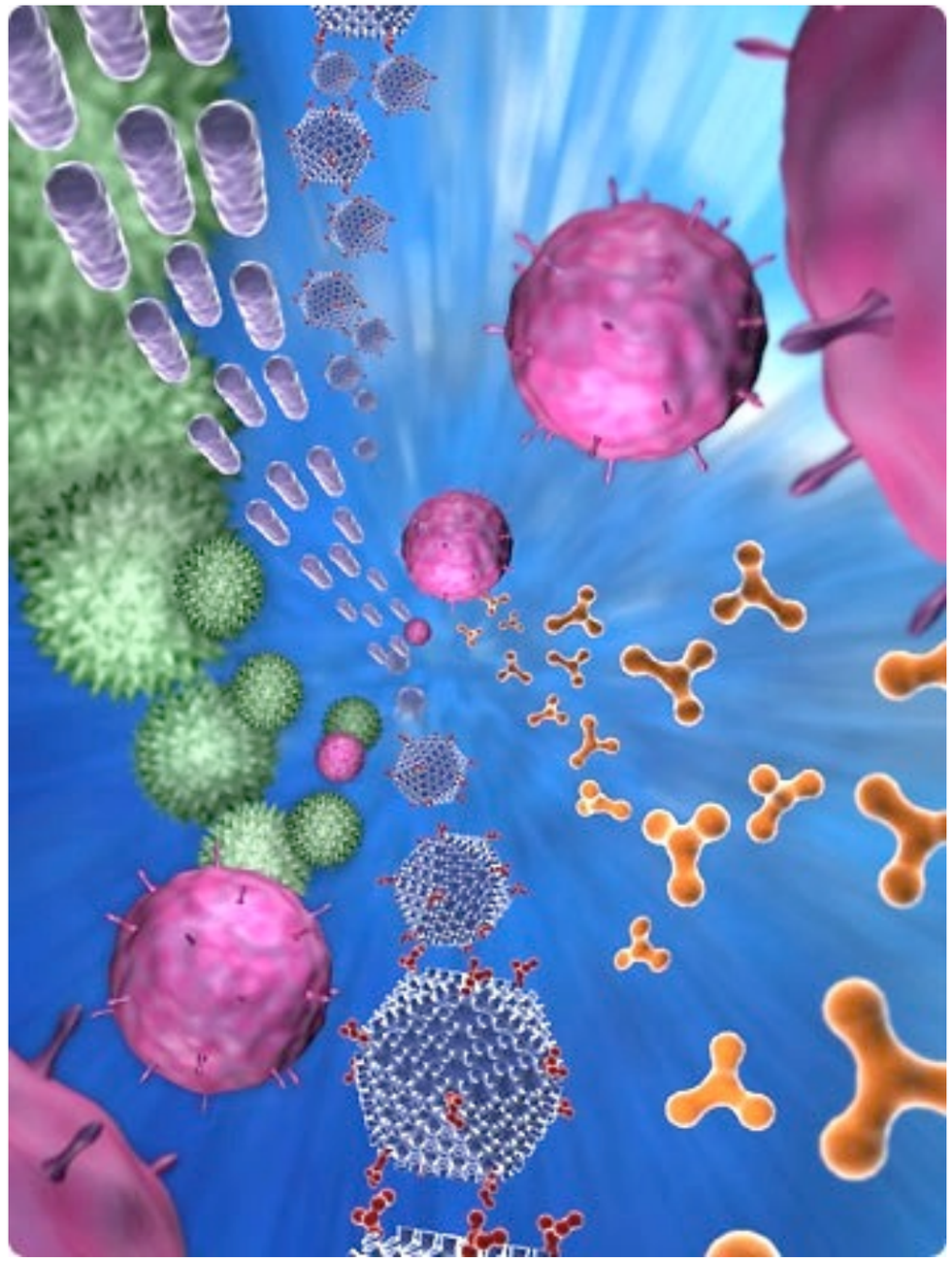
- 70-80% of Immune globulin production (IgA)
- Activated & maintained only by feeding stimulation of intestinal mucosa



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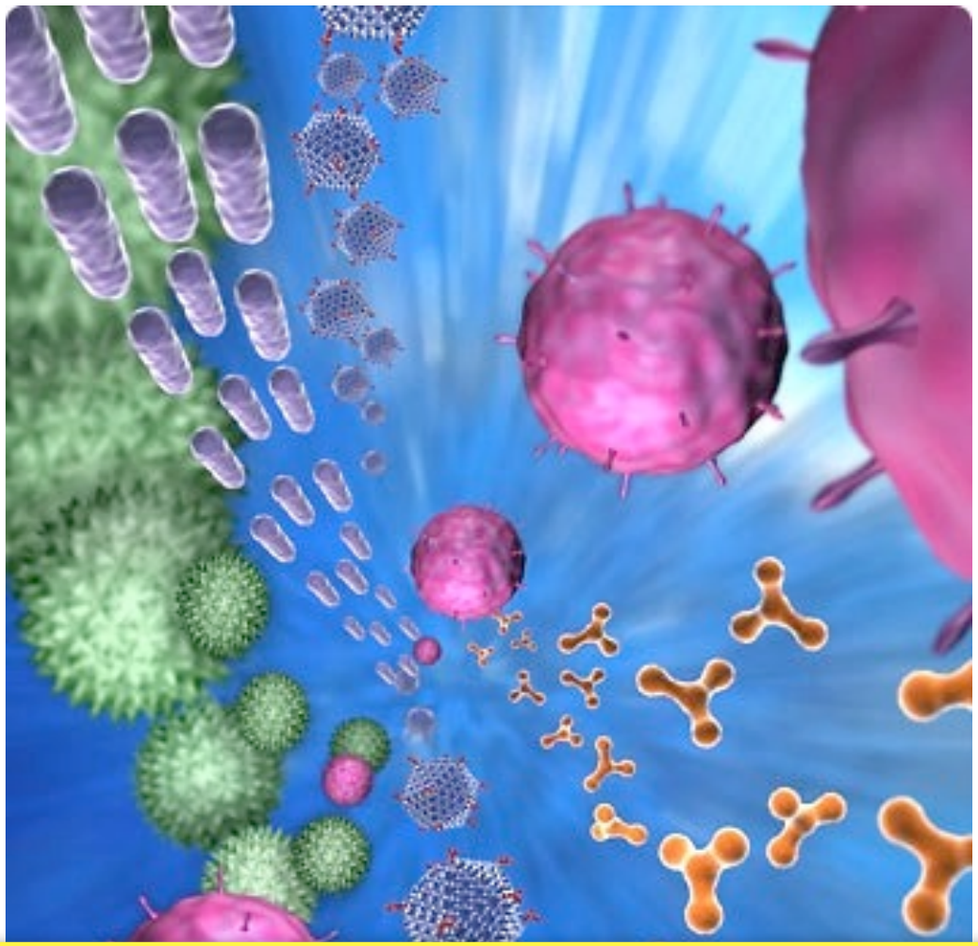

Enteral feeding should be started early within 24-48 hr following admission (C). Advance to goal over 48-72 hr (E)

ASPEN-SCCM ICU Guidelines, JPEN, May-June 2009

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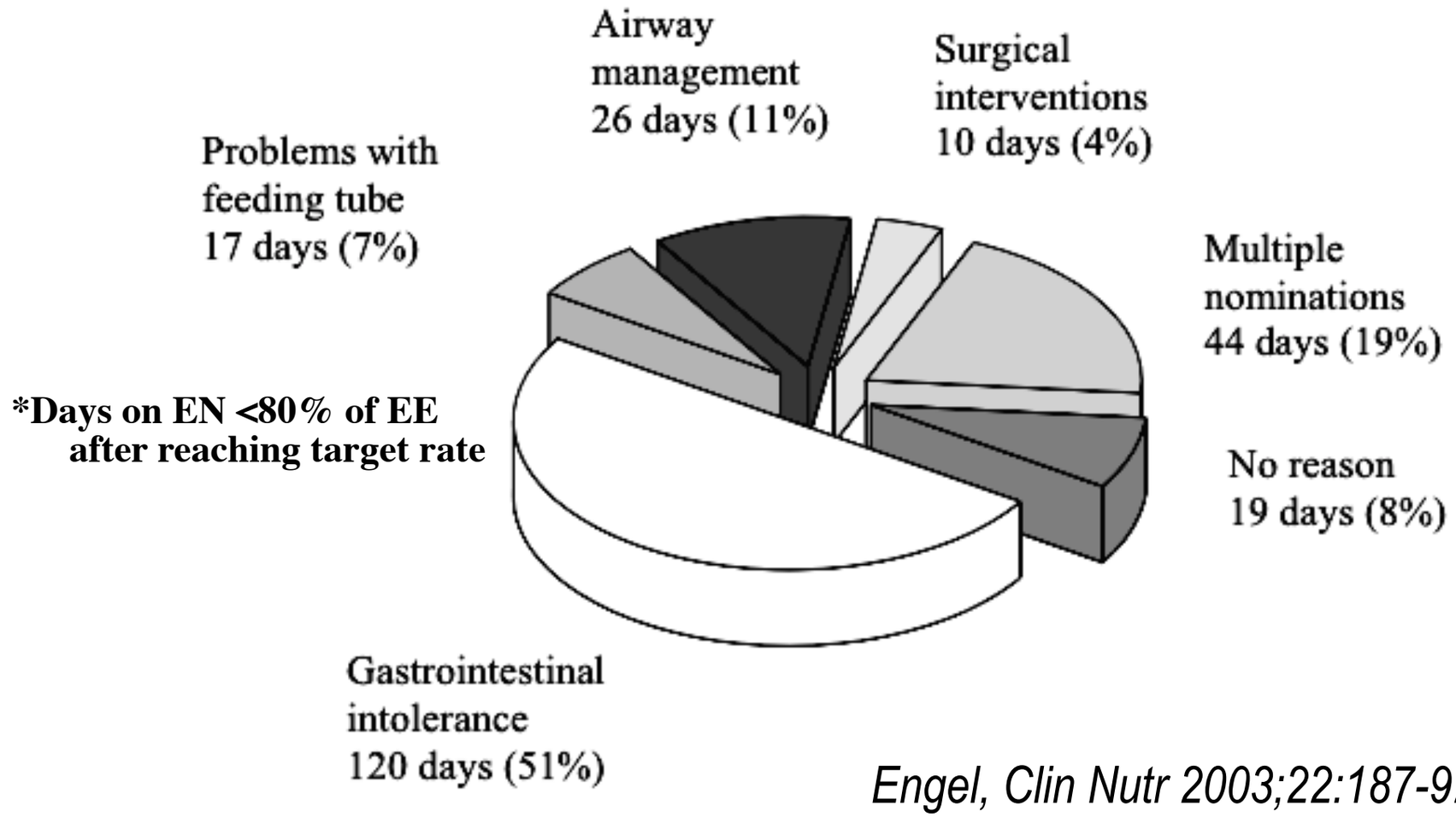

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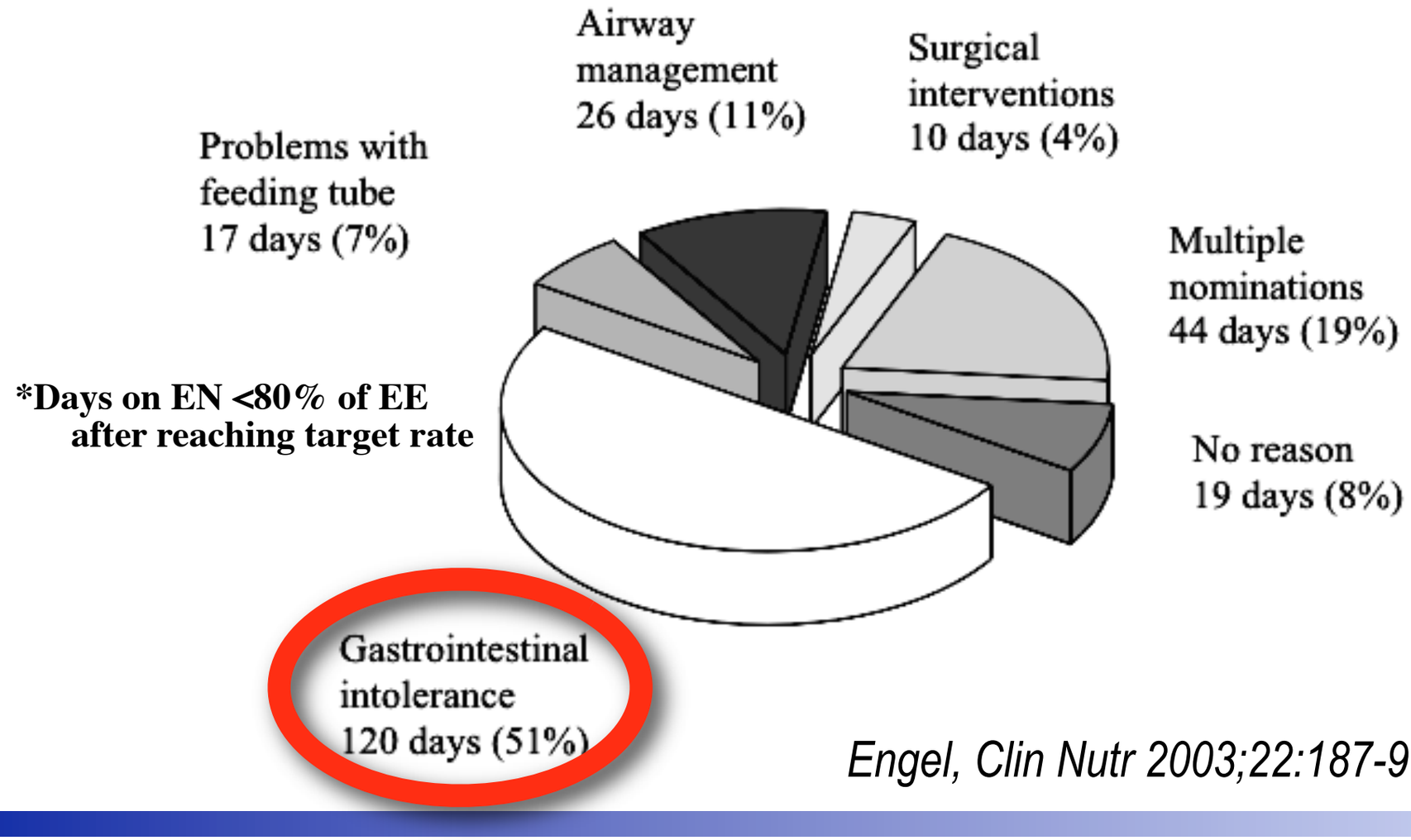

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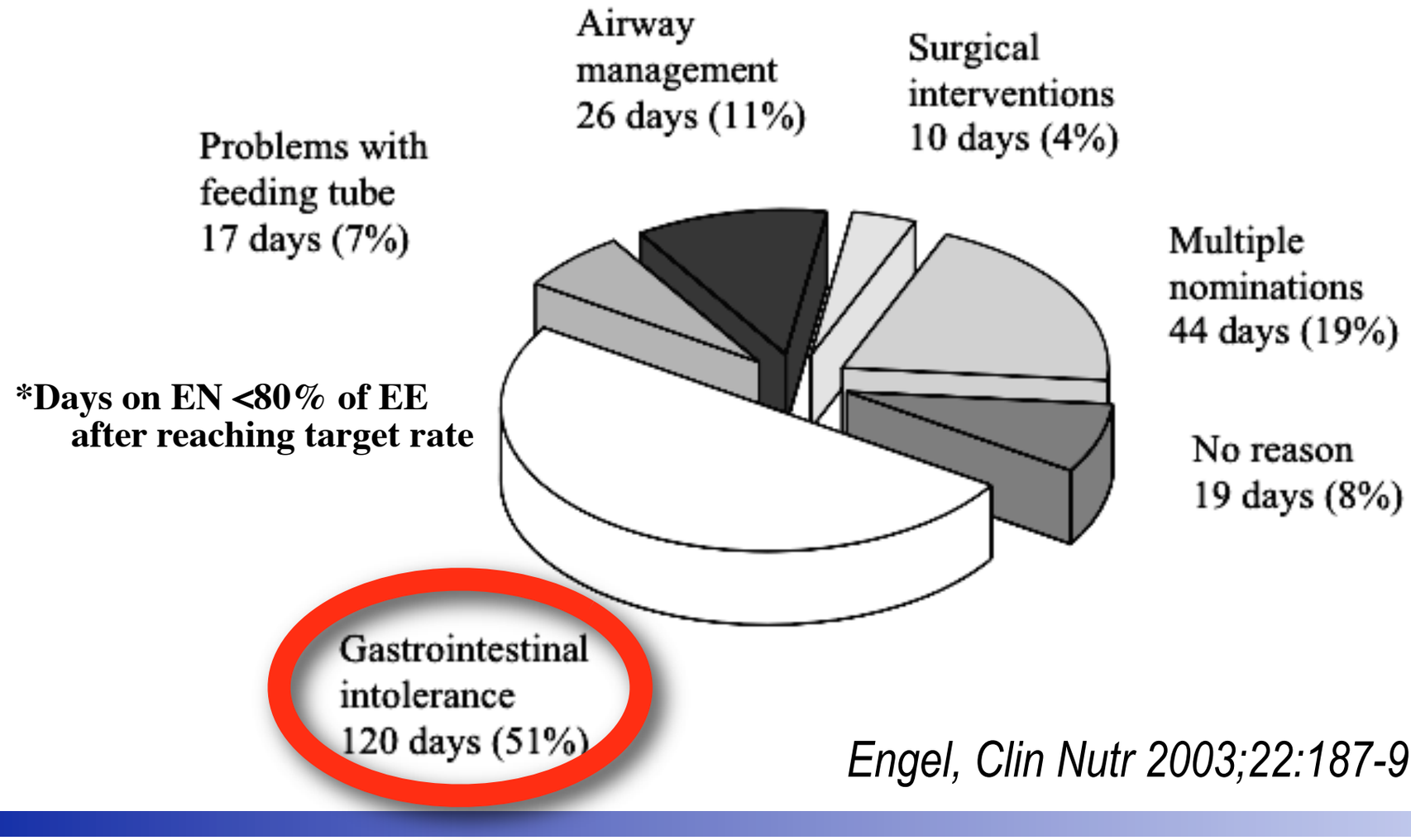

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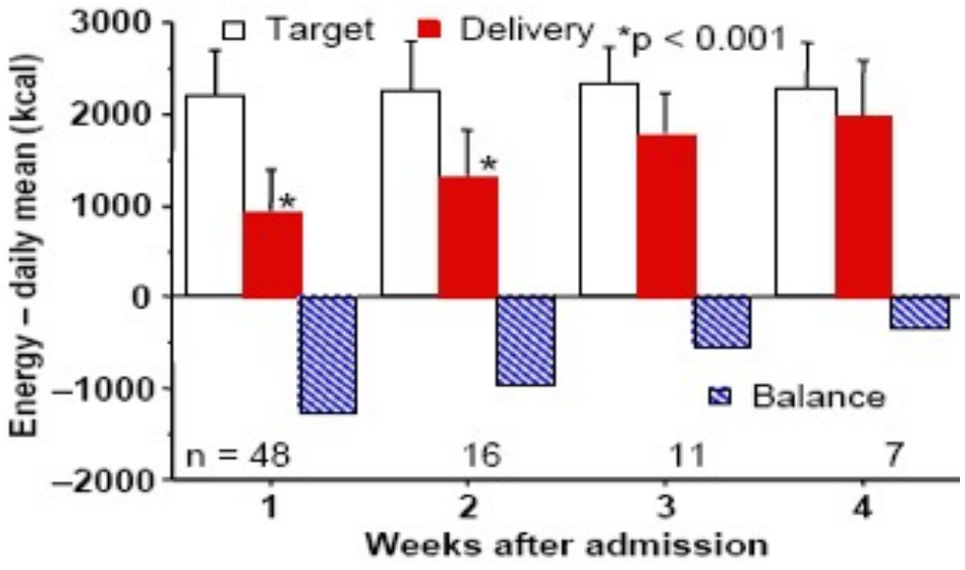

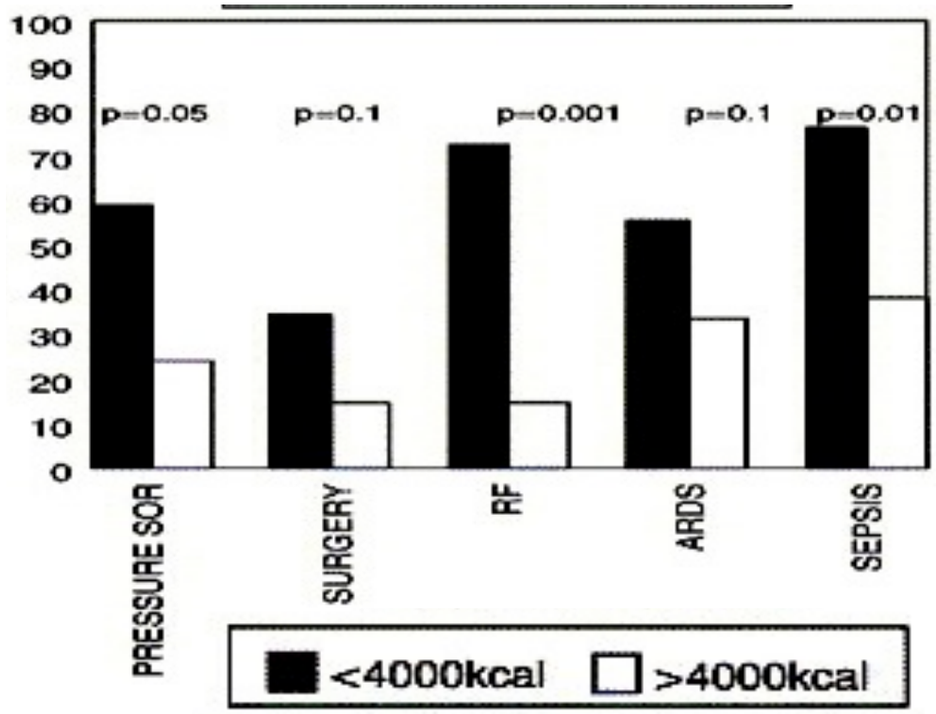

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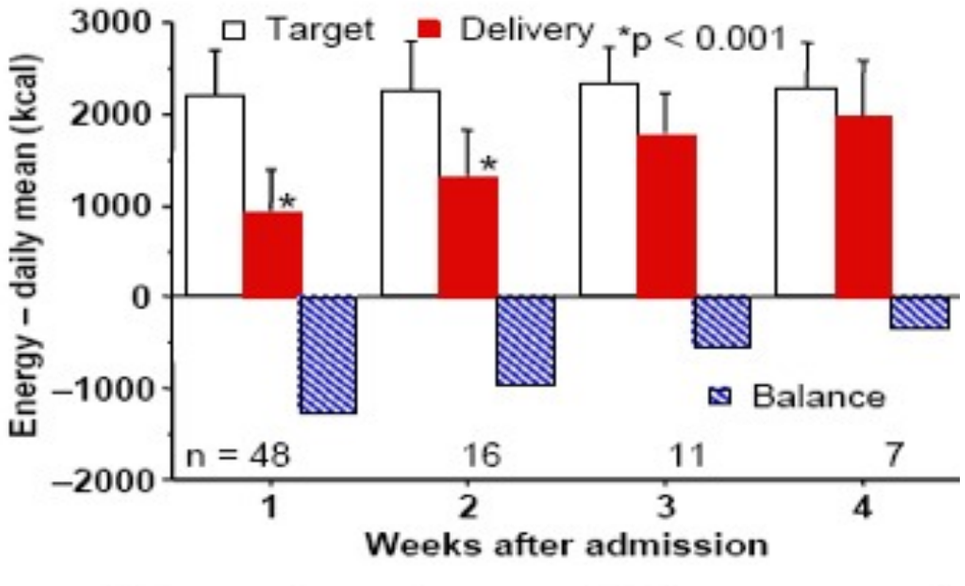

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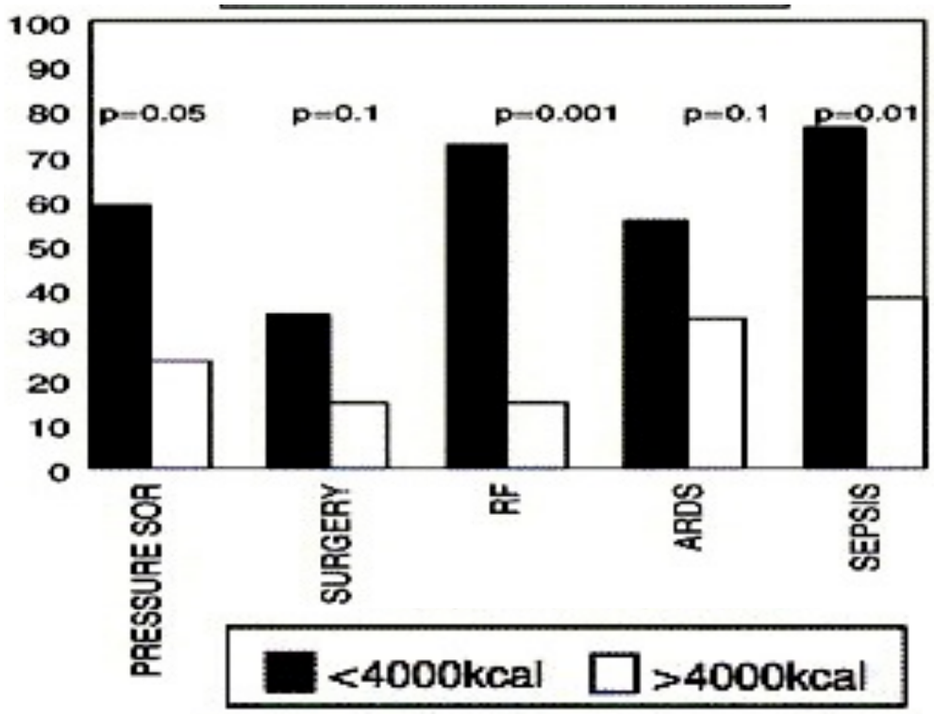

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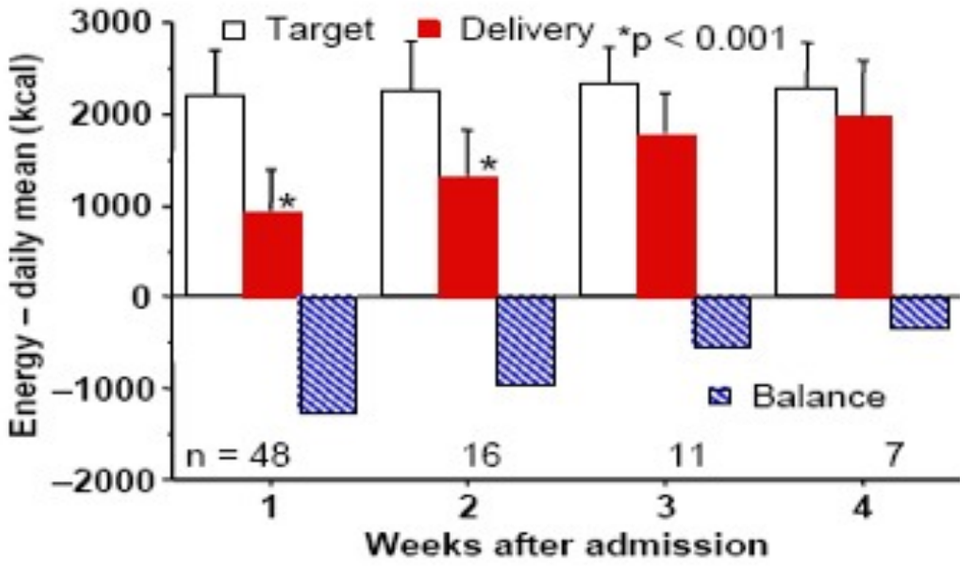

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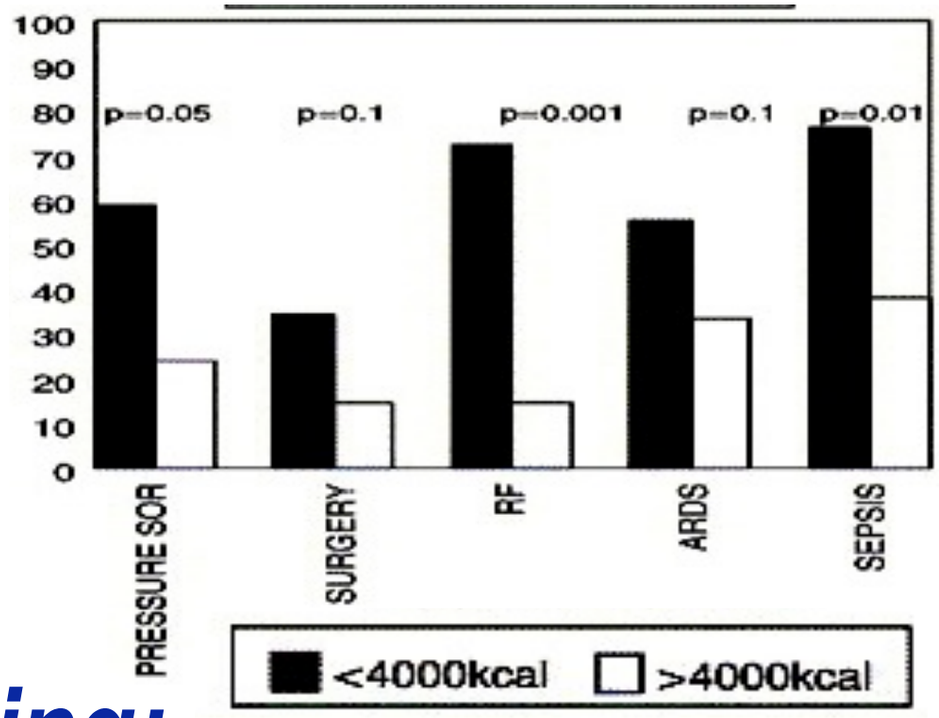

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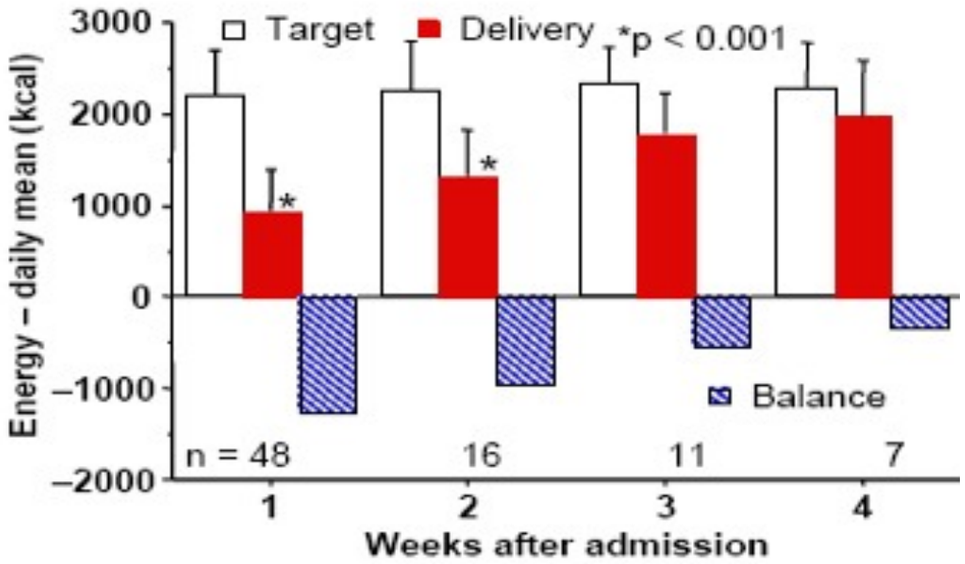

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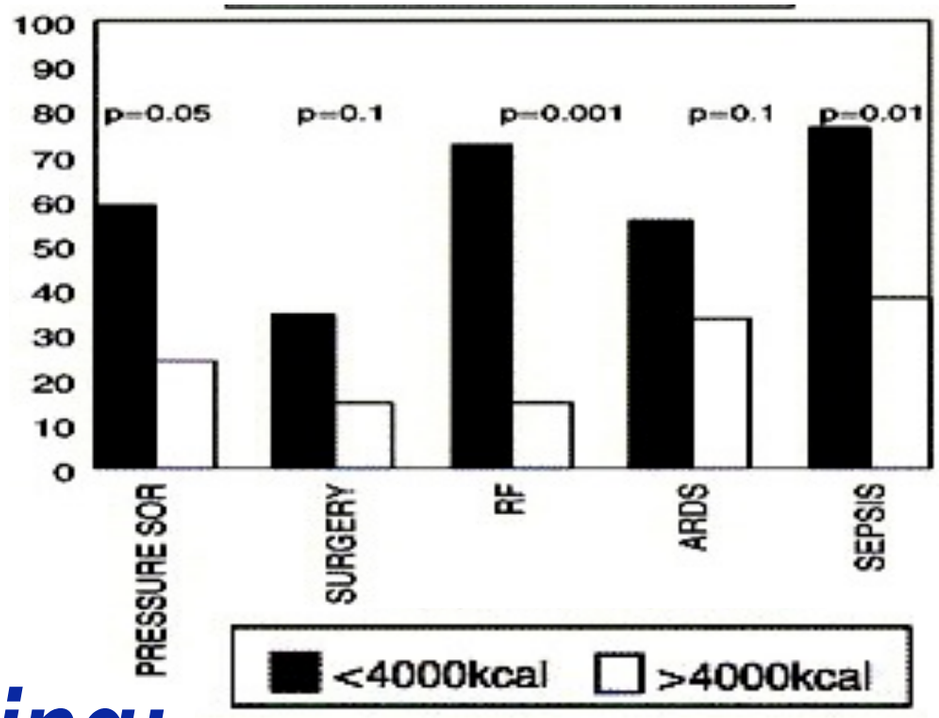
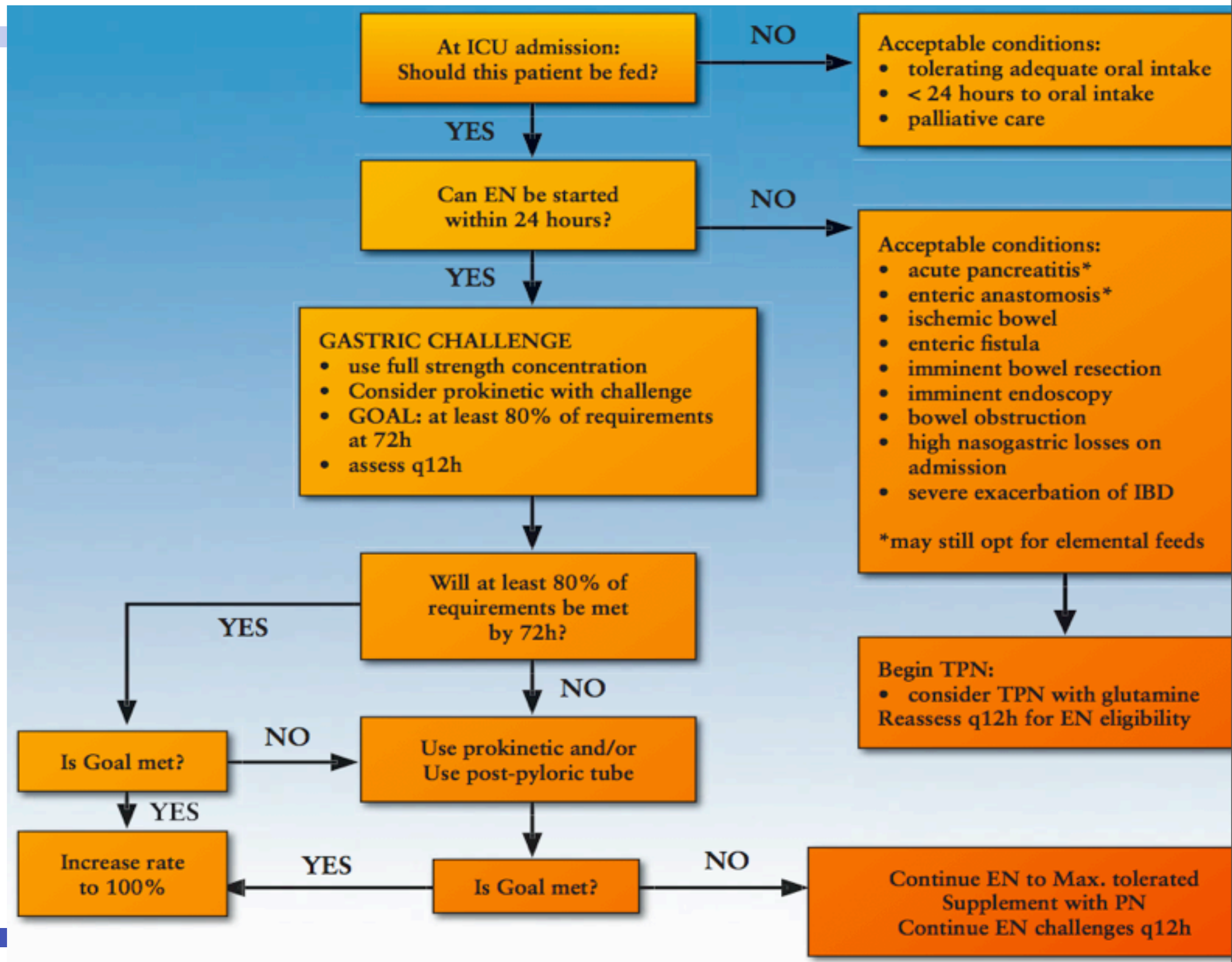


However, with optimized feeding:

- **Early energy supply >1500 kcal in day 1-3 in ICU patients was associated with lower mortality & morbidity**

MBerger, Curr Opin Clin Nutr Metab Care, Mar 2009 *Kreymann, Weiman et al. ESPEN 2008*

Optimize EN delivery with SOPs *(ACCEPT trial)*



"Algorithm for Critical Care Enteral & Parenteral Therapy"- ANZICS CTG

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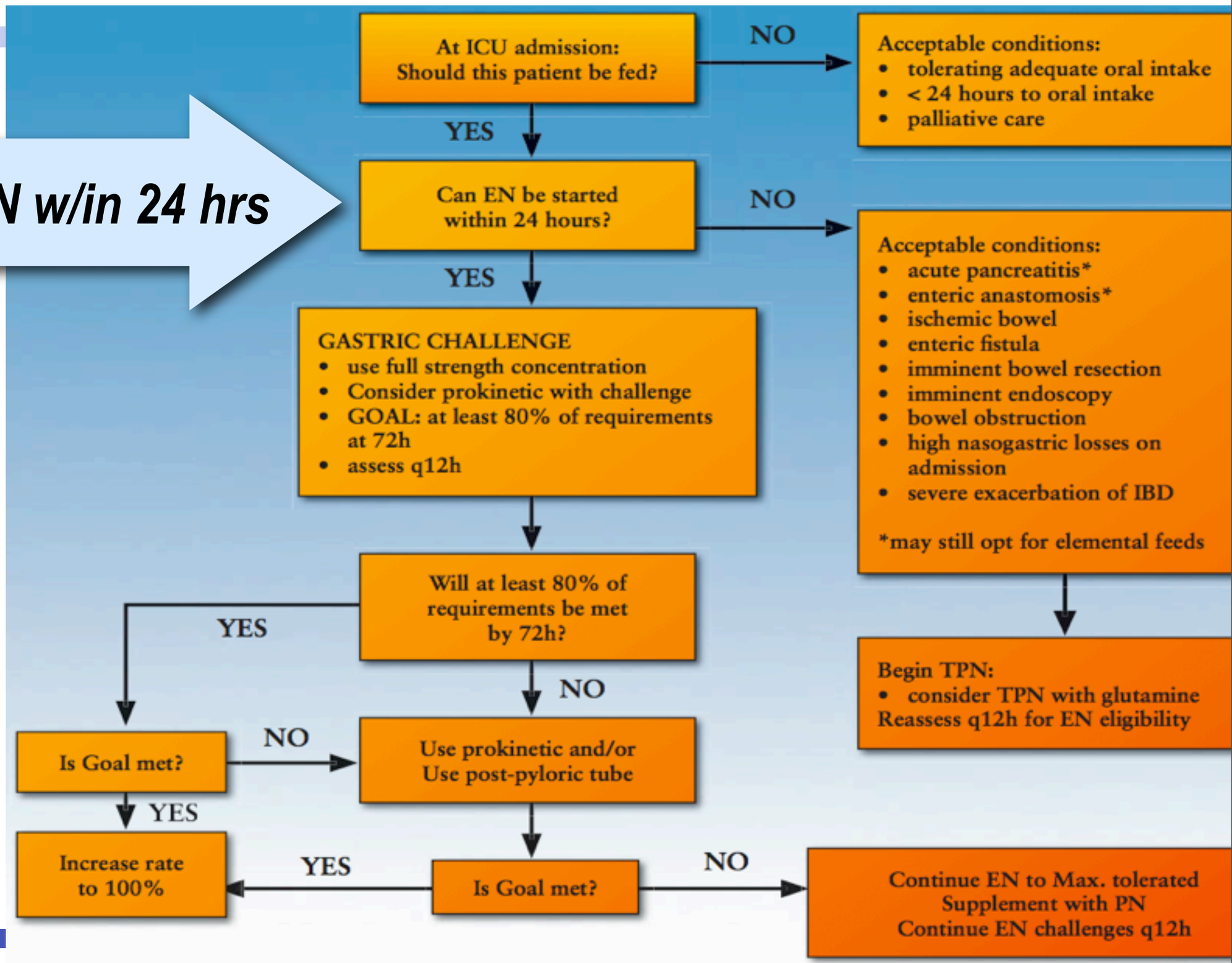

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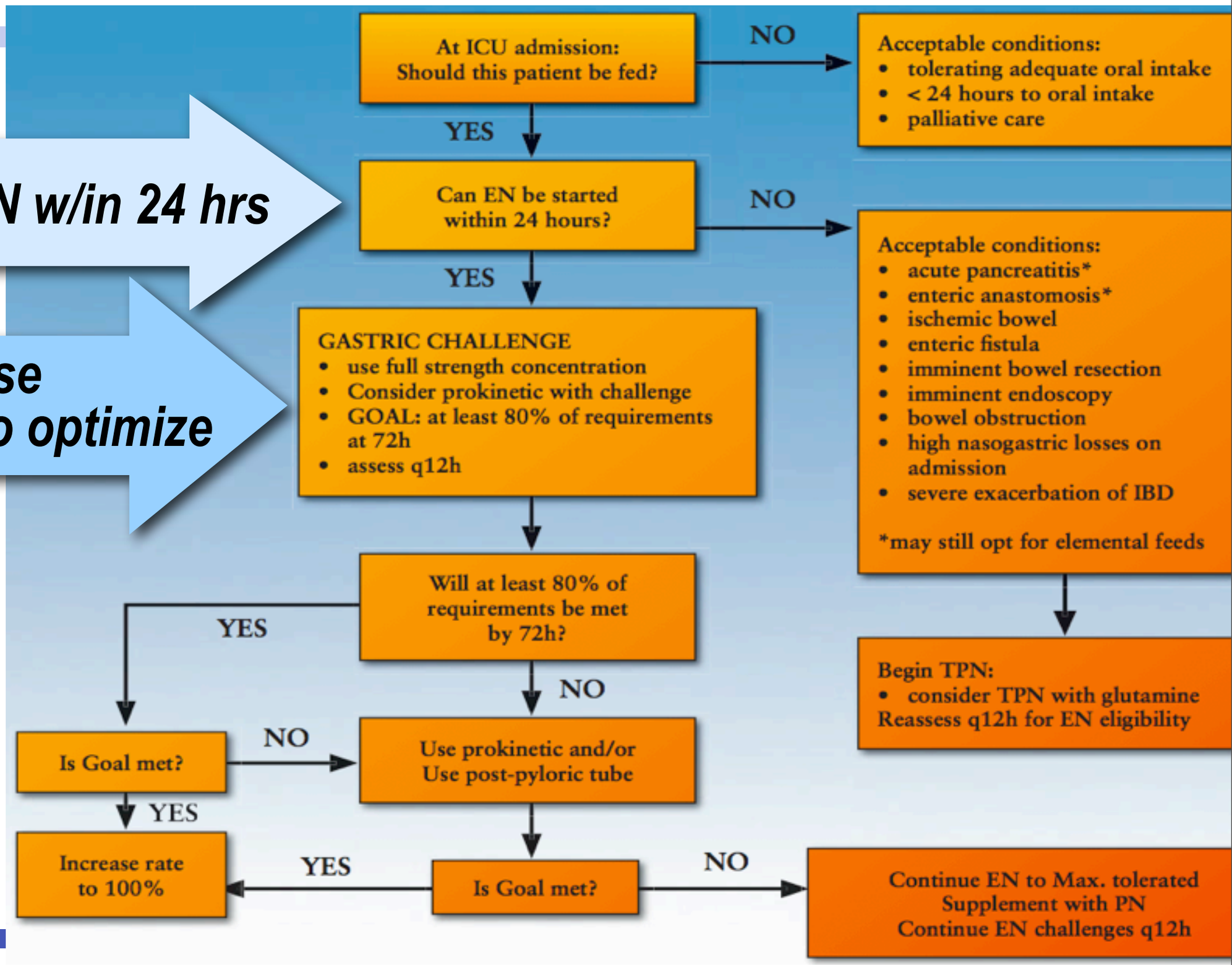

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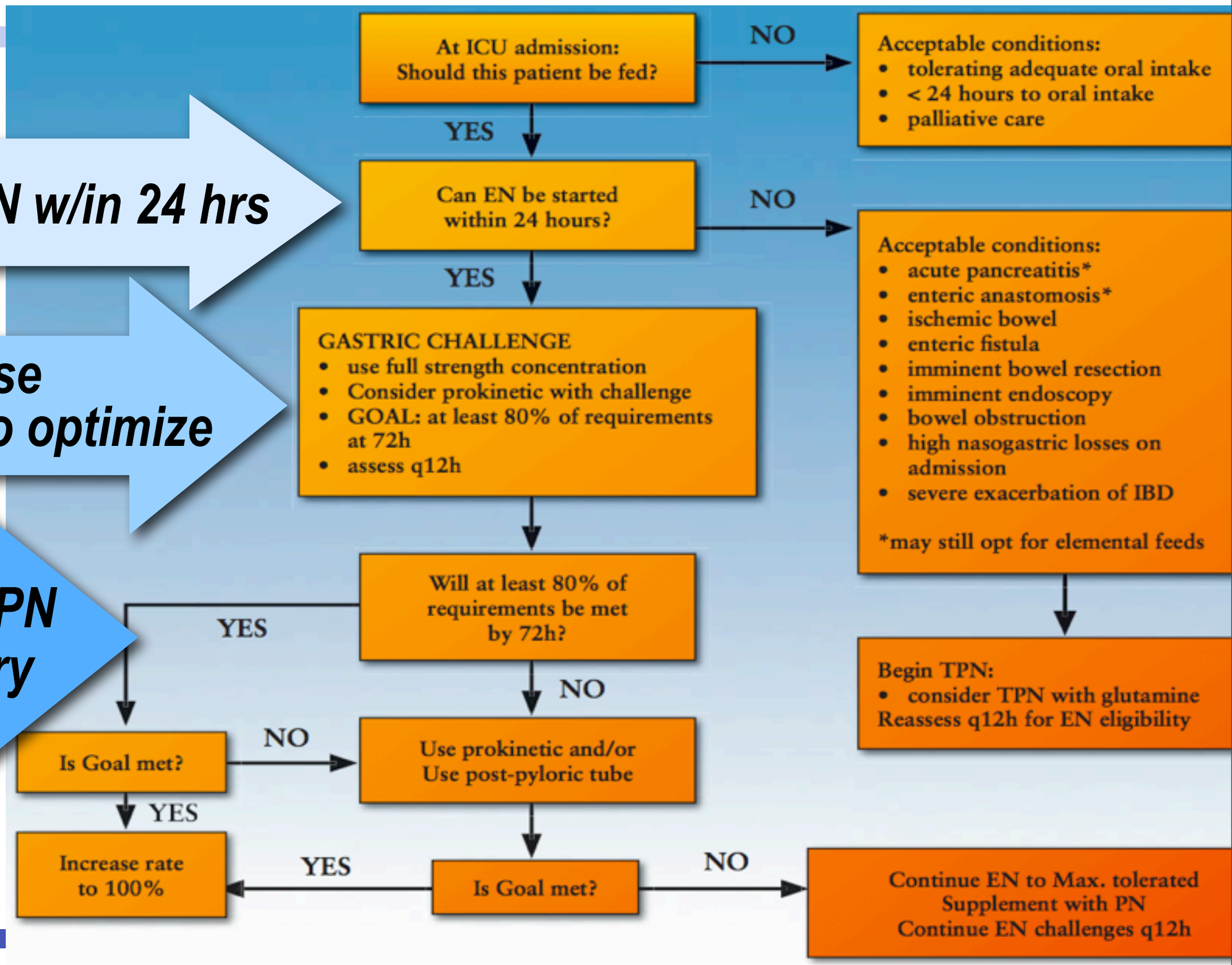
Combine with PN when necessary



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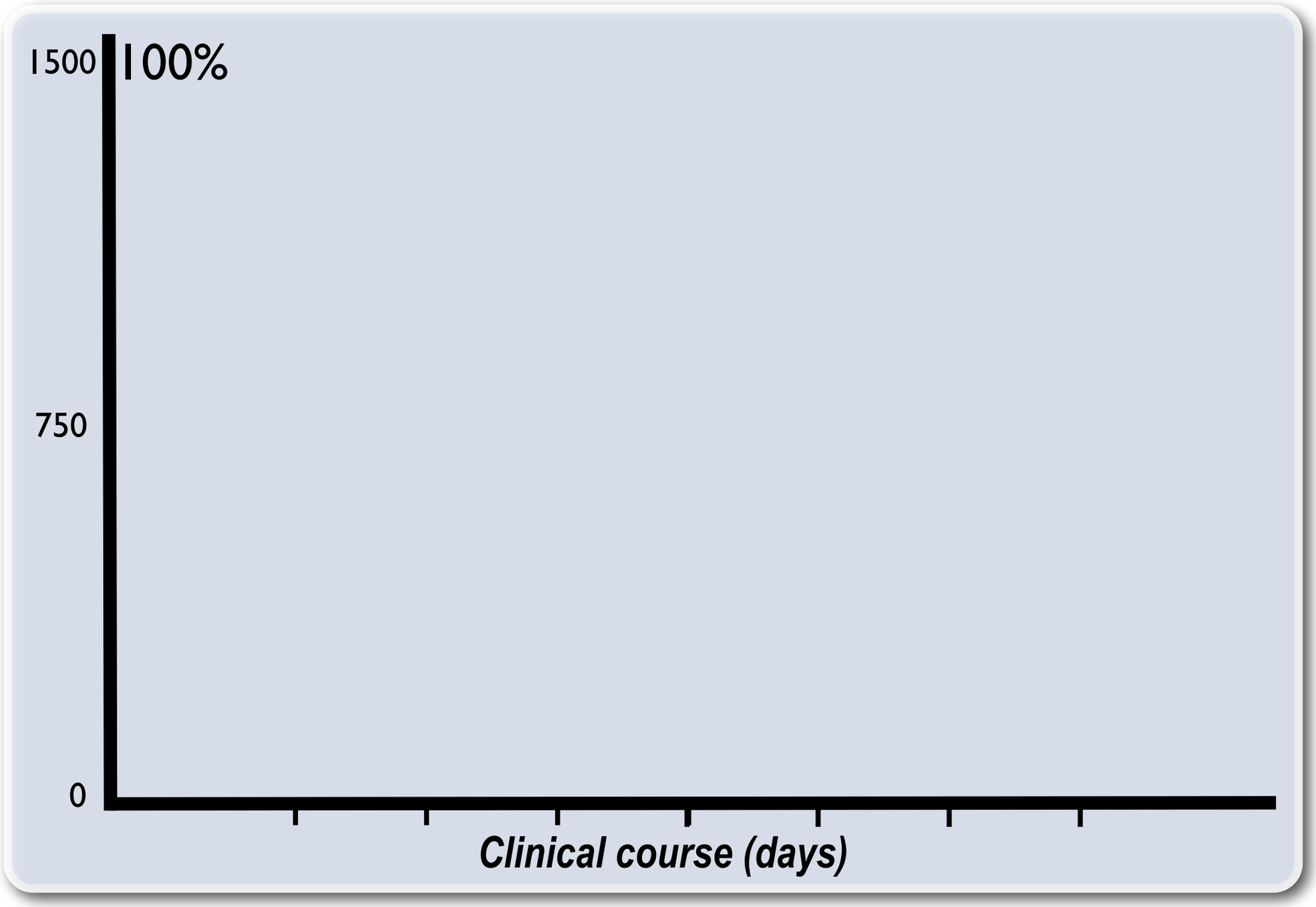
Combine EN-PN to achieve goals



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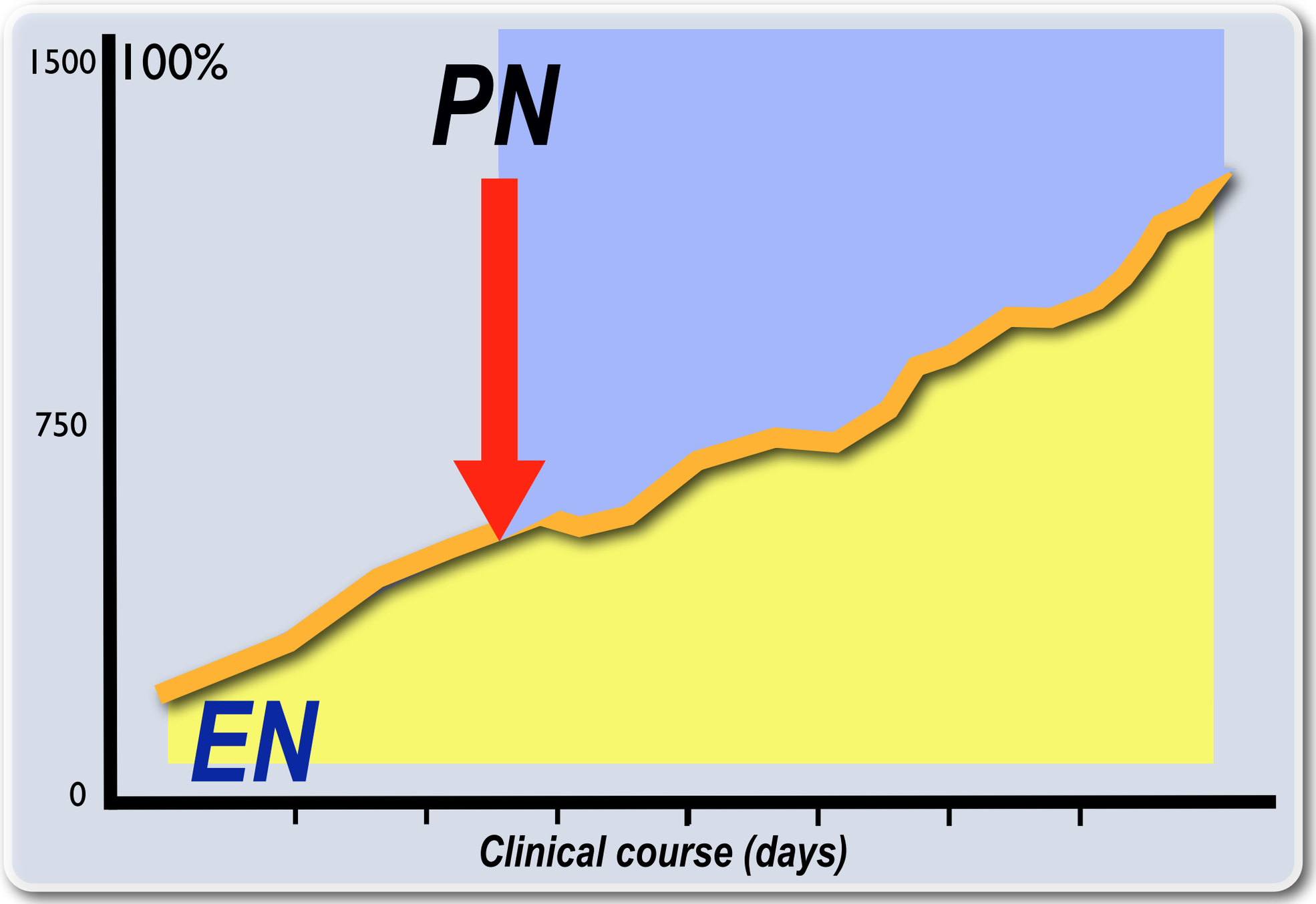

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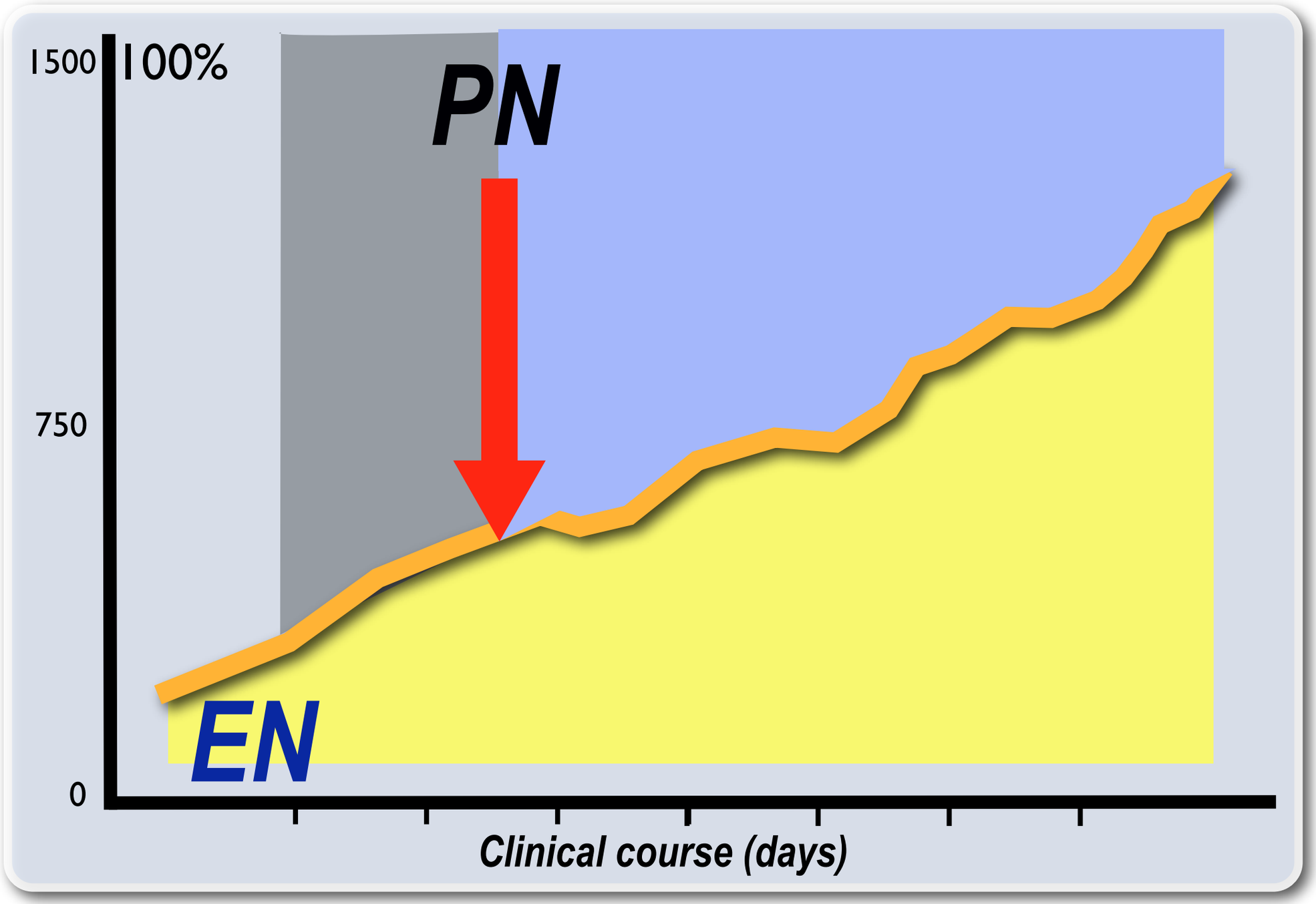

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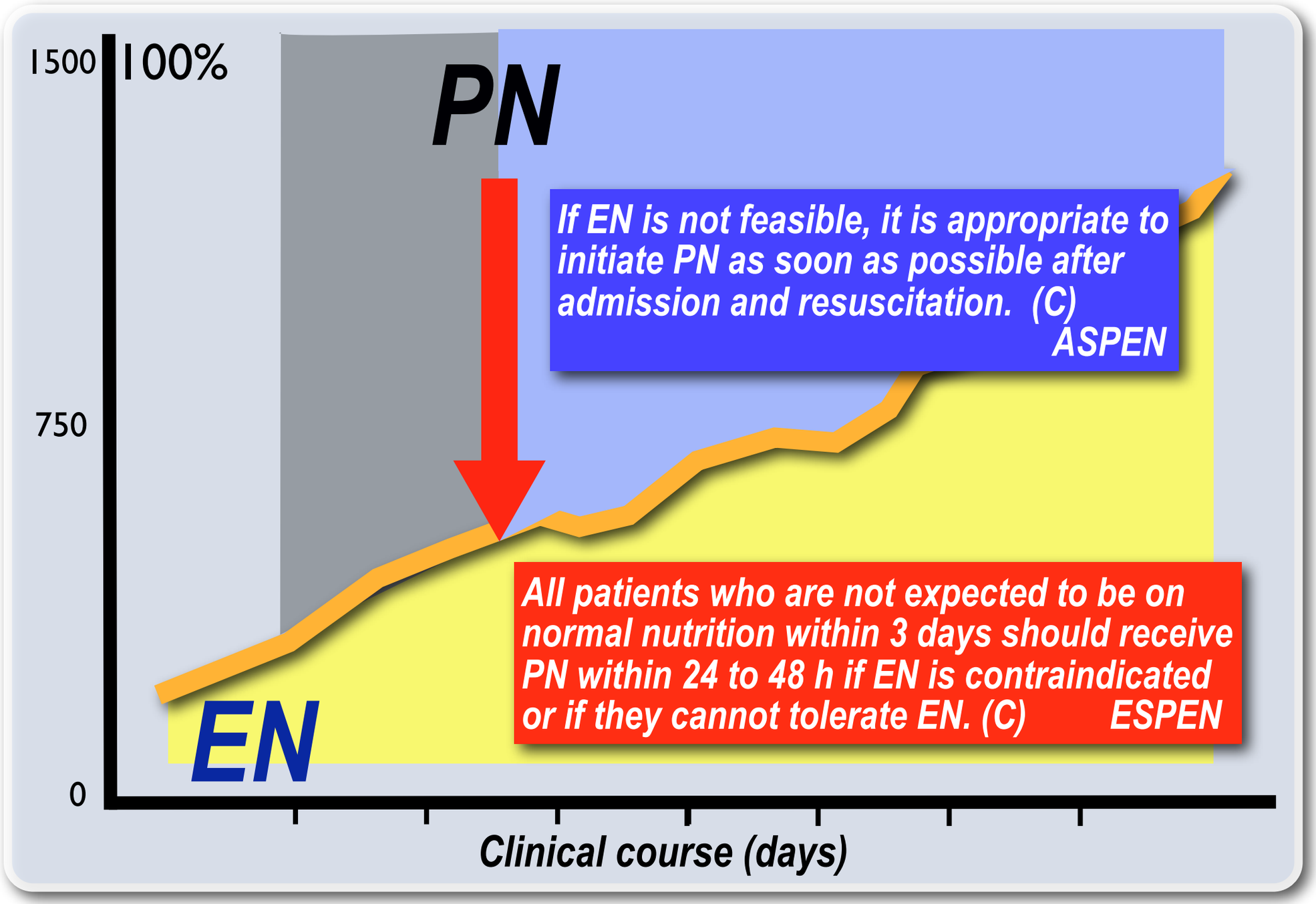

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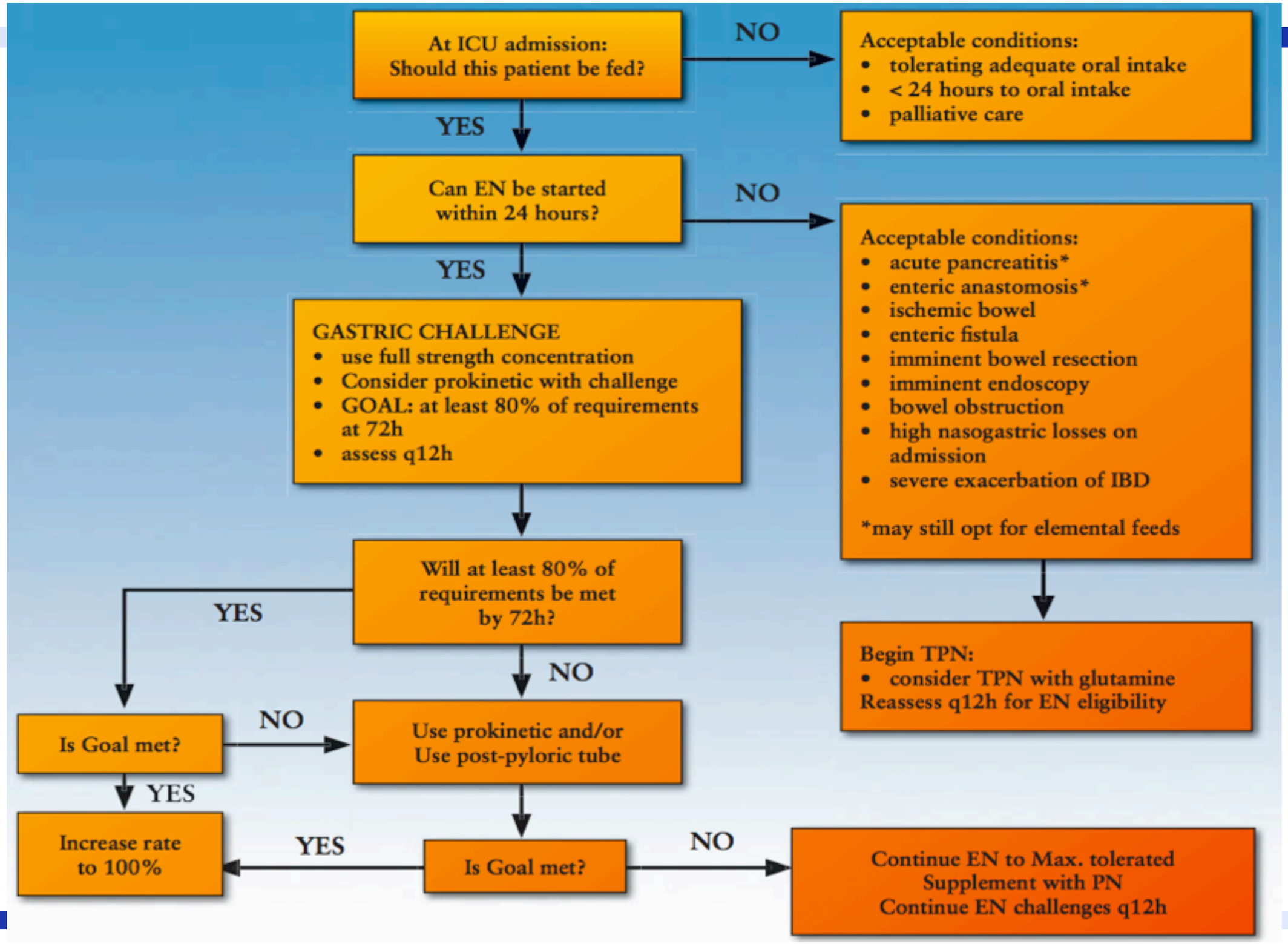
When to start supplemental PN



ANZICS CTG

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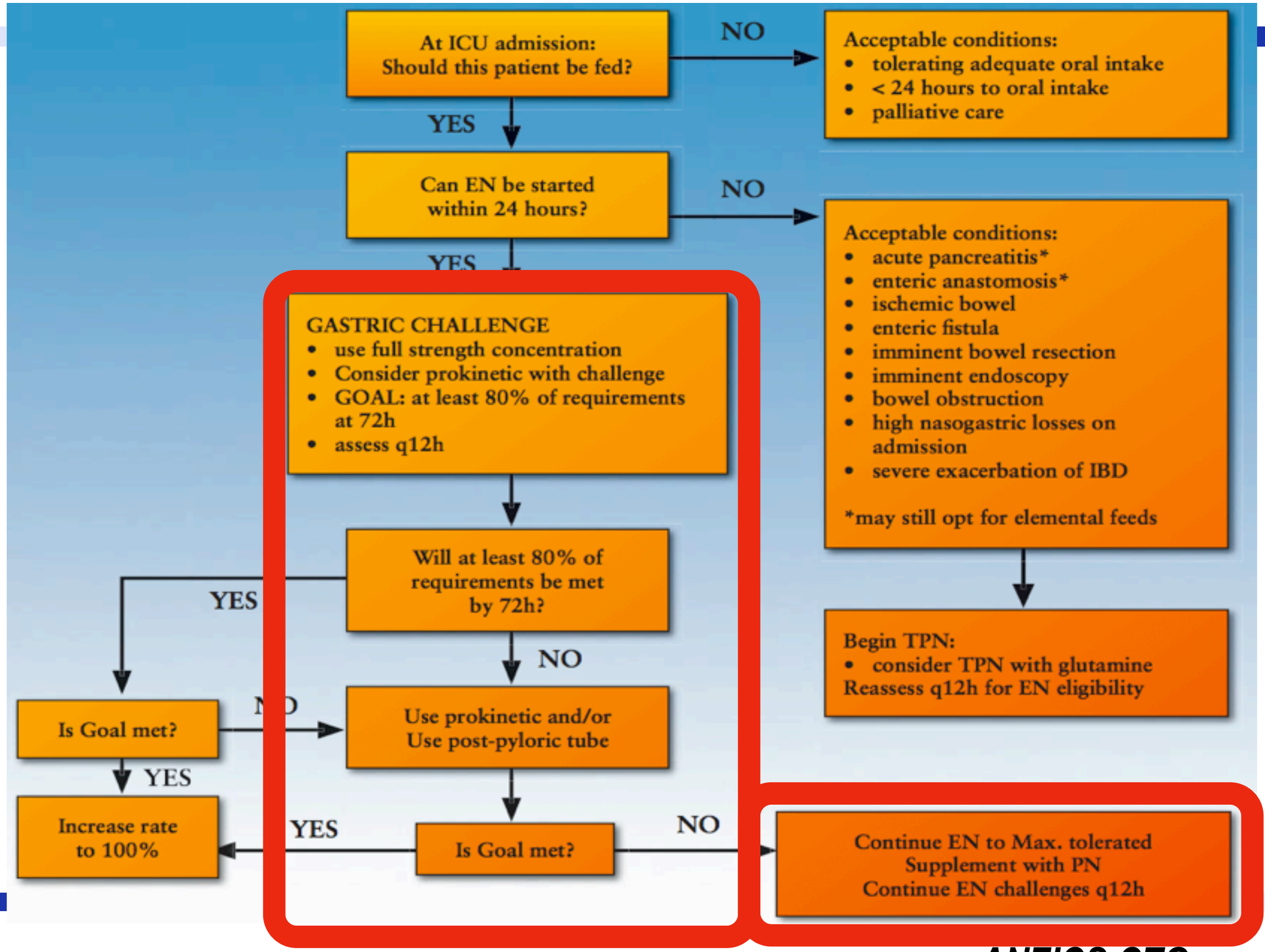
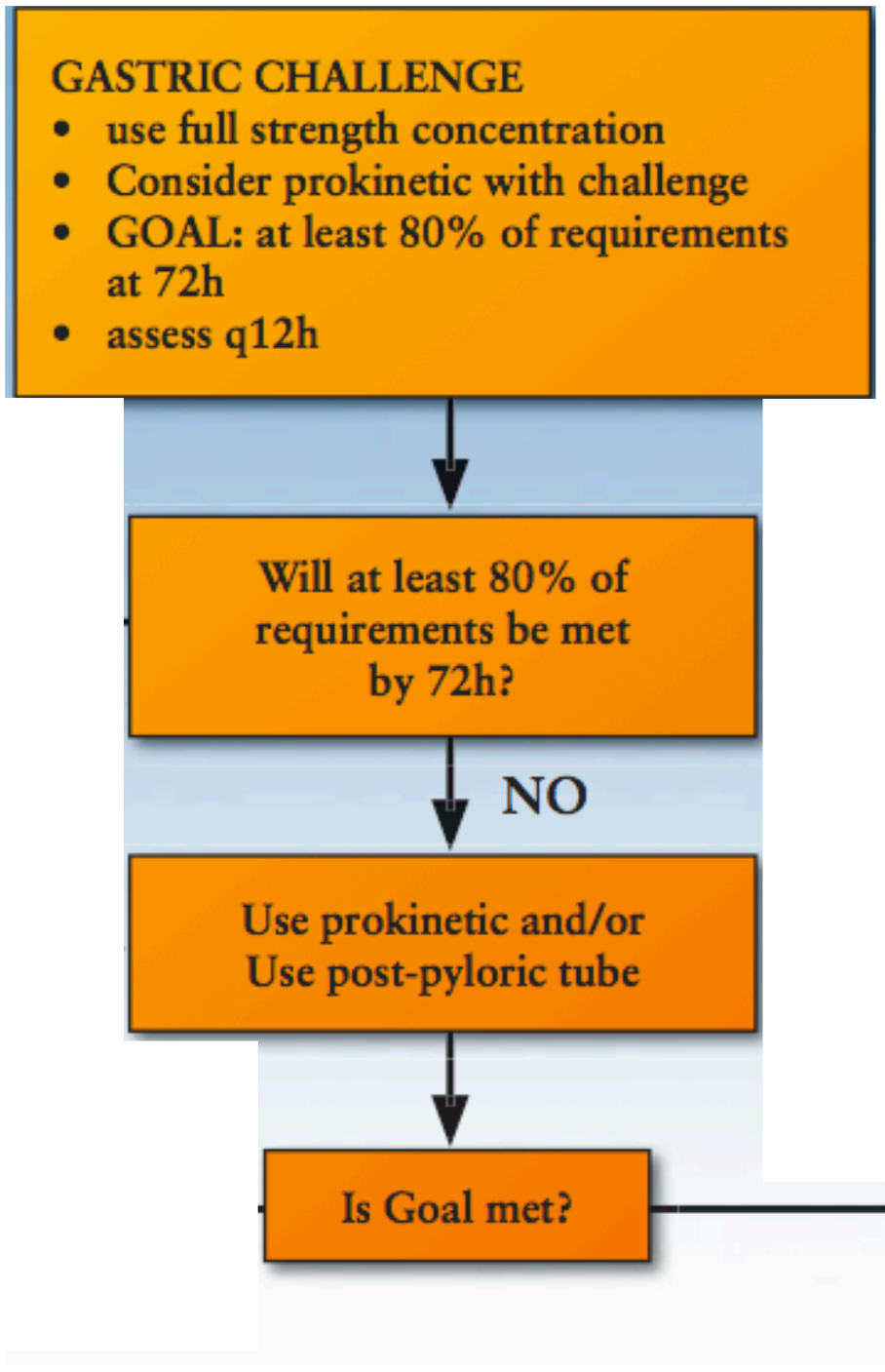


ANZICS CTG

Start supplemental PN by 48 hr



Start supplemental PN if 60% of the EN target is not reached by the 48th hr, because it is unlikely that 80% of requirements will be met by 72 hrs.

If EN tolerance improves to 80% by 72 hrs, PN may be discontinued, but if not, the resulting calorie deficit can be avoided.

It is easier to discontinue PN than to chase a rapidly increasing calorie deficit.

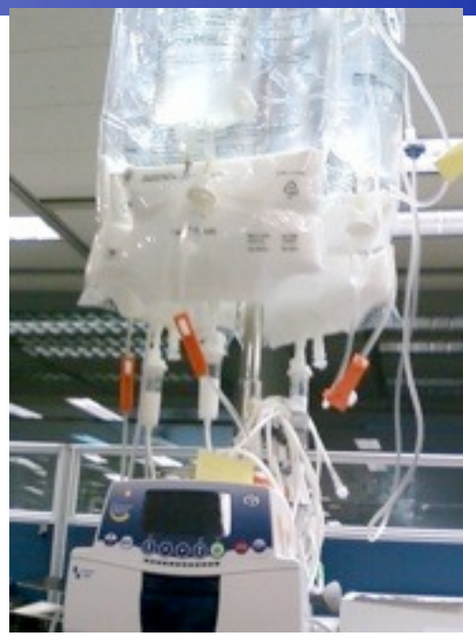
Benefits of combined EN-PN

- *Gut immunity can be stimulated by partial EN*
- *When tolerance to EN is limited by gut dysfunction, PN can deliver the full requirement of protein, calories & micronutrients*

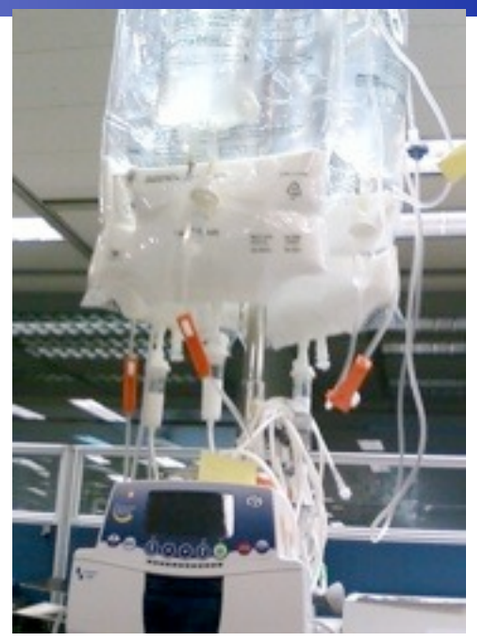
- *Adequate calories & protein are important to:*
  - *Improve wound healing*
  - *Restore/ maintain immune competence*
  - *Minimize morbidity & mortality*

PN is best given in 3-compartment bags

- *Optimal energy utilization (CHO + fat)*
- *Control respiratory quotient*
- *Minimize harmful hyperglycemia*
- *Greater stability and safety;*
  less contamination/ delivery errors



PN is best given in 3-compartment bags



- *Optimal energy utilization (CHO + fat)*
- *Control respiratory quotient*
- *Minimize harmful hyperglycemia*
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Pichard, Clin Nutr 2000;19:245-51

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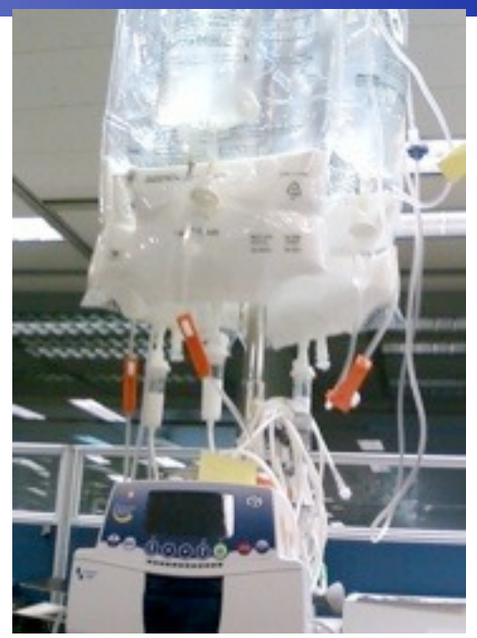

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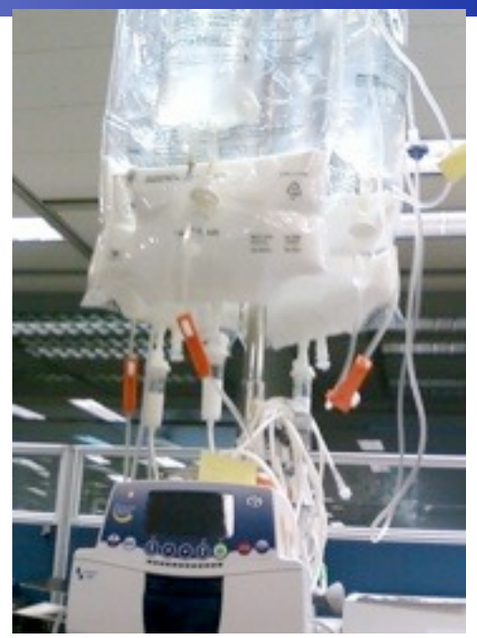

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- *Optimal nitrogen sparing is achieved when all components of PN are administered simultaneously over 24 hours (A)*

ESPEN PN Guidelines for ICU, 2009

Nutritional immunomodulation

- ***Early enteral feeding (EN) can stimulate gut immunity & gut function***
- ***Early PN for critically ill patients with poor EN tolerance avoids the infections and other complications associated with caloric deficits***
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Hyperglycemia: pro-inflammatory effect

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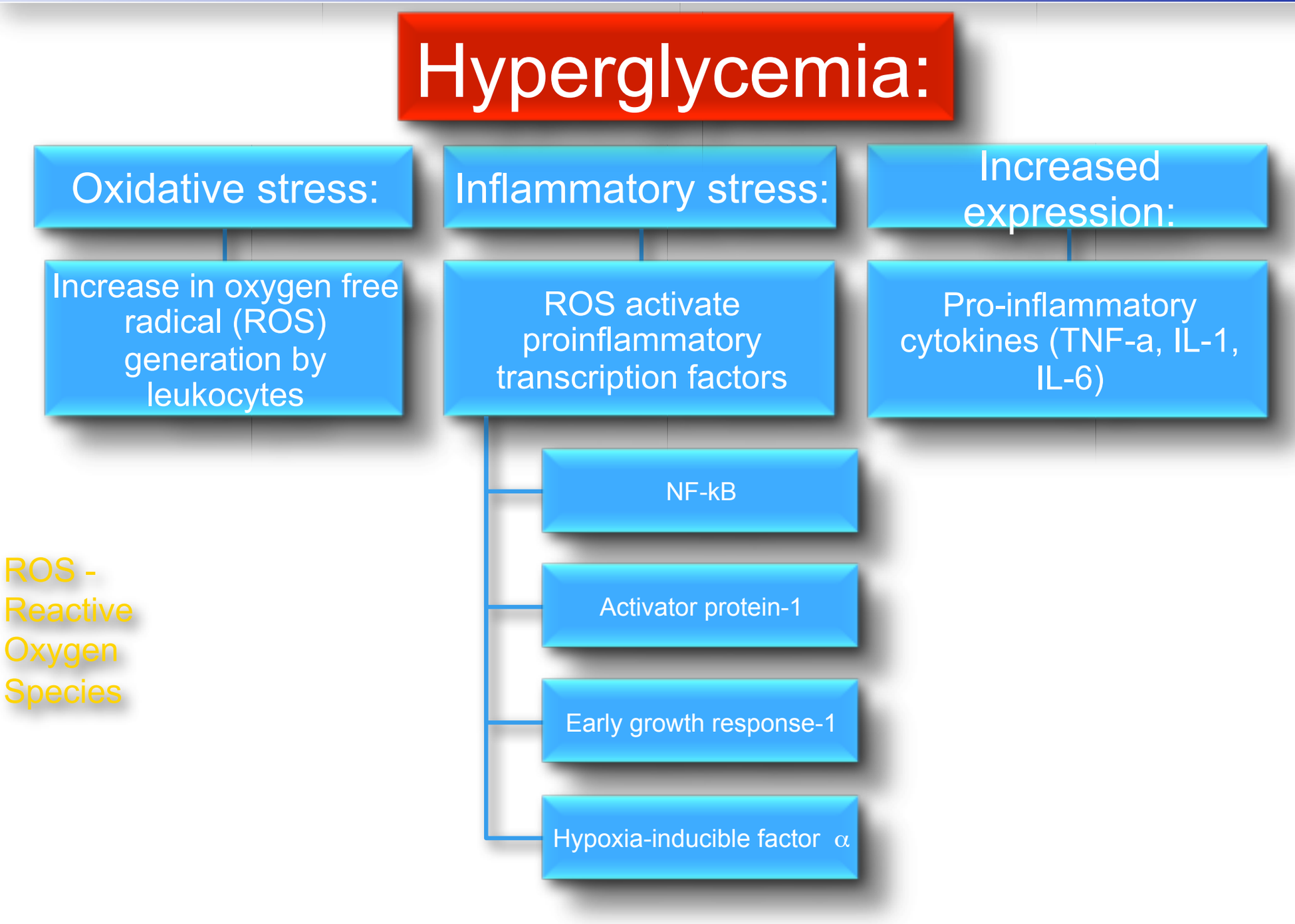
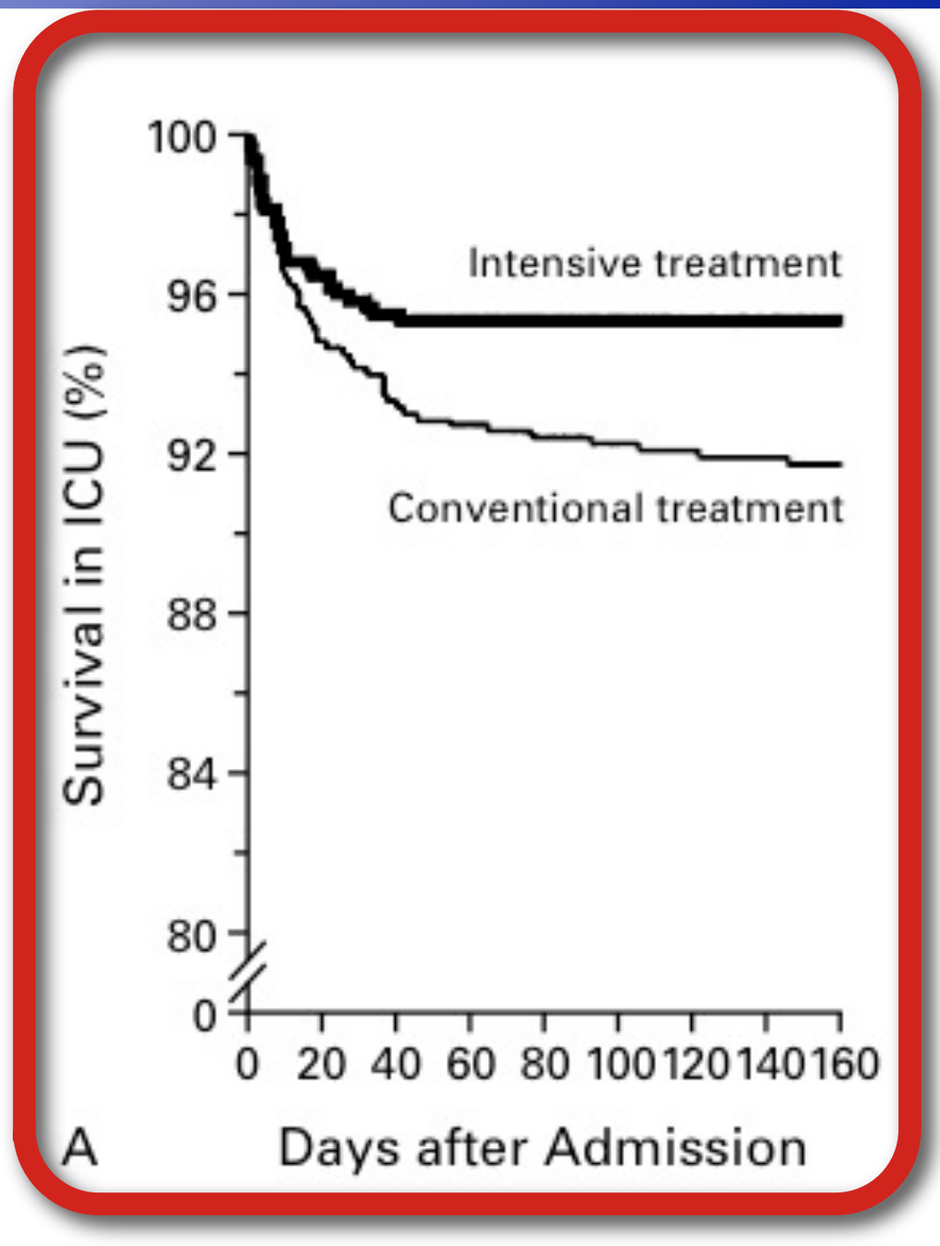


ROS - Reactive Oxygen Species

Sriram, PENSA 2009, Kuala Lumpur

Glycemic control in ICU: ↓morbidity & mortality

- *Intensive vs conventional insulin therapy**
- *Tight glucose control = improved survival (80-110mg/dl)*



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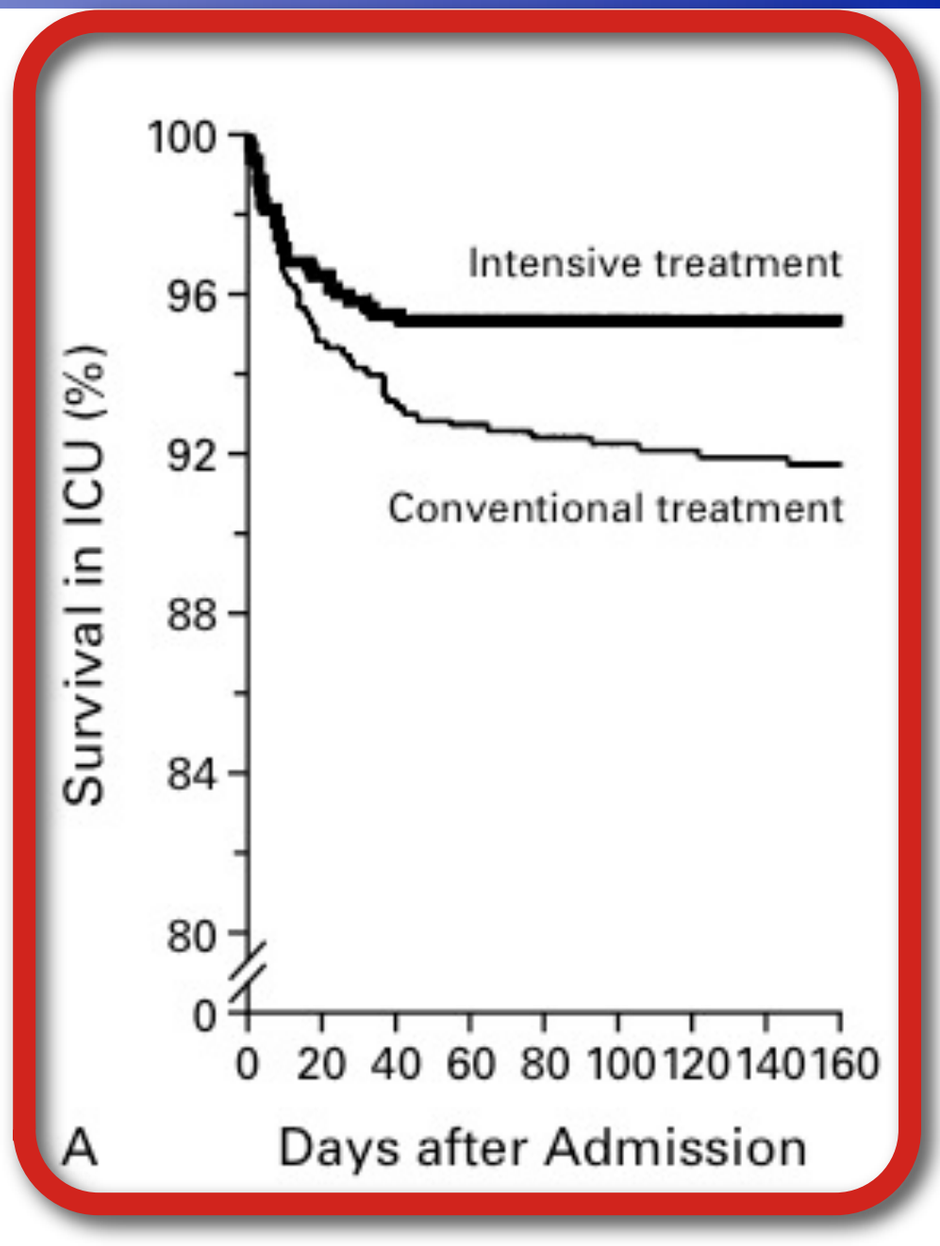

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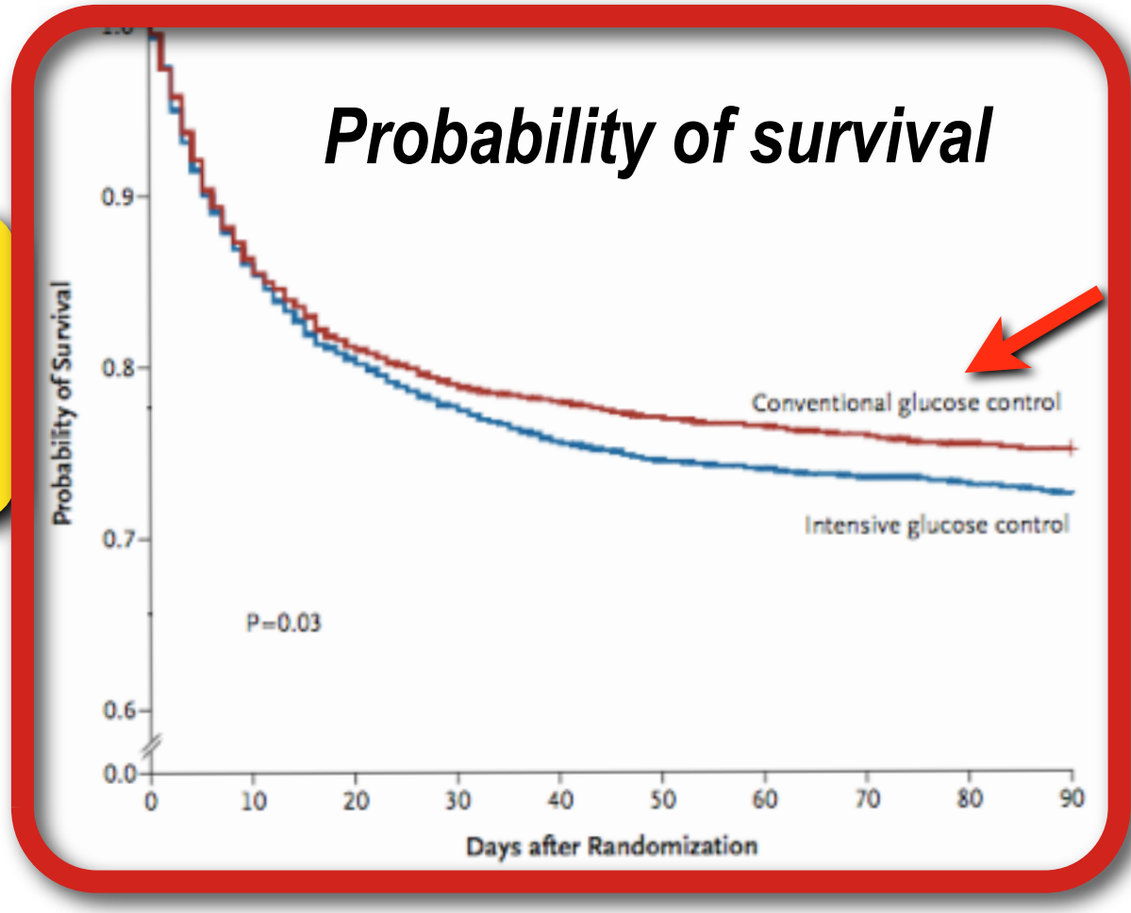

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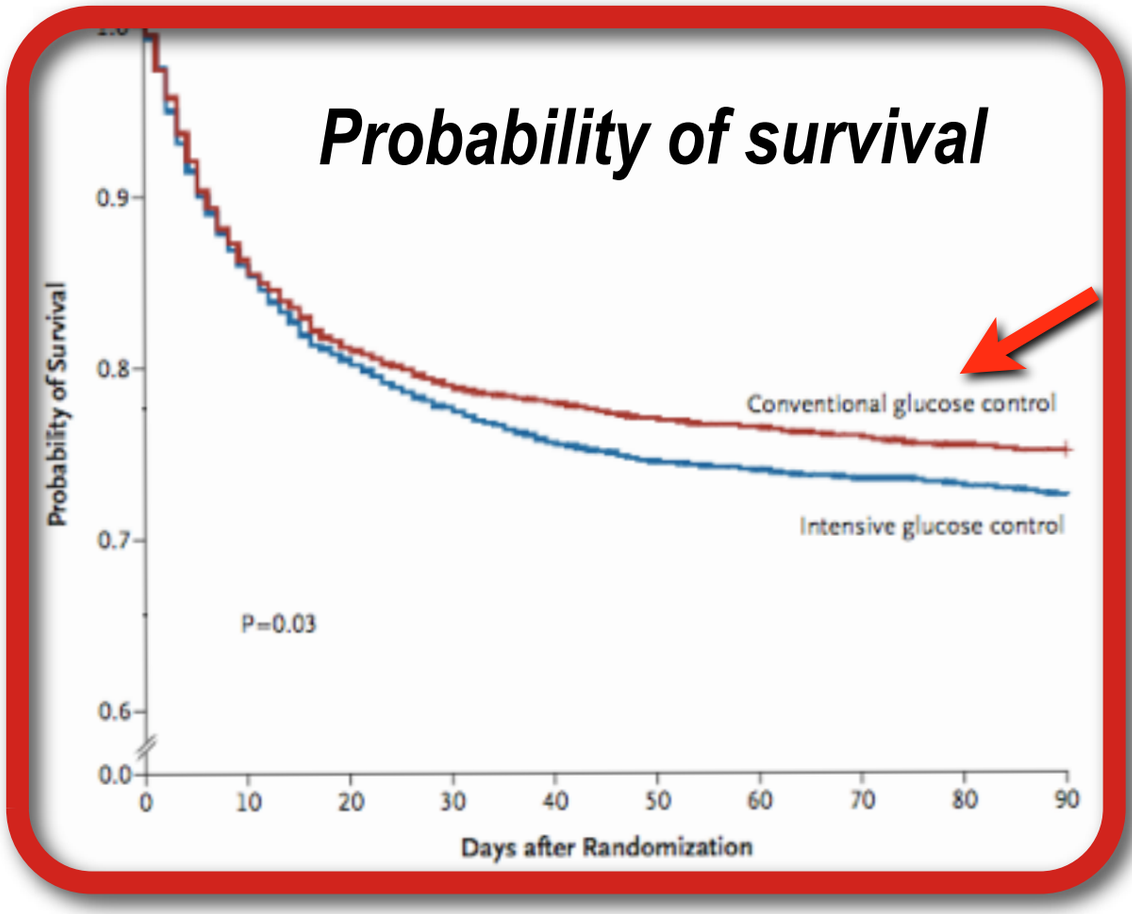

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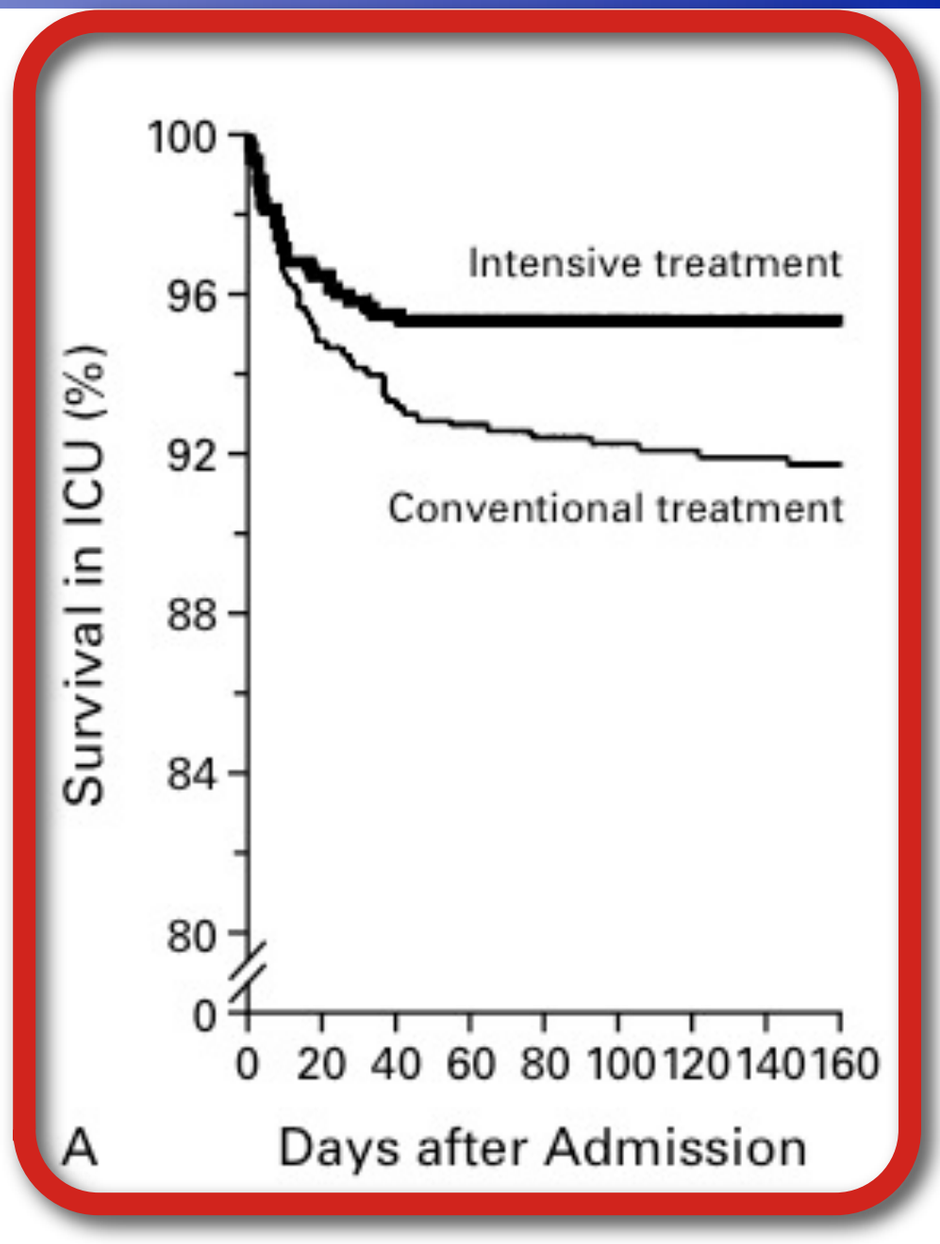

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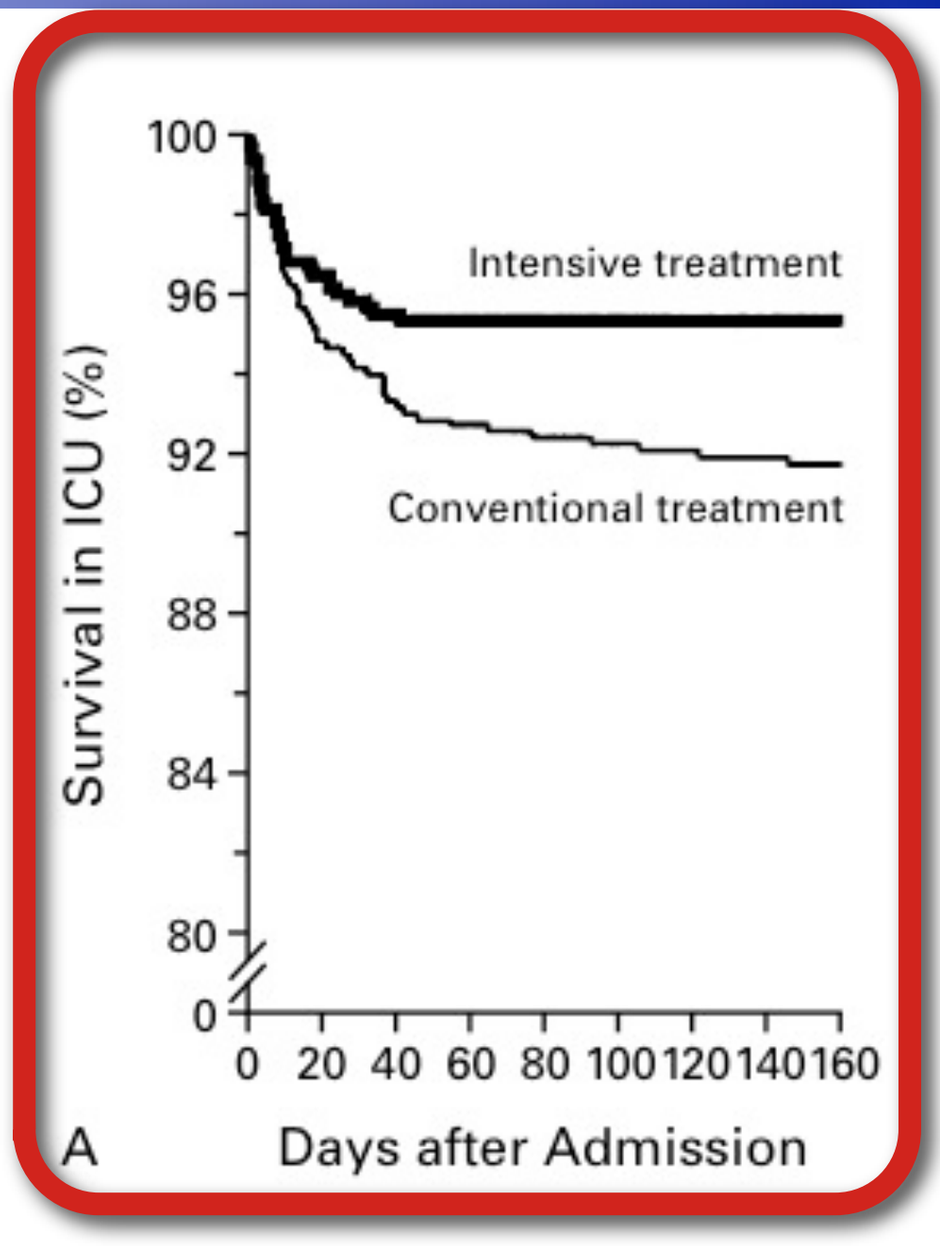

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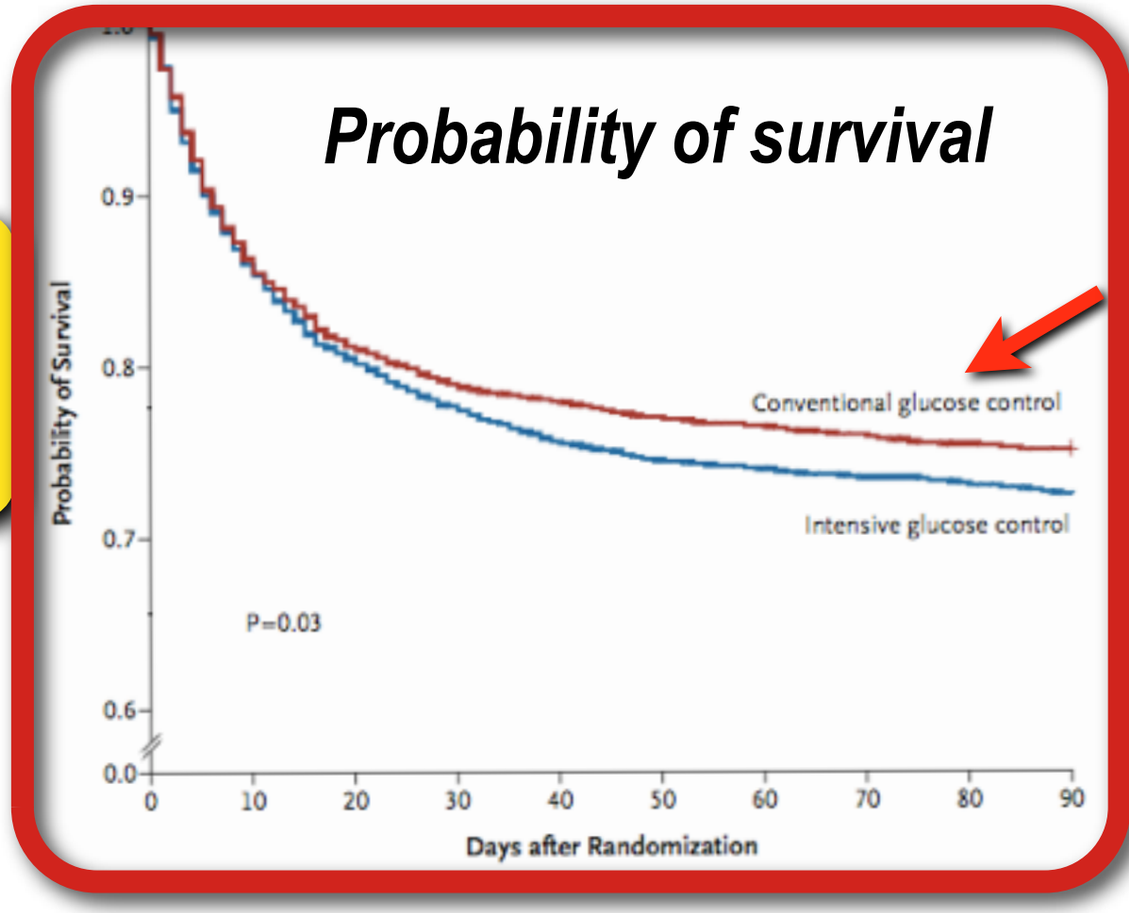

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ENGLAND of MEDICINE

RCH 26, 2009 VOL. 360 NO. 13

bility of survival

Glycemic control is easier to achieve by:
= dual energy concept (glucose + lipids)
= preoperative oral nutrition supplements
= glutamine to lower insulin resistance

Asprer, PhilSPEN, Nov 2009

*Van den Berghe, N Engl J Med 2001;345:1359-67 and Crit Care Med 2003;31:359-66
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Value of combining lipids with glucose

Value of combining lipids with glucose

- **Energy from lipids allows lower glucose supply, thereby enhancing glycemic control**

  Asprer, PhilSPEN Annual Convention, Nov 2009

- **Lipids are tolerated better in sepsis**

  Stoner et al. J Surg 1983; 70:32-5

- **Helps to control respiratory quotient by reduced CO_2 production**

  Nanni G et al. J Trauma 1984 Jan; 24(1):14-30
  Tappy L, et al. Crit Care Med 1998; 26:860-867

- **In cancer, tumors utilize glucose as the main energy source but are unable to use lipids**

  Bongaerts et al. Medical Hypotheses. 67, 1213–1222, 2006
  Daly, J.M.; JPEN 14(5), 1990, DeBlaauw, I Clin. Nutr., 1997

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ASPEN-ESPEN 2009 Guidelines: Glutamine

When PN is indicated in ICU the amino acid solution should contain 0.2–0.4 g/kg/day of L-glutamine (e.g. 0.3–0.6 g/kg/day alanyl-glutamine dipeptide). (A)

ASPEN-ESPEN 2009 Guidelines: Glutamine

When PN is used in the critical care setting, consideration should be given to supplementation with parenteral glutamine. (C)

The addition of enteral glutamine to an EN regimen should be considered in burns, trauma, and mixed ICU patients. (B)

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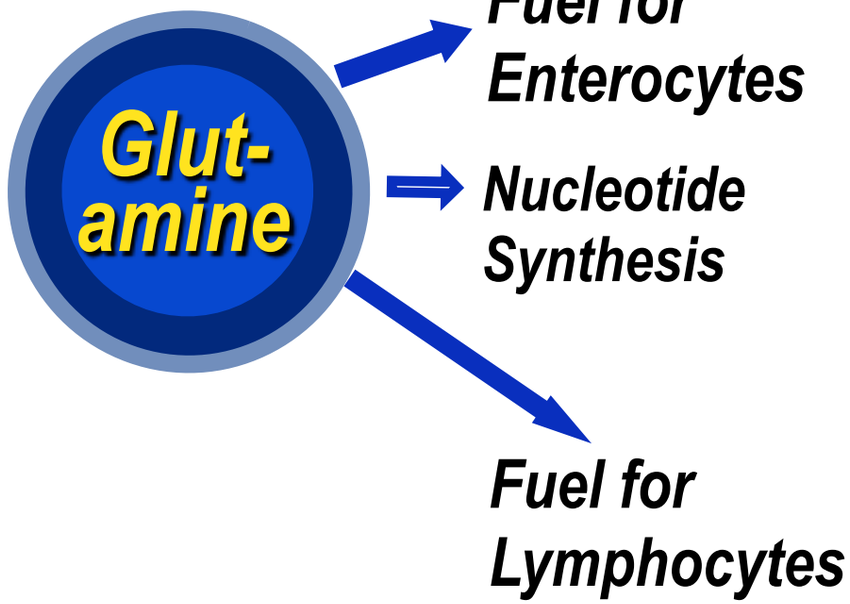
ASPEN ICU Guidelines, JPEN, May-June 2009
ESPEN ICU Guidelines, Clinical Nutrition, Aug 2009

Beneficial effects of glutamine

Kelly & Wischmeyer,
Curr Opin Clin Nutr Metab Care 2003, 6:217–222
As presented at PENSA 2007, Manila

Beneficial effects of glutamine



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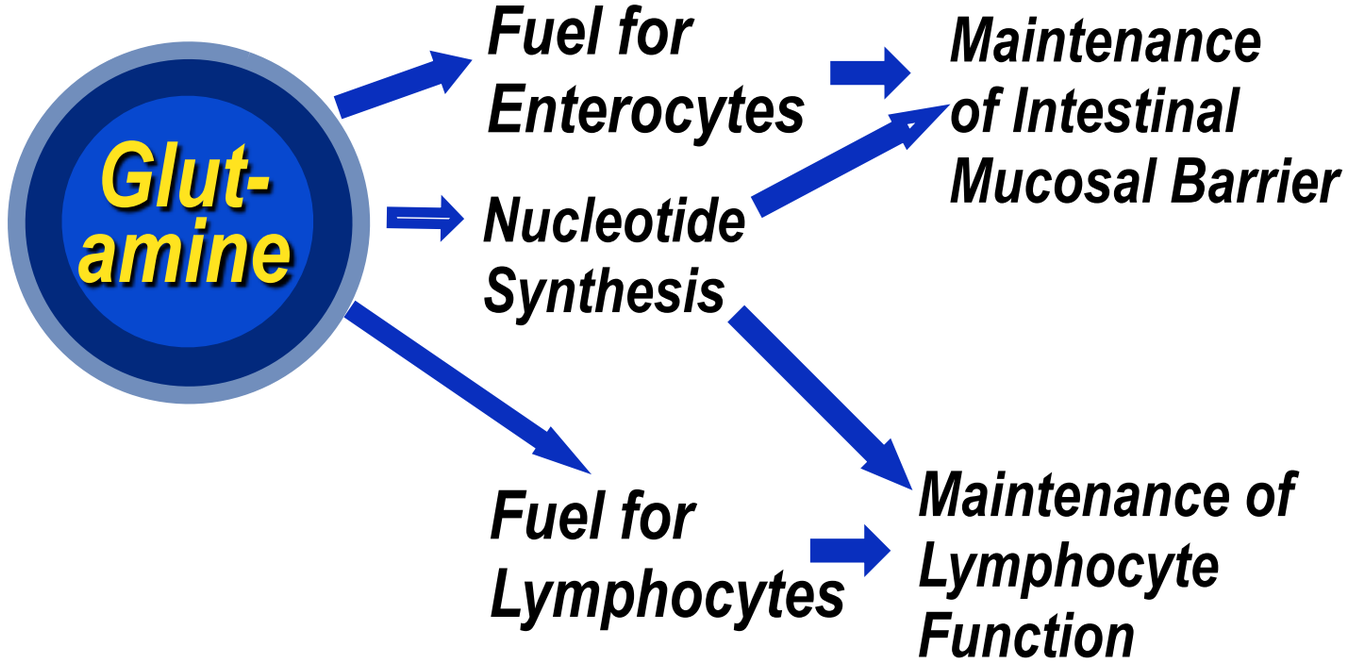

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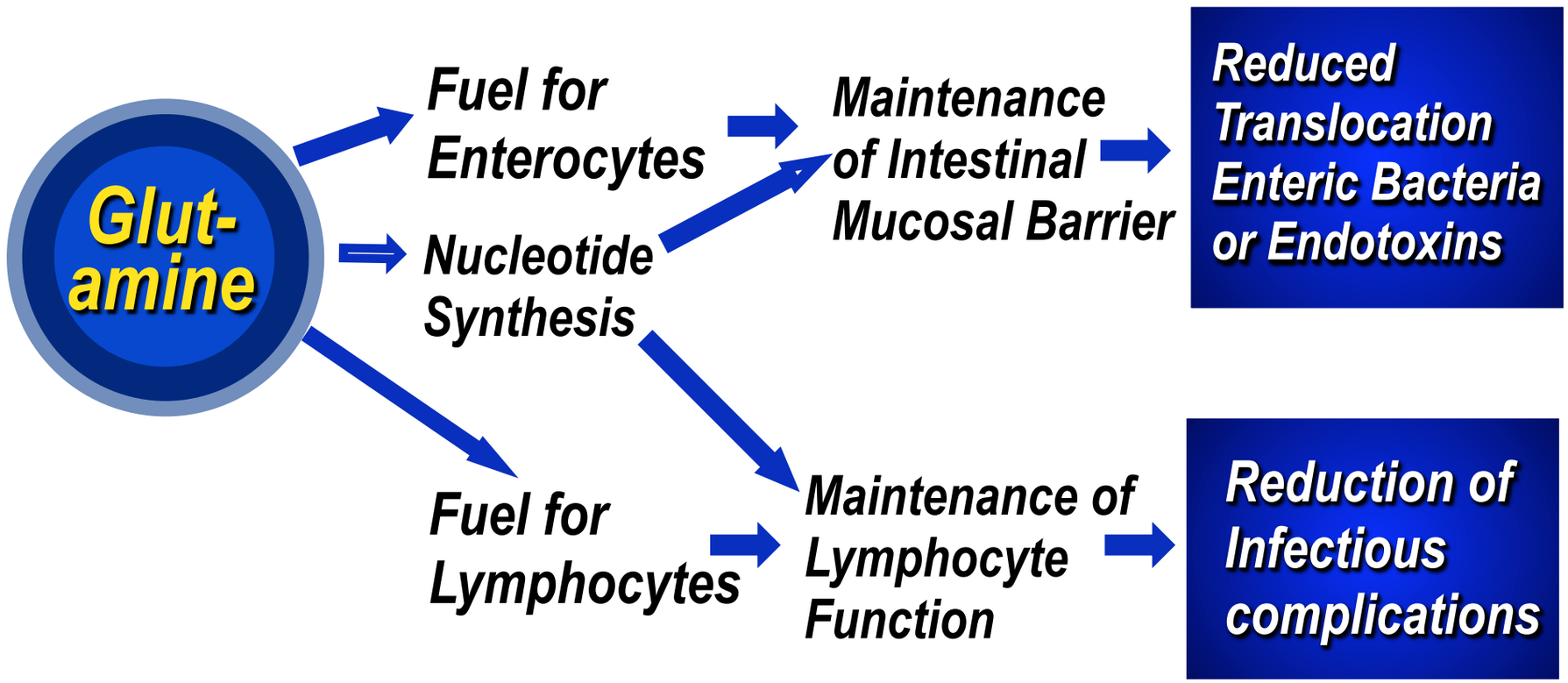

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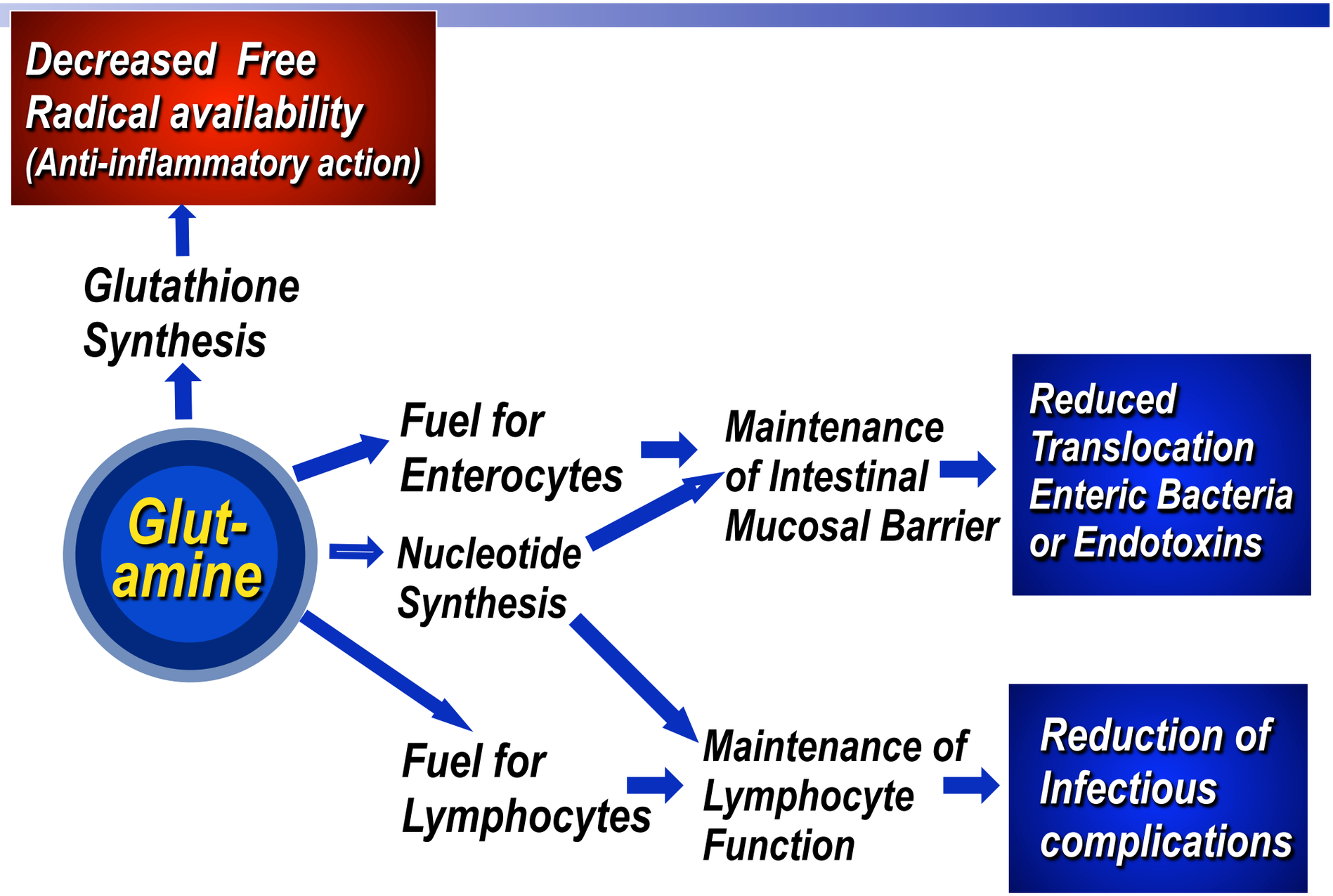

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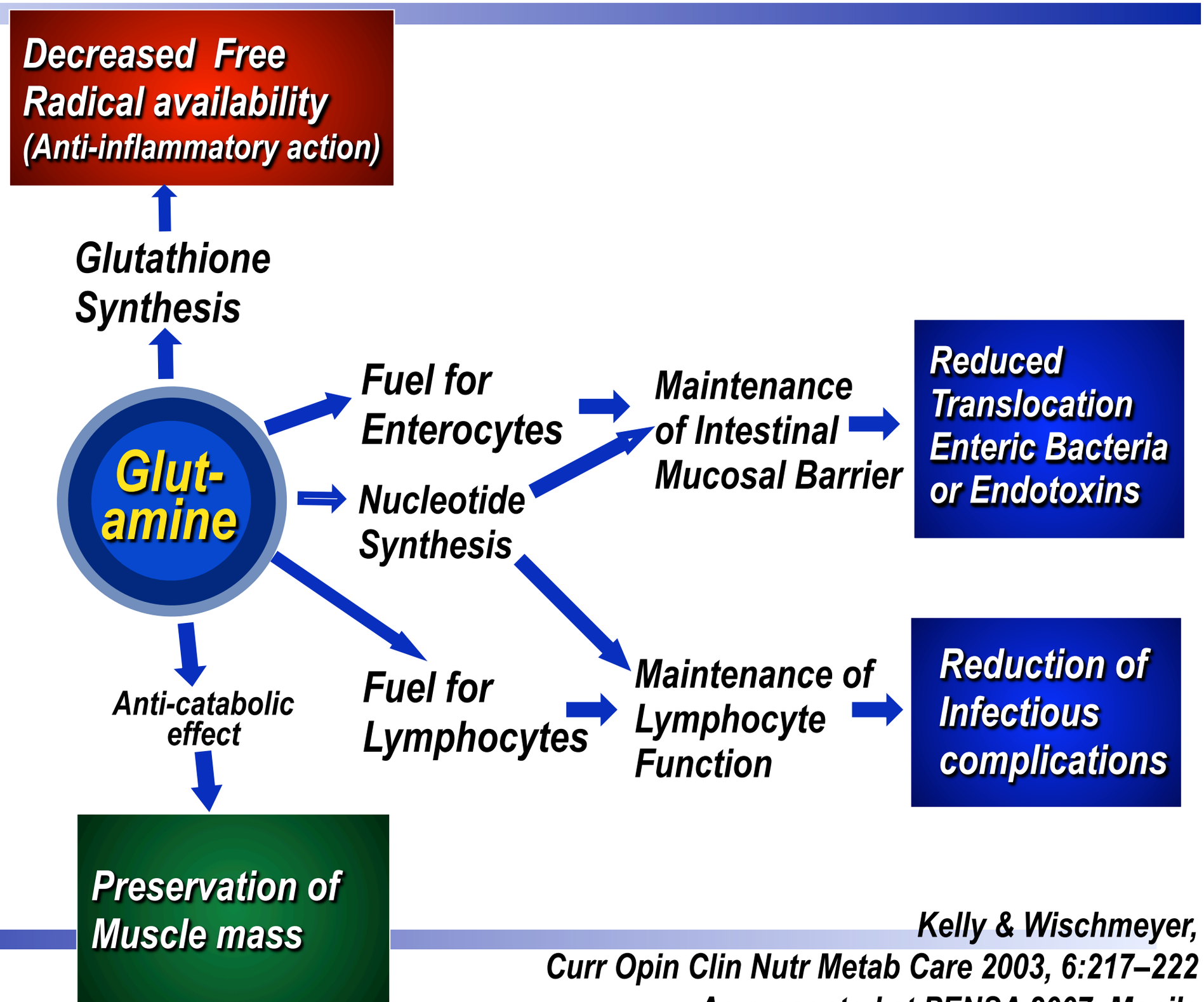

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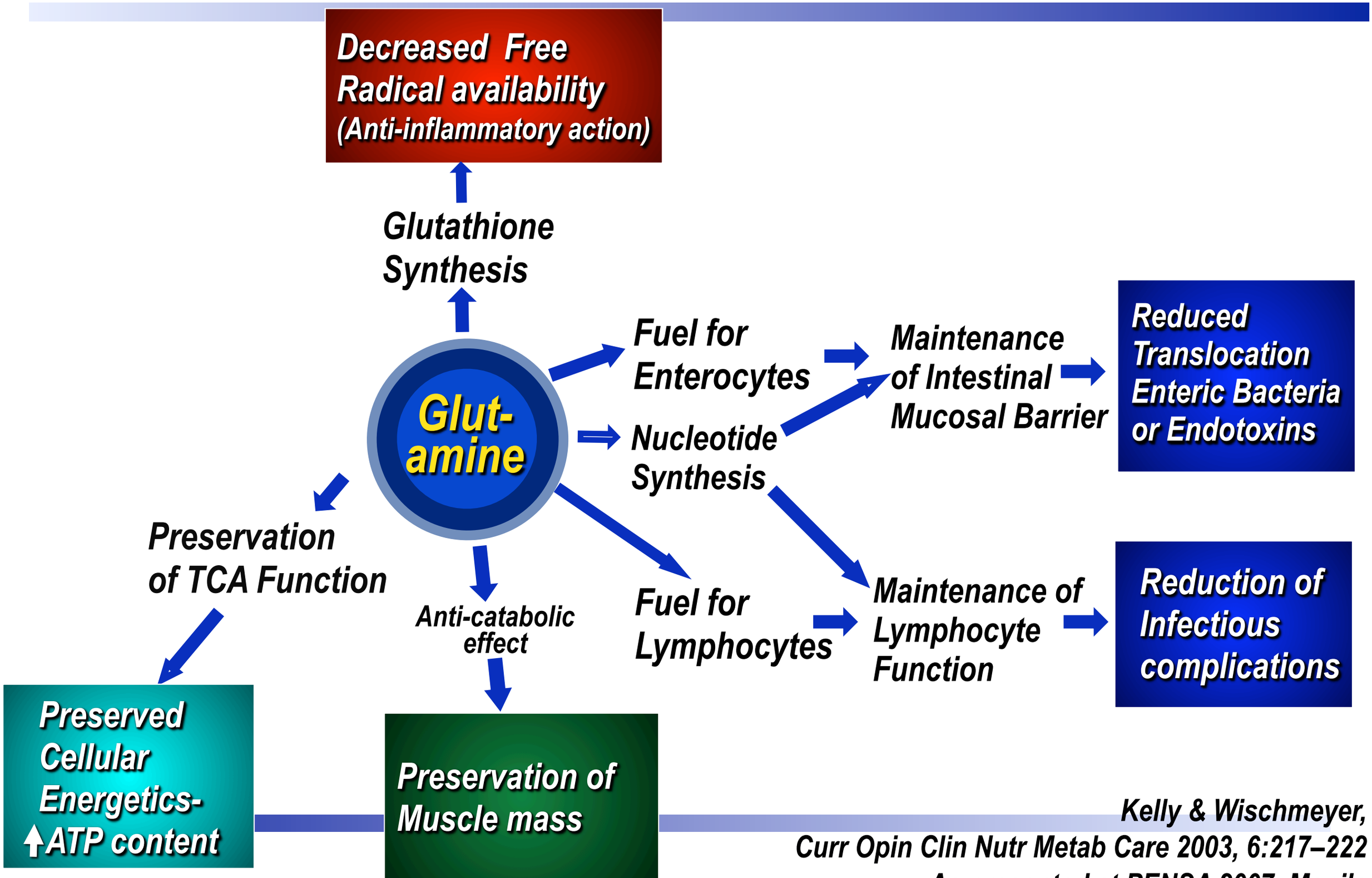

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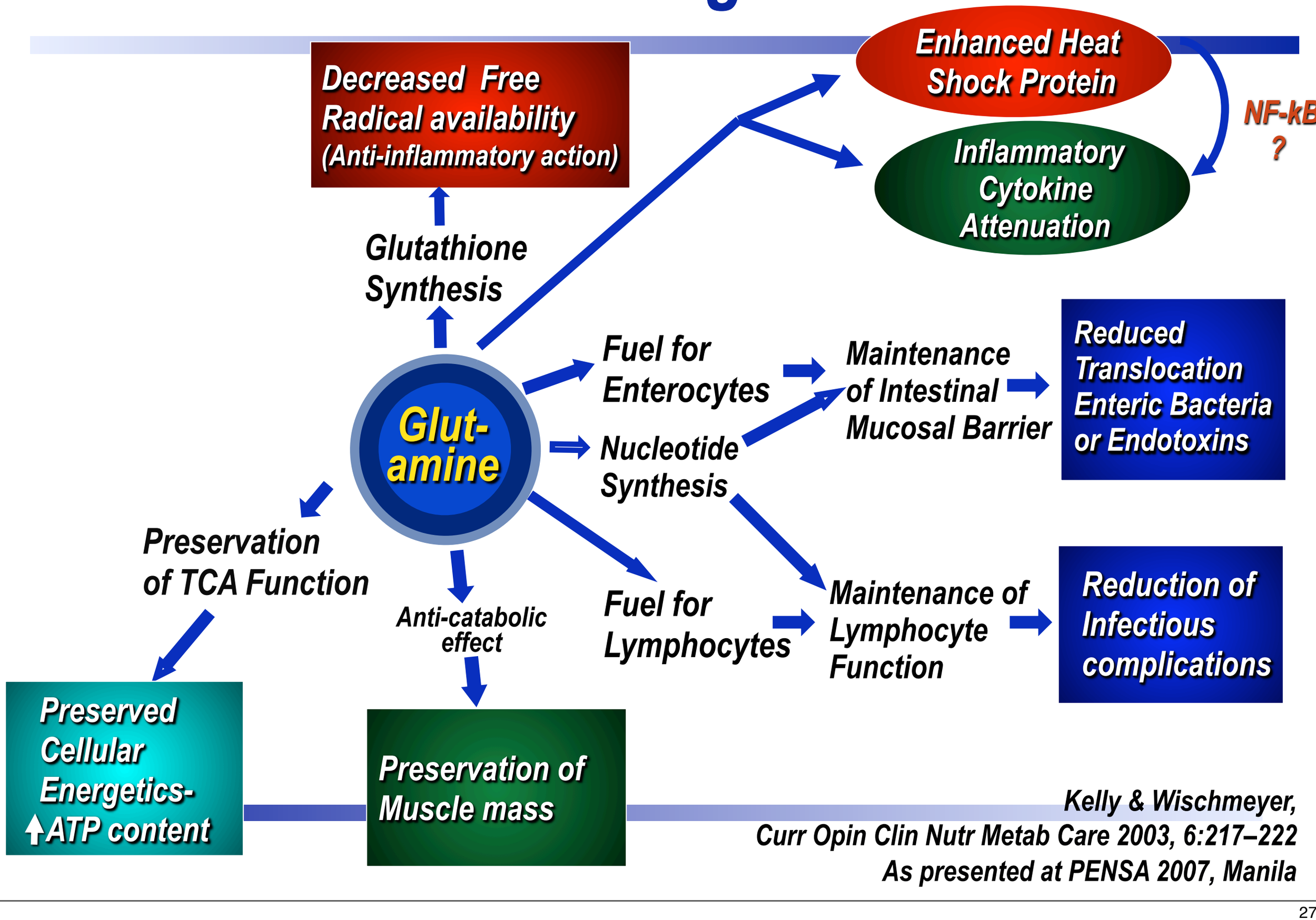

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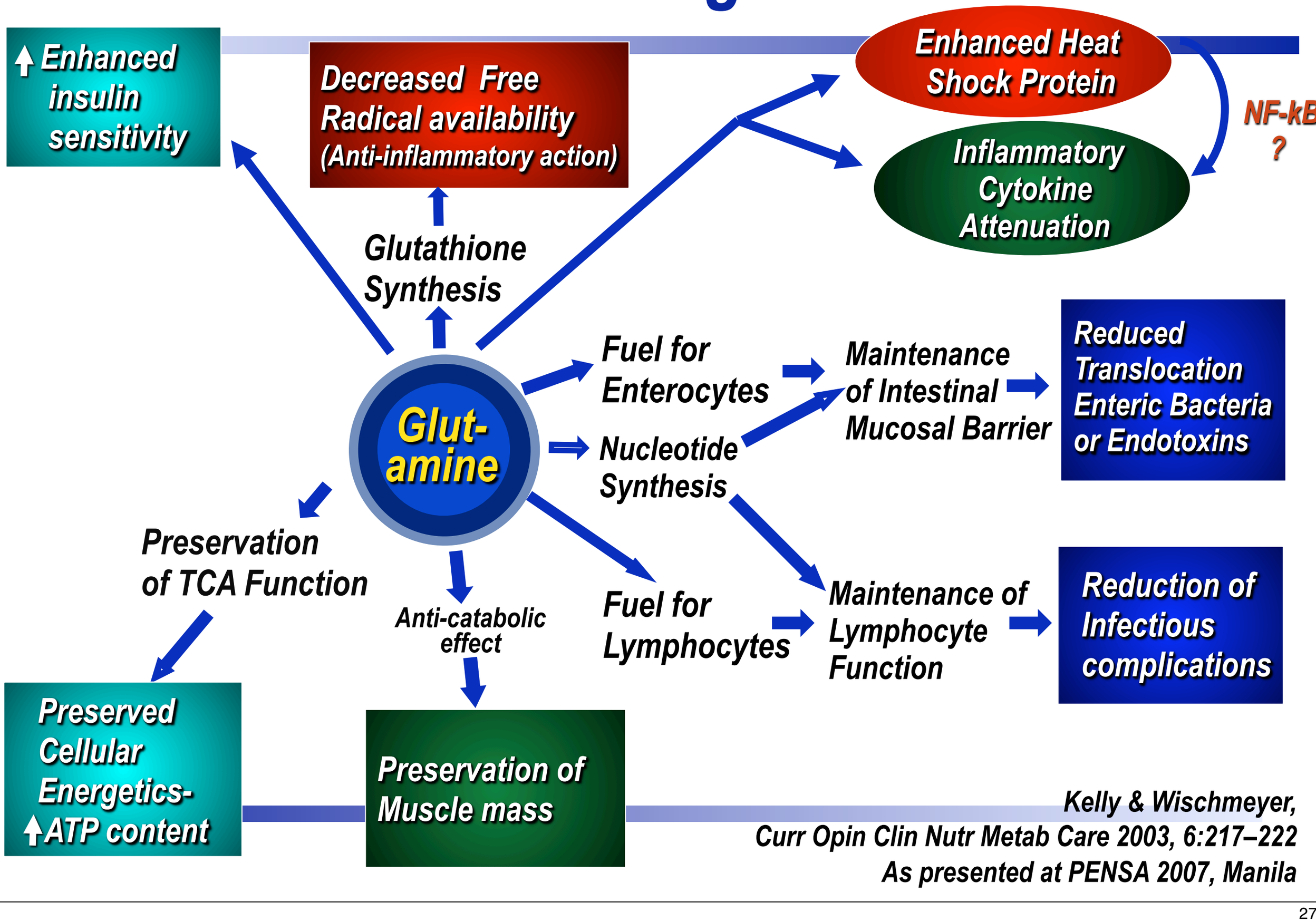

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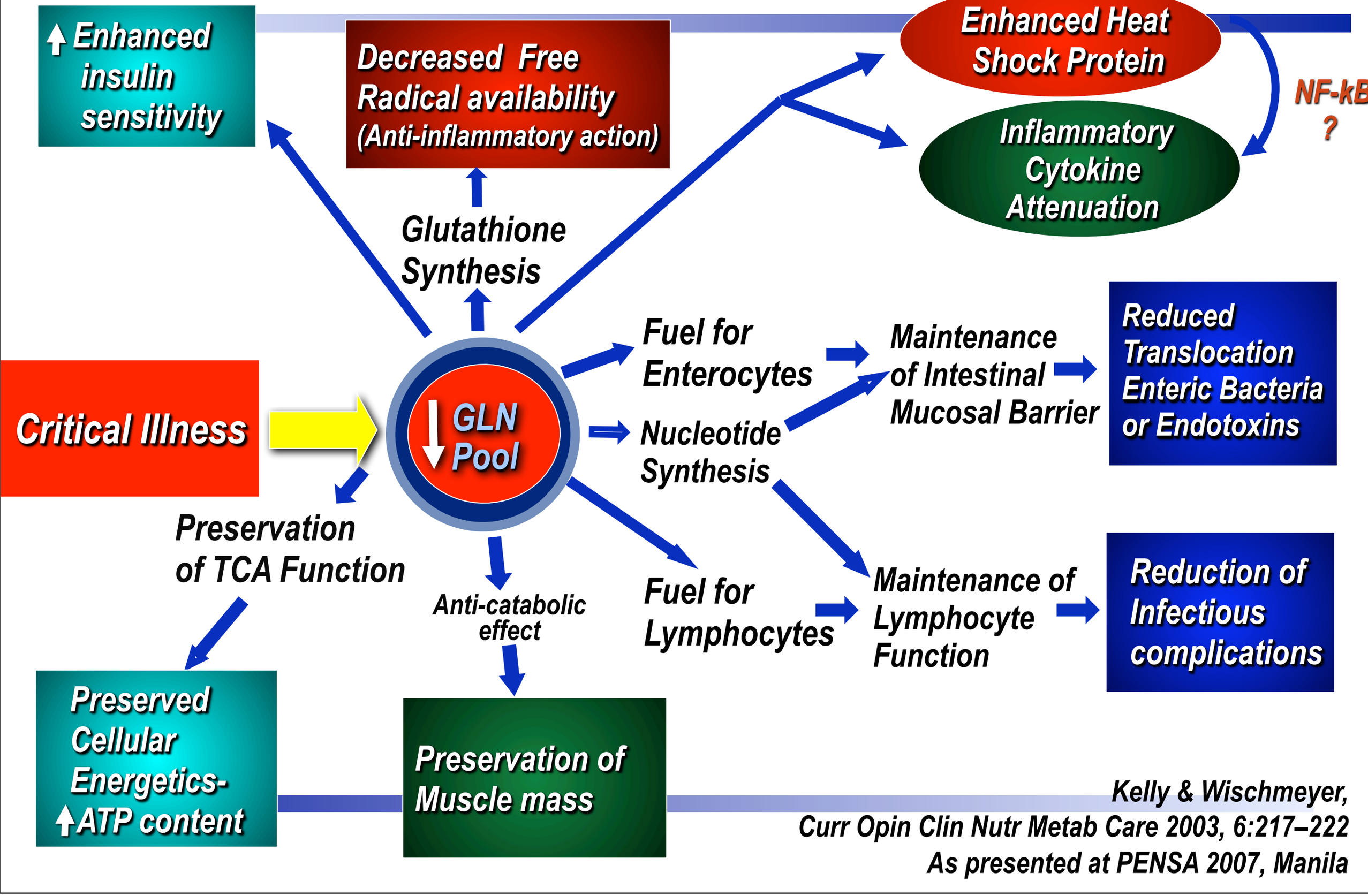

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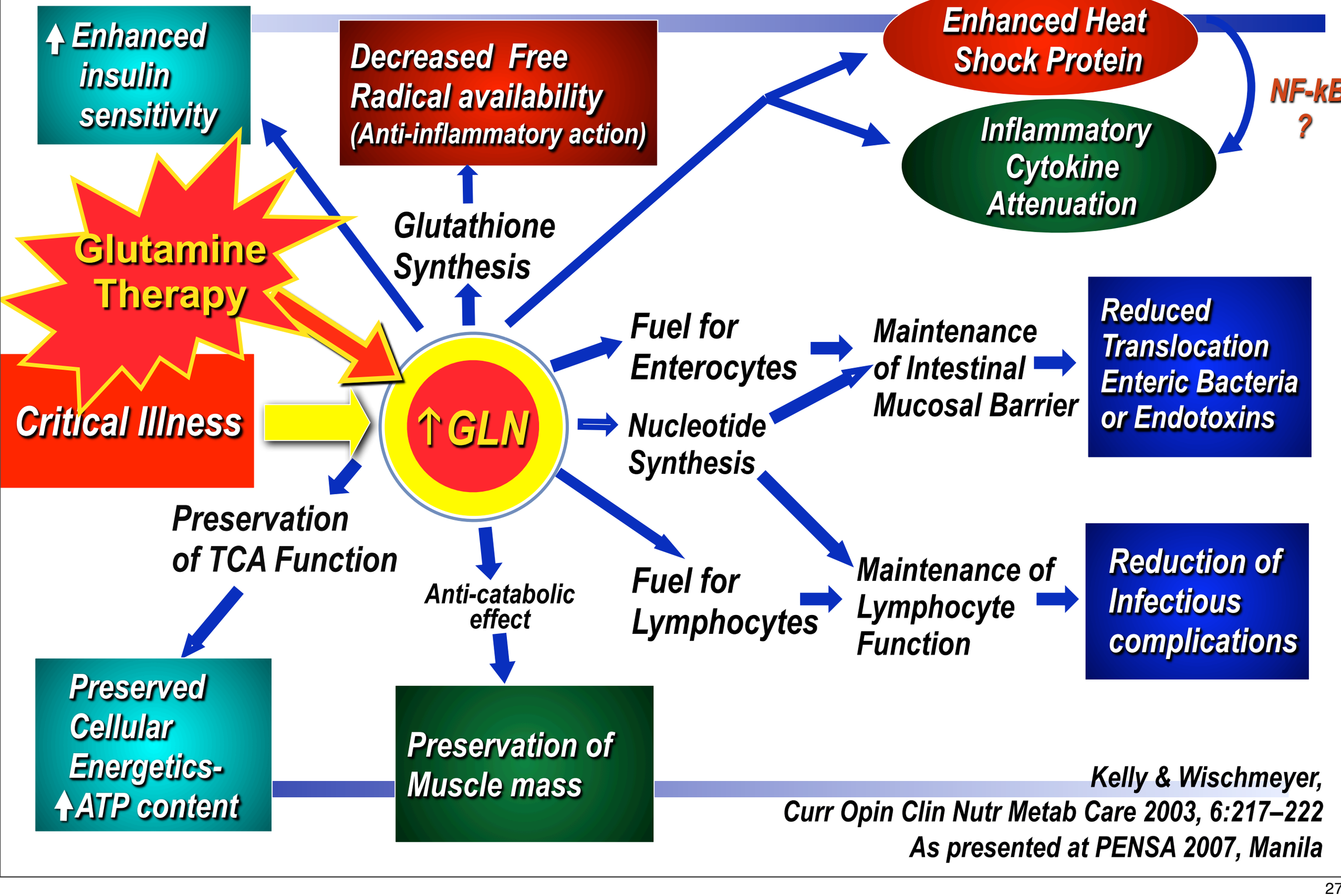

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Glutamine: mechanisms of action

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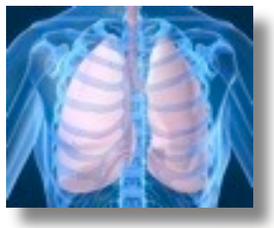
- *Modulation of cytokine production*
- *Modulation of cellular immunity*
- *Protection of gut integrity & barrier function*
- *Cell protection (elaboration of heat-shock protein)*
- *Reduction in oxidative stress; glutathione*
- *Counteracting insulin resistance*
- *Counteracting apoptosis*

Proposed organ-specific effects of glutamine in critical illness

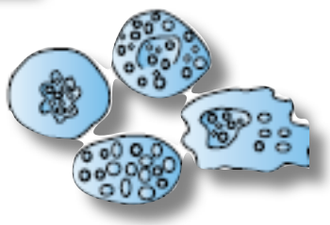


LUNG

- Major fuel for endothelial cell
- Preserves cell metabolism following endotoxin injury

HEART

- Major fuel for cardiomyocytes



IMMUNE CELLS

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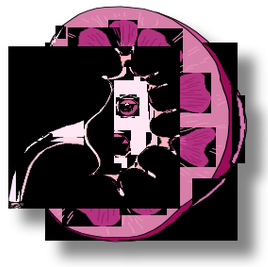
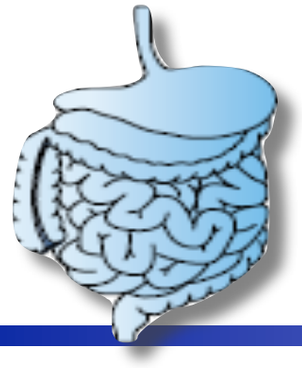


KIDNEY

- Acid/base regulation
- Central role in N transport within the body
- NH_3 metabolism



GASTROINTESTINAL TRACT

- Major fuel; Supports nucleotide biosynthesis
- Protects epithelial cells against endotoxin/oxidant related injury
- Enhances glutathione concentration post-stress

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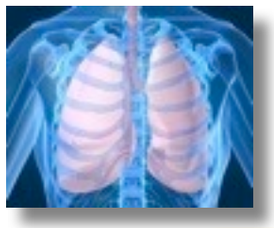

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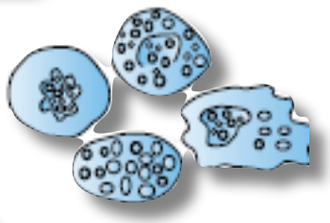

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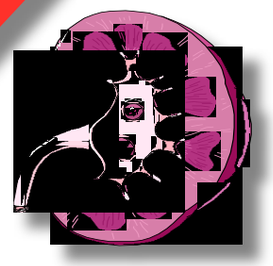

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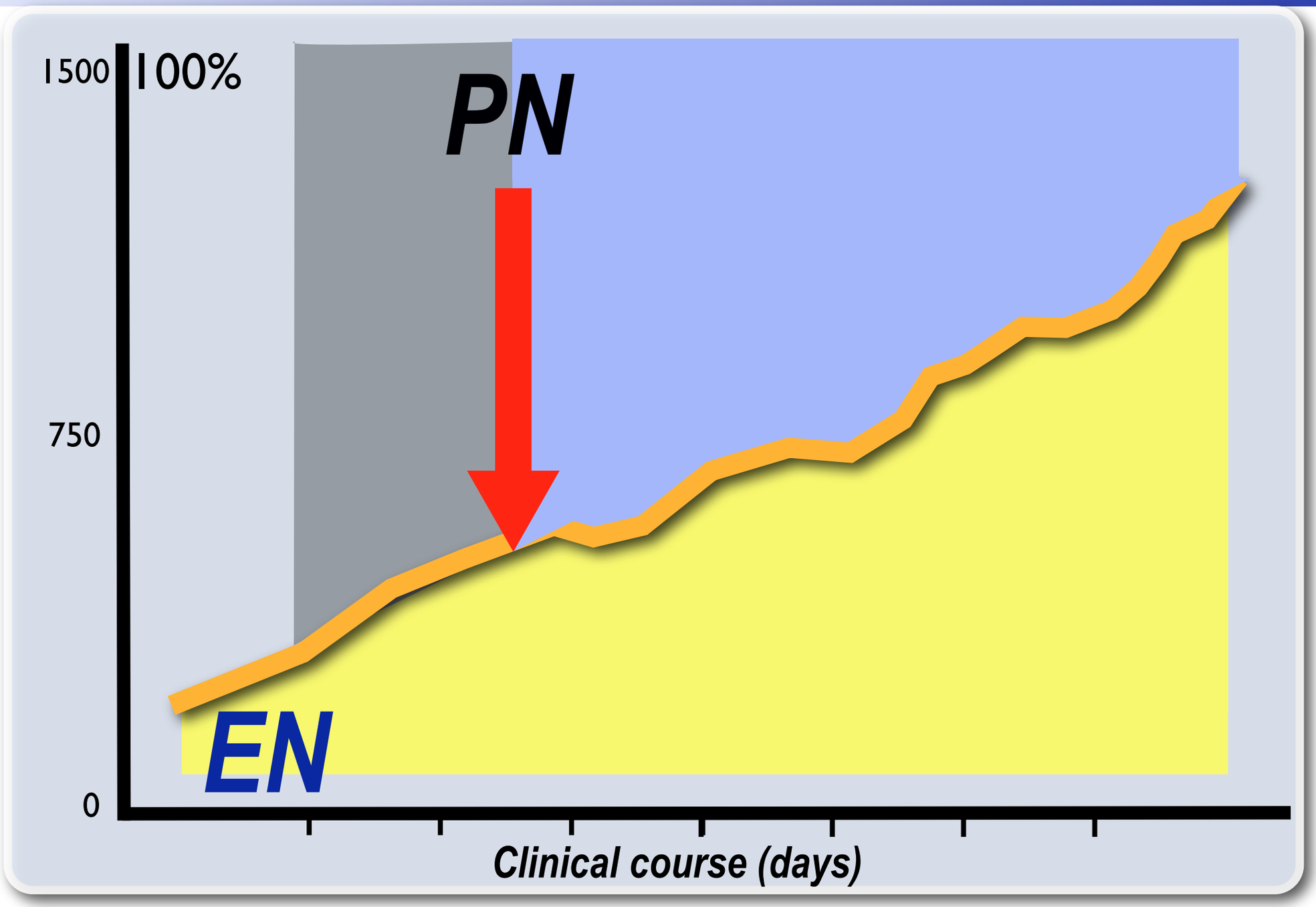
IV glutamine may stimulate gut immunity



McClave & Heyland, NCP, 2009.

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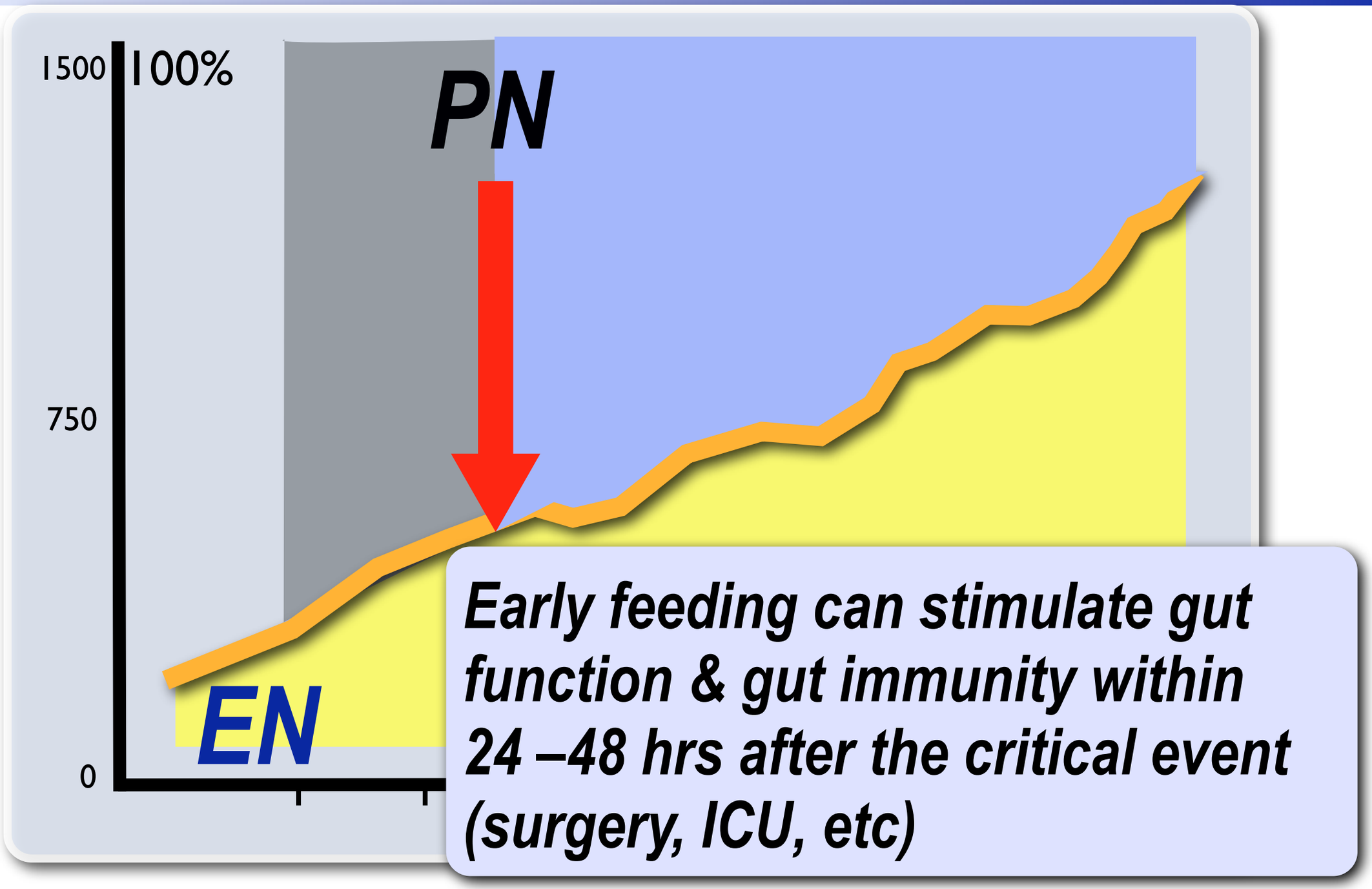

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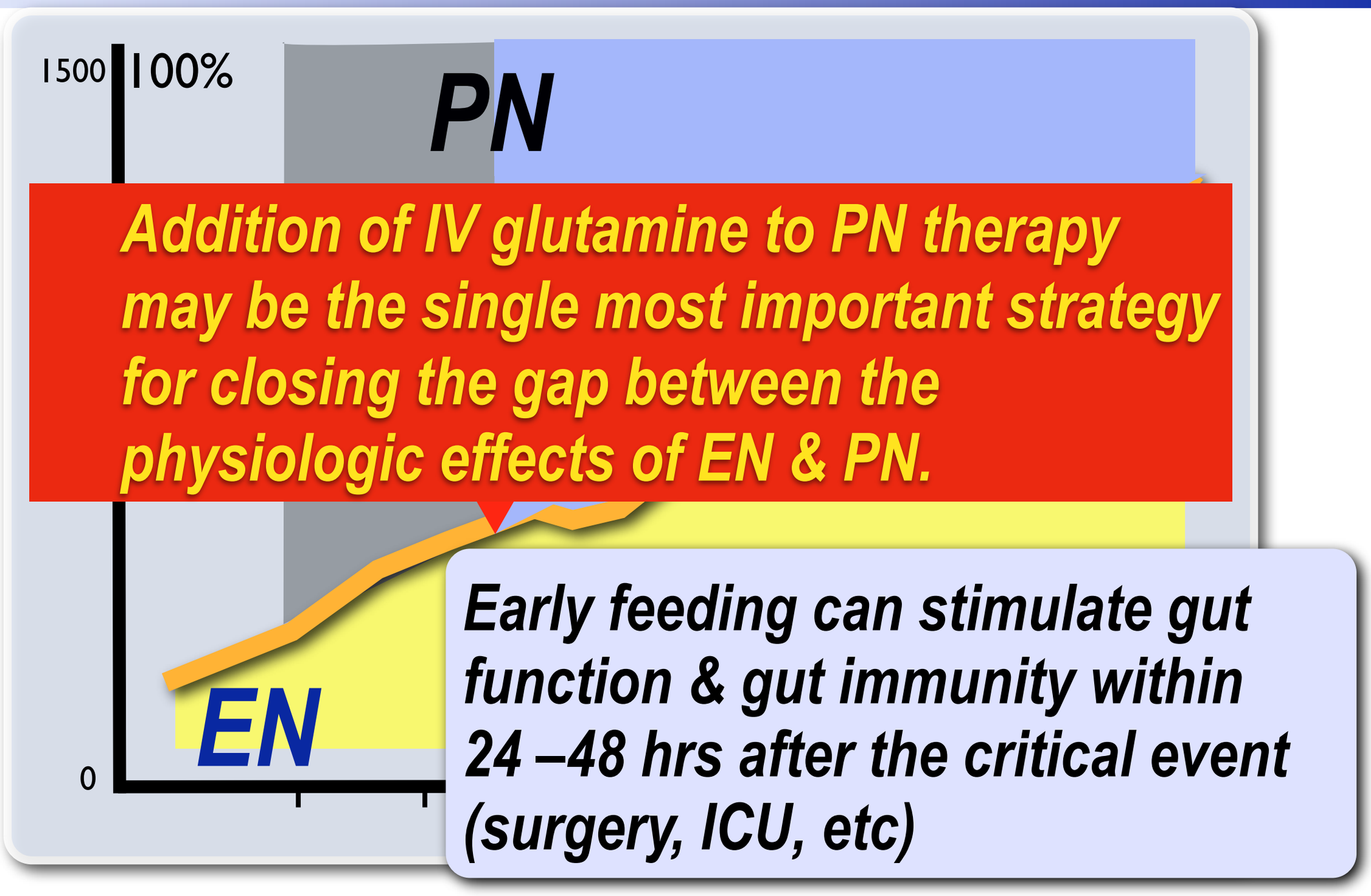

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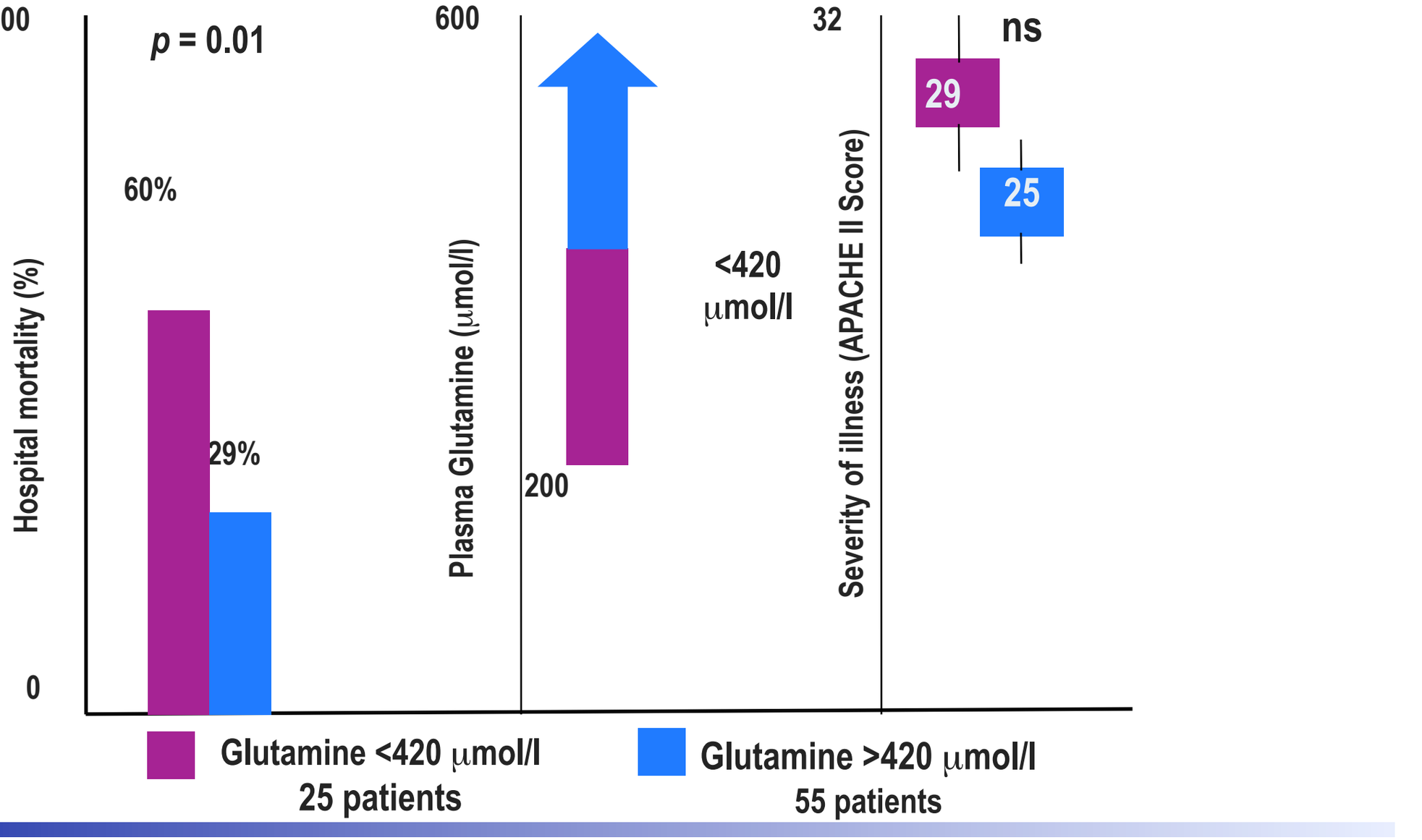
Is there actual evidence of depletion?

Patient group/ catabolic state	GLUTAMINE DEPLETION	
	Intramuscular	Plasma
Sepsis Trauma	Gamrin 1996, Hammarqvist 1997, Engel 2003, Gore 2003	Engel 2003, Gamrin 1996, Goeters 2002, Griffiths 1997, Houdijk 1998, Jackson 199, Jensen 1996, Jones 1999, Luiking 2004, Roth 1982, Gore 2003, Druml 2001
Burns	Mittendorfer 1999, Biolo 2000	Parry-Billings 1990, Garrel 2003
MOF		Tjäder 2004
Severe acute pancreatitis	Roth 1986	Roth 1986
Major Surgery	Blomqvist 1995, Fläring 2003, Hammarqvist 1989, Morlion 1998, Stehle 1989	Fläring 2003, Mertes 2000, Powell-Tuck, Spittler 2001
Bone marrow transplantation		Ziegler 1992

Is there actual evidence of depletion?

- **ICU patients w/ pancreatitis**
  Roth, Klin Em 1982
- **ICU trauma patients**
  Stehle, Amino Acids Landes 1994
- **ICU patients**
  Palmer, Nutrition 1996
- **Burns & trauma, incl sepsis patients**
  Wischmeyer et al, NCP, 2003
- **ICU patients**
  Oudemans-Van Straaten, ICM 2001

Glutamine depletion = higher mortality !



Oudermans-van Straaten et al . Intensive Care Med 2001; 27:84-90

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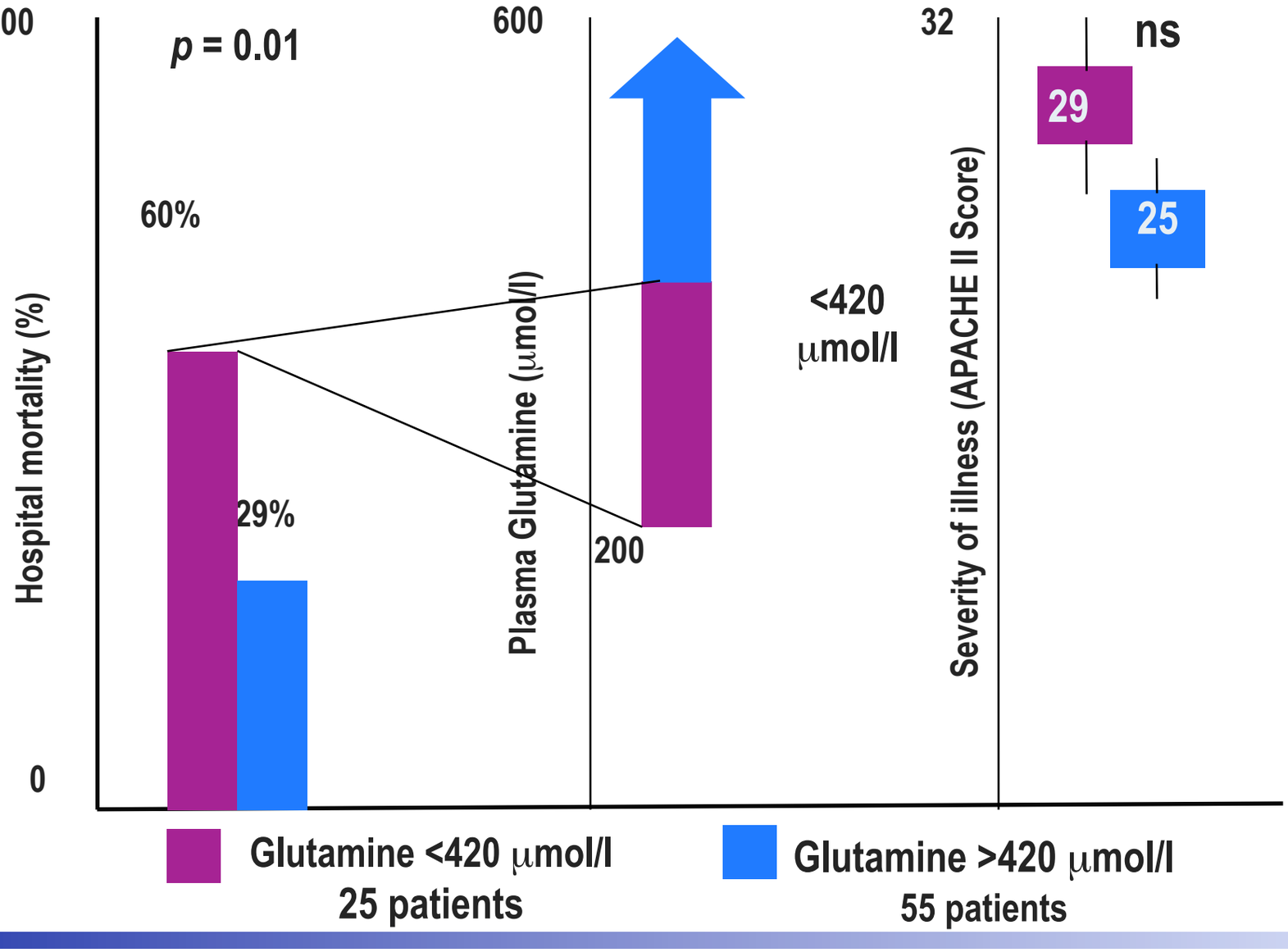

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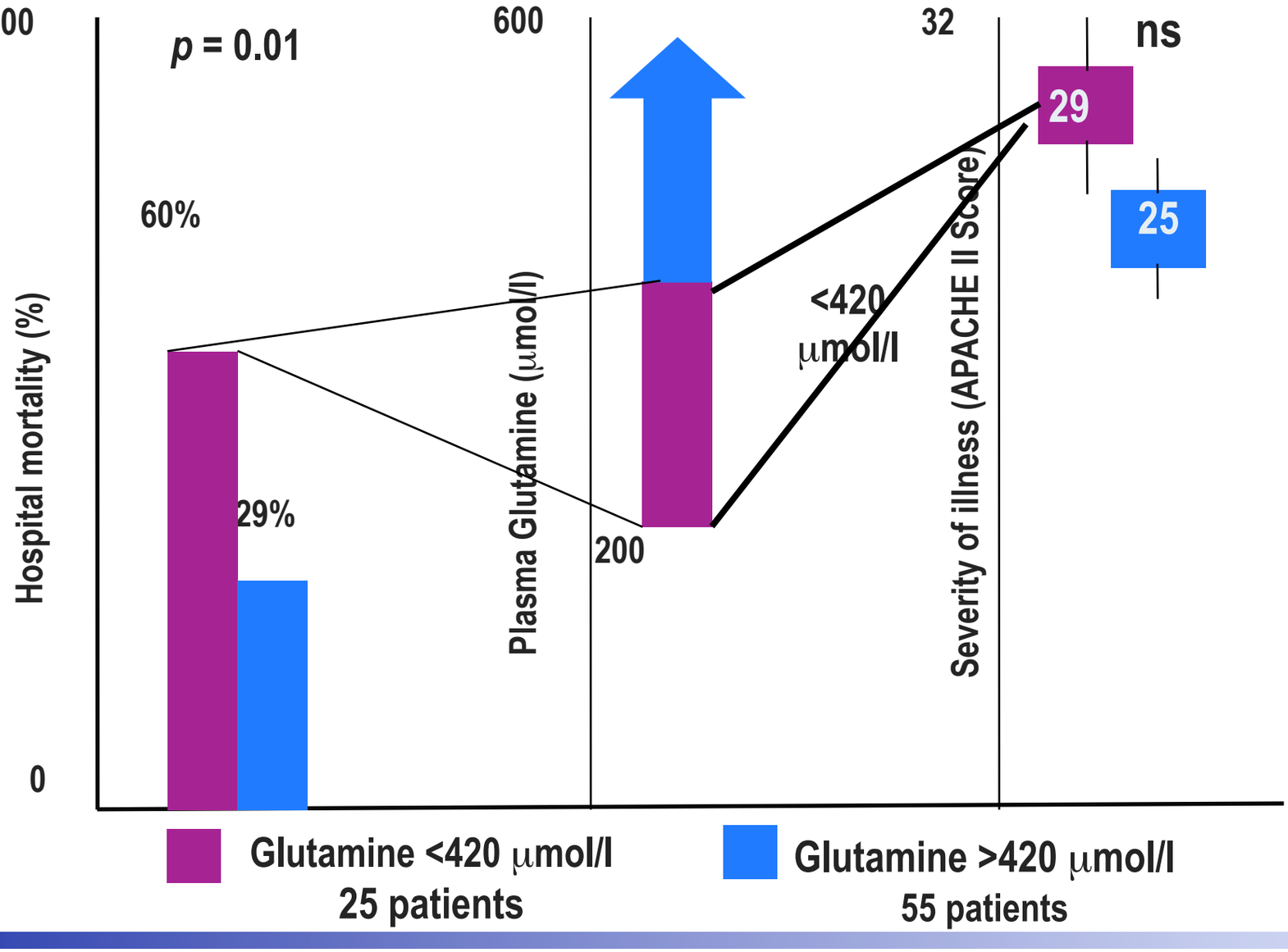

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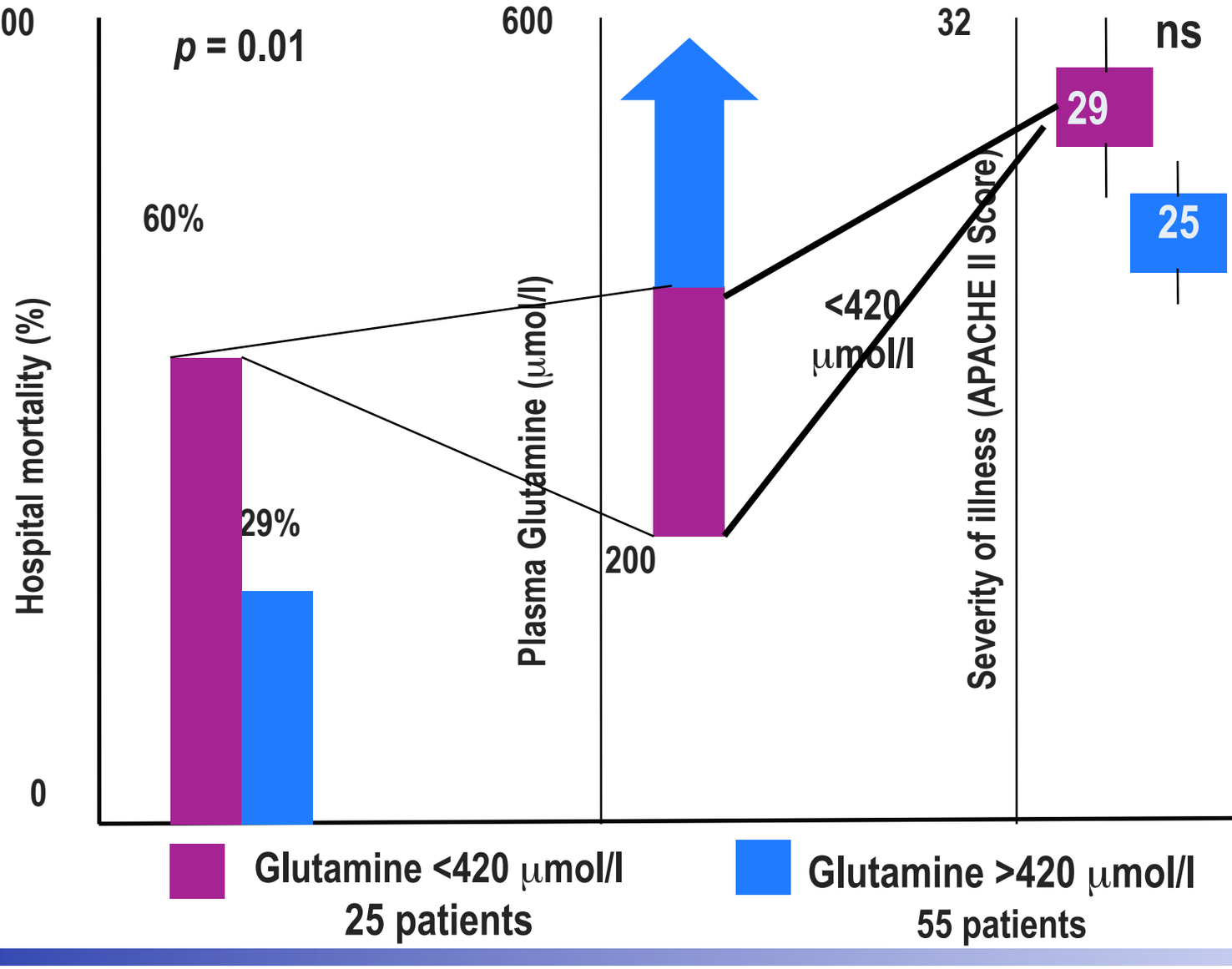
Depleted plasma glutamine is a predictor of mortality (more sensitive than APACHE II score)



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Pre-op glutamine: effect on immune indices

ELSEVIER

NUTRITION

Nutrition 25 (2009) 920–925

www.nutritionjml.com

Applied nutritional investigation

Effect on immune indices of preoperative intravenous glutamine dipeptide supplementation in malnourished abdominal surgery patients in the preoperative and postoperative periods

Jonathan M. Asprer, M.D., Luisito O. Llido, M.D.*, Reynaldo Sinamban, M.D., Ewald Schlotzer, M.D., and Hrishikesh Kulkarni, M.D., Ph.D.

St. Lukes Medical Center, Clinical Nutrition, Obesity, and Weight Management Center, Philippines

- ***Pre-op parenteral glutamine resulted in increased white blood cell, granulocyte, and lymphocyte counts***
- ***When supplementation was discontinued before surgery, this increase was not sustained in the post-op period***
- ***Glutamine is best when given both pre- & post-op***

Asprer, Llido, Sinamban et al, Nutrition 25 (2009) 920-925

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Glutamine in surgical patients: meta-analysis

The impact of glutamine dipeptides on outcome of surgical patients: systematic review of randomized controlled trials

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Glutamine-supplemented PN in abdominal surgery

- ☑ ***Improved N- balance (significant)***
- ☑ ***Decreased infection rate (significant)***
- ☑ ***Reduced length of hospital stay (significant)***

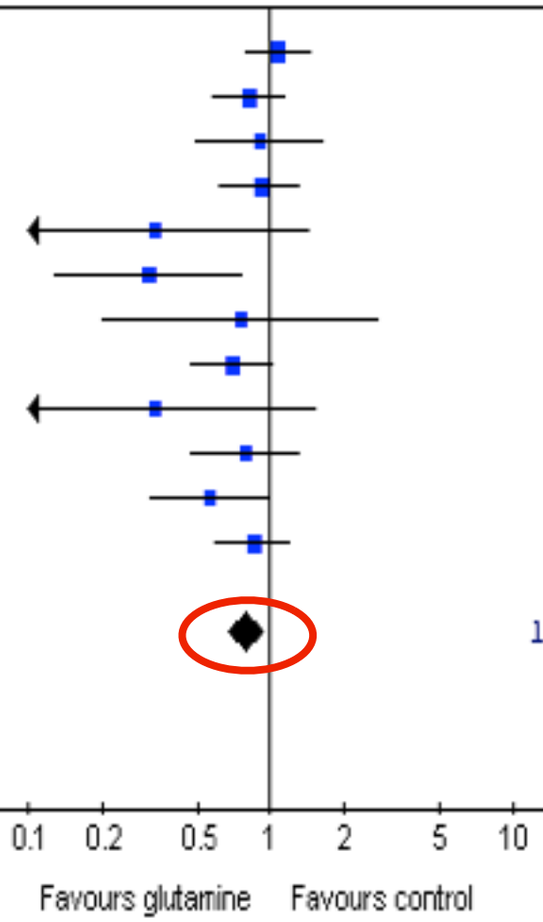
Effect of glutamine in critical illness: Systematic review of literature

Infectious complications

Review: glutamine New review (Version 01)
Comparison: 03 Glutamine vs Control
Outcome: 02 Infectious Complications

Study or sub-category	Glutamine n/N	Control n/N	RR (random) 95% CI	Weight %	RR (random) 95% CI	Year
Griffiths	28/42	26/42		17.16	1.08 [0.78, 1.48]	1997
Houdijk	20/35	26/37		14.79	0.81 [0.57, 1.16]	1998
Wischmeyer	7/12	9/14		6.02	0.91 [0.49, 1.68]	2001
Hall	38/179	43/184		13.15	0.91 [0.62, 1.33]	2003
Zhou	2/20	6/20		1.16	0.33 [0.08, 1.46]	2003
Fuentes-Orozco	4/17	12/16		3.00	0.31 [0.13, 0.77]	2004
Zhou 2004	3/15	4/15		1.46	0.75 [0.20, 2.79]	2004
Dechelotte 2006	23/58	32/56		12.87	0.69 [0.47, 1.03]	2006
Palmese	2/42	6/42		1.07	0.33 [0.07, 1.56]	2006
Estivariz	13/30	16/29		7.99	0.79 [0.46, 1.33]	2008
Fuentes-Orozco 2008	9/22	16/22		7.06	0.56 [0.32, 0.99]	2008
Perez-Barcena	11/15	13/15		14.28	0.85 [0.59, 1.22]	2008
Total (95% CI)	487	492		100.00	0.79 [0.68, 0.93]	

Total events: 160 (Glutamine), 209 (Control)
Test for heterogeneity: Chi² = 13.14, df = 11 (P = 0.28), I² = 16.3%
Test for overall effect: Z = 2.81 (P = 0.005)



Canadian Critical Care Grp *Updated Jan 2009, see www.criticalcarenutrition.com*

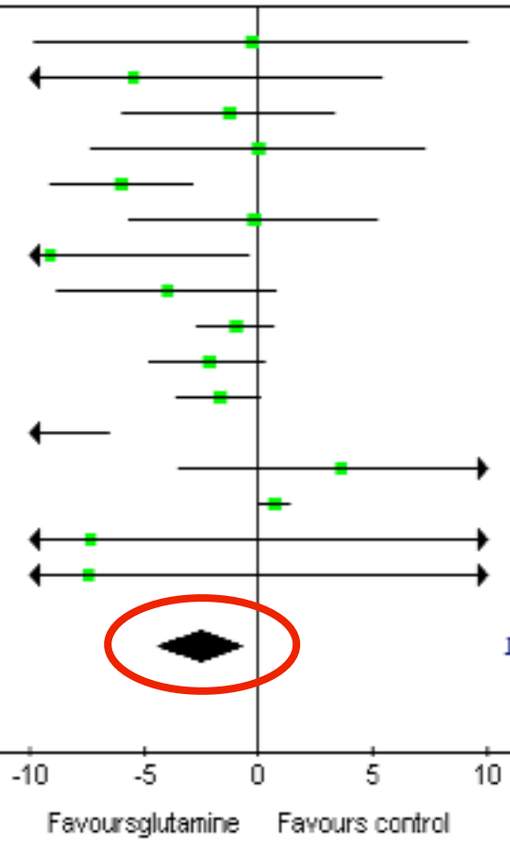
Effect of glutamine in critical illness: Systematic review of literature

Length of stay

Review: glutamine New review (Version 01)
Comparison: 03 Glutamine vs Control
Outcome: 03 Length of Stay

Study or sub-category	Glutamine N	Glutamine Mean (SD)	Control N	Control Mean (SD)	WMD (random) 95% CI	Weight %	WMD (random) 95% CI	Year
Houdijk	35	32.70(17.10)	37	33.00(23.80)		2.83	-0.30 [-9.83, 9.23]	1998
Powell-Tuck	83	43.40(34.10)	85	48.90(38.40)		2.26	-5.50 [-16.48, 5.48]	1999
Brantley	31	19.50(8.80)	41	20.80(11.50)		6.87	-1.30 [-5.99, 3.39]	2000
Wischmeyer	12	40.00(10.00)	14	40.00(9.00)		4.12	0.00 [-7.36, 7.36]	2001
Zhou	20	67.00(4.00)	20	73.00(6.00)		9.14	-6.00 [-9.16, -2.84]	2003
Fuentes-Orozco	17	16.50(8.90)	16	16.70(7.00)		5.93	-0.20 [-5.65, 5.25]	2004
Peng	25	46.59(12.98)	23	55.68(17.36)		3.24	-9.09 [-17.82, -0.36]	2004
Zhou 2004	15	42.00(7.00)	15	46.00(6.60)		6.64	-4.00 [-8.87, 0.87]	2004
Palmese	42	12.00(4.60)	42	13.00(3.40)		11.32	-1.00 [-2.73, 0.73]	2006
Sahin	20	14.20(4.40)	20	16.40(3.90)		10.07	-2.20 [-4.78, 0.38]	2007
Cai	55	22.10(4.90)	55	23.80(5.10)		11.13	-1.70 [-3.57, 0.17]	2008
Estivariz	15	20.00(2.00)	12	30.00(6.00)		8.54	-10.00 [-13.54, -6.46]	2008
Fuentes-Orozco 2008	22	30.18(10.42)	22	26.59(13.30)		4.36	3.59 [-3.47, 10.65]	2008
Luo 2008	11	7.60(0.70)	9	6.90(0.90)		12.36	0.70 [-0.02, 1.42]	2008
McQuiggan	10	32.00(13.60)	10	39.30(36.30)		0.55	-7.30 [-31.33, 16.73]	2008
Perez-Barcena	15	35.50(33.60)	15	42.90(28.80)		0.63	-7.40 [-29.80, 15.00]	2008
Total (95% CI)	428		436			100.00	-2.56 [-4.39, -0.74]	

Test for heterogeneity: Chi² = 62.15, df = 15 (P < 0.00001), I² = 75.9%
Test for overall effect: Z = 2.76 (P = 0.006)



Effect of glutamine in critical illness: Systematic review of literature

Mortality

Review: glutamine New review (Version 01)
Comparison: 03 Glutamine vs Control
Outcome: 01 mortality

Study or sub-category	glutamine n/N	Control n/N	RR (random) 95% CI	Weight %	RR (random) 95% CI	Year
Griffiths	18/42	25/42		23.68	0.72 [0.47, 1.11]	1997
Houdijk	4/41	3/39		2.13	1.27 [0.30, 5.31]	1998
Jones	10/26	9/24		8.66	1.03 [0.50, 2.08]	1999
Powell-Tuck	14/83	20/85		11.63	0.72 [0.39, 1.32]	1999
Brantley	0/31	0/41			Not estimable	2000
Wischmeyer	2/15	5/16		1.99	0.43 [0.10, 1.88]	2001
Garrel	2/21	12/24		2.30	0.19 [0.05, 0.76]	2003
Hall	27/179	30/184		19.12	0.93 [0.57, 1.49]	2003
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Xian-Li	0/20	3/21		0.52	0.15 [0.01, 2.73]	2004
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Sahin	2/20	6/20		2.00	0.33 [0.08, 1.46]	2007
Cai	17/55	20/55		15.66	0.85 [0.50, 1.44]	2008
Duska	2/10	0/10		0.51	5.00 [0.27, 92.62]	2008
Estivariz	1/32	6/31		1.03	0.16 [0.02, 1.27]	2008
Fuentes-Orozco 2008	2/22	5/22		1.86	0.40 [0.09, 1.85]	2008
Luo 2008	1/23	0/9		0.45	1.25 [0.06, 28.15]	2008
McQuiggan	0/10	2/10		0.51	0.20 [0.01, 3.70]	2008
Perez-Barcena	3/15	0/15		0.53	7.00 [0.39, 124.83]	2008
Total (95% CI)	782	782		100.00	0.75 [0.61, 0.93]	

Total events: 115 (glutamine), 159 (Control)
Test for heterogeneity: Chi² = 16.81, df = 18 (P = 0.54), I² = 0%
Test for overall effect: Z = 2.65 (P = 0.008)

0.1 0.2 0.5 1 2 5 10
Favours glutamine Favours control

Canadian Critical Care Grp *Updated Jan 2009, see www.criticalcarenutrition.com*

Glutamine role in nutrition therapy - supported by current practice guidelines

- ***Canadian Critical Care Grp - www.criticalcarenutrition.com***

- ***American Society of Parenteral & Enteral Nutrition ASPEN - www.nutritioncare.org Society of Critical care Medicine (SCCM)***

- ***European Society of Parenteral & Enteral Nutrition ESPEN - www.espen.org***

Clinical Applications of L-Glutamine: Past, Present, and Future

Paul E. Wischmeyer, MD
From the Department of Anesthesiology, University of Colorado Health Sciences Center, Denver, Colorado

- ***High dose, parenteral glutamine appears to demonstrate the highest potential benefit***
- ***Recommendations for clinical use of glutamine:***
  - ***Critical illness***
  - ***Surgery- pre- & post-op***
  - ***Oncology***

  0.35- 0.57 g GLN/ kg BW per day for at least 5 days
- ***No evidence of harm has been observed in studies***

Nutrition in Clinical Practice 18: 377-385, 2003

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ESPEN Guidelines: Fish oil

ELSEVIER

ESPEN Guidelines on Parenteral Nutrition: Intensive care

Pierre Singer [a], Mette M. Berger [b], Greet Van den Berghe [c], Gianni Biolo [d], Philip Calder [e], Alastair Forbes [f], Richard Griffiths [g], Georg Kreyman [h], Xavier Leverve [i], Claude Pichard [j]

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ESPEN ICU Guidelines, Clinical Nutrition, Aug 2009

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Addition of EPA & DHA to lipid emulsions has demonstrable effects on cell membranes and inflammatory processes.

Fish oil-enriched lipid emulsions probably decrease length of stay in critically ill patients. (B)

ESPEN ICU Guidelines, Clinical Nutrition, Aug 2009

ASPEN Guidelines: Fish oil

Guidelines for the Provision and Assessment of Nutrition Support Therapy in the Adult Critically Ill Patient:

Volume 33 Number 3
May/June 2009 277-316

10.1177/0148607109335234
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ASPEN-SCCM ICU Guidelines, JPEN, May-June 2009

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Immune-modulating EN formulas (w/ agents such as glutamine, arginine*, ω-3 fatty acids, AOx, NA) should be used for:

- ***major elective surgery***
- ***trauma (ATI >20)***
- ***critically ill patients on mechanical ventilation***
- ***head & neck cancer***
- ***burns (>30% BSA)***

Surgical ICU patients (A) Medical ICU patients (B) *Caution in severe sepsis

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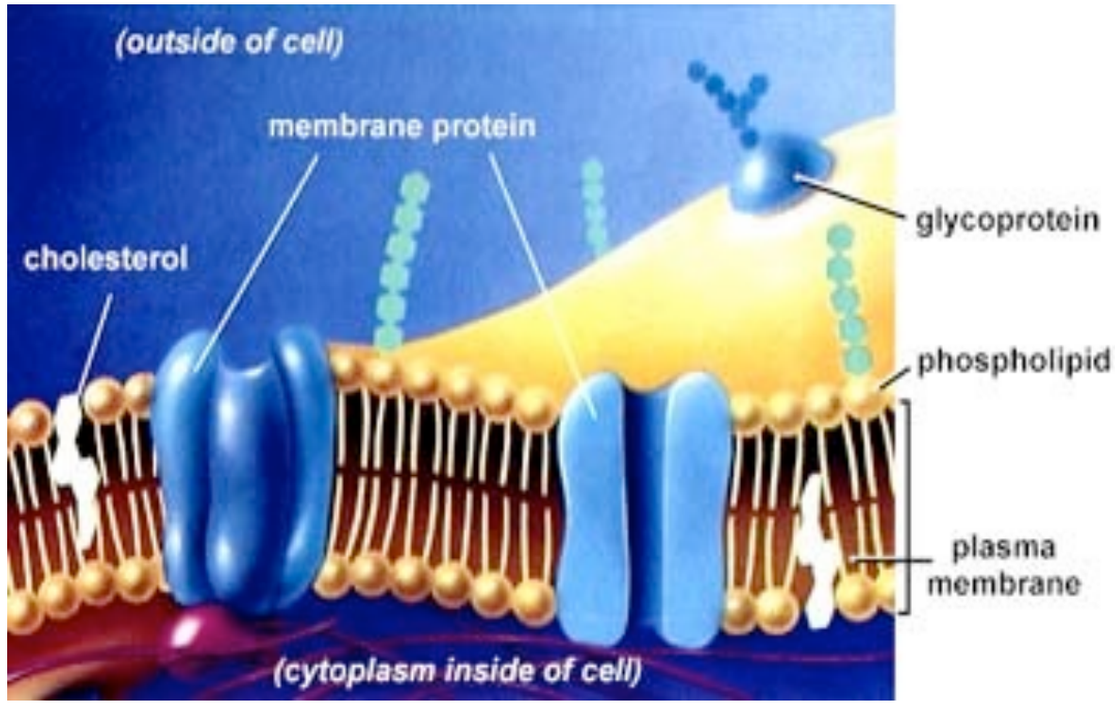
Surgical ICU patients (A) Medical ICU patients (B) *Caution in severe sepsis

Patients with ARDS & severe ALI should be placed on an enteral formulation characterized by an anti-inflammatory lipid profile (ie, ω-3 fish oils, borage oil) and antioxidants. (Grade A)

ASPEN-SCCM ICU Guidelines, JPEN, May-June 2009

Benefits of ω-3 FA in clinical nutrition

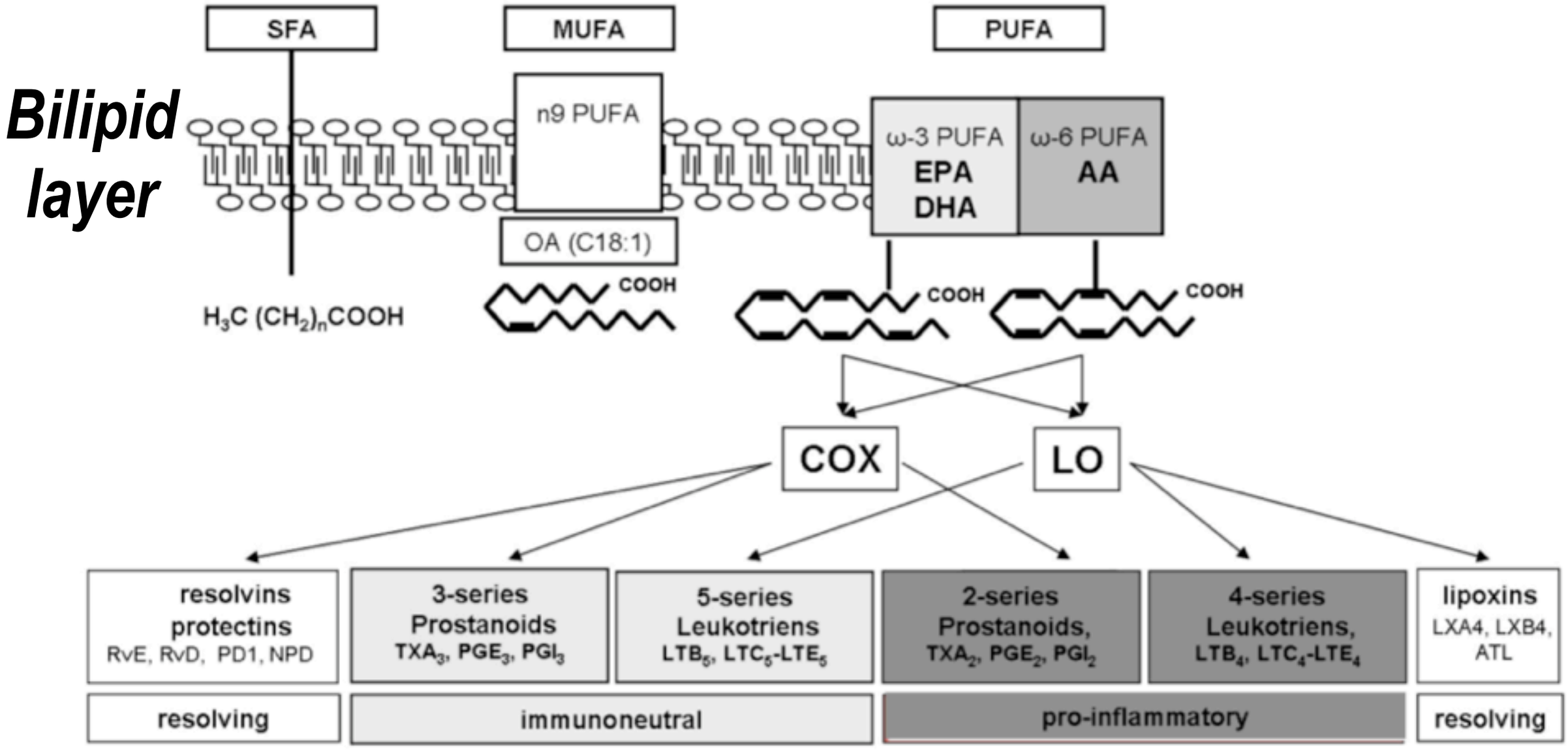
- *Biologic effects of ω-3 FA: immune-modulating, organ-protective*



- *ω-3 FA are incorporated in phospholipid pool of cell membranes and replace the ω-6 FA thereby increasing membrane fluidity and favorably influencing lipid mediator and cytokine production*

Koch & Heller, Clin Nutr Supp, Jan 2005

Lipid mediators from ω-6 & ω-3 fatty acids



Wendell & Heller. Anti-Cancer Agents in Medicinal Chemistry, 2009, Vol. 9, No. 4

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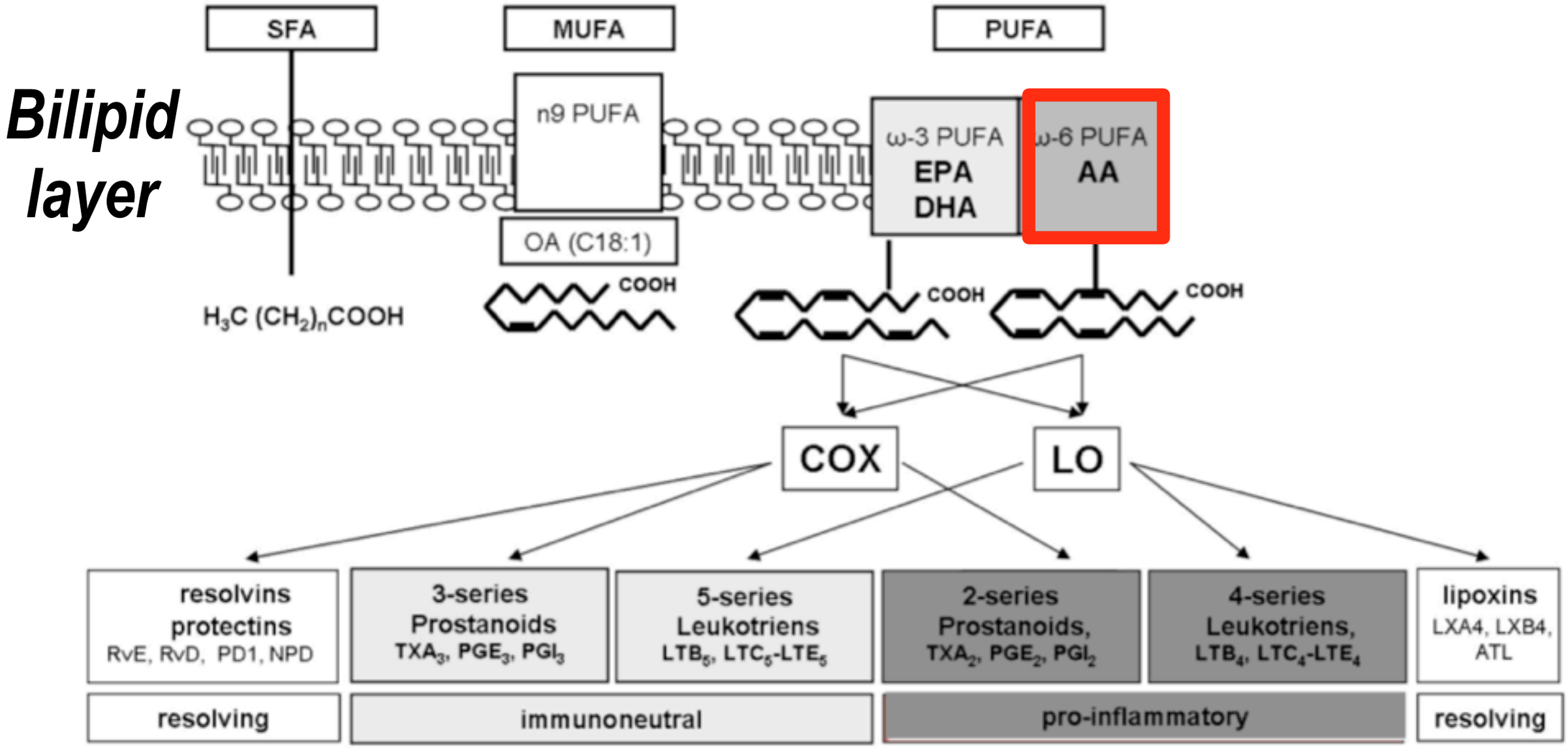

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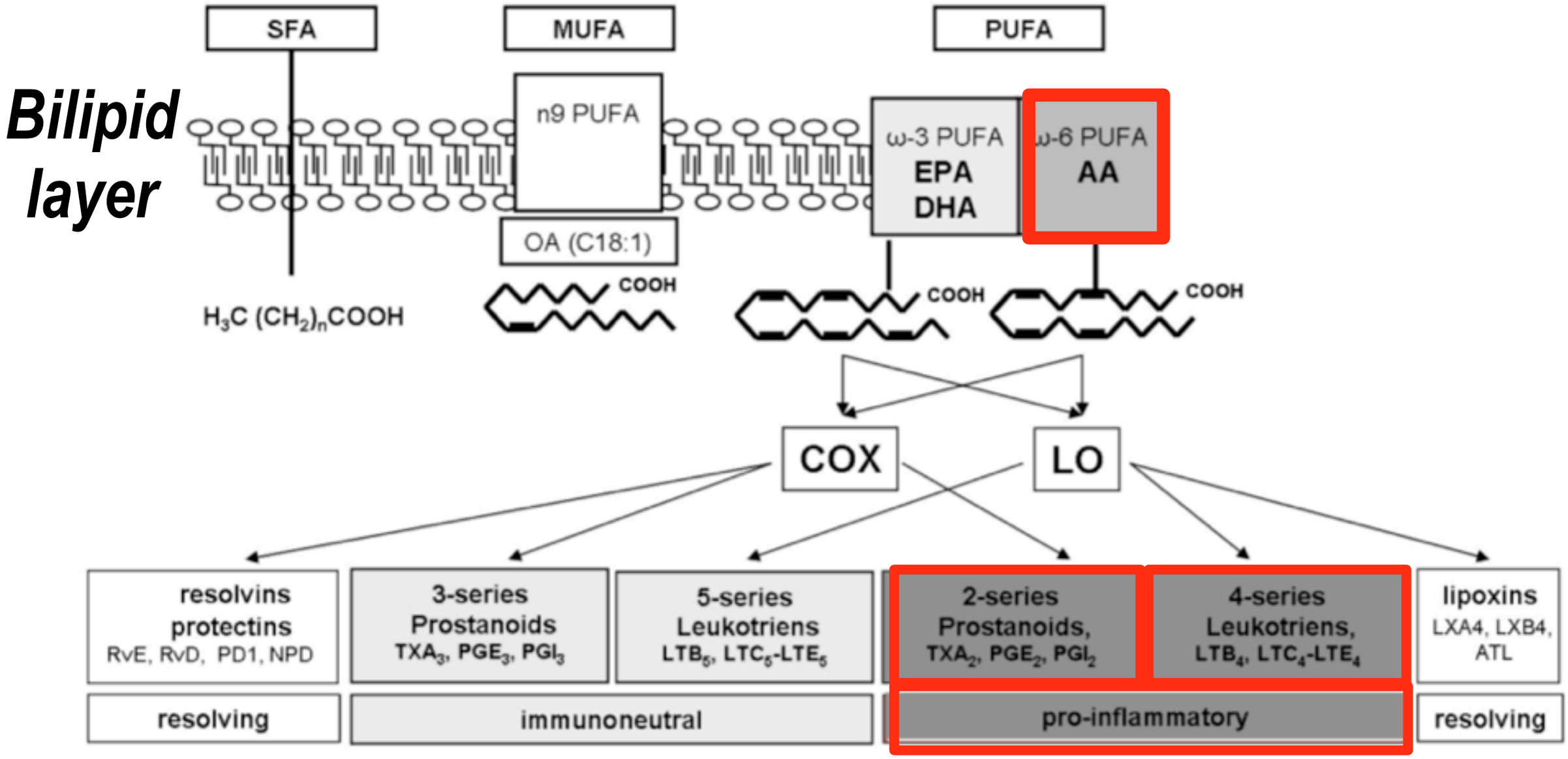

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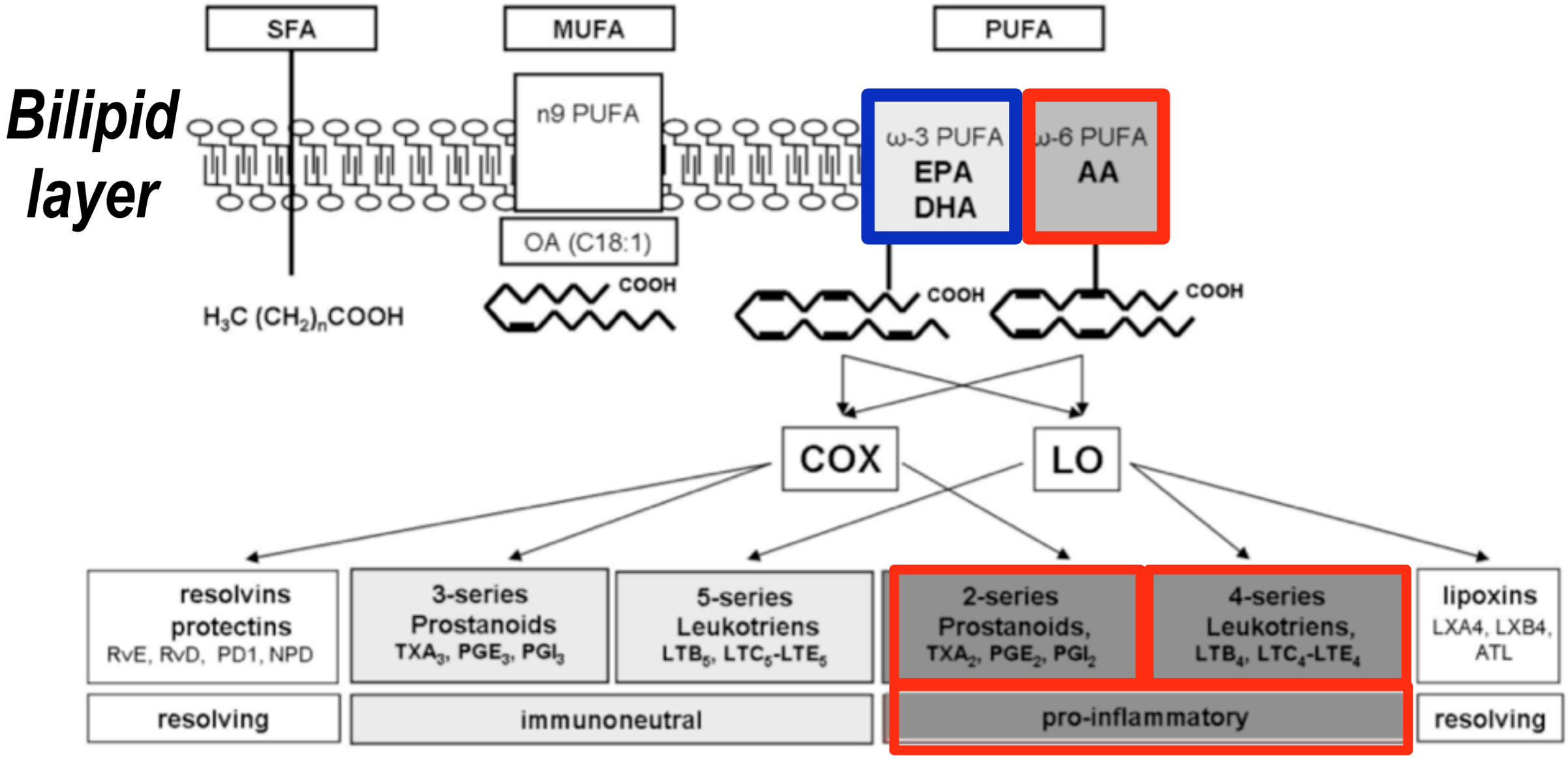

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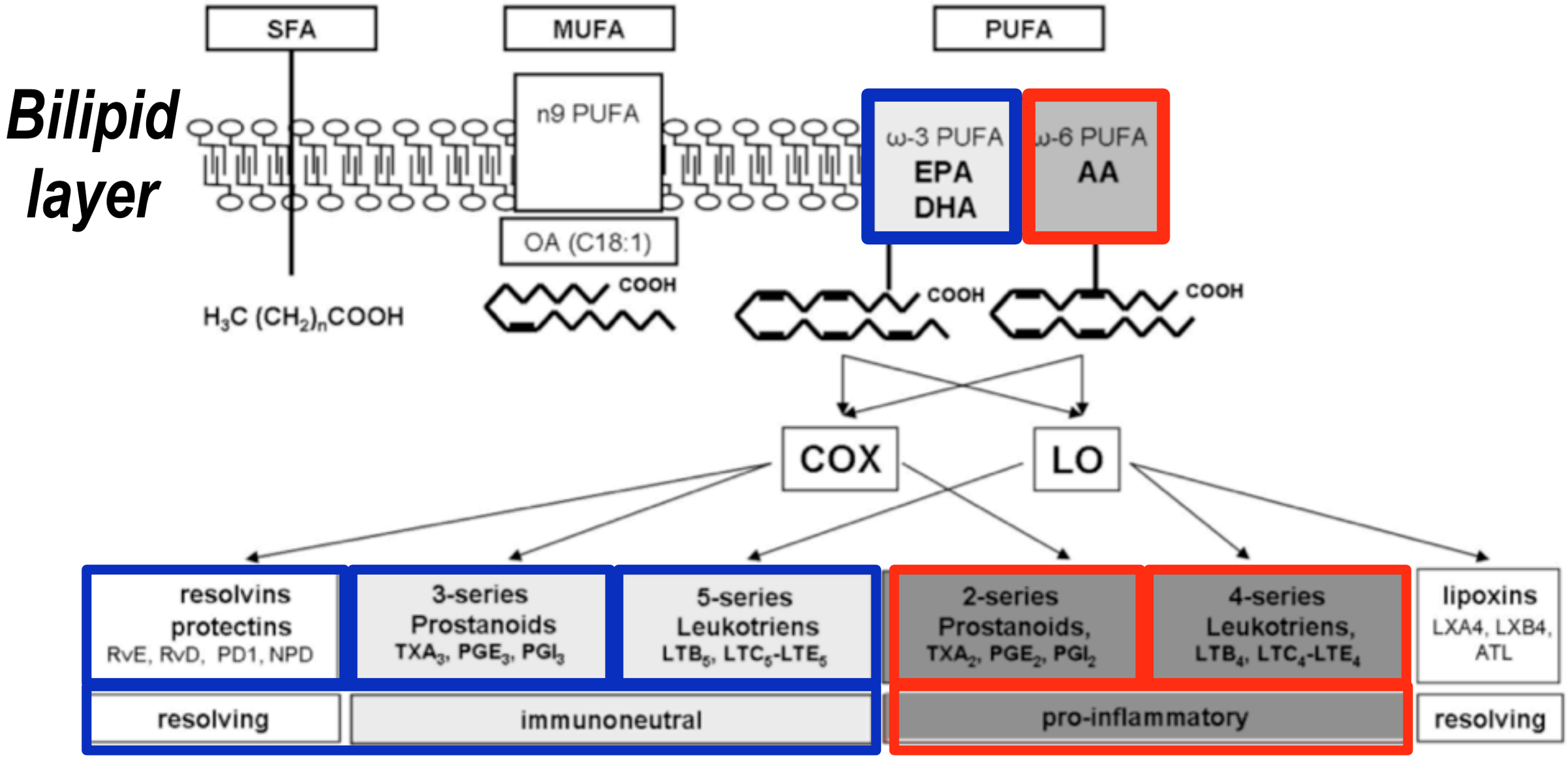

Wendell & Heller. Anti-Cancer Agents in Medicinal Chemistry, 2009, Vol. 9, No. 4

Invited Review

Fish Oil Lipid Emulsions and Immune Response: What Clinicians Need to Know

Nutrition in Clinical Practice
Volume 24 Number 4
August/September 2009 487-499

10.1177/0884533609339071
http://ncp.sagepub.com
hosted at
http://online.sagepub.com

Dan Linetzky Waitzberg, MD, PhD; and Raquel Susana Torrinhas, RB, MSc

- ***ω-3 PUFA (EPA & DHA) in fish oil can modulate inflammation through its effects on the immune response***
- ***Parenteral infusion of ω-3 PUFAs is advantageous, especially in severely ill patients***
- ***Fish oil lipid emulsion decreases the length of hospital and ICU stay in surgical patients***
- ***Currently available lipid emulsions containing fish oil:***
  (1) Only fish oil (Omegaven);
  (2) Fish oil in a balanced fat mixture (SMOF lipid)
  (soybean oil-- MCT-LCT -- olive oil -- fish oil)

Clinical benefits of fish oils

- *Improved ventilation parameters*
- *Reduced infectious complications*
- *Better preservation of organ function*
- *Reduced number of new organ failures*
- *Shorter ICU stay*
- *Shorter hospital stay*
- *Possible mortality benefit*
- *Potential anti-cancer effects*

Key messages from guidelines

- ***Assess nutrition risk in all surgical/ hospital patients***
- ***Initiate EN early (w/in 24-48hr) to stimulate gut immunity***
- ***Supplement PN early (w/in 48-72hr) when gut dysfunction prevents reaching targets with EN alone***
- ***Determine requirements accurately; avoid hyperglycemia***
- ***Optimize nutrition strategy by using dual-energy with lipids & glucose in a 3-chamber bag (AIO) over 24 hrs***
- ***Consider pharmaconutrients esp. glutamine, fish oils***

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- *systematically developed*
- *to assist practitioners*
- *making patient care decisions*
- *in specific clinical circumstances*

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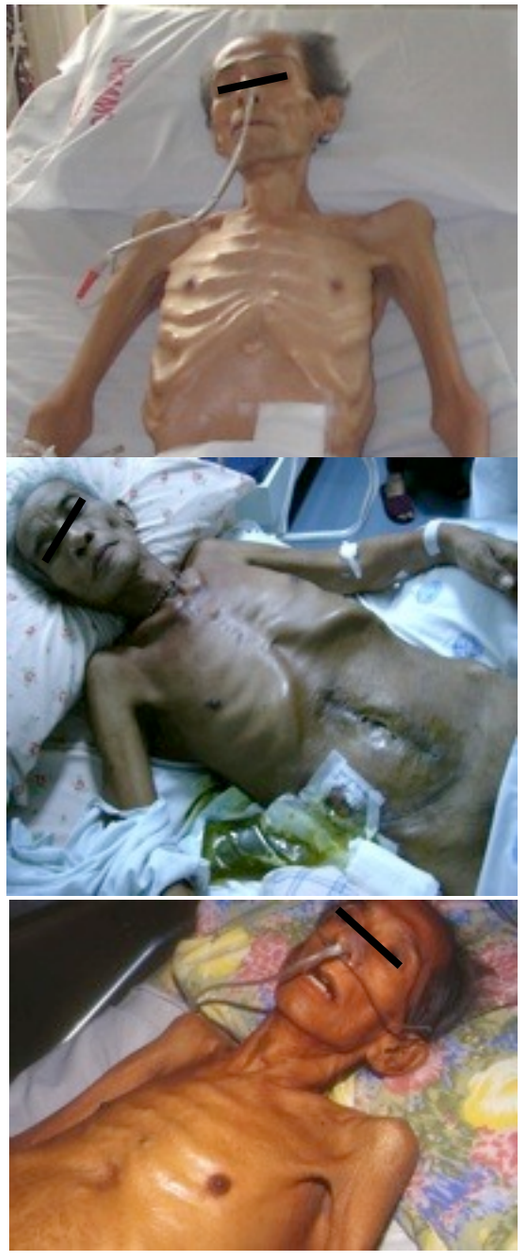

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CLINICAL PRACTICE

There is sufficiently robust evidence to support astute, well-informed clinicians in the rational implementation of clinical nutrition therapy.