Nutritional Requirements for Critically Ill Children with Acute Kidney Injury

NKF- 15th Annual Renal Professionals Forum

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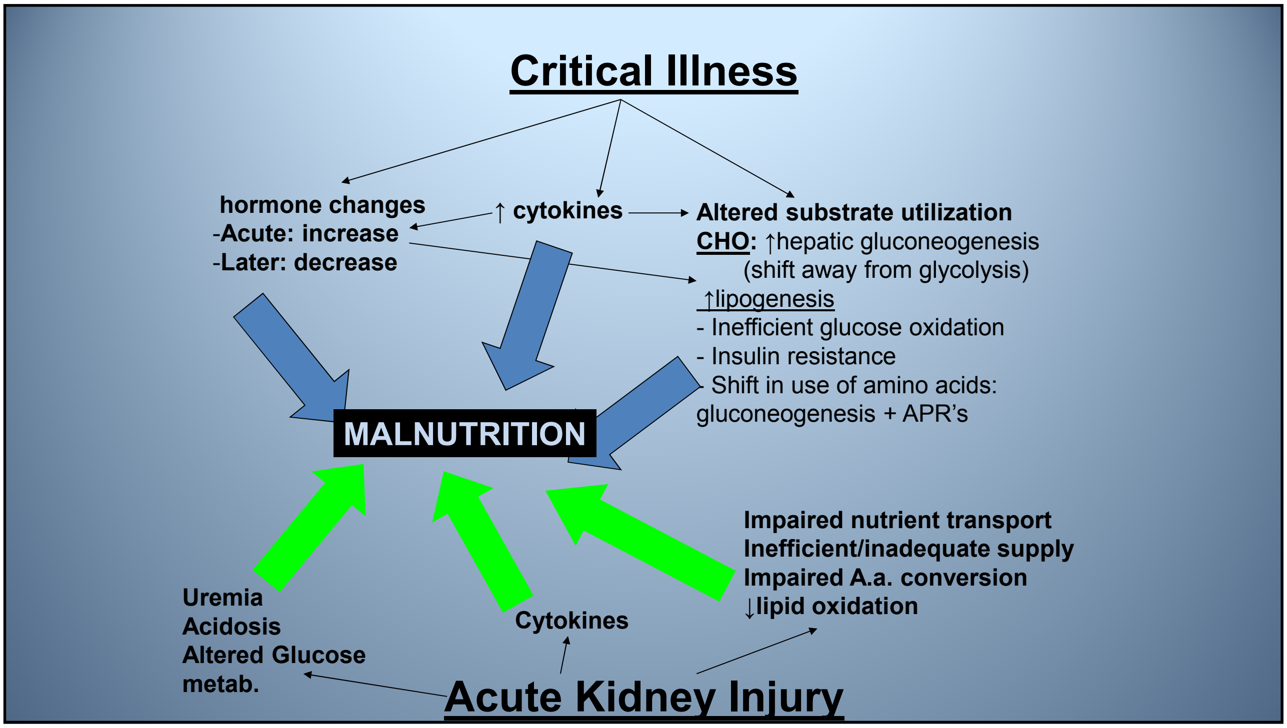
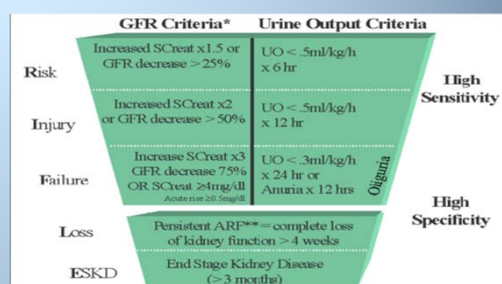
Nutritional Concerns in the Acute Phase of Critical Illness

- Critically ill patients commonly have anorexia and may be unable to feed
- Energy deficit and lean-tissue wasting, associated with adverse outcomes
- The catabolic response to acute critical illness is much more pronounced than that evoked by fasting in healthy individuals
- Immobilization, pronounced inflammation and endocrine stress response
- Nutrition support is often deferred



Pediatric Acute Kidney Injury (AKI): Definition

- The presence of malnutrition in the context of AKI is associated to increased morbidity and mortality.
  - It is not a problem restricted to the kidneys
  - It's a systemic disease process
- AKI exerts a fundamental impact
  - On the course of disease
  - The evolution of associated complications
  - Prognosis independently from the underlying disease
- Despite the advances in the ability to provide dialysis to children, the outcome of AKI remains surprisingly poor
- MORTALITY in critically ill patients
  - 53 % in the ATN trial
  - 44.7 % in the RENAL trial



Crit Care. 2005; 9(5): 523–527

Table 6 | Pediatric-modified RIFLE (pRIFLE) criteria

	Estimated CCl	Urine output
Risk	eCCl decrease by 25%	<0.5 ml/kg/h for 8 h
Injury	eCCl decrease by 50%	<0.5 ml/kg/h for 16 h
Failure	eCCl decrease by 75% or eCCl <35 ml/min/1.73 m^2	<0.3 ml/kg/h for 24 h or anuric for 12 h
Loss	Persistent failure >4 weeks	
End stage	End-stage renal disease (persistent failure >3 months)	

eCCl, estimated creatinine clearance; pRIFLE, pediatric risk, injury, failure, loss and end-stage renal disease.

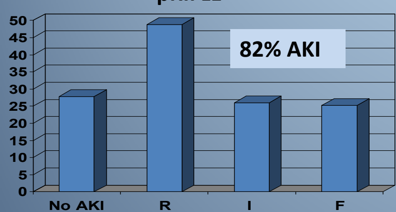
Kidney International (2007) **71**, 1028–1035.

Pediatric AKI: A common problem in critically ill children

- General PICU

Most Critically ill children
Vasopressors/Ventilated
Urinary catheter

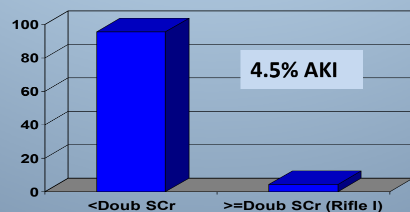
pRIFLE



Kid Int 2007; 71: 1028-35

All PICU
Admx SCr baseline

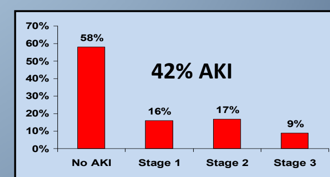
SCr Doubling (pRIFLE I)



Pediatr Crit Care Med 2007; 8:29 –35

All PICU stay>48hrs

pRIFLE

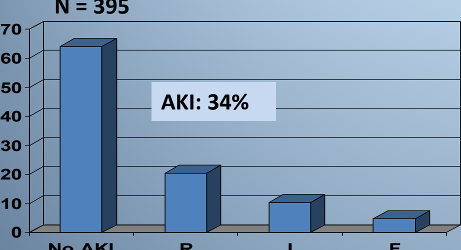


Al-Kandari et al, ASN, 2008

Pediatric AKI: Incidence in PICU Population & Definition-dependent

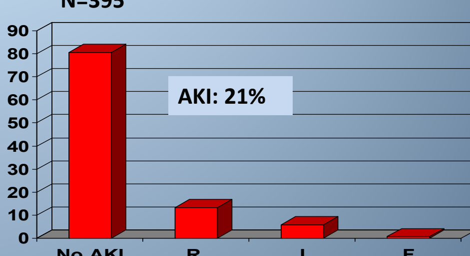
- Cardiac Surgery

N = 395



Kidney Int. 2009 Oct;76(8):885-92

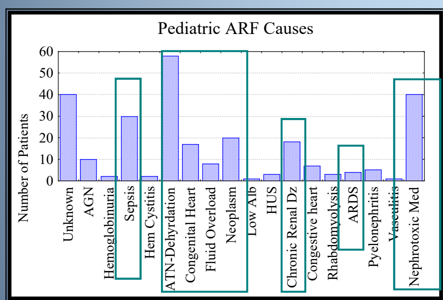
N=395



Anesth Analg 2009;109:45–52
(Aprotinin study)

Pediatric AKI:
Changing Epidemiology

Previously: Primary renal diseases



Stickle SH et al: Am J Kid Dis 45:96-101, 2005

Table 4. Characteristics and outcome of the acute renal failure (ARF) cases (n = 44)

Etiologies of ARF	
HUS	8 (18.2)
Hematology: oncology pathologies	8 (18.2)
Cardiac surgery	5 (11.4)
Sepsis	4 (9.1)
Trauma	3 (6.8)
Diabetic ketoacidosis	3 (6.8)
Chronic renal failure	3 (6.8)
Others	10 (22.7)

Pediatr Crit Care Med 2007 Vol. 8, No. 1

Pediatr Nephrol (2009) 24:1379–1384

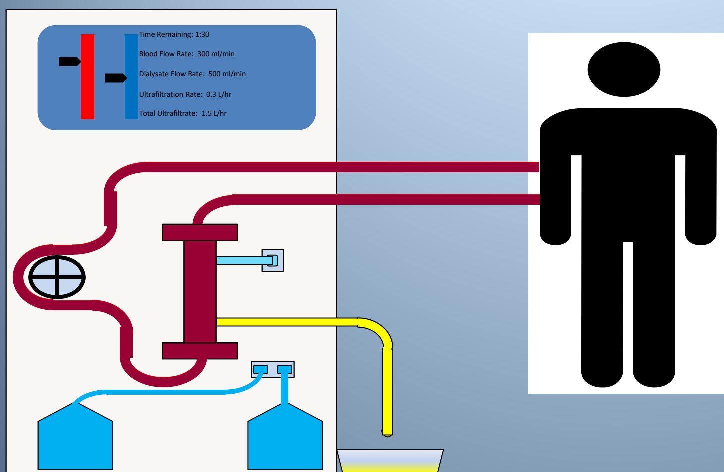
Table 2 Causes of acute kidney injury

Cause	Numbers and percentages=100
Bone marrow transplantation related	27
Primary renal disease	14
Dehydration	10
Nephrotoxic medication	8
After cardiac surgery	8
Congenital anomalies of the urinary tract	2
Multiple etiologic factors with underlying chronic diseases	31
Total	100

Management of AKI

- Largely supportive
- Aimed preventing of life-threatening fluid or electrolyte complications
- Avoiding or minimizing further renal injury
- Severe AKI or milder AKI in association with severe fluid overload or solute imbalance may require renal replacement therapy (RRT)
- Providing appropriate nutrition to allow recovery from acute illness and renal dysfunction

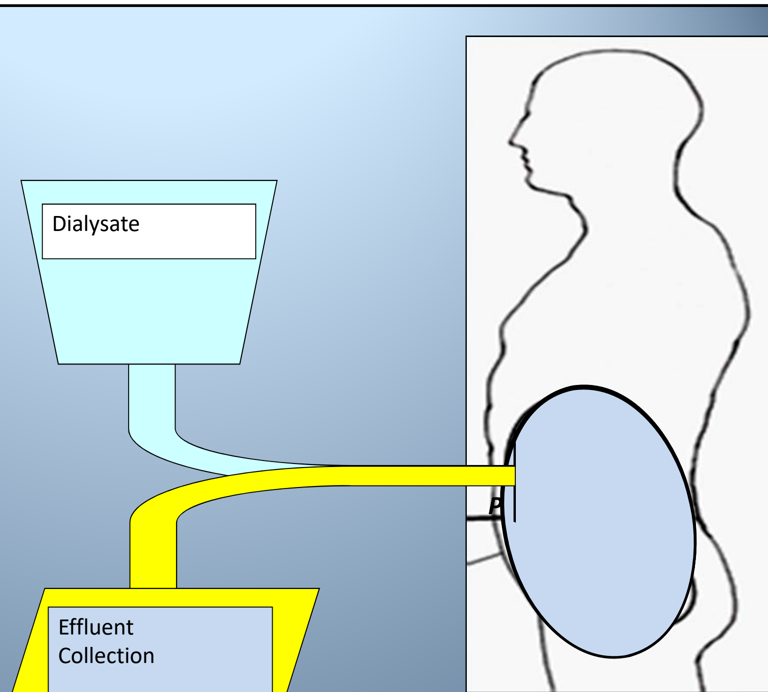
Hemodialysis



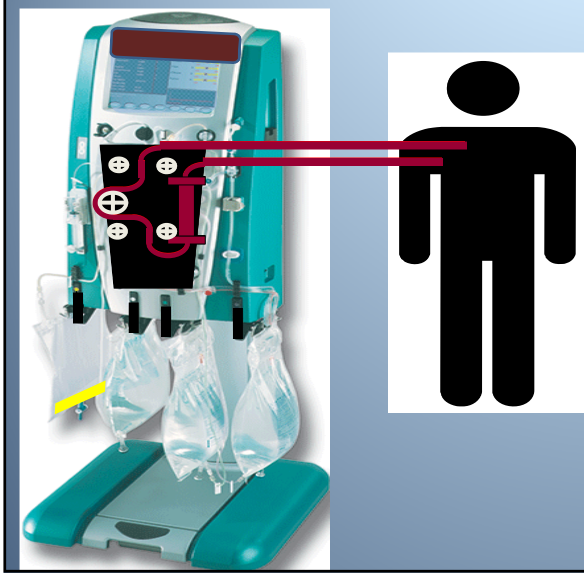
- Blood perfuses extracorporeal circuit
- Machine mixes dialysate on-line
- High efficiency system
- Requires vascular access; anticoagulation
- Technically complex
- May be poorly tolerated by critically ill patient

Peritoneal Dialysis

- Sterile dialysate introduced into peritoneal cavity through a catheter
- Possibly better tolerated
- Lots of pediatric experience in chronic setting
- Low efficiency system
- Risk for leak/infection

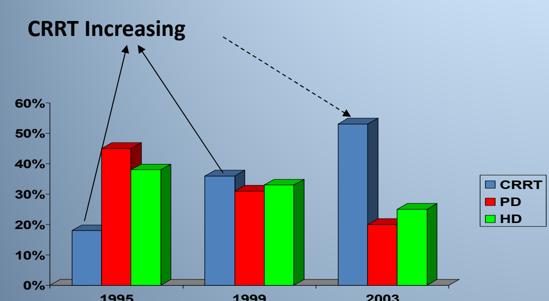


Continuous Renal Replacement Therapy (CRRT)



- ICU modality
- Technically similar to HD
  - SLOW: Better tolerated by ICU patient
  - CONTINUOUS: Preserve metabolic stability; maintain fluid balance for oliguric patients who require high daily input (IV medications, parenteral nutrition)

Trends in Pediatric RRT



Warady et al, Pediatr Neph 2000, 15:11-3

12-US Multicentre ppCRRT
Most include Dialysis

Table 2. CRRT technical characteristics[a]

Characteristic	*n* (Circuits)	%
Modality		
CVVHD	746	48
CVVHDF	466	30
CVVH	321	21
SCUF	16	1

Clin J Am Soc Nephrol 2: 732-738, 2007

Why CRRT in the Critically Ill with AKI?

- Reduces hemodynamic instability preventing secondary ischemia
  - Precise Volume control/immediately adaptable
  - Uremic toxin removal
  - Effective control of uremia, hyperphosphatemia, hyperkalemia
- Acid base balance
  - Rapid control of metabolic acidosis
- Electrolyte management
  - Control of electrolyte imbalances
- Management of sepsis/plasma cytokine filter
- Allows for improved provision of nutritional support

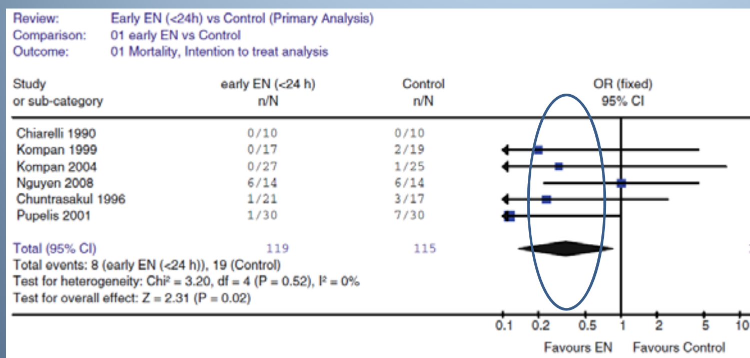
No Growth occurs during Acute Illness

Focus : Prevent Malnutrition

Children at Risk:
High basal rate of metabolism
Limited reserves
Baseline poor nutrition
+
Uremia and acidosis
Altered renal Amino Acid metabolism, lipid metabolism,
Fluid and Solute Clearance,
+
↑Losses from Renal Replacement Therapy

Initiation of Nutrition in the Acute Phase of Critical Illness

- **Is it beneficial to initiate early feeds in the acute phase of critical illness?**
- Meta-Analysis, 6 small trials, 234 patients
- Survival benefit with immediate initiation (24 h) of enteral nutrition as compared to delayed initiation



Doig GS et al. Intensive Care Med 2009

Review of Energy Needs and Utilization of Fuel

- Prospective observational study

  a) Intakes of calories and protein recorded. Balance calculated by subtracting actual intake from RDA, over a max of 14 days.

  b) Patients were evaluated also at discharge, 6 weeks and 6 months following discharge

  Anthropometric parameters : Wt, Ht, OHC, MUAC,CC, BSF,TSF

24 % Undernourished on Admission

Mean Energy deficits	Mean Protein deficits;
27 kcal/kg – Preterm neonates	0.6 g/kg/day – Preterm
20 kcal/kg – Term neonates	0.3 g/kg/day – Term Newborns
12 kcal/kg – Older children	0.2 g/kg/day – Children

6 months follow up, almost all children had recovered their nutrition status.

Hulst J et al.Clin Nutr 2004;23:223-32 & 1381-9

Malnutrition in PICU population with AKI

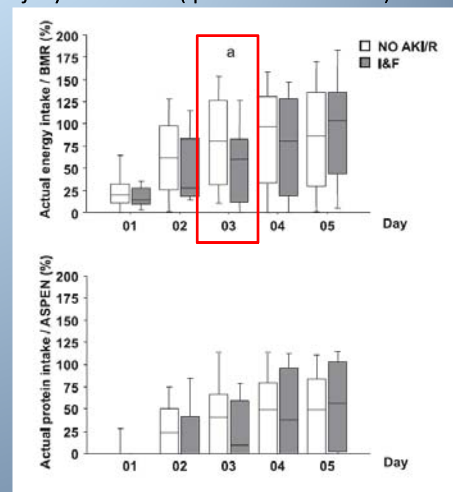
Retrospective Review : all PICU admissions over an 8 month period Kyle UG et al Clin J Am Soc Nephrol, 2013

- ❑ Incidence of Malnutrition was 20% in PICU population
- ❑ Incidence of Malnutrition was 33% in PICU Patients with AKI- Injury or Failure (pRIFLE Definition)

Table 2. ORs in patients with AKI compared with no AKI

	% (*n*)	% (*n*)	OR (CI)	*P*
Acute malnutrition	Normal	Moderate/severe		
No AKI	86.3 (88)	13.7 (14)	1	
Risk	72.7 (32)	27.3 (12)	2.4 (0.99–5.6)	0.05
Injury/failure	66.7 (14)	33.3 (7)	3.1 (1.1–9.1)	0.03
Chronic malnutrition				
No AKI	82.4 (84)	17.6 (18)	1	
Risk	63.6 (28)	36.4 (16)	2.7 (1.2–5.9)	0.02
Injury/failure	76.2 (16)	23.8 (5)	1.5 (0.5–4.5)	0.51
PRISM III	≤6	>7		
No AKI	71.2 (74)	28.8 (30)	1	
Risk	52.3 (23)	47.7 (21)	2.3 (1.1–4.7)	0.03
Injury/failure	38.1 (8)	61.9 (13)	4.0 (1.5–10.7)	0.01
PELOD	≤21	>22		
No AKI	98.0 (100)	2.0 (2)	1	
Risk	93.2 (41)	6.8 (3)	3.7 (0.6–22.7)	0.17
Injury/failure	81.0 (17)	19.0 (4)	11.8 (2.0–69.3)	0.01
Hospital LOS	≤14	>15		
No AKI	61.8 (63)	38.2 (39)	1	
Risk	52.3 (23)	47.7 (21)	1.5 (0.7–3.0)	0.29
Injury/failure	33.3 (7)	66.7 (14)	3.2 (1.2–8.7)	0.02
Survival	Alive	Died		
No AKI	97.1 (99)	2.9 (3)	1	
Risk	100 (44)	0 (0)		
Injury/failure	85.7 (18)	14.3 (3)	5.5 (1.0–29.4)	0.05

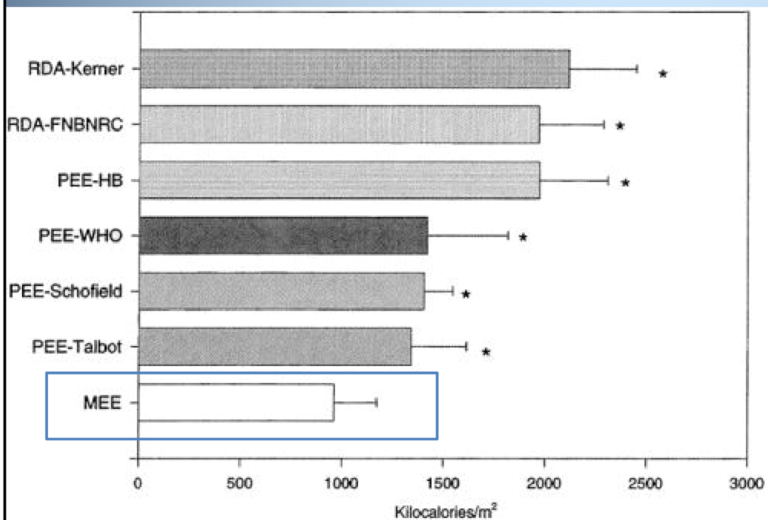
Moderate/severe wasting is weight for age <2 z-scores below normal. Moderate/severe stunting is height for age <2 z-scores below normal, using the 2000 Centers for Disease Control and Prevention growth charts. OR, odds ratio; CI, confidence interval; PRISM III, Pediatric Risk of Mortality Score; PELOD, Pediatric Logistic Organ Dysfunction; LOS, length of hospital stay.



Energy Expenditure in Critically Ill Children

- **What are the energy requirements for critically ill patients?**
- The nutritional requirements and the nature of substrate utilization in critically ill children have not been well defined.
- In some critically ill adults
  – Hypermetabolic state occurs during critical illness
  – Energy expenditure is significantly greater than that in the normal resting nonstressed state
- Extrapolating from adult studies
  – Energy requirements in critically ill children can be estimated by adding a stress-related correction to the resting energy expenditure
  – There are several published formulas

Comparison of MEE vs. PEE



- Total of 37 patients
- Measurements were obtained within 24 hrs of their illness or injury
- Actual energy expenditure was overestimated by using current formulas

Briassoulis et al. Crit Care Med 2000

Energy and Substrate Use in Acute Illness

- Coss-Bu helped define the metabolism of children during acute illness- Normal metabolic or hypermetabolic
- Hyper metabolic was defined as a state when the MEE at rest by indirect calorimetry was >10% above the predicted energy requirements
- The average energy given to the children was 0.25 MJ/kg/day (55kcal/kg/d)
- Measurements were obtained on average 12 days after admission

	Normal Metabolic (n = 14)	Hypermetabolic (n =19)
mREE (MJ/Kg/d)	0.16 +- 0.05 (38 kcal/kg/day)	0.28 +- 0.1 (66 kcal/kg/d)
Fat Oxidation (mg/min)	22 +-29	27+- 70
npRQ	1.21	0.86

Coss-Bu et al *Am J Clin Nutr* 2001

Energy Expenditure in Acute Critical Illness

- Energy requirements depend on the phase of the illness
  - Acute phase vs convalescent phase
- The incidence of hypermetabolism is low in the acute phase
- Energy expenditure predicted by using RDA or specific formulas overestimates the actual energy expenditure in the acute phase of illness.
- It is not clear if providing a caloric intake greater than the MEE is clinically detrimental or beneficial in children.

Metabolic Fuel Changes during AKI and Acute Critical Ilness

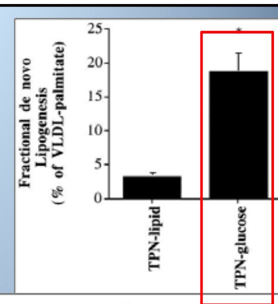
How should we distribute the calories provided?

Fuel Substrate Changes in Acute Illness:

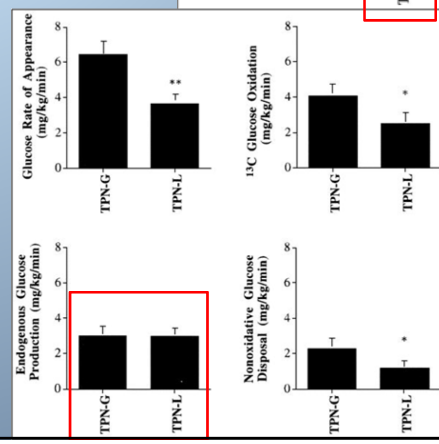
1. ↓ Carbohydrate Utilization *:* ~ 4 mg/kg/min of Glucose
2. ↑ Free fatty acid Utilization
3. Protein Catabolism to supply gluconeogenesis and hepatic acute phase proteins

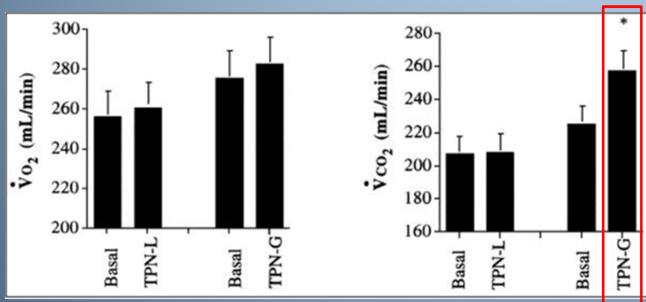
Substrate Utilization and Nutrient Composition

Tappy et al. Crit Care Med 1998



- TPN Composition
  - 75%CHO:15% AA: 10% Lipid
  - 15%CHO: 15%AA: 70% Lipid
- Measured indirect glucose metabolism and de novo lipogenesis: C^{13} Glucose, C^{13} Acetate





Lipid Metabolism in Acute Critical Illness

- **During starvation:**
  - Reduction in insulin and increase in glucagon secretion
  - Mild sympathetic activation stimulates hormone sensitive lipoprotein lipase to increase the release of FFA from adipose tissue.
  - Much of the excess FFAs are converted by the liver to ketone bodies
- **Early phase of Critical Illness: ↑ FFA Utilization Occurs**
  - the nutritional hormones are no longer substrate controlled
- ***Yet in Acute Kidney Injury***
  - Impaired Lipolysis: *Lipase Activity ~50%*
  - ↓ Lipoprotein Lipase
  - ↓ Hepatic Triglyceride Lipase

Lipid Metabolism in AKI

Impaired Lipolysis:

Lipase Activity ~50%

Altered Lipid Profile :

↑ LDL and VLDL

↓ ***Cholesterol and HDL-Cholesterol***

Cholesterol: Conditional Essential Nutrient in AKI?

- Ten adults with normal lipemia
- Standard 20% lipid emulsion and 20% lipid emulsion with 4g/L of free cholesterol
- Results:
  - Reduced Plasma Triglycerides with reduced plasma ½ life and ↑ total body clearance
  - Fraction of Lipid Oxidation Improved
- No studies to date evaluating if this free cholesterol would show improved TG clearance and utilization in patients with AKI.

Druml et al, Wien Klin Worchenschr 2003;115/21-22:767-774

Type of Lipid Used in Nutritional Formulations

- May affect inflammation: n-3 fatty acids have anti-inflammatory effects while n-6 fatty acids are proinflammatory
- OMEGA study
  - N = 272 patients
  - Enteral administration of n-3 fatty acids plus antioxidant supplement
  - No benefit in mortality and other outcomes
- Parenteral administration of different fatty acids
  - No benefit with the administration of fish oil based FA (n-3)
  - No effect on outcomes with the use of olive oil based FA (n-6)

Acute Kidney Injury and Catabolic Stress

- Physiologic changes due to AKI and critical illness cause derangements in substrate metabolism and lead to catabolic state, hypoalbuminemia, loss of lean body mass
- Muscle protein catabolism and atrophy occur as a result of:
  - Systemic inflammation
  - Oxidative stress
  - Insulin resistance
  - Metabolic acidosis
  - Uremic toxic metabolic impairment
- Hepatic acute phase protein synthesis rather than anabolism
- Maintenance of protein balance in such conditions requires that at least adequate energy and protein intake be provided during acute illness.

Protein Catabolism and Nitrogen Balance

- Adult Studies:
  - Protein Catabolic Rate ~ 1.4 - 1.7 g/kg/d
- Pediatric Studies:
  - Urea Nitrogen Appearance ~ 185- 290mg/kg/d
  - Protein Catabolic Rate ~ 1.1- 1.8 g/kg/d
  - Amino acid loss on CRRT 11-12% of daily protein intake

Macias WL, et al. JPEN 1996
Chima CS, et al. JASN 1993
Kuttnig M, et al. Child Nephrol Urol 1991
Maxvold N, et al. Crit Care Med 2000

Protein Intake and ICU Outcomes

- Prospective Cohort Danish Study:
- N=113 Adults, Intubated, severe sepsis or >15% Burn
- Energy and Protein Intake, Nitrogen and Energy Balance was monitored

	Low Protein/AA Intake (53.8 g/d)	Medium Protein/AA Intake (84.3 g/d)	High Protein/AA Intake (114.9 g/d)
K-M Survival Probability on Day 10	49%	79%	88%

- **Only ↑ Protein Provision was Associated with ↓ Mortality:**

HR (Risk of Death vs time) ↓ 2% for every additional gram of protein provided.

- **No Associated found Between Hazard of Mortality and Energy**

Allingstrup MJ et al. Clin Nutr 2012;31:462-468

Protein Intake and Outcomes in ICU Patients on RRT

N=50 Mechanically Ventilated, CRRT Patients with APACHE 26 ± 8

Daily Energy (kcal) kept constant and determined by IC when available or Schofield Equation.
Three sequential isocaloric protein-feeding regimens were provided

	Control: N=10	Intervention: N=40
Protein Diet	2g/kg/d x 6 days	1.5 - 2.0 - 2.5 g/kg/d Escalation at 48˚ Intervals
Nitrogen Balance	Negative Over Time	Positive over time in Response to ↑ Protein Support
Energy Expenditure (IC): Increased by 56±24 cal/day over the study period		

Nitrogen balance was associated with outcome
For every 1g/d increase in nitrogen balance, the probability of survival increased by 21%. (OR 1.21 ; 95% CI 1.017-1.444)
Enterally fed patients had a better outcome

Scheinkestel CD et al. Nutrition 2003;19:909-16

Nutrition and CRRT

Can Nitrogen Balance be achieved in AKI patients on CRRT?

- Nitrogen metabolism was studied in two cohorts
- Patients received equal amounts of calories
- The higher protein diet improved nitrogen balance and could be safely administered to AKI patients on CRRT

	Moderate Protein Intake	High Protein Intake
Protein Intake	1.2 g/kg/d	2.5 g/kg/d
Nitrogen Balance	-5.5 g N/d	-1.9 g N/d
Positive Nitrogen Balance during a 24h period	36.7%	53.6%
Mean Plasma Urea	18 mmol/L	26.6 mmol/L
Survival	31.1%	37.5%

Bellomo et al Renal Failure 1997

Protein Losses on Renal Replacement Therapy: Slow IHD, PD, CVVHD

	IHD (Qb=80ml/min, D=1.8L/hr x 12 hr, SA=0.7m2	PD:IPD for 10hr/day: Acute PD for 36hrs : CAPD for 24hr/day	CVVHD(Qb=150mL/min, D= 1-2L/hr,UF= 0.67L/hr, SA=0.5m2
AA/Protein loss (grams)	6g/day	IPD=12.9 g/d Acute PD=23.3 g (15.5g/d) CAPD= 8.8 g/d	12g/day
% AA intake lost via RRT	16%	NA	5-12%
Diet prescription AA/Protein NP kcal [CHO: Lipid]	 40 g/day 2000-2400 kcal/d	NA	 2.5g/kg/day 35kcal/kg/day [60:40]

Kihara M et al. Intensive Care Med 1997;23:110-3
Blumenkrantz MJ et al. Kidney Int 1981;19:593-602
Bellomo R et al, Int J Artif Organs 2002; 25:261-8

Protein Losses on RRT

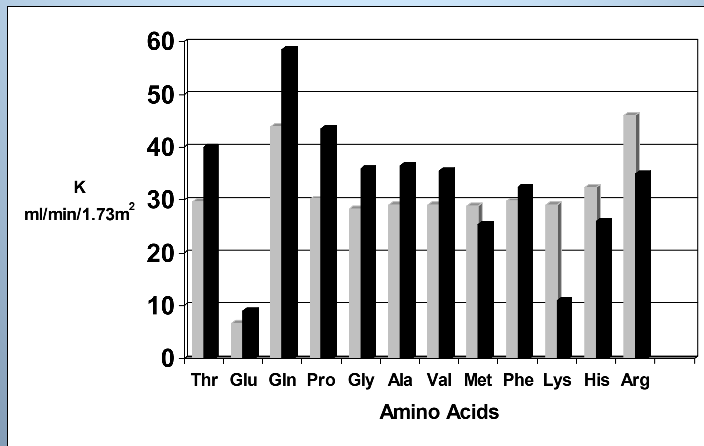
	Davenport (1989)	Davies (1991)	Bellomo (2002)	Maxvold (2000)
Calorie Intake NPkcal (CHO:Fat)	1450 kcal (~70:30)	2000-2400 kcal	2100 kcal (60:40)	1.25 x mEE (70 : 30)
AA Intake g/day	60 g AA (1L Vamin9)	60:84:112 AA 1L of Vamin9:14:18	2.5g/kg/day (1 L Synthamin 17)	1.5g/kg/day Aminosyn II
AA Loss/day	2.4g/d : 7.9g/d	NA	~ 12g/day	CVVH:12.5g/d/1.73m2 CVVHD:11.6g/d/1.73m2
% Dietary AA Loss	13%	12%	~ 12%	~11.5%
N2 Balance: g/day	NA	NA	-1.8g/d	CVVH: -3.68 g/d CVVHD: -0.44 g/d
RRT Prescript: UF rate: L/hr HF SA = m2	 0.5L/hr : 1L/hr 0.6 m2	UF:0.5L/hr: D:1L/hr : D2L/hr 0.43m2	UF:0.67L/hr D :1-2L/hr 0.5 m2	UF : 2L/hr D : 2L/hr 0.3 m2

Davenport A et al, Blood Purif 1989;7:192-6 Davies SP et al, Crit Care Med 1991;19:1510-5
Bellomo R et al, Int J Art Organs 2002;25:261-8 Maxvold N et al Crit Care Med 2000;28:1161-5

Combined Results of Clearance of Essential Amino Acids by CRRT.

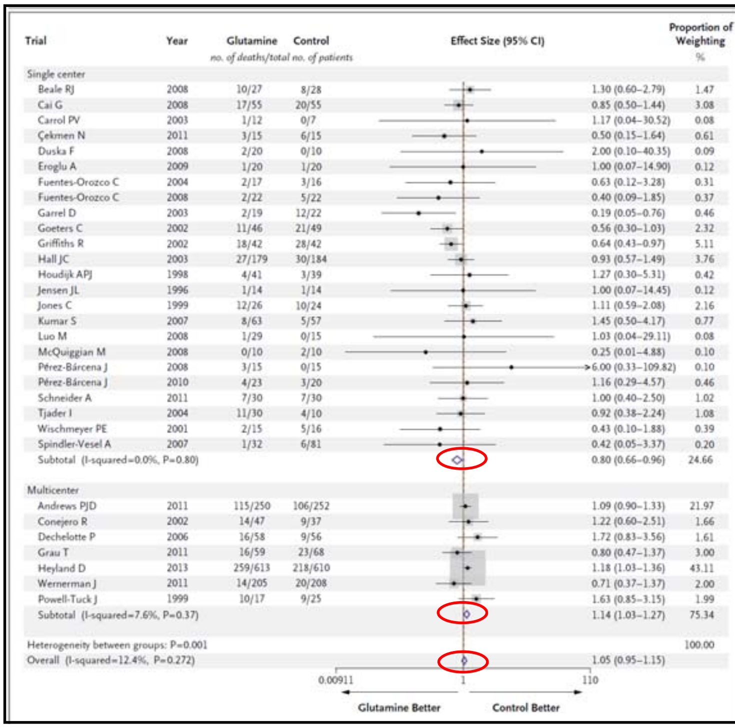
Zappitelli et al Intensive Care Med 2009 (n=15)

and Maxvold et al, Crit Care Med 2000 (n=6)



Several studies, adult and child: ~ 10-20% intake "lost" through hemofilter.

Both studies: Highest losses with Glutamine



Effect of Glutamine Supplementation on Survival

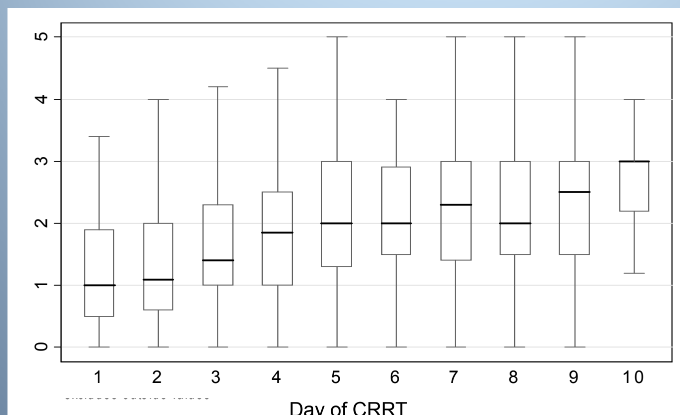
- Glutamine is the most abundant free AA
- Low glutamine levels have been associated with poor outcome in critical illness
- Single center randomized trials suggested that administration of Glutamine might decrease risk of infection, LOS, and risk of death.
- Multicenter studies have shown no benefit or decreased risk of death when glutamine was administered parenterally

Heyland D et al. NEJM 2013

Protein and calorie prescription for children and young adults receiving CRRT: a report from the Prospective Pediatric Continuous Renal Replacement Therapy Registry group.

Daily change in protein prescription during treatment with CRRT

Protein intake (g/kg/day)



- N = 195 children
- Mean age 8.8 years
- By the 5th day, the median delivery of protein reached 2 g/kg/d gradually increasing to 3 g/kg/day by day 10

Zappitelli M et al, Crit Care Med 2008

Trace Metal and Folate CRRT Clearance in Children

- **Should we replace micronutrients?**
- Trace metal deficiencies have been implicated in lymphocyte, platelet, antioxidant dysfunction and poor wound healing
- Micronutrients that are water soluble, non protein bound and relatively small (<10,000Dalton) are readily cleared
- Selenium, chromium and folate clearances were high
- Folate level decreased significantly by Day 5

	K Day 2 (ml/min/1.73 m^2)	K Day 5 (ml/min/1.73 m^2)	Serum concentrations			
			Initiation	Day 2	Day 5	Reference range[a]
Selenium	10.1, 9.5 (7.4, 13.3)	8.6, 7.2 (6.5, 11.4)	55, 49 (39, 66)	61, 59 (46, 70)	64, 63 (45, 86)	23–190 (μg/l)
Copper	0.4, 0.3 (0.2, 0.6)	0.5, 0.4 (0.3, 0.5)	88, 87 (69, 100) **L**[b]	110, 106 (80, 140)	104, 103 (95, 128)	90–190 (μg/dl)
Chromium	24, 25 (22, 32)	25, 26 (19, 29)	2, 2 (1, 2)	2, 2 (2, 3)	2, 2 (2, 3)	0–2.1 (μg/l)
Zinc	4.2, 3.2 (2.2, 4.6)	4.0, 2.9 (2.3, 4.2)	66, 53 (32, 79) **L**[b]	68, 61 (49, 79)	76, 68 (50, 101)	60–120 (μg/dl)
Manganese	9.0, 4.6 (0.3, 8.5)	38.2, 5.1 (0.2, 20.2)	9, 4 (2, 6) **H**[b]	8, 3 (2, 7) **H**[b]	8, 3 (2, 3) **H**[b]	0–2 (μg/l)
Folate	29, 16 (14, 22)	16, 16 (13, 18)	16, 12 (7, 23)	10, 9 (6, 14)	8, 7 (6.4, 7.9)	5.4–40 (ng/l)

Zappitelli M, et al, Intensive Care Med 2009

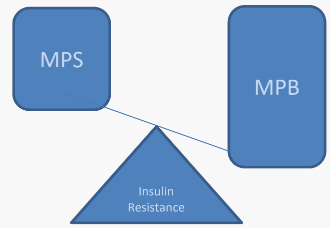
Insulin and Muscle Protein Balance

Insulin- Anabolic hormone for Muscle Metabolism:

Catabolic State:

Insulin effect on MPS (AA Uptake)
Insulin effect on MPB (Ubiqutin-Proteasome)

Ikizler,TA. J Renal Nutr 2007;17:13-16



Imbalance of MPB with MPS result in PEW

Reid M, Li YP. Resp Res 2001;2:269-272

Benefit of Insulin Therapy in the Critically Ill: insulin dose vs glycemic control

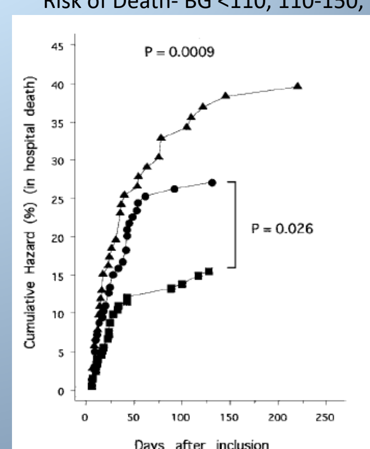
Is it feasible and safe to maintain normoglycemia?

- N= 1548
- Randomized to insulin infusion or conventional approach
- Normoglycemic Control [80-110 mg/dl]

↓ Polyneuropathy
↓ Bacteremia
↓ Inflammation
↓ Anemia

Reduction of Mortality

Risk of Death- BG <110, 110-150, >150



Van den Berghe G, et al. Crit care Med 2003

Nutrition in Children with AKI

Nutritional parameter	
Nutrition modality	-Early enteral feeding is beneficial. Some patients may require parenteral nutrition supplement
Energy	35 to 60 kcal/kg/day (0.15-0.27 MJ/kg/day) 25-35%Carbohydrate: 35-45% Lipid *(Insulin as needed for Hyperglycemia)* 25-40% Protein
Protein	2 - 3 g/kg/day with AKI *(Increase intake if on High flow CRRT (by 20%)*
Lipids	No recommendation on the type of formulation that should be provided
Vitamins	Daily recommended intake (± replacement) Monitor serum folate, water soluble vitamin levels
Trace elements	Daily Recommended Intake
Monitoring	MEE, Nitrogen Balance, Glucose, lytes, TG, Vitamins, Trace elements
Conditional Nutrients??	Glutamine, free Cholesterol

Questions?

Thank You!