What is Excellent Supportive Care in Patients with Acute Kidney Injury?

How Do I Feed the Patient?

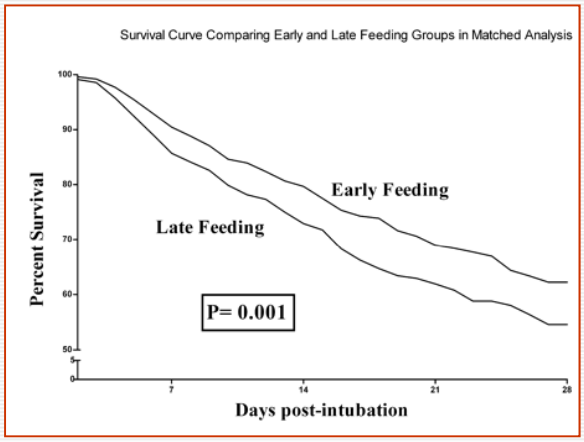
Wilfred Druml, MD
Division of Nephrology
Vienna General Hospital
Medical University of Vienna
Vienna, Austria

wilfred.druml@meduniwien.ac.at

Renal Week – ASN Denver 2010

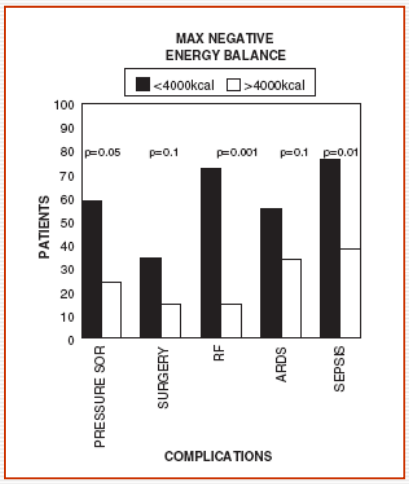
Effects of Early Enteral Feeding on the Outcome of Critically Ill Mechanically Ventilated Medical Patients

Artinian V. et al. ***Chest 2006; 129; 960-67***



Estimates of survival among 1,264 critically ill medical patients in early feeding group and 1,264 patients in late feeding group. Groups were matched according to likelihood they would be fed by using a propensity score.

Computerized energy balance and complications in critically ill patients: An observational study



Dvir D et al.
Clin Nutr 2006; 25; 37-44

Complications according to cumulative energy balance above or below 4000 kcal. RF = renal failure.

„EARLY GOAL DIRECTED NUTRITION“

Nutrition Support in the Acutely / Critically Ill Patient should be...

- initiated EARLY (= within 24 h after admission)
- quantitatively sufficient
  (= GOAL-defined/ directed)
- complete (including micronutrients)
- qualitatively adapted (specific nutrients?)
- and must be monitored

Nutrition Support in AKI

…unfortunately, very few and mostly quite old studies on this subject…

Nutrition Support in AKI

Metabolic Perturbations in AKI

- renal dysfunction ("acutely uremic state")
- SIRS / acute phase reaction - acute disease state
- underlying illness (type, severity, duration)

plus

- general effects of extracorporal circulation /RRT (bioincompatibility etc.)
- specific effects of CRRT (nutrient loss etc.)

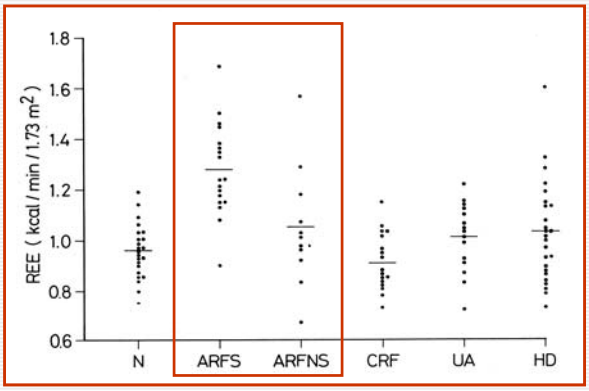
Nutrition Support in AKI

Specific Metabolic Derangements Induced by AKI…

- Activation of protein catabolism
- Periphereal insulin resistence
- Inhibition of lipolysis
- Metabolic acidosis
- Induction of an inflammatory reaction
- Hyperparathyreoidism/ impairment of vitamin D_3 – activation
- Reduced potassium tolerance / hyperkalemia
- Augmented response to additional intercurrent disease (i.e. infections, acidosis, nuritent deficiencies)

Energy Metabolism in Acute Renal Failure and Chronic Renal Failure

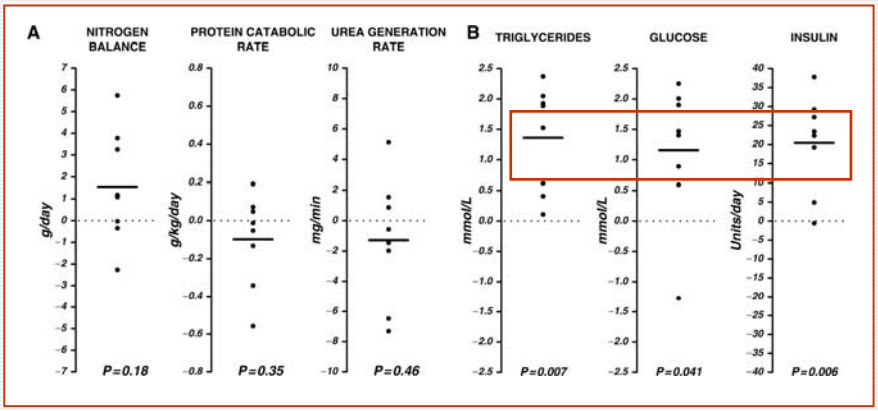
Schneeweiss B et al. ***Am J Clin Nutr 1990; 52: 596-601***



Resting energy expenditure in healthy controls (N), patients with ARF and sepsis (ARFS), ARF without sepsis (ARNS), chronic renal failure (CRF), advanced uremia (UA) and on regular hemodialysis therapy (HD)

Effects of different energy intakes on nitrogen balance in patients with acute renal failure

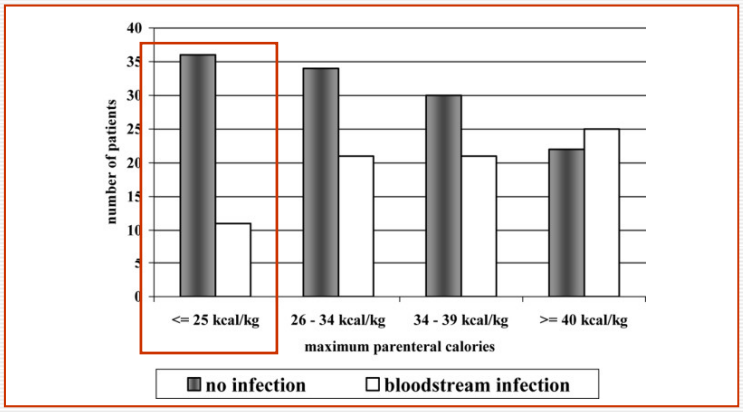
Fiaccadori Enrico et al. ***NDT 2005; 20: 1976-80***



Differences between the higher calorie-TPN (40 kcal/kg/d) and lower calorie-TPN regimens (30 kg/KG/d) during 3 days in terms of nitrogen balance, protein catabolic rate and urea generation rate, of triglycerides, glucose and daily insulin use.

The risk for bloodstream infections is associated with increased parenteral caloric intake in patients receiving parenteral nutrition

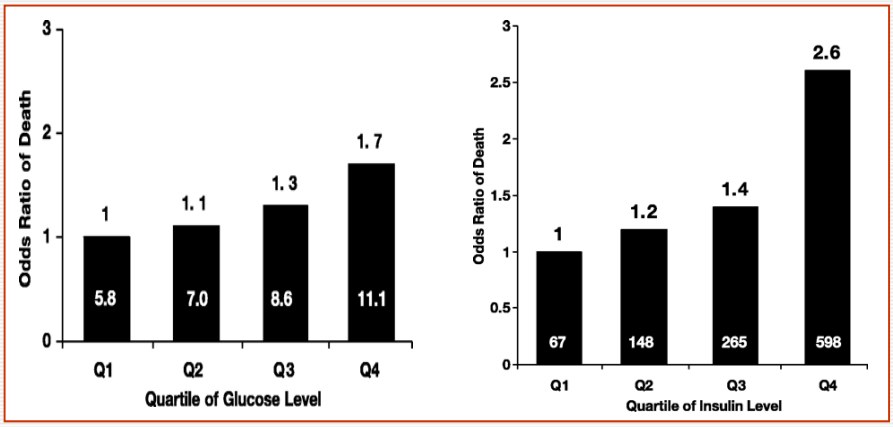
Dissanaike S *et al.* ***Critical Care 2007 11:R114***



Occurrence of bloodstream infections according to quartile of maximum daily parenteral caloric intake

Insulin resistance in critically ill patients with acute renal failure

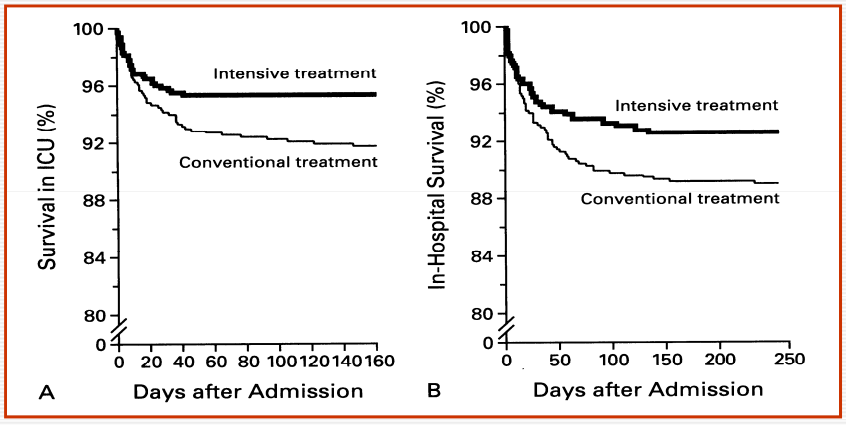
Basi S et al. *Am J Physiol 2005;289: F259-F264*



Risk profile for glucose level (left) and insulin level (right) in quartiles in subset of 90 patients (P = 0.03)

Intensive Insulin Therapy in Critically Ill Patients

Van den Berghe G. et al *N Engl J Med 2001; 345: 1359*



Kaplan-Meier Curves Showing Cumulative Survival of Patients Who Received Intensive Insulin Treatment or Conventional Treatment (discharged alive from ICU - Panel A, from the hospital - Panel B)

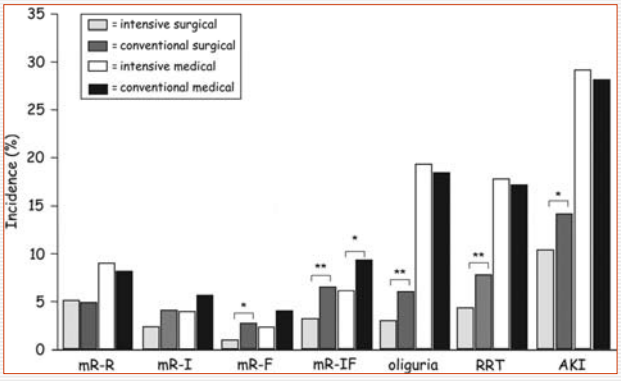
Intensive Insulin Therapy in Critically Ill Patients

Van den Berghe G. et al ***N Engl J Med 2001; 345: 1359-67***

Variable		Conventional (N = 783)	Intensive (N = 765)	p - Value
> 14 d intensive care	%	15.7	11.4	0.01
> 14 d ventilation	%	11.9	7.5	0.003
ARF/ HD - CRRT	%	8.2	4.8	0.007
Hyperbilirubinemia	%	26.7	22.4	0.04
CI-polyneuropathy	%	51.9	28.7	0.001
No. of transfusions/pat		2	1	0.001
Cummulative TISS-28		563	431	0.001
Death/ MODS+ Sepsis		33	8	0.02
Mortality	%	10.9	7.2	0.01

Tight blood glucose control is renoprotective in critically ill patients

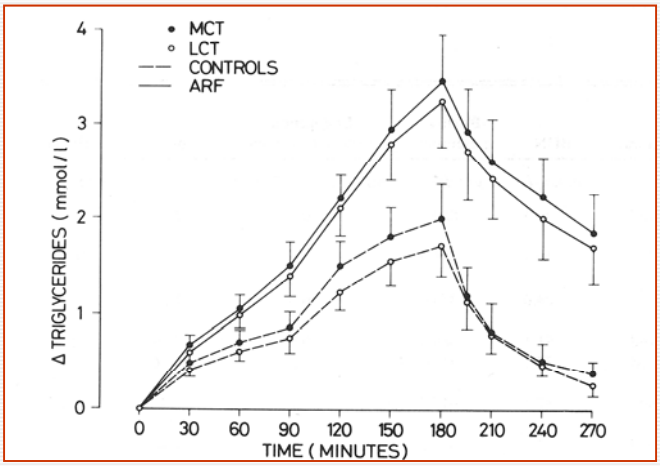
Schetz M et al. ***J Am Soc Nephrol. 2008;19:571-8.***



Impact of IIT *versus* conventional treatment on the incidence of different renal outcome categories (RIFLE) in surgical and medical patients. *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

Fat Elimination in Acute Renal Failure : long-chain vs medium-chain triglycerides

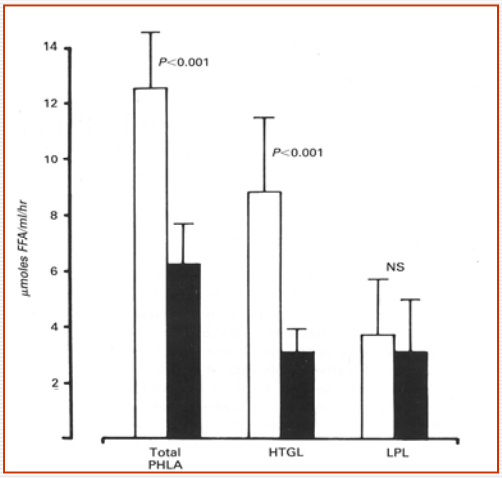
Druml W et al. *Am J Clin Nutr 1992; 55: 468 - 472*



Increase in plasma triglycerides above basal concentrations

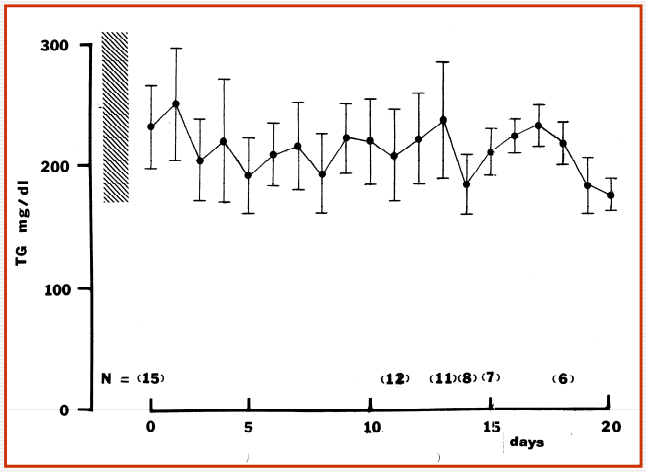
Lipid Metabolism in ARF

Druml W et al. *Kidney Int 1983; 24 (Suppl.16): S-139-142*



Total post-heparin lipolytic activity (PHLA), hepatic triglyceride lipase (HTGL), and lipoprotein lipase activity (LPL) in ARF

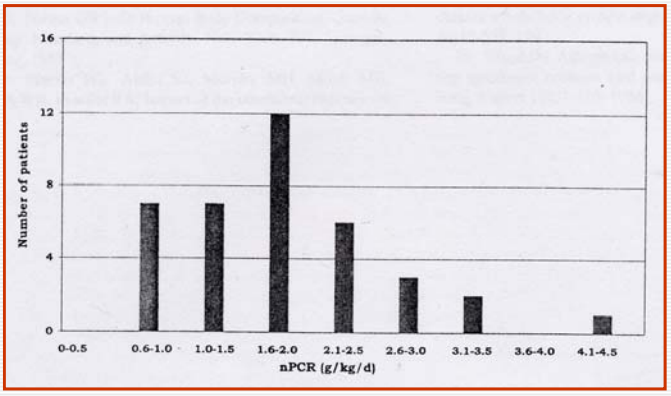
Lipid Utilization in Acute Renal Failure



Plasma triglycerides during infusion of 1 g/kg.b.w./day of a lipid emulsion in patients with acute renal failure

Catabolism in critical illness: estimation from urea nitrogen appearance and creatinine production during CRRT

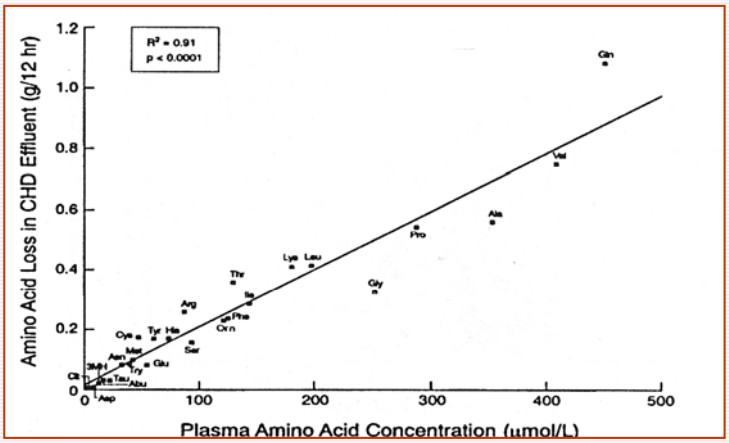
Leblanc M et al. ***Am J Kidney Dis 1998; 32:444-53***



Distribution of nPCR in g/kg per day in the 38 patients

Amino Acid Loss and Plasma Concentrations During Continuous Hemodiafiltration

Frankenfield DC et al. *JPEN 1993; 17: 551 - 61*



Mean losses of individual amino acids in CHD effluent as a function of mean plasma concentrations of each amino acid.

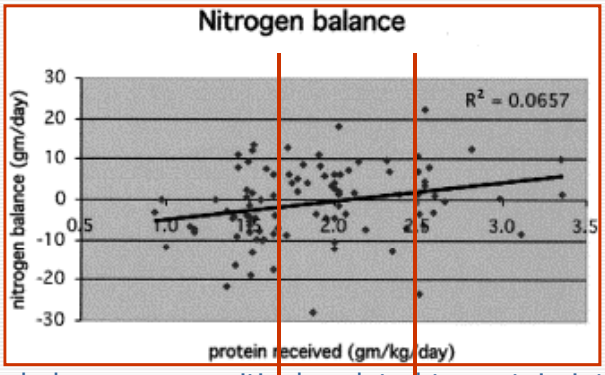
Nutrition in Critically Ill Patients with Acute Renal Failure

Protein / Amino Acid - Requirements

Author	Year	Modality	PCR	recomm. intake (g/kg b.w./day)
Kierdorf	1991	CVVH	1.5	1.5
Chima	1993	CAVH	1.7±0.7	1.6 - 1.8
Ikizler	1995	HD	1.74±0.6	> 1.5
Macias	1996	CVVH	1.4 - 1.6	> 1.5
Leblanc	1998	CVVH	1.75±0.8	> 1.5

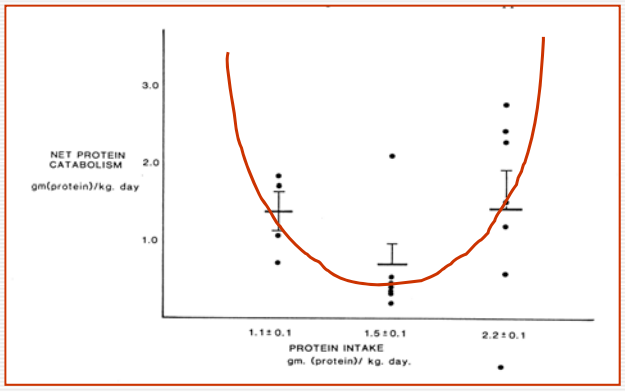
Prospective randomized trial to assess caloric and protein needs of critically Ill, anuric, ventilated patients requiring CRRT

Scheinkestel CD et al. *Nutrition 2003; 19: 909*



Nitrogen balance was positively related to protein intake (P = 0.0075) and was more likely to become positive with protein intakes larger than 2 g · kg^{-1} · d^{-1} (P = 0.0001)

Amino Acid / Protein Intake What do we want ?

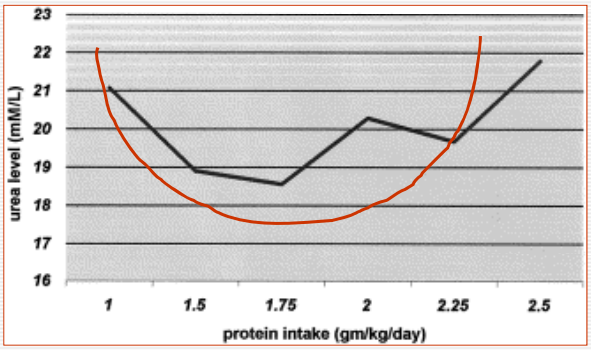


Rates of net proten catabolism in septic patients receiving TPN at three rates of protein intake

from Shaw JHF et al. *Ann Surg 1987; 205: 288 -294*

Impact of increasing parenteral protein loads on amino acid levels and balance in critically ill anuric patients on continuous renal replacement therapy

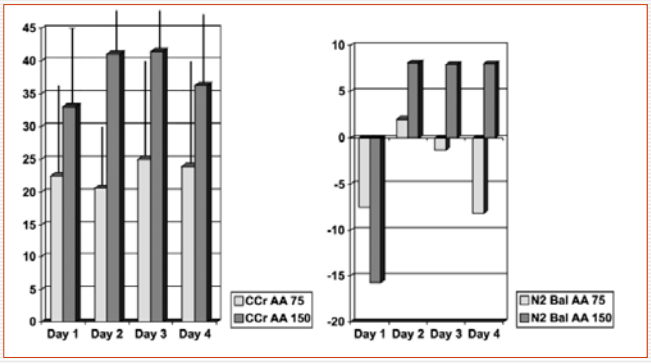
Scheinkestel CD et al. ***Nutrition 2003; 19:733***



Average urea level on each feeding regimen
(1 to 2.5 g · kg^{-1} · d^{-1} of protein input)

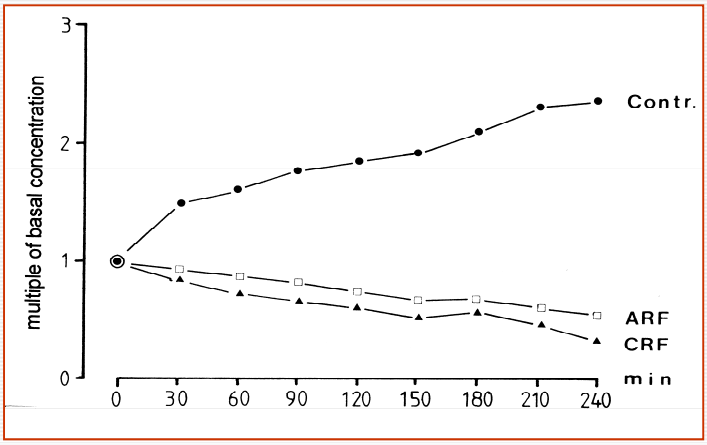
High-dose amino acid infusion preserves diuresis and improves nitrogen balance in non-oliguric acute renal failure

Singer Pierre ***Wien klin Wochenschr 2007; 119: 218-22***



Daily variations of creatinine clearance and nitrogen balance in the groups with low (75 g/day) (N = 6) and high (150 g/day) (N = 8) amino acid intake

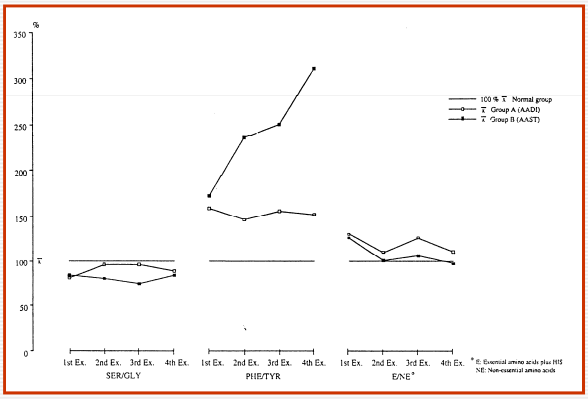
Phenylalanine and Tyrosine Metabolism in Renal Failure



Plasma concentrations of tyrosine after infusion of a phenylalanine containing amino acid solution

Influence of a Novel Amino Acid Solution (enriched with dipetide Glycyl -Tyrosine) on Plasma Amino Acid Concentrations of Patients with ARF

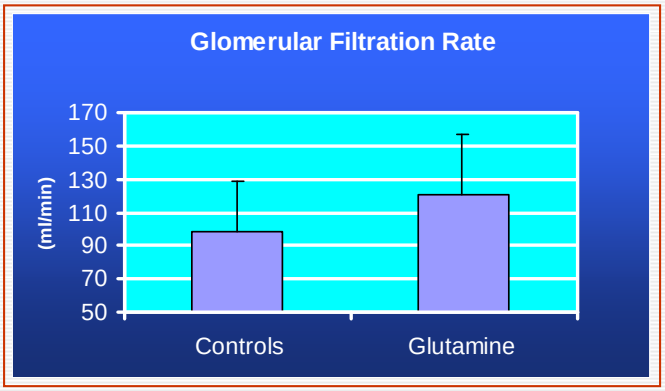
Smolle KH et al. ***Clin Nutr 1997; 16: 239 - 246***



Changes of the serine/ glycine, phenylalanine/ tyrosine and essential/ non-essential amino acid ratios in plasma

An oral glutamine load enhances renal acid secretion and function

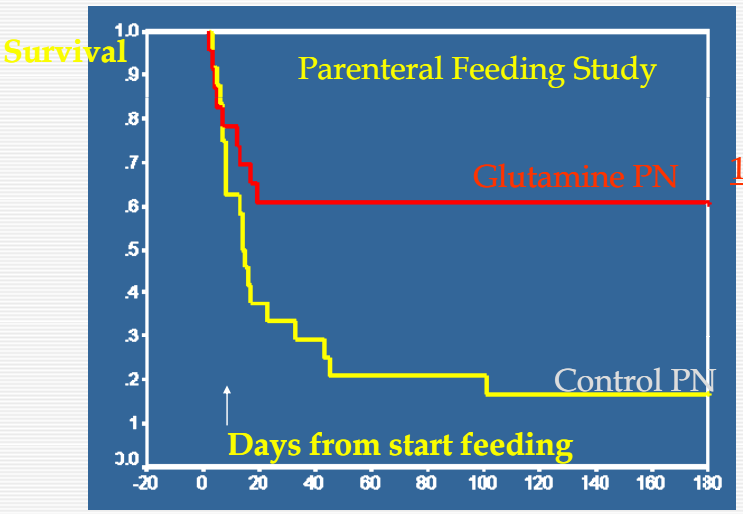
Welbourne T et al. *Am J clin Nutr 1998; 67: 660-3*



Impact of oral glutamine (2g) on renal function

Survival of renal failure patients

APACHE II score > 10 and renal organ failure at some point in ICU stay



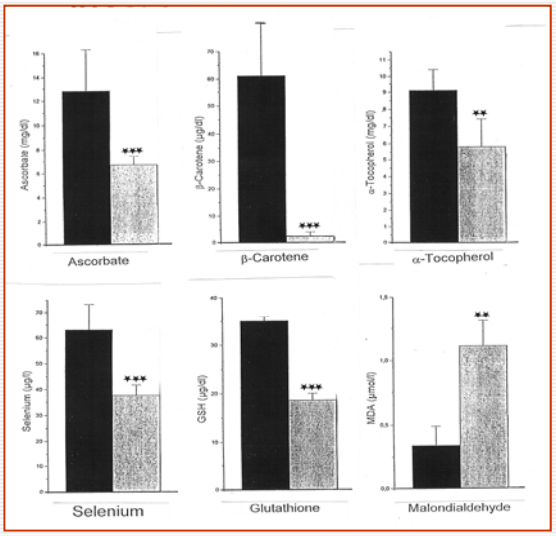
14 survivors
23 ARF

(p=0.02)

4 survivors
24 ARF

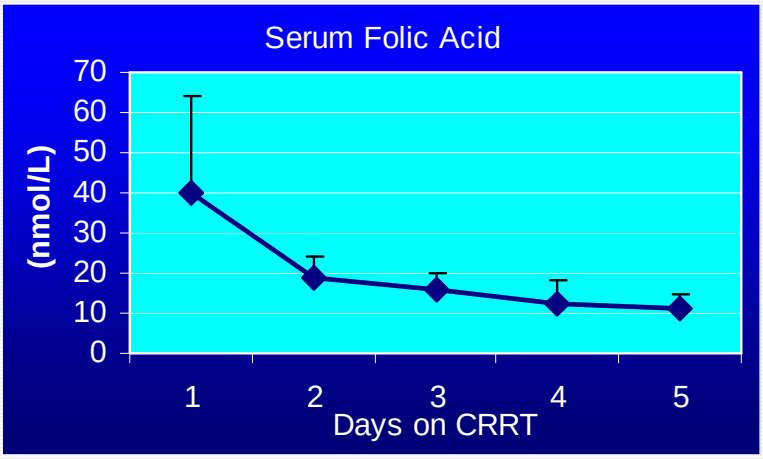
Griffiths, Jones, Palmer. Nutrition 1997; 13:295-302

Antioxidant Status in AKI



adapted from Metnitz PGH & Druml W.
Acta Aaesthest Scand 2000; 44: 236-240

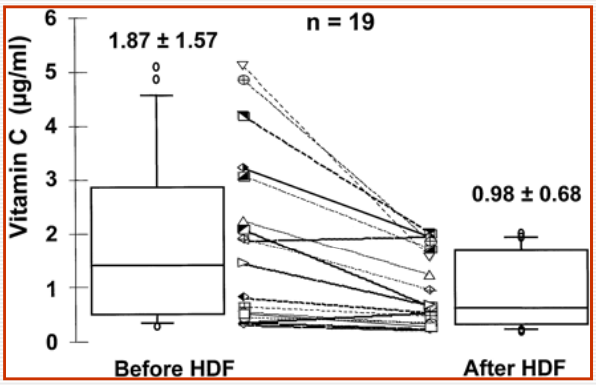
Serum concentrations and clearances of folic acid during venovenous CRRT



Fortin M-C et al. *Intensive Care Med 1999; 25: 594 - 598*

Convective and diffusive losses of vitamin C during hemodiafiltration session: a contributive factor to oxidative stress in HD patients

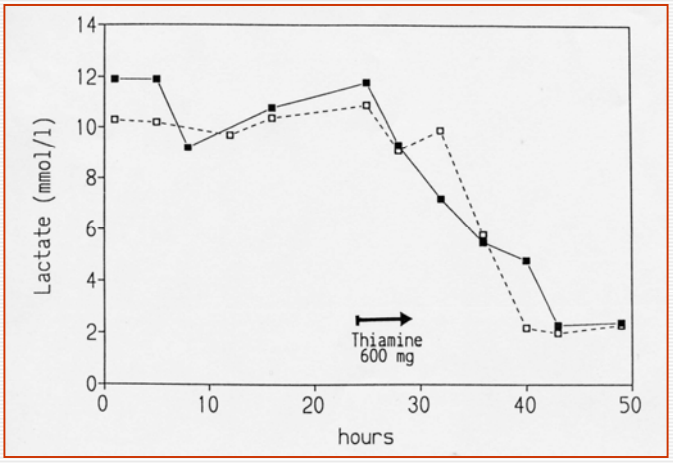
Morena M. et al. *NDT 2002; 17: 422-27*



Dialytic losses of vitamin C (*n*=19). Blood samples were collected before and after HDF session

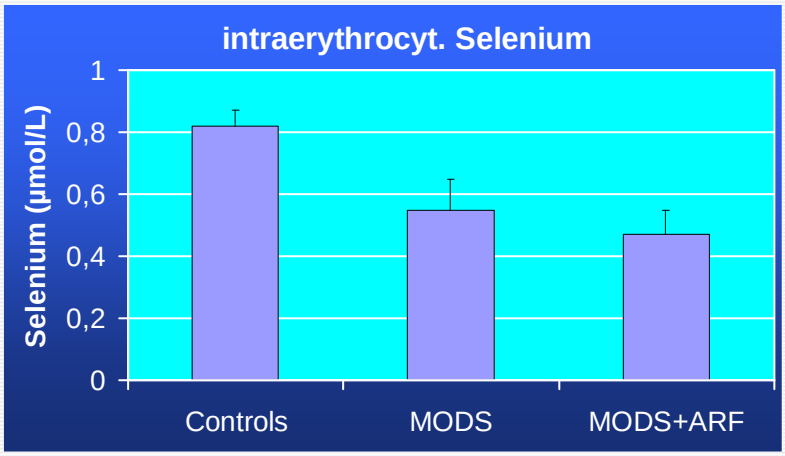
Lactic Acidosis in Thiamine - Deficiency

Madl Christian et al. *Clin Nutr 1993; 12: 67*



Plasma lactate concentrations in two patients with thiamine deficiency before and after thiamine infusion

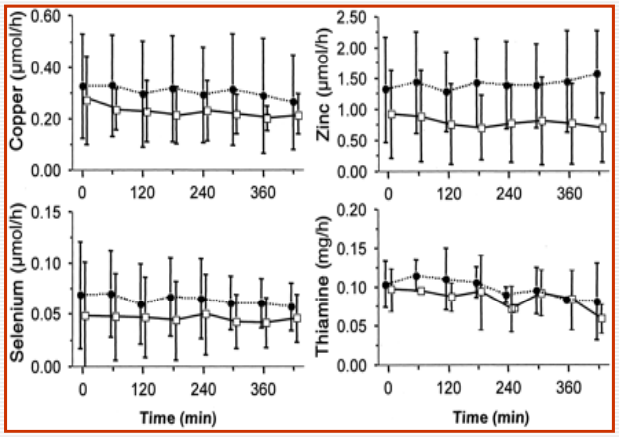
Impact of ARF on Antioxidant Status in Multiple Organ Failure



adapted from Metnitz PGH & Druml W.
Acta Aaesth Scand 2000; 44: 236-240

Copper, selenium, zinc, and thiamine balances during CVVHDF in critically ill

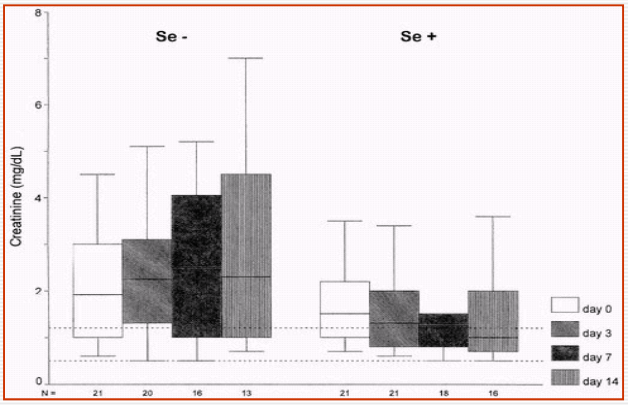
Berger Mette et al. *Am J clin Nutr 2004; 80: 410*



Copper, selenium, zinc, and thiamine concentrations in effluents from patients with ARF during CRRT with sodium bicarbonate (Bic group; •) or sodium lactate (Lac group;) as a buffer

Selenium replacement in patients with severe SIRS improves clinical outcome

Angstwurm MWA et al. ***Crit Care Med 1999; 27: 1807-13***



Creatinine (mg/dL) values in patients in the Se– (control) group and the Se+ (selenium-treated) group at days 0, 3, 7, and 14. Se+ vs. Se–: day 3, $p = .034$; day 7, $p = .030$; day 14, $p = .057$

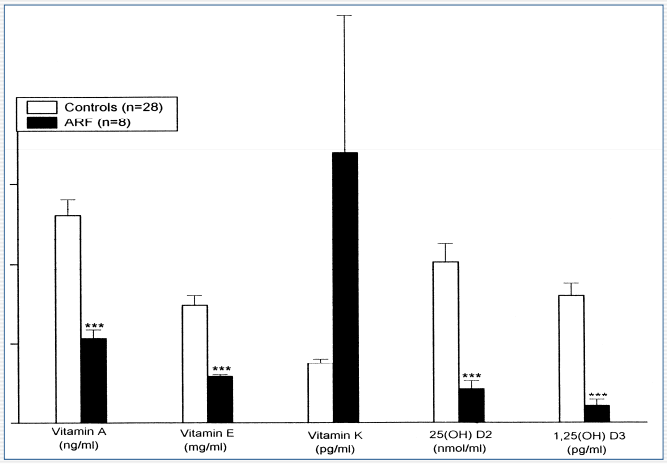
Nutrient losses during RRT

- Glucose / heat…
- Amino acids (glutamine)
- Peptides
- Albumin / protein
- Water soluble vitamins
- Trace elements (selenium)
- Choline
- Carnitine
- etc ....

NOTE : *These losses have to be considered when designing a nutritional regimen*

Fat Soluble Vitamins in ARF

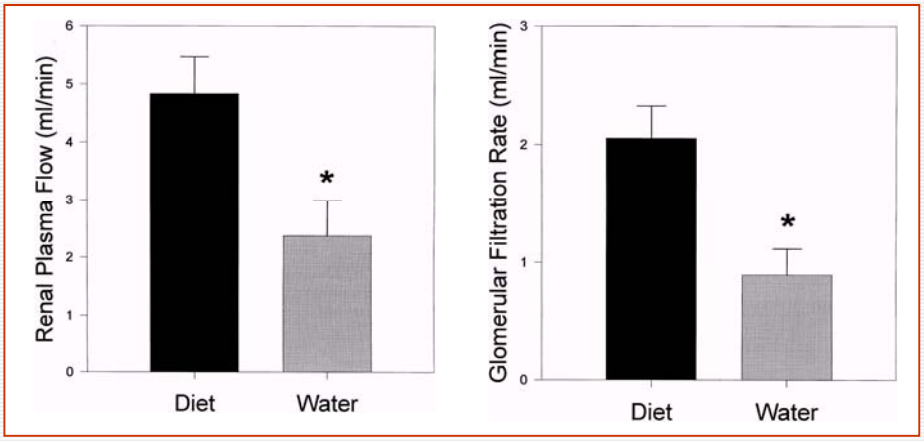
Druml W et al. ***Min Electrolyte Metab 1998; 24: 220-26***



Plasma concentrations of fat soluble vitamins in patients with ARF

Enteral Feeding Improves Outcome and Protects against Gly-induced ARF

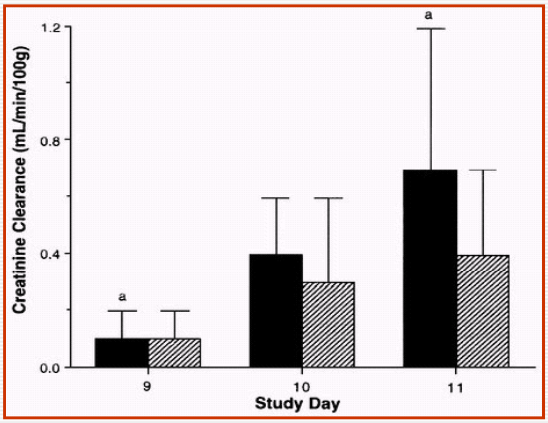
Roberts PR et al. ***Am J Respir Crit Care Med 1997; 156: 1265***



Renal plasma flow and glomerular filtration rate (ml/min) after glycerol injection (rhabdomyolysis) in animals receiving an enteral diet versus water. * indicates $p < 0.05$

Recovery from ischemic ARF is improved with EN compared with PN

Mouser JF et al. *Crit Care Med 1997; 25: 1748-54*



Creatinine clearance (mean/SD) in rats infused with enteral nutrition (solid bars) or parenteral nutrition (hatched bars).[a] $p < .05$)

Effect of ARF Requiring Renal Replacement Therapy on Outcome in Critically Ill Patients

Metnitz PGH et a *Crit Care Med 2002; 30 : 2051-57*

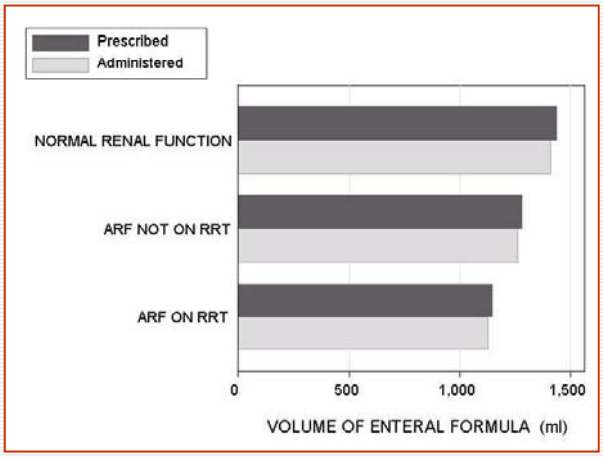
Multvariate predictors : Results of stepwise logistic regression analysis

Variable	Estimate	*p* Value	Odds Ratio
Intercept	−2.58460	<.001	
SAPS II score	0.00798	.166	1.08
Cardiopulmonary resuscitation	0.06160	.004	1.86
Multiple vasoactive medication	0.02930	<.001	1.34
Mechanical ventilation	0.02930	<.001	1.34
Single vasoactive medication	0.01160	.012	1.13
Treatment of complicated metabolic acidosis/alkalosis	0.00768	.034	1.08
Care of drains	−0.00883	.002	0.91
Enteral nutrition	−0.01480	<.001	0.86

SAPS, Simplified Acute Physiology Score.

Enteral Nutrition in Acute Renal Failure

Fiaccadori Enrico et al. *Kidney int 2004; 65: 999-1008*



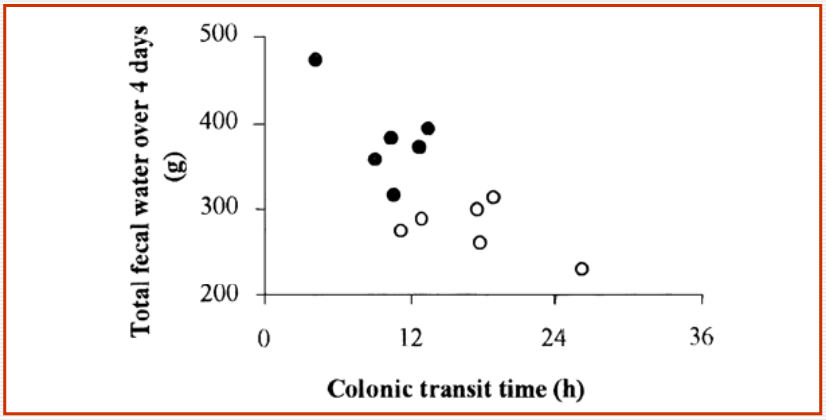
Mean prescribed and administered volumes, p 0.001 in all groups

Nutrition Support in AKI

…whenever possible prefer the enteral route, however,….

Small bowel motility and colonic transit are altered in dogs with moderate renal failure

Lefebvre HP et al. *Am J Physiol 2001; 231: R230*



Correlation between the total amount of water excreted in feces over 4 days and the colonic transit time (P = 0.004) and values before and after RF

Nutrition Support in AKI

Limits of Enteral Nutrition in AKI

- in many cases, the underlying disease process does not allow enteral nutrition (GI surgery etc.)
- in patients with MODS various intestinal functions are severely compromised (= “intenstinal failure”)
- ARF per se has a major impact on gastrointestinal motility

Note : *the sicker a patient is, the more difficult it is to provide a quantitatively sufficient enteral nutrition !!*

Nutrition Support in AKI

...in many patients a combination of enteral and parenteral nutrition will become necessary to meet the nutrient requirements...

ENTERAL NUTRITION IN AKI

Commercial Formulas

- specific “nephro“ (semi-) elemental (powder) formulas*
  (designed according to „low protein“ diet in CKD)
- standard (high molecular) - diets
  (ready to use, liquid formulas -
  designed for non - uremic patients)
- specific „nephro“ high molecular diets*
  (ready to use, liquid formulas, reduced or moderate protein content, various additions)

***NOTE: These diets have been designed for HD and CKD patients, but not specfically for patients with AKI**

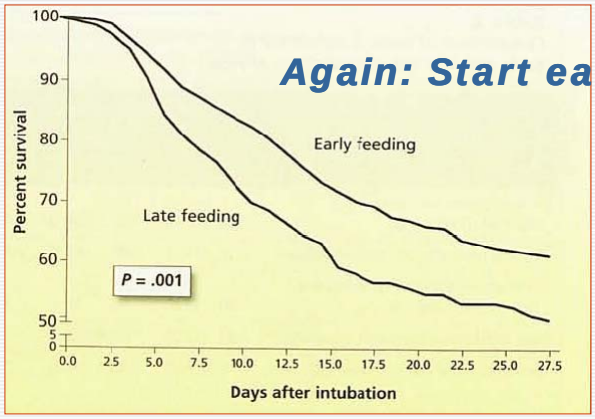
Nutrition in Acute kidney Injury

Substrate Requirements

Energy :	20 - 25 (max. 30)	kcal/kg b.w./day
Carbohydrates (glucose)	3 - 5 (max. 7)	g/kg b.w./day
Lipids	0.8 - 1.2 (max. 1.5)	g/kg b.w./day
Amino acids (protein) (essential + non-essential AA)		
conservative therapy	0.6 - 1.0 (max. 1.2)	g/kg b.w./day
extracorporal therapy	1.0 - 1.4 (max. 1.7)	g/kg b.w./day
Vitamins	(combination products)	
water soluble vit.	2 x (max. 3)	RDA/ vials/day
	(limit vitamin C intake < 250 mg/day !)	
fat soluble vitamins	1 x (max. 2)	RDA/ vials/day
Trace elements	(combination products)	
	1 x (max. 2)	RDA/ vials/day
	(higher requirement for selenium ?)	
Electrolytes (requirements must be assessed individually)		
(CAVEAT: hypokalemia and/ or hypophosphatemia after start of TPN)		

Early enteral nutrition and outcomes of critically ill patients treated with vasopressors and mechanical ventilation

Khadid I. et al. ***Am J Crit Care 2010; 19: 761-8***



Survival of the patients in the early and late enteral nutrition goups.

Nutrition Support is an Obligatory Aspect of Supportive Care in Patients with AKI

wilfred.druml@meduniwien.ac.at