Acute Kidney Injury

Chronic Renal Failure

Acute liver failure

Cirrhosis

Post liver transplant

- Pre Renal
  - Actual volume loss : dehydration, bleed….
  - Effective volume loss
    - Cirrhosis (splanchnic hypervolaemia, central hypovolaemia
  - Impaired renal blood flow
    - decreased RBF as part of cirrhosis : rationale re NSAI
    - intra-abdominal hypertension
- Renal
  - Paracetamol and tubular insult
  - Glomerulonephritis : viral / autoimmune
  - IgA nephropathy
  - Hypertension, diabetes, intersitial nephritis,
  - Contrast -volume depletion also
  - Immunosupressant induced renal injury
- Post Renal

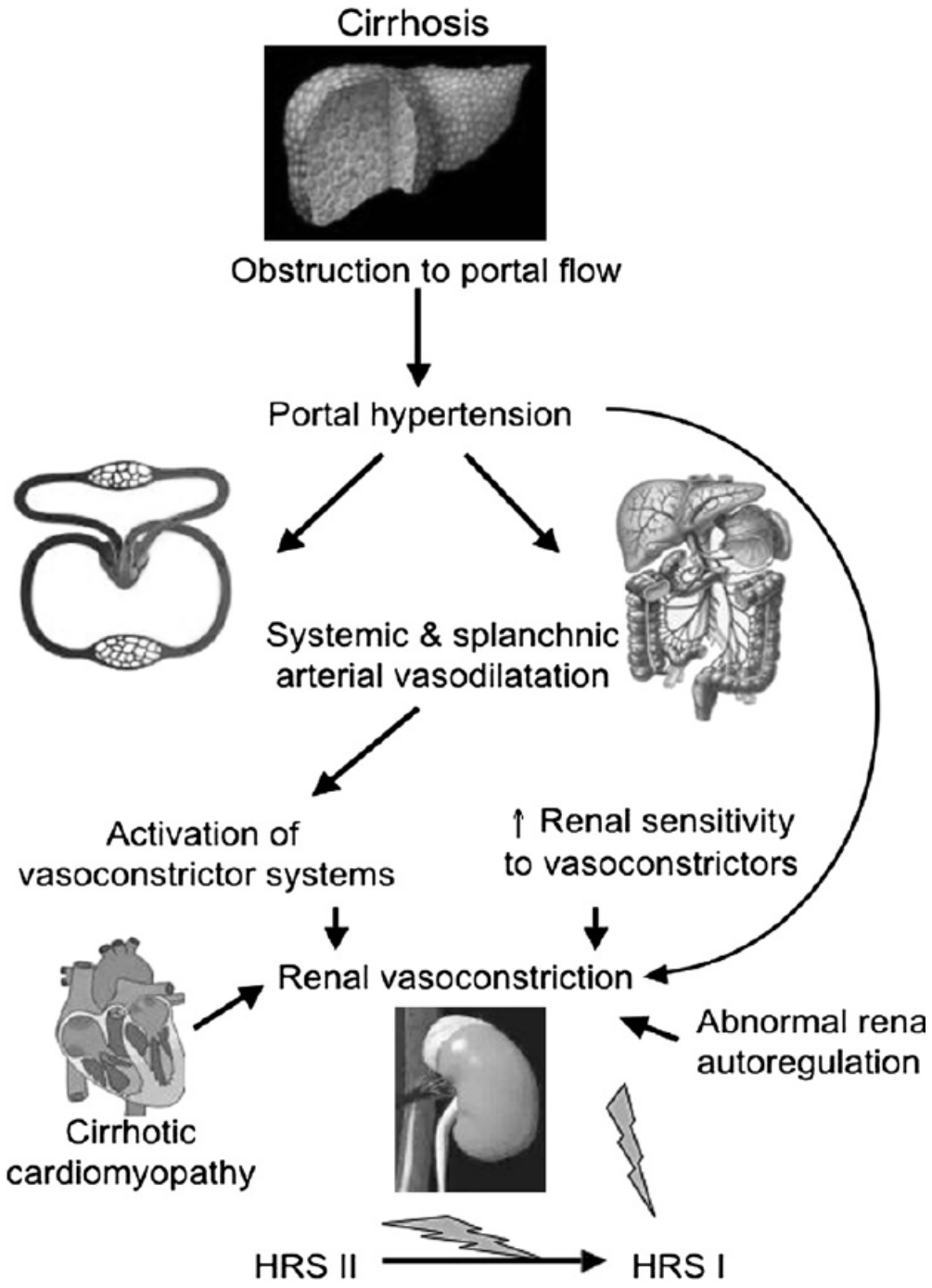
Avoidable AKI

- Contrast
  - Rehydration ± saline load
  - Role of NAC or NaHC03 unclear
- NSAI
  - Avoid at all costs

- Inappropriate recognition of renal dysfunction
  - Creatine
  - Muscle mass
    - Recent review poor correlation of eGFR and iohexol or isotope methods
    - eGFR only predicted 30% of those with GRF of < 60
    - Proteinuria appeared highly predictive of development of AKI

Definitions

- AKI vs CKD
- ALF vs Cirrhosis
- Prognosis
- Rx options


Cirrhosis
Obstruction to portal flow
Portal hypertension
Systemic & splanchnic
arterial vasodilatation
Activation of
vasoconstrictor systems
↑ Renal sensitivity
to vasoconstrictors
Renal vasoconstriction
Abnormal rena
autoregulation
Cirrhotic
cardiomyopathy
HRS II
HRS I

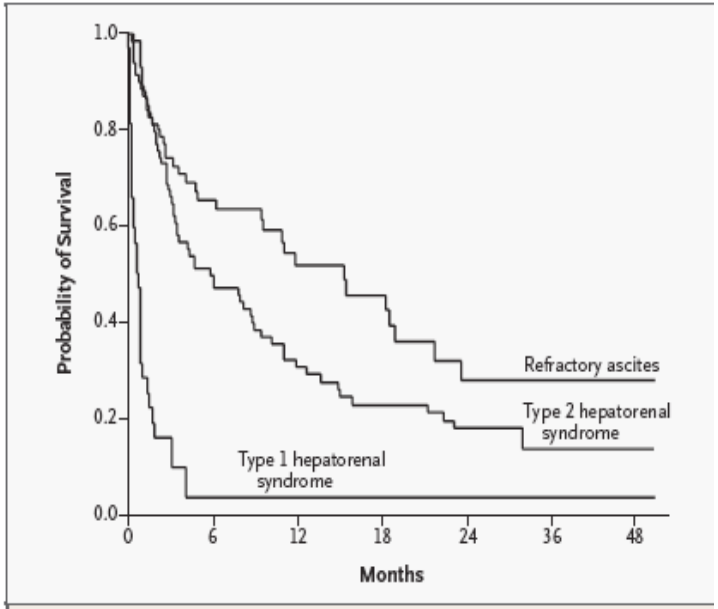


Figure 2. Probability of Survival among Patients with Cirrhosis, Refractory Ascites, and the Hepatorenal Syndrome.

Type 1 hepatorenal syndrome is a progressive impairment in renal function, defined by a doubling of the initial serum creatinine concentration in less than two weeks to a value greater than 2.5 mg per deciliter (221 μmol per liter). Type 2 hepatorenal syndrome is a stable or slowly progressive impairment in renal function that does not meet the criterion for type 1 hepatorenal syndrome.

Box 1 International Ascites Club (IAC) proposed diagnostic criteria for hepatorenal syndrome[10]

- Cirrhosis with ascites
- Serum creatinine >133 μmol/l (1.5 mg/dl)
- No improvement in serum creatinine (decrease to a level of ≤133 μmol/l or 1.5 mg/dl) after at least 2 days of diuretic withdrawal and volume expansion with albumin. The recommended dose of albumin is 1 g/kg body weight/day up to a maximum of 100 g/day
- Absence of shock
- No current or recent treatment with nephrotoxic drugs
- Absence of parenchymal kidney disease as indicated by proteinuria >500 mg/day, microhaematuria (>50 red blood cells/high power field) and/or abnormal renal ultrasonography

Issues :
Not even eGFR
Creatine is produced in the liver
Woman vs men
Ethnic diversity
Decreased muscle mass in cirrhosis

N Engl J Med 2004;350:1646-54.

Management of Cirrhosis and Ascites

Pere Ginès, M.D., Andrés Cárdenas, M.D., Vicente Arroyo, M.D., and Juan Rodés, M.D.

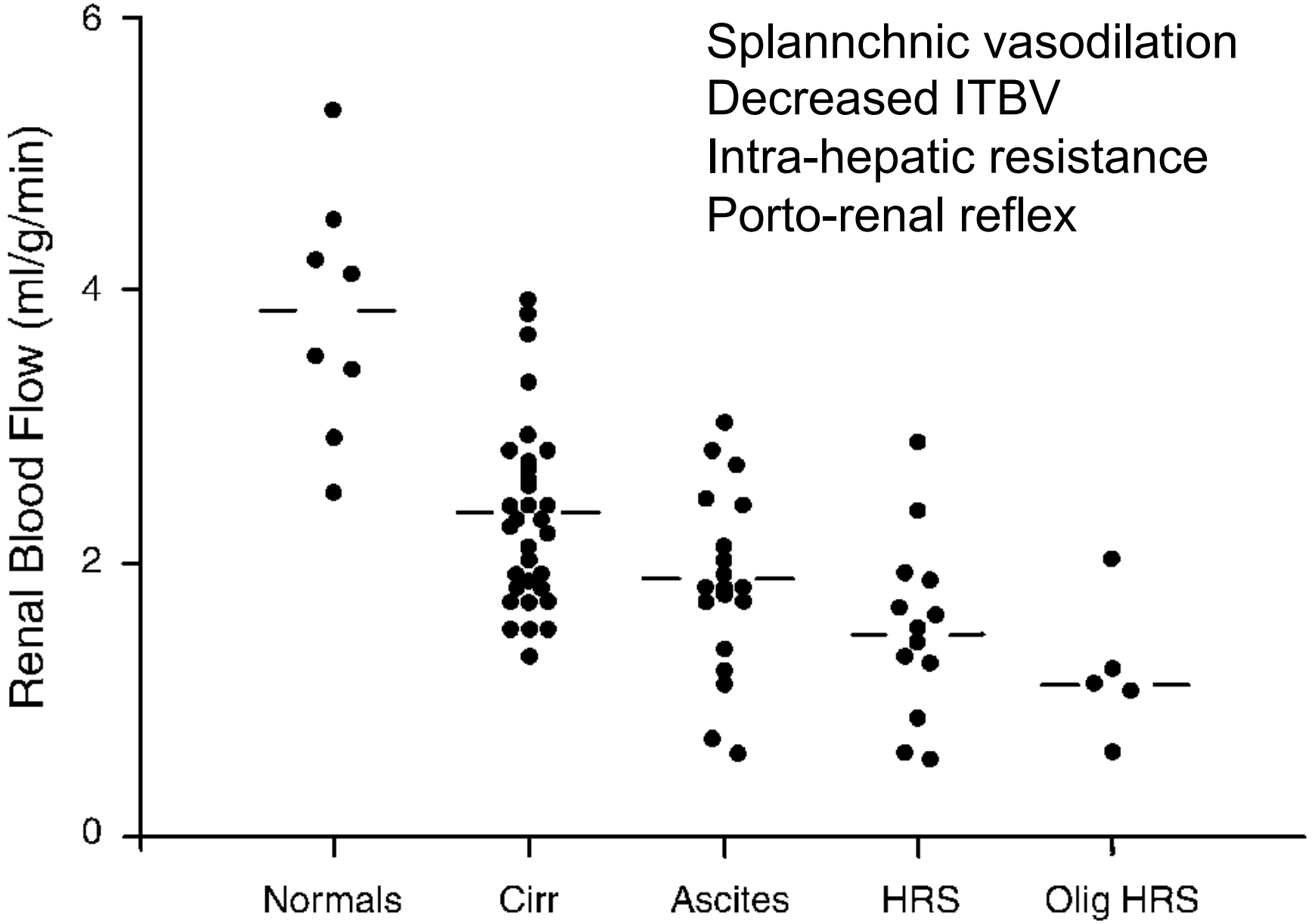
Consider acute renal dysfunction in cirrhosis : RIFLE

Working Party proposal for a revised classification system of renal dysfunction in patients with cirrhosis

Florence Wong, *Gut* 2011;**60**:702–709.

Table 2 Proposed diagnostic criteria of kidney dysfunction in cirrhosis

Diagnosis	Definition
Acute kidney injury	Rise in serum creatinine of ≥50% from baseline or a rise of serum creatinine by ≥26.4 μmol/l (≥0.3 mg/dl) in <48 h HRS type 1 is a specific form of acute kidney injury
Chronic kidney disease	Glomerular filtration rate of <60 ml/min for >3 months calculated using MDRD6 formula HRS type 2 is a specific form of chronic kidney disease
Acute-on-chronic kidney disease	Rise in serum creatinine of ≥50% from baseline or a rise of serum creatinine by ≥26.4 μmol/l (≥0.3 mg/dl) in <48 h in a patient with cirrhosis whose glomerular filtration rate is <60 ml/min for >3 months calculated using MDRD6 formula



Ring-Larsen et al.

Terlipressin and albumin vs albumin

Martin-Llahi M Gastroenterology 2008:134

- 1-2 mg 4hrly
- Albumin daily 1g/kg
- N=23 each grp
- Improved renal function 43 vs 8%
- No difference in 2 mnth survival
- CVS complications
  - 4 Alb vs 10 T + Alb

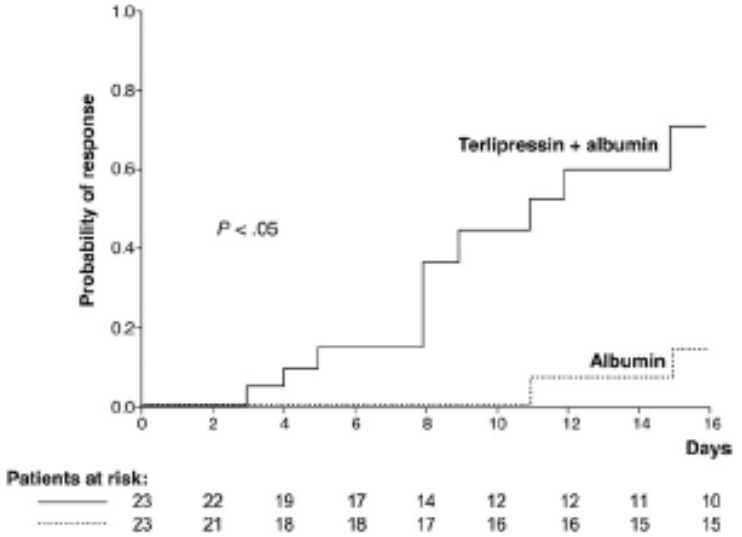
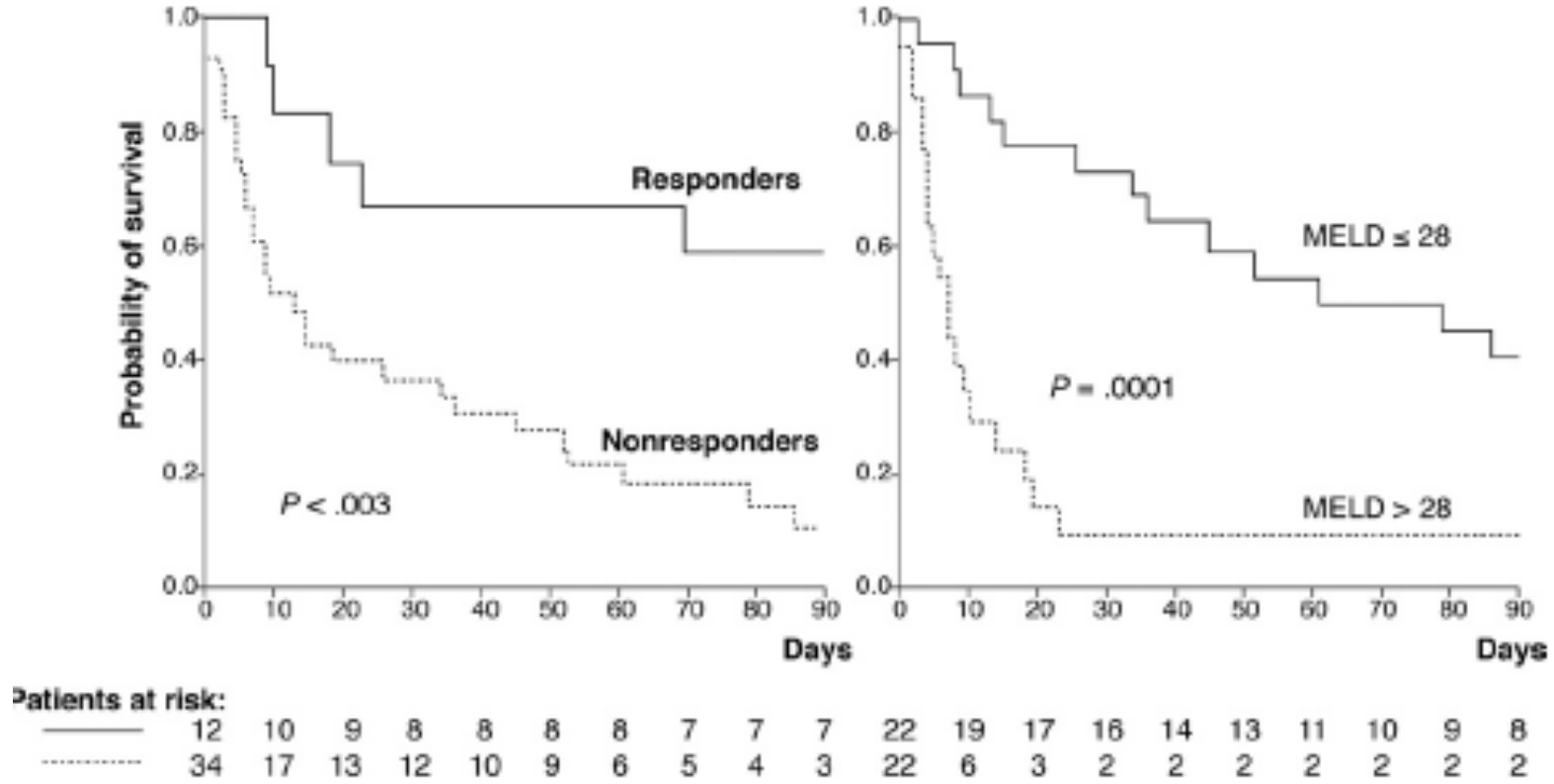


Table 2. Independent Predictive Factors of Response to Treatment

Variable	Responders (n = 12)	Nonresponders (n = 34)	*P* value
Assigned to terlipressin + albumin therapy (*n*)	10 (83%)	13 (38%)	.005
Serum creatinine (*μmol/L*)	256.4 ± 70.7	369.4 ± 194.5	.000
Urine volume (*mL/day*)	880 ± 440	496 ± 419	.005
White cell (*per mm*^{3})	6649 ± 3556	10932 ± 8107	.001

NOTE. Plus-minus values are means ± SD.
P values result from the multivariate analysis.



Previous studies CP score 11

Martin-Llahi M Gastroenterology 2008:134

RCT Terlipressin in Type I HRS

Sanyal A Gatroenterology 2008 :134:1360

1 mg 6 hrly vs placebo

Albumin in both groups

If no response (30% decrease in creat) at day 4 ⇧ to 2mg 6 hrly

14 days Rx : 56 in each grp

Success defined as creatinine < 1.5 mg/dl for 48 hrs by Day 14

Rx success : 25 vs 12.5 %

Baseline to day 14

decrease in creatinine

0.7 vs 0 mg/dl

Similar survival between grps

HRS reversal

improved 180 day outcome

Table 2. Treatment Outcomes

End point	Terlipressin n (%)	Placebo n (%)	*P* value
All patients	(n = 56)	(n = 56)	
Treatment success at day 14	14 (25.0)	7 (12.5)	.093
HRS reversal	19 (33.9)	7 (12.5)	.008
Patients who received >3 days of treatment	(n = 36)	(n = 39)	
Treatment success at day 14	14 (38.9)	7 (17.9)	.046
HRS reversal	19 (52.8)	7 (17.9)	.002

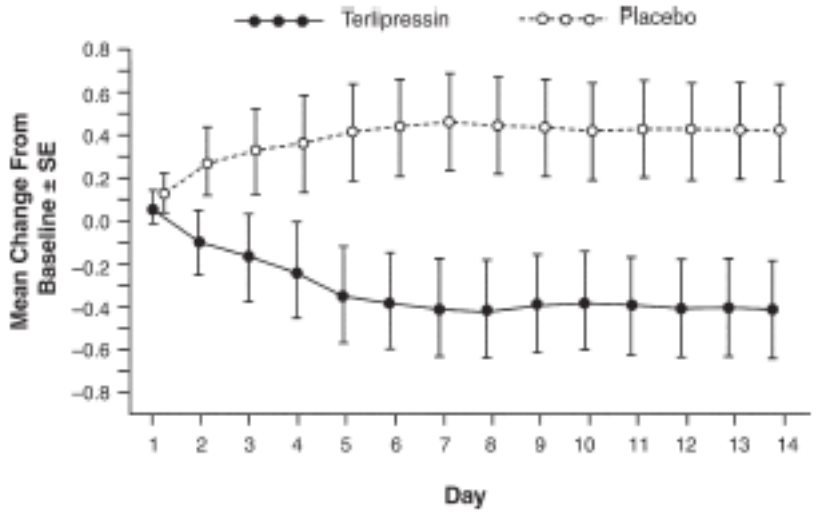


Figure 2. Mean change from baseline in SCr (mg/dL) to end of treatment. Data include all patients in the ITT population at each time point.

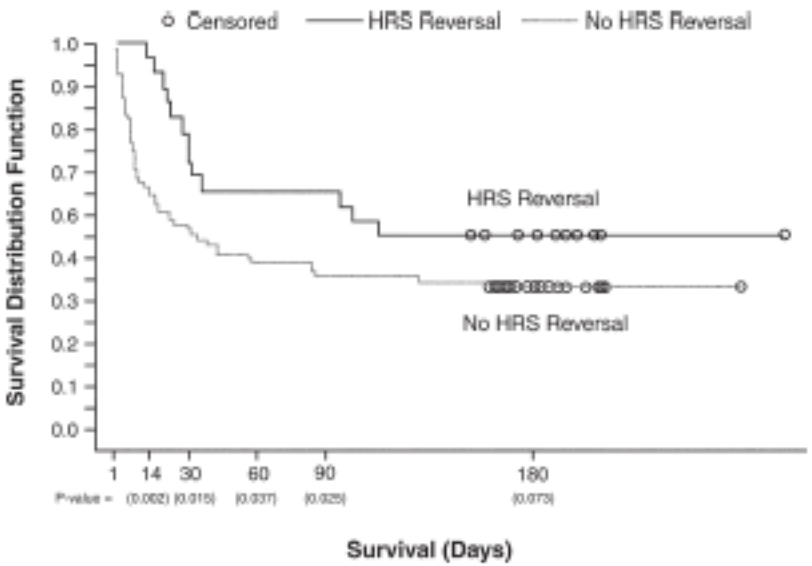
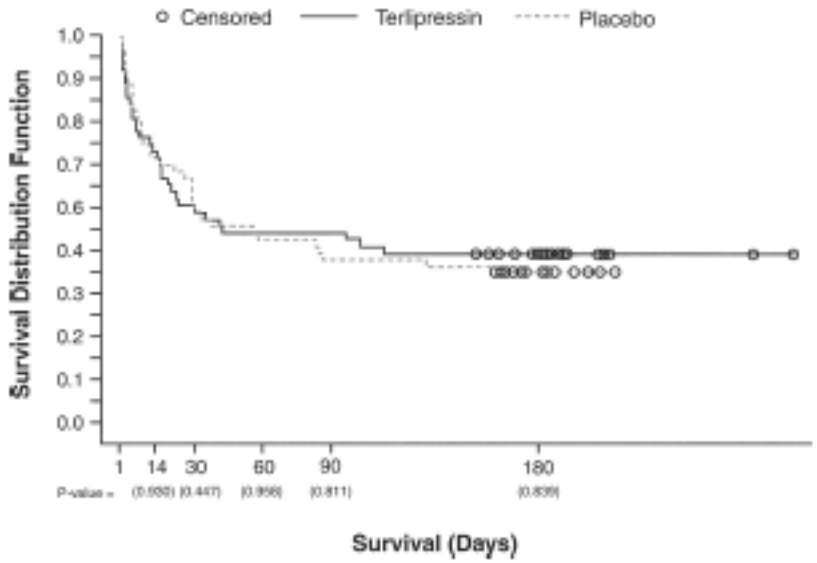


Table 3. Overview of Safety Data

Safety parameter (number of patients with AE)	Terlipressin (n = 56) n (%)	Placebo (n = 55) n (%)
AEs up to 7 days posttreatment		
All	52 (92.9)	49 (89.1)
Related	18 (32.1)	12 (21.8)
Serious AEs up to 30 days posttreatment		
All	37 (66.1)	36 (65.5)
Related	5 (8.9)	1 (1.8)
Deaths up to 30 days posttreatment		
All	27 (48.2)	27 (49.1)
Related	0 (0.0)	0 (0.0)
Withdrawals because of AEs up to 7 days		
All	3 (5.4)	2 (3.6)
Related	3 (5.4)	0 (0.0)



Sanyal A Gatroenterology 2008 :134:1360

Norepinephrine for the treatment of HRS ?

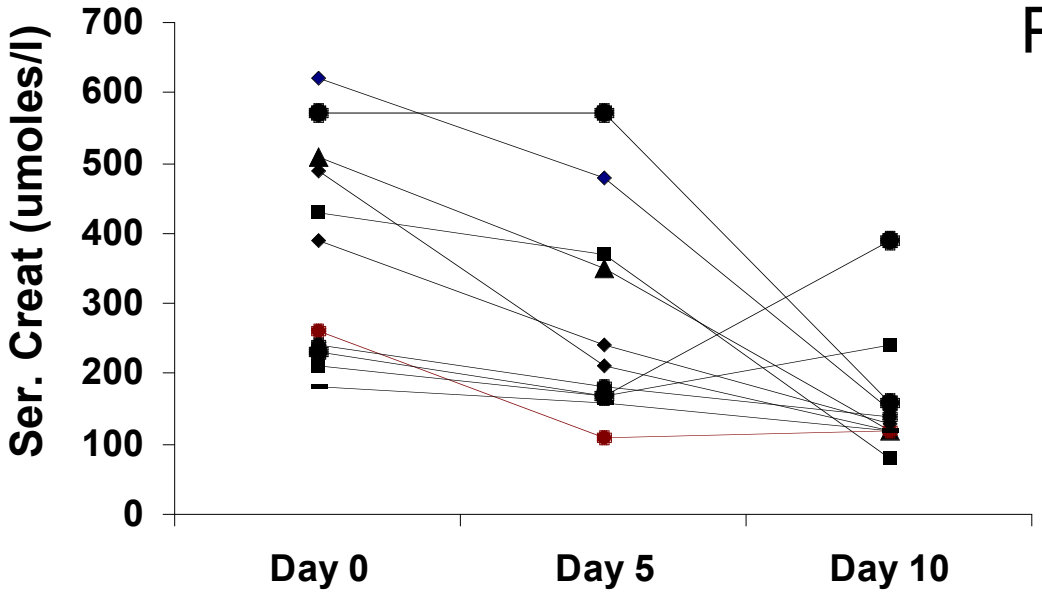
Duvoux et al. Hepatology 2002

Sharma P, Kumar A, Shrama BC, Sarin SK. An open label, pilot, randomized controlled trial of noradrenaline versus terlipressin in the treatment of type 1 hepatorenal syndrome and predictors of response. Am J Gastroenterol 2008;103:1689-1697.

Terlipressin vs NE *n=40*

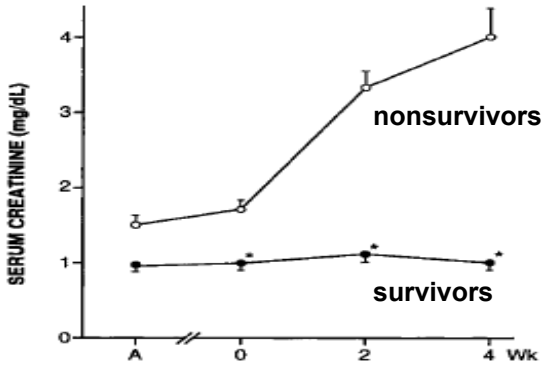
Predictors of outcome :

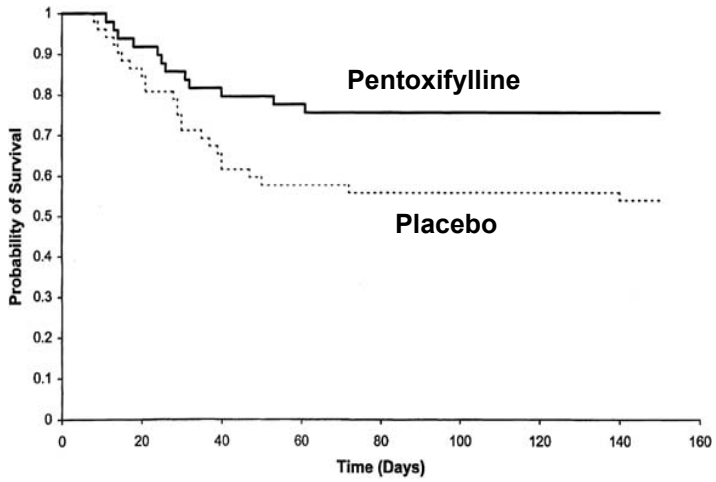
- Creatinine clearance
- MAP
- Renin



NA 0.5-3mg/h
MAP >100mmHg increaase
or U.O >50ml/h

Pentoxifylline and Alcoholic Hepatitis





PTX 12/49 (24.5%) died

Placebo 24/52 (46.1%) died

p=0.037

40% reduction in mortality

65% reduction in HRS

Steroid non responders do not benefit from switch to Ptx

Louvet et al J Hep 2008;48:465

E Akriviadas Gastroenterology 2000

Glucocorticoids plus *N*-Acetylcysteine in Severe Alcoholic Hepatitis

N Engl J Med 2011;365:1781-9.

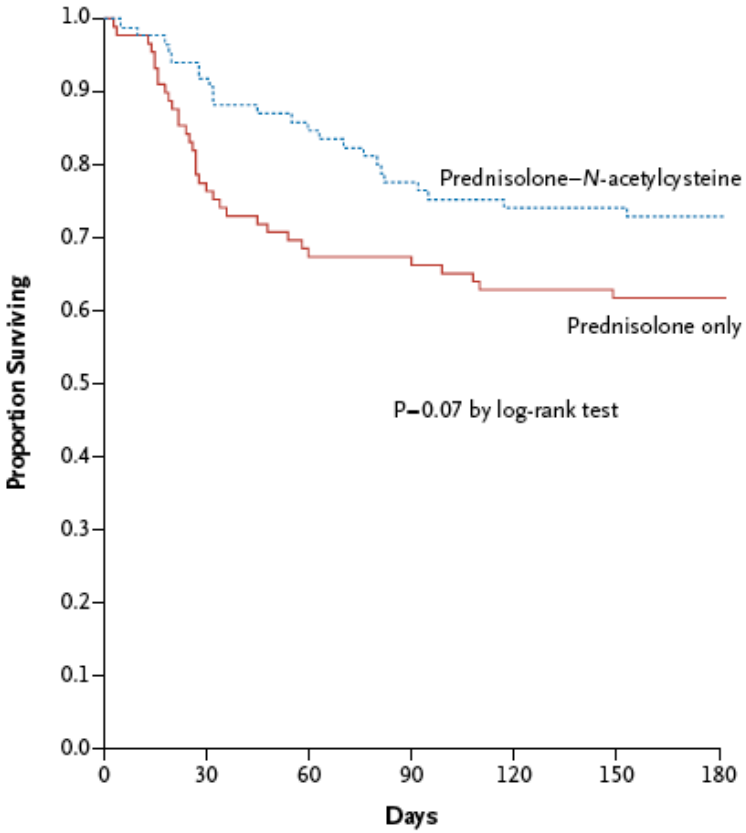


Figure 2. Kaplan–Meier Curves for 6-Month Survival in the Intention-to-Treat Population.

Mortality at 1 mnth 8 vs 24%
3 mnth 22 vs 34 and
6 mnth 27 vs 38

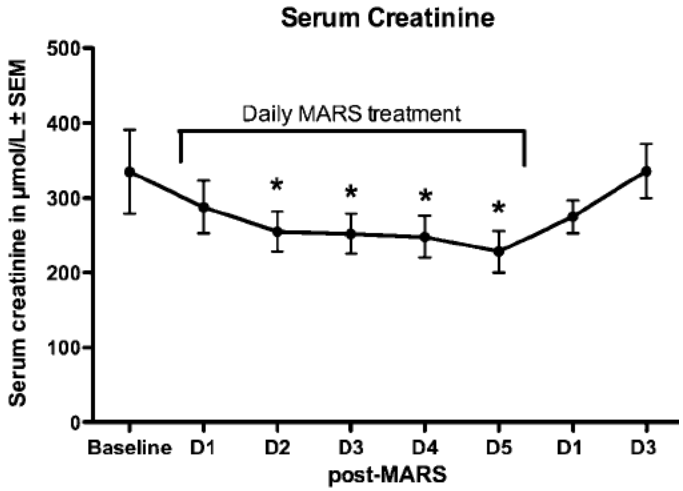
Less HRF 9 vs 22

Decreased infection

52 patients
Enteral feeding and 14 days Rx
No benefit

Moreno et al J Hepatology 2010

	Pre-MARS	Post-MARS
Renin (normal 6.4—23.8 ng/l)	76.92±16.45	61.24±21.74
Aldosterone (normal 27—444 pmol/l)	2295±1141	1443±841
Norepinephrine (normal 0.8—3.4 nmol/l)	4.08±0.58	4.80±0.72
Atrial natriuretic factor (normal 23—52 pg/ml)	113.0±28.5	106.2±19.8
Tumour necrosis factor α (normal <2.1 pg/ml)	5.86±1.24	6.96±1.11
Interleukin-6 (normal 0.4—8.9 pg/ml)	110.6±23.7	145.2±20.7



Midronine to identify responders and these then offered TIPS

Hepatology 2004

Gut 2010 59: 381-386

Molecular adsorbent recirculating system is ineffective in the management of type 1 hepatorenal syndrome in patients with cirrhosis with ascites who have failed vasoconstrictor treatment

Florence Wong,

Terlipressin + Albumin vs Albumin

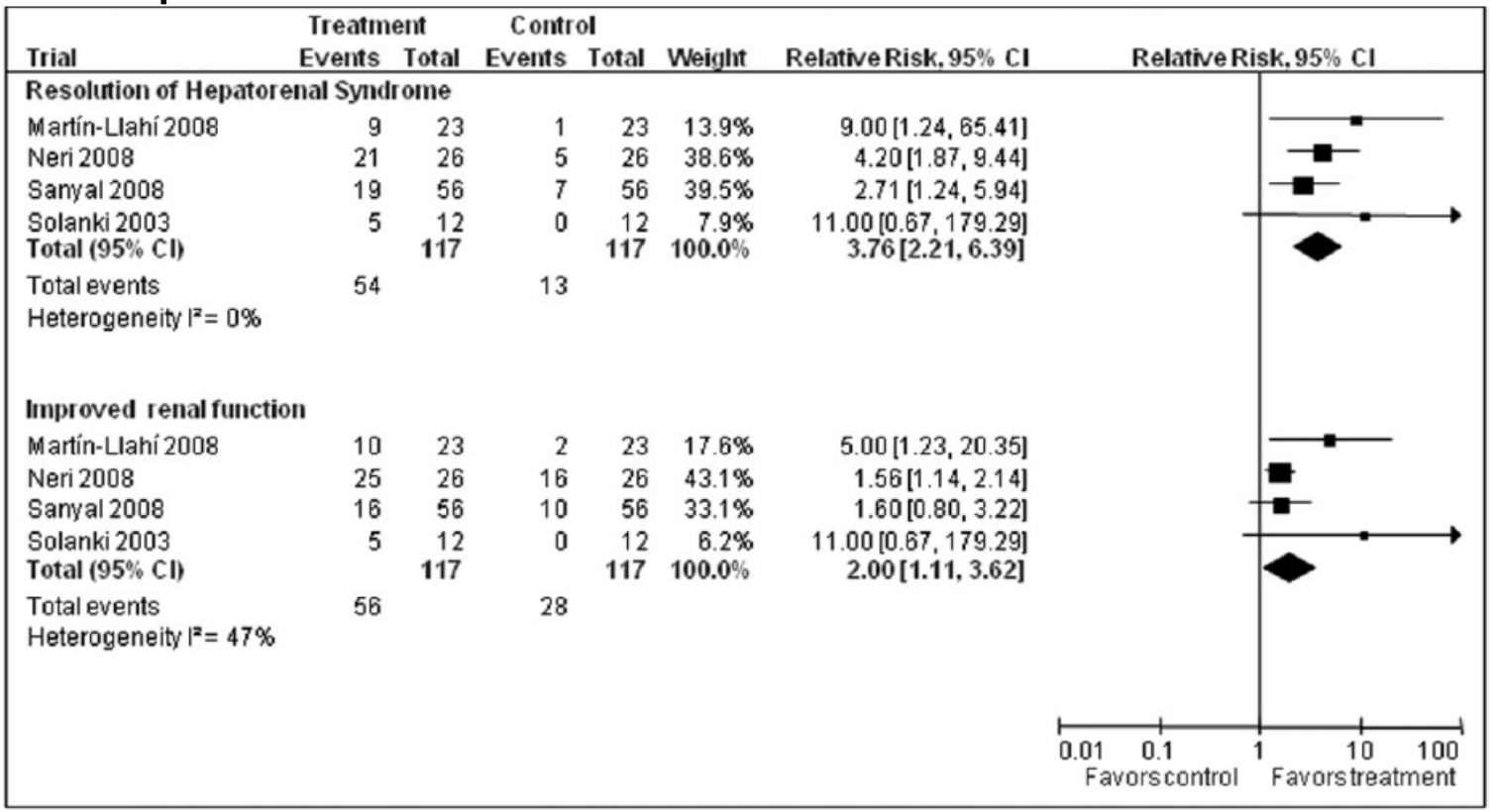


Fig. 3. Forest plots of random effects meta-analyses on terlipressin plus albumin versus albumin for patients with HRS. The outcome measures are reversal of HRS and improved renal function. The included patients received terlipressin alone or with albumin versus no intervention or albumin.

Vasoconstrictors + Alb : Effect on mortality at 15 days but not at 30, 90 or 180 days RR 0.6 (0.37-0.97)

Terlipressin + Albumin vs Albumin : decreased mortality in type I RR 0.83 (0.65-1.05)

Predictors of Response to Therapy with Terlipressin and Albumin in Patients with Cirrhosis and Type 1 Hepatorenal Syndrome

André Nazar

Hepatology 2010;51:219-226

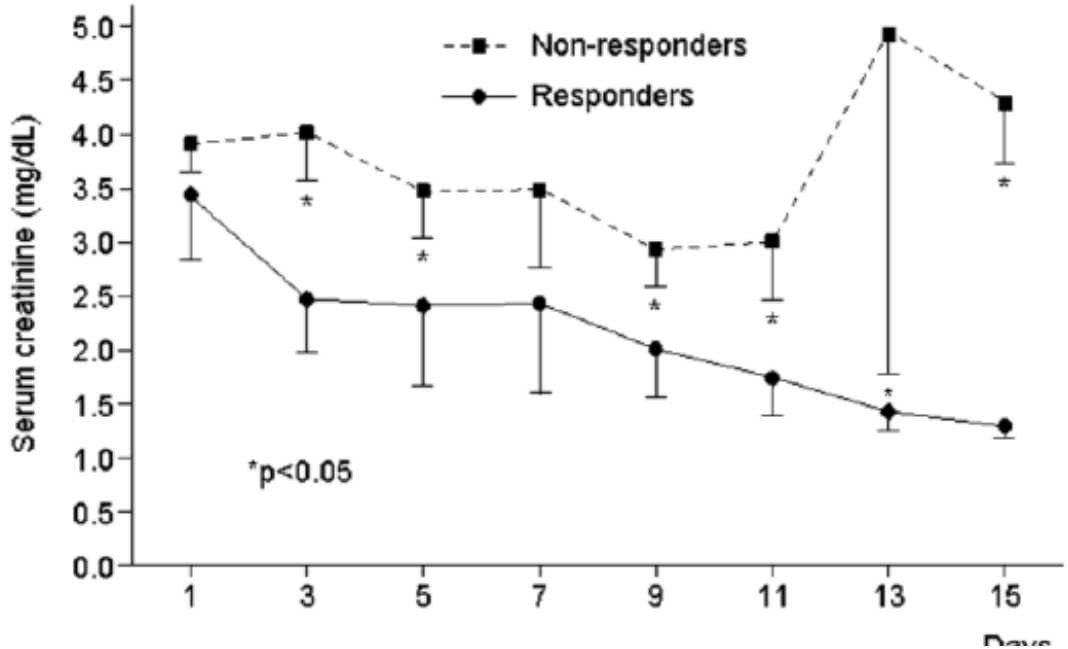


Table 4. Variables with Independent Predictive Value of Response to Treatment with Terlipressin and Albumin in Patients with Type 1 HRS

Variables	Odds Ratio	95% Confidence Interval	*P*
Baseline serum bilirubin	0.901	0.834–0.974	0.009
Δ MAP at day 3 ≥5 mm Hg	9.482	1.007–89.316	0.049

Predictors of response to terlipressin plus albumin in hepatorenal syndrome (HRS) type 1: Relationship of serum creatinine to hemodynamics

Thomas D. Boyer Terlipressin Study Group

Table 1. Summary of the effects of baseline characteristics on HRS reversal and survival (univariate analysis, ITT population).

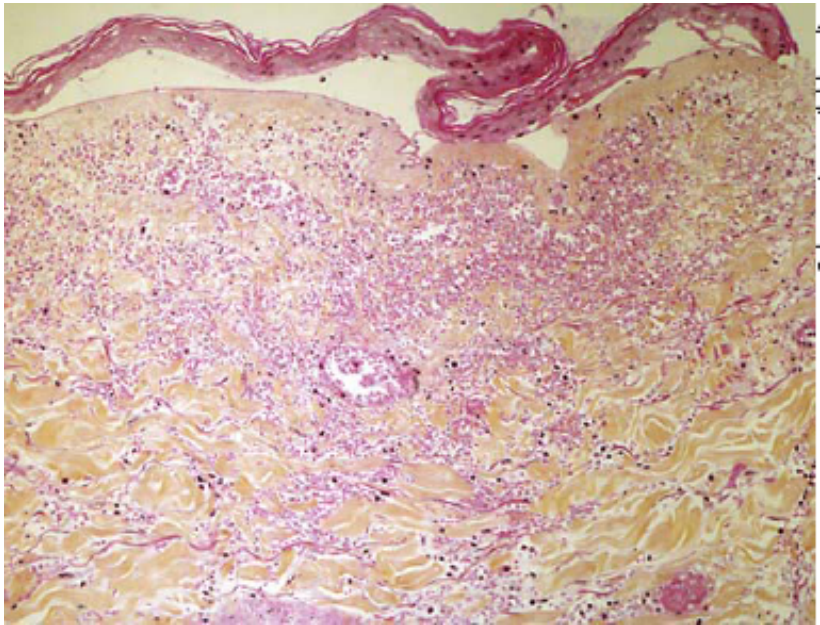
Baseline parameter	HRS Reversal			Survival		
	RR	95% CI	*p* value	RR	95% CI	*p* value
Treatment group	2.71	1.24-5.94	0.009	0.93	0.58-1.51	0.782
Alcoholic hepatitis	0.97	0.49-1.92	0.890	2.29	1.41-3.72	<0.001
Gender	0.57	0.31-1.08	0.055	1.00	0.59-1.69	0.963
MELD score	0.95	0.91-0.99	0.017	1.05	1.01-1.10	0.030
Child-Pugh score	0.87	0.75-1.02	0.065	1.15	1.00-1.32	0.051
Serum creatinine	0.65	0.46-0.93	0.021	1.40	1.22-1.60	<0.001
Bilirubin	1.00	0.97-1.02	0.805	1.01	1.00-1.03	0.087
MAP	0.99	0.96-1.02	0.459	1.02	0.99-1.04	0.216
Serum sodium	0.99	0.95-1.04	0.730	0.99	0.95-1.03	0.519

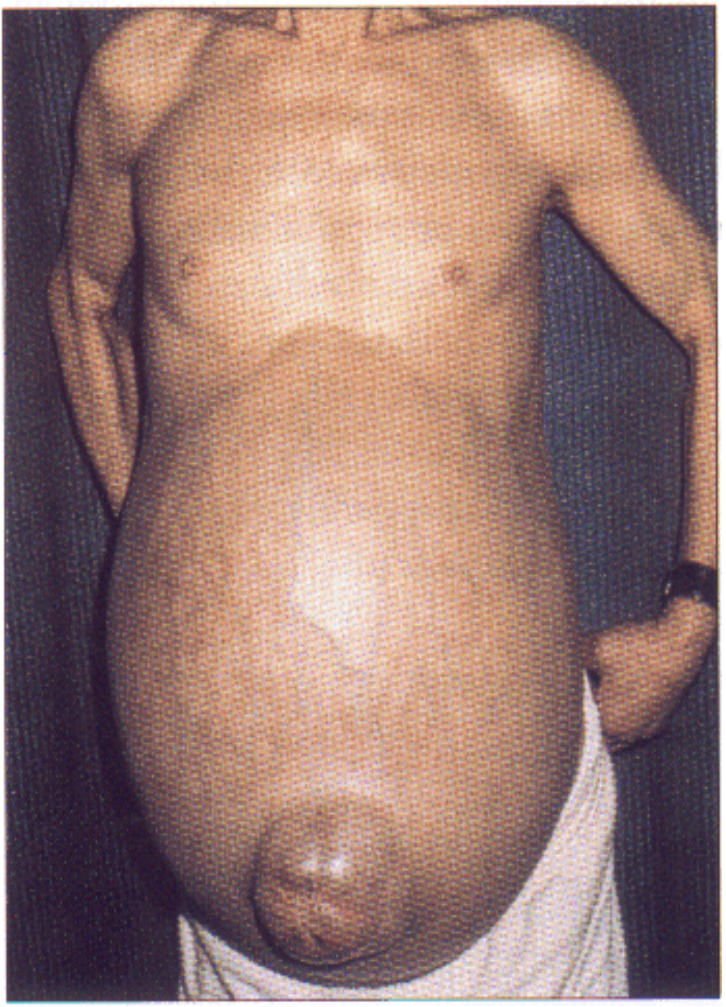
Journal of Hepatology **2011** vol. 55 | 315–321

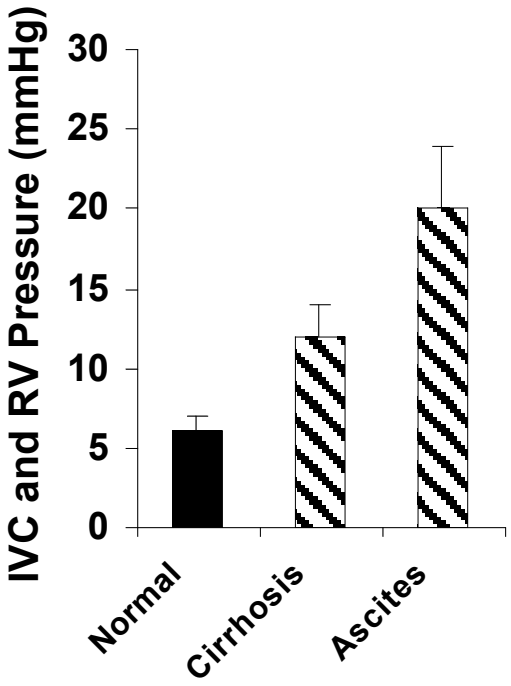
Blue fingers and toes

Myocardial events

Diarrhoea - almost inevitable



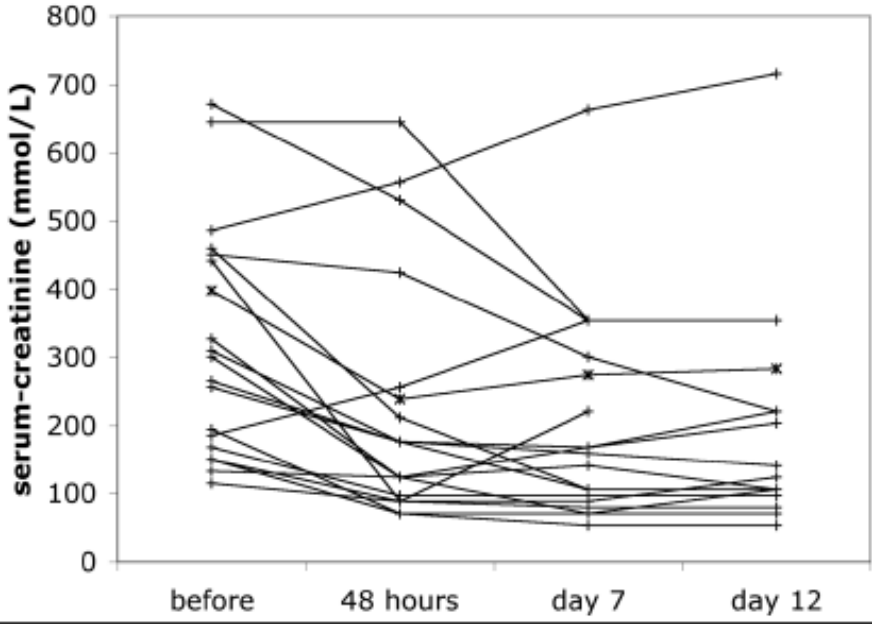




RPP 61 to 67 mmHg

Andreas Umgelter

Critical Care Vol 12 No 1



Consider IAP and renal perfusion pressure

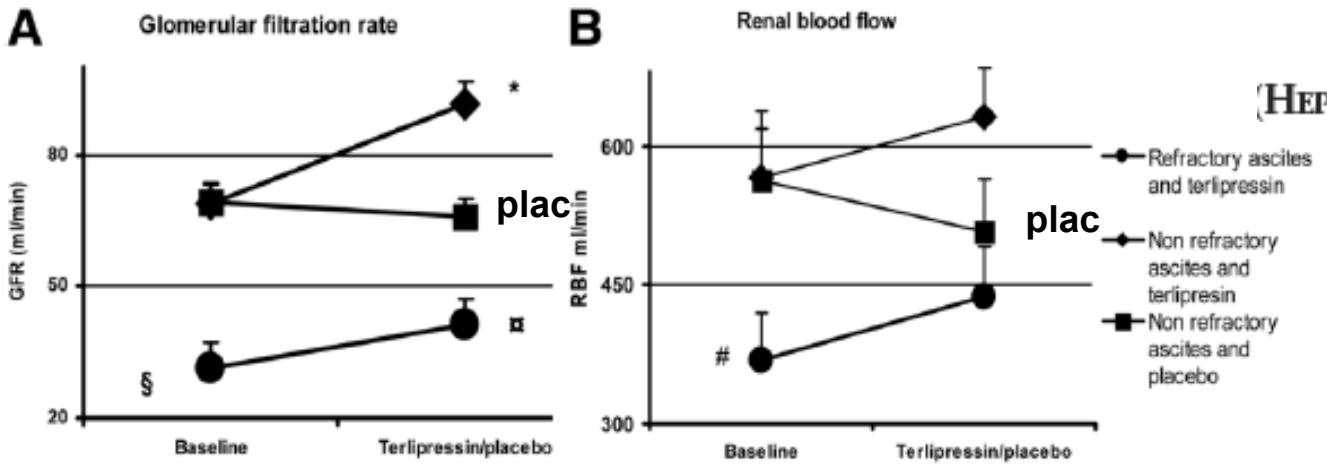
Options

1. ***Decrease IAP***
2. ***Increase RPP***
3. ***Improve central blood volume***

Terlipressin Improves Renal Function in Patients with Cirrhosis and Ascites Without Hepatorenal Syndrome

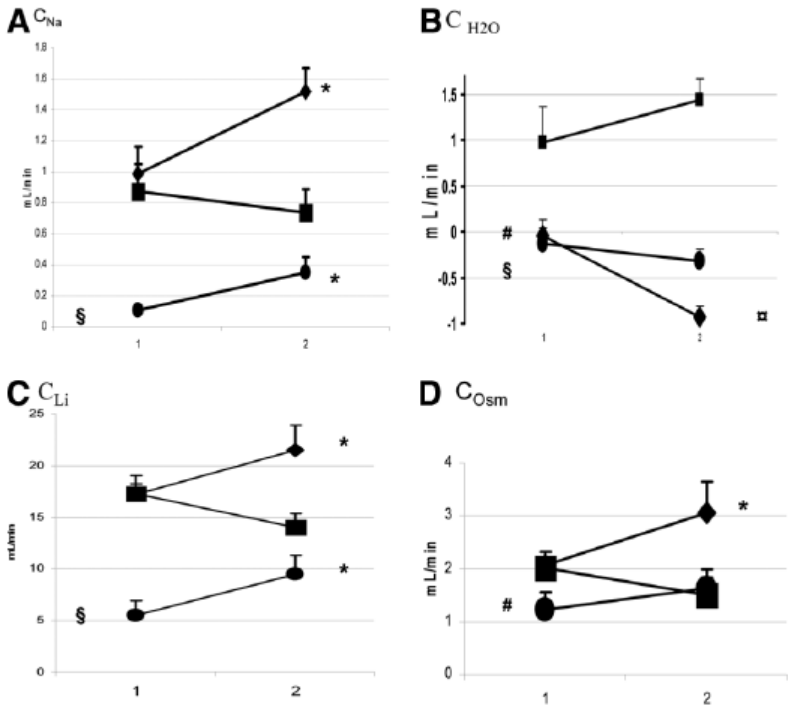
Aleksander Krag.

[Hepatology 2007;46:1863-1871.



MAP no relationship to changes in GFR

Reversal of RAA, NE levels



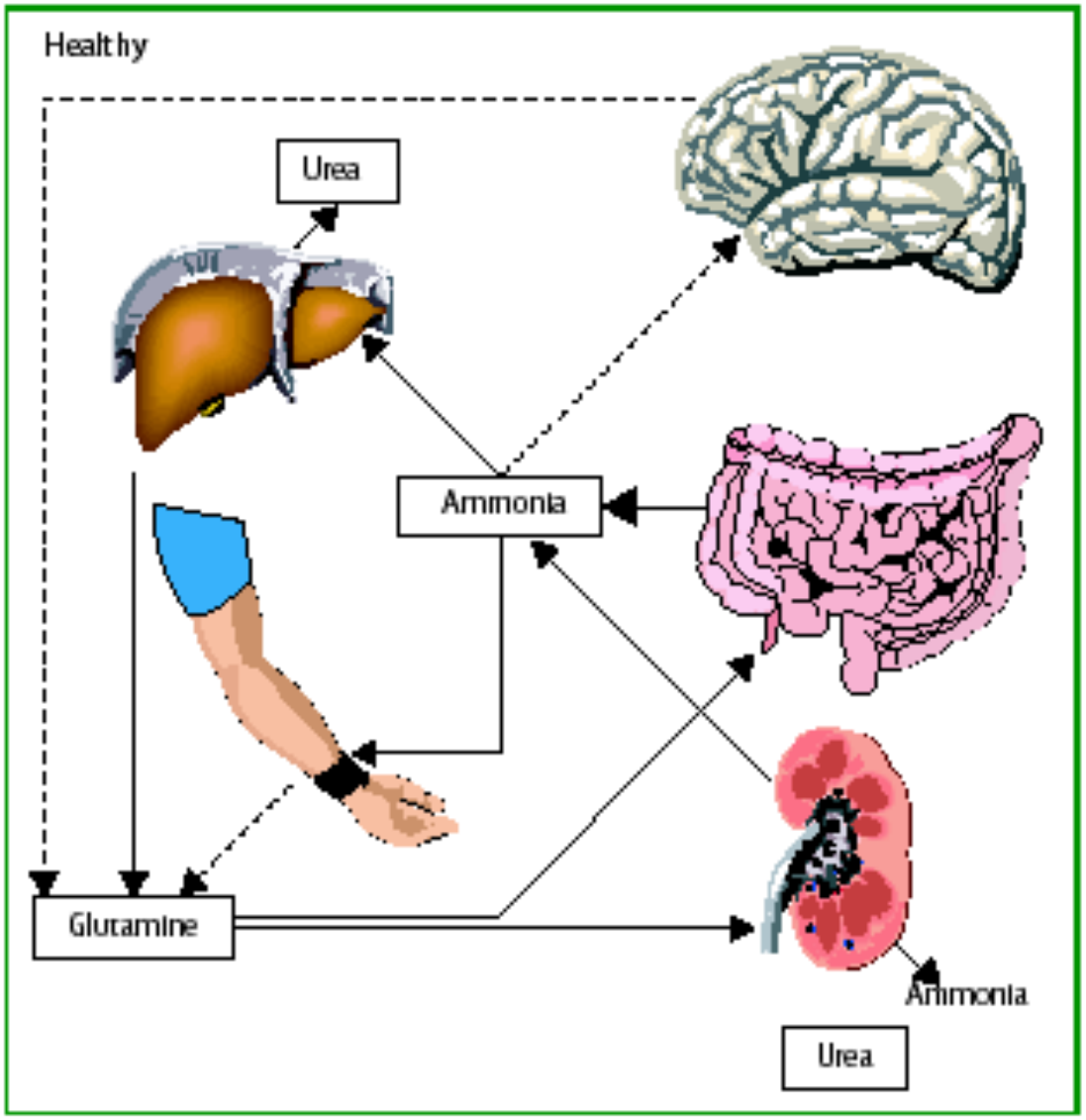
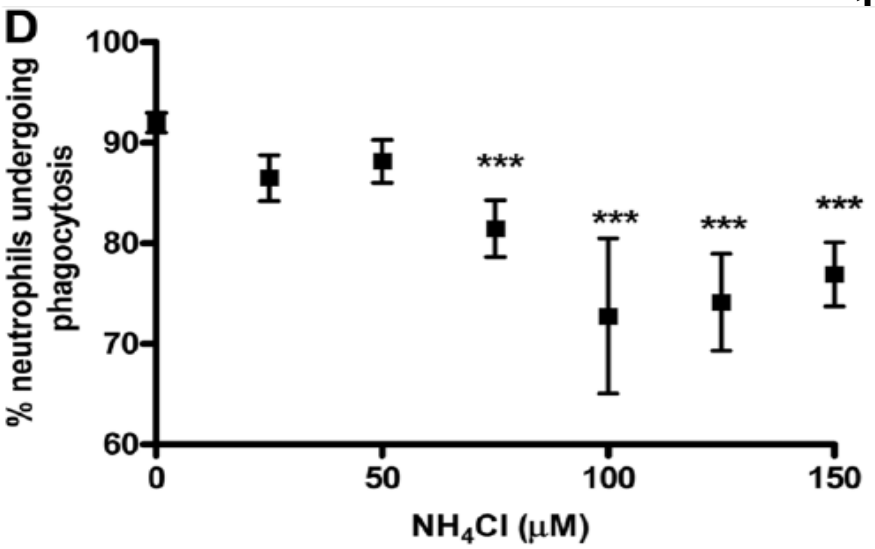
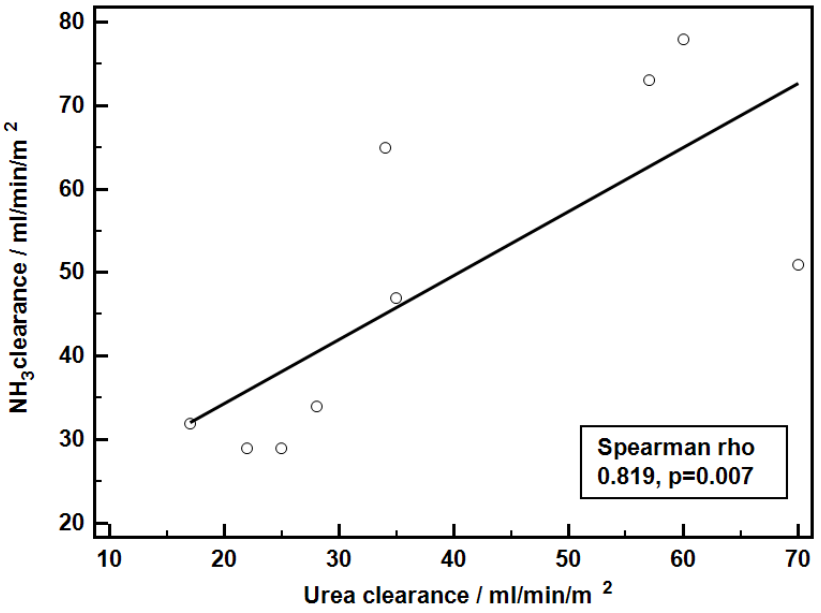


Figure: Interorgan trafficking of ammonia in health and in cirrhosis
In healthy individuals, liver removes ammonia by detoxification into urea. In patients with cirrhosis, metabolic capacity of liver is reduced, resulting in hyperammonaemia: muscle becomes important organ of ammonia detoxification into glutamine. Glutamine acts as temporary buffer that can both regenerate ammonia (enterocytes) and excrete ammonia (kidneys).

(HEPATOLOGY 2008;48:1202-1212.

CVHF Arterial NH4 > 100
10 FHF 10 AoCLD *Slack A ESICM 2010*





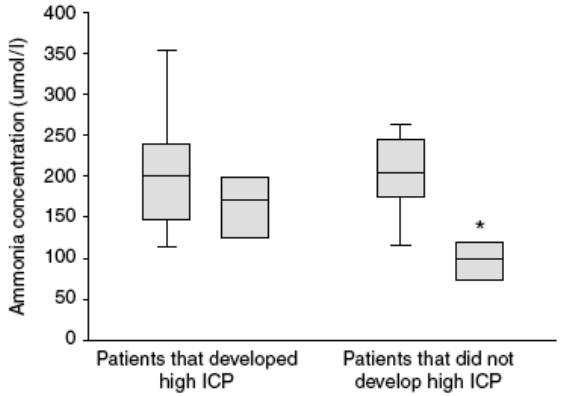
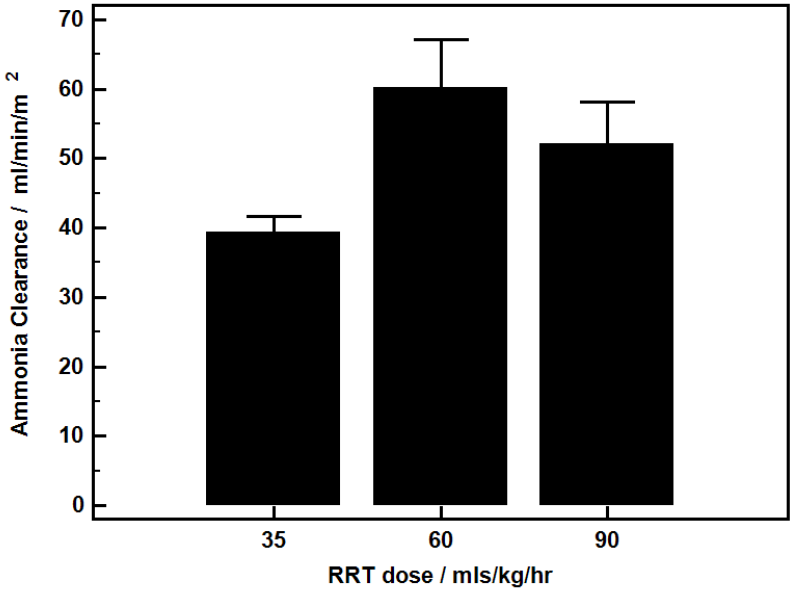


Figure 1 Arterial ammonia concentration (μmol/L) in two groups of patients with fulminant hepatic failure (FHF): patients who did develop high ICP and patients who did not. For each group, baseline values and values taken later during FHF are given. *$P < 0.05$ versus baseline values in both groups.



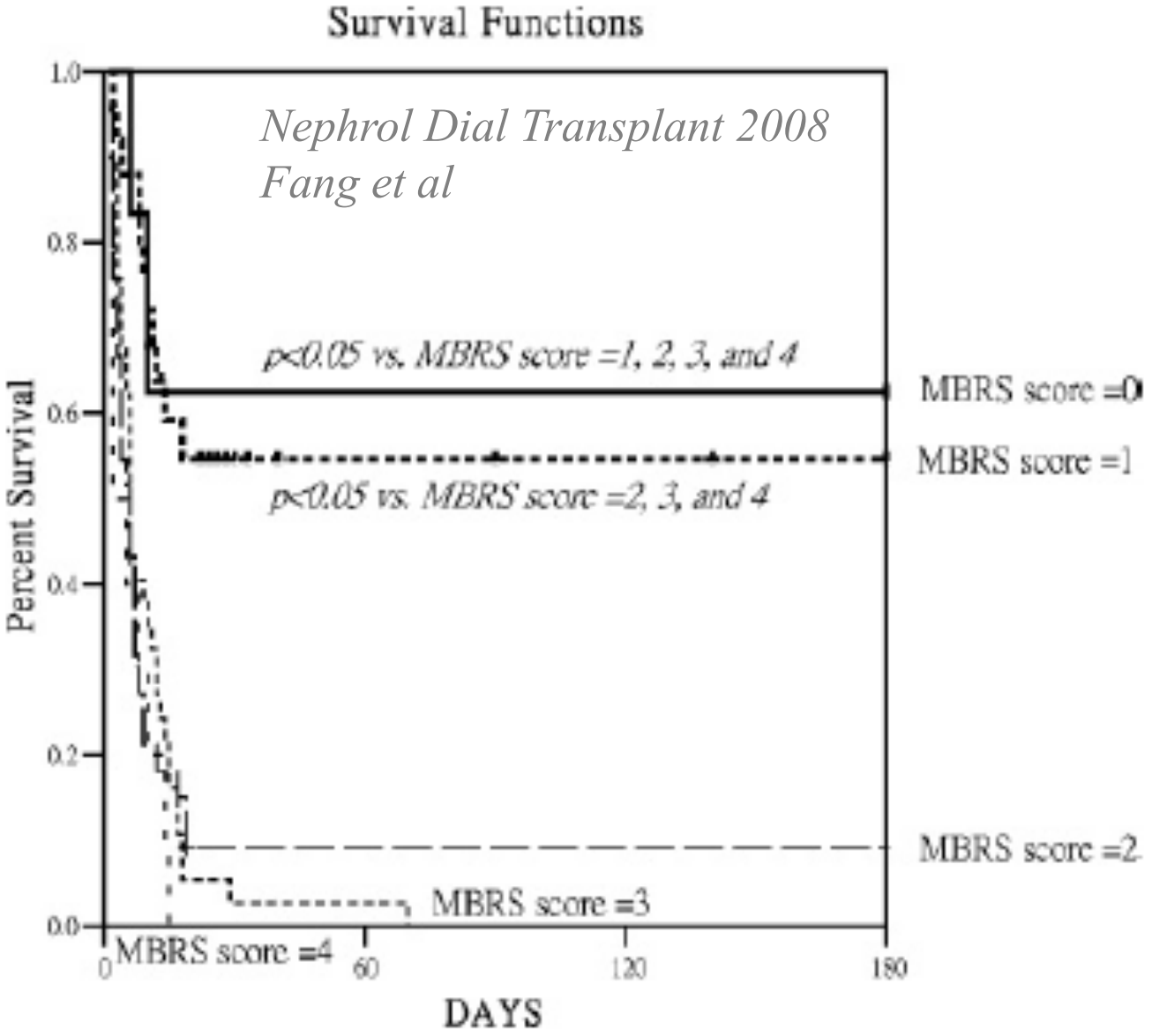


Fig. 1. Cumulative survival in 111 critical ill cirrhotic patients with acute renal failure according to their MBRS score after the first day of admission to a specialized hepatogastroenterology intensive care unit.

111 patients
ITU admissions
with cirrhosis +
ARF

2003-2005

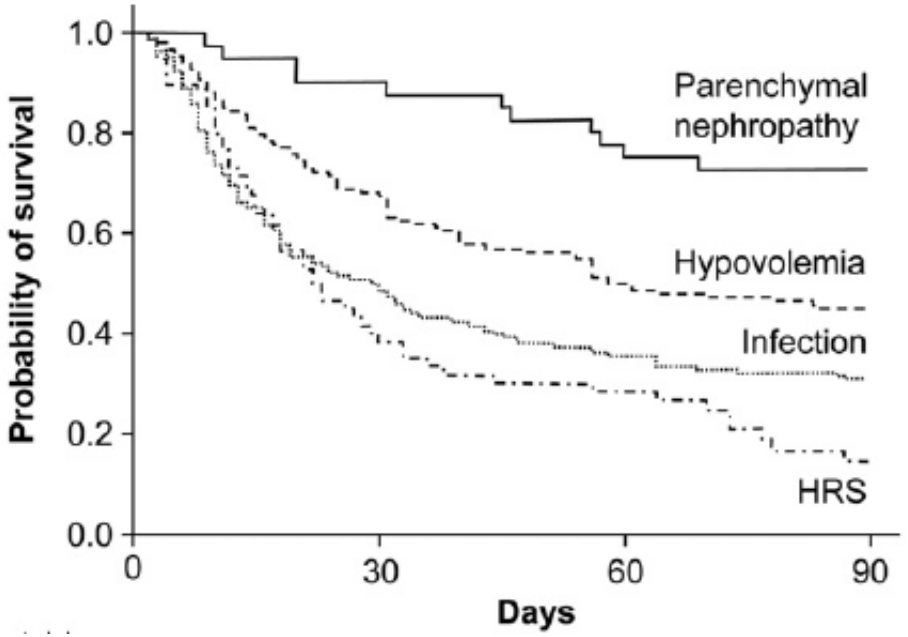
Scoring system
MAP 80
Bili 80
Resp failure
Sepsis

ROC 0.89
mortality > 90%
if score > 2

Prognostic Importance of the Cause of Renal Failure in Patients With Cirrhosis

GASTROENTEROLOGY 2011;140:488–496

MARTA MARTÍN-LLAHÍ,



Creatinine >1 .5 mg/dl
463 patients over 6 years
Single centre

	Odds ratio	*P*	95% confidence interval
Hypovolemia-related	2.32	.049	1.00–5.36
Bacterial infections	2.61	.027	1.11–6.11
Hepatorenal syndrome	6.88	.001	2.19–21.55
MELD score at diagnosis	1.13	.0005	1.08–1.18
Serum sodium at diagnosis	0.96	.020	0.92–0.99
Hepatic encephalopathy at diagnosis[a]	1.94	.005	1.22–3.09

3 month mortality

Continuous renal replacement therapy (CRRT) in patients with liver disease: Is circuit life different?☆

Journal of Hepatology 51 (2009) 504–509

Retrospective chart study in patients undergoing RRT without initial anticoagulation

Coagulation data

Renal function and coagulation status prior to initiation of CRRT.

Parameter	ALF	ACLD	Post-LTx	Sepsis	Haematological
Urea mmol/l	16 (11.7)	23.6 (16.3)	15.9 (8.4)	22.0 (10.4)	25.1 (13.5)
Creatinine μmol/l	313.5 (147)	319.2 (340)	236.1 (87)	386.8 (273)	304 (155)
INR	5.66 (3.1)[a]	2.67 (0.74)	2.82 (0.97)	2.05 (0.89)	1.75 (0.29)
APTT (s)	120.6[b] (48.7)	104.4 (54.4)	67.5 (28.6)	53.9 (21.7)	52.5 (12.9)
Platelet count 10^9/l	109.5 (97.7)	80.4 (51.1)	71.3 (35.2)	204.6 (136)	53.5 (56.7)

Circuit life

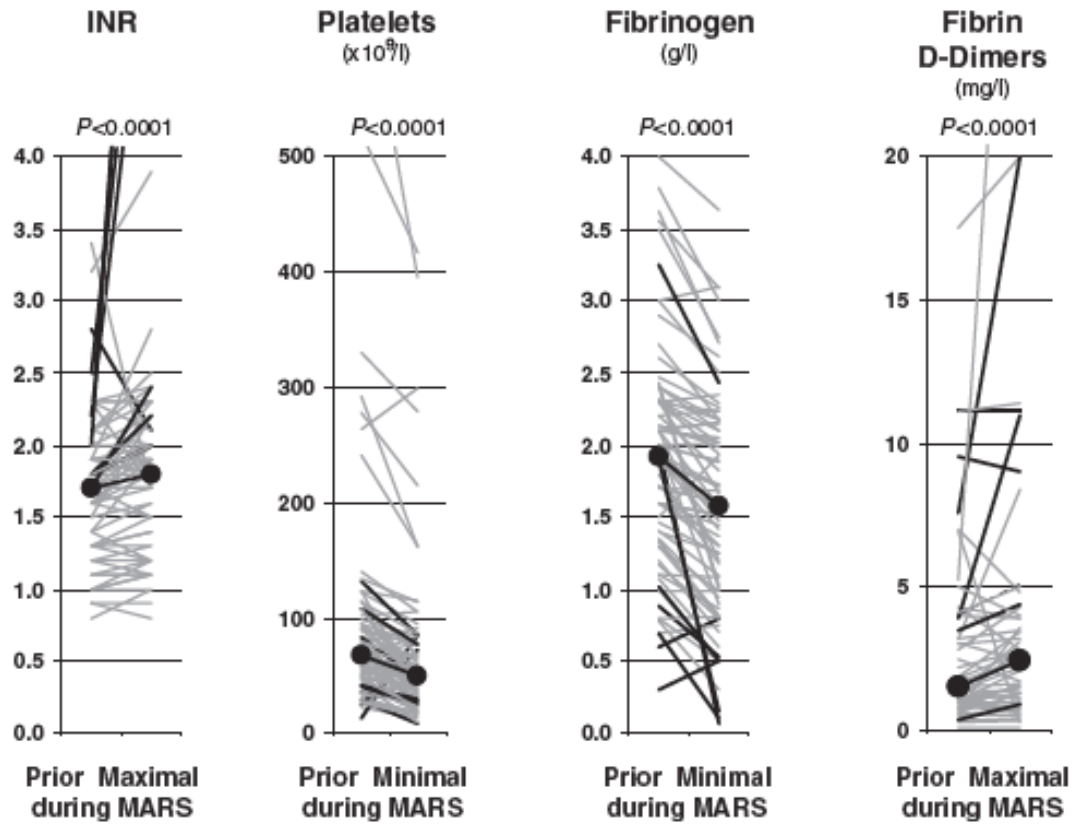
Duration of continuous renal replacement (CRRT) circuits.

Parameter	ALF	ACLD	Post-LTx	Sepsis	Haematological
Mean filter life in hours – 1st–3rd filter	10.4 (8.6)	11.1 (7.8)	8.1 (6.2)	11.6 (11.4)	21.7 (19.7)*
Number of filters used/48 h	4.3 (1.3)	4.2 (2.1)	5.3 (1.5)	4.6 (1.5)	2.4 (1.1)**
Number of filter clots the 1st 3 CRRT circuit	2.1 (0.7)	1.9 (1.1)	1.9 (1.1)	2.1 (1.1)	1.8 (1)
Number of PRBC transfusion	4.8 (4.2)	4.2 (4.16)	2.2 (2.1)	3.0 (1.6)	1.2 (1.3)

Anticoagulation added to a sub group and filter life increased from 5.6 to 19 hours

Artificial liver support with the molecular adsorbent recirculating system: activation of coagulation and bleeding complications Liver International (2007)

Esther B. Bachli[1*†], Reto A. Schuepbach[1*], Marco Maggiorini[1,2], Reto Stocker[3], Beat Müllhaupt[4] and Eberhard L. Renner[4‡]



Doria et al
Clinical Transplantation 2004;18:365

Significant worsening of PT, all TEG variables, factor VIII, von WB, DDimers

Molecular adsorbent recirculating system and hemostasis in patients at high risk of bleeding: an observational study *Critical Care* 2006, 10:R24 Peter Faybik[1],

Statistical decrease in platelets and fibrinogen and other TEG functions but no evidence of clot lysis / fibrinolysis however

Citrate pharmacokinetics and metabolism in cirrhotic and noncirrhotic critically ill patients

Crit Care Med 2003 Vol. 31, No. 10

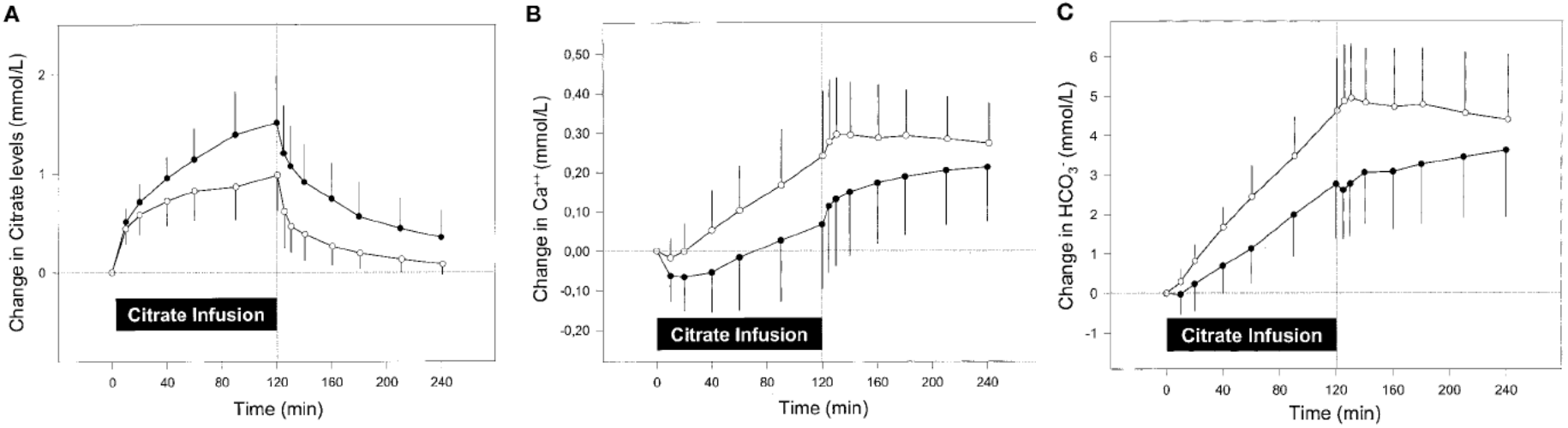
Ludwig Kramer

Table 3. Citrate pharmacokinetics

	Cirrhotic Patients	Control Group	*p* Value
Total dose, mmol	77 ± 21	72 ± 10	.40
$C_{baseline}$, mmol/L	0.51 ± 0.13	0.06 ± 0.13	<.001
C_{max}, mmol/L	1.60 ± 0.50	1.01 ± 0.39	.007
T_{max}, mins	115 ± 12	114 ± 16	.93
AUC, mmol × min/L	282 ± 130	131 ± 68	<.001
$t_{1/2}$, mins	69 ± 33	36 ± 18	.001
Vd_z	27 ± 9	29 ± 10	.52
Vd_{ss}	23 ± 6	21 ± 6	.34
Clearance, mL/min	340 ± 185	710 ± 397	.002

NaCitrate @ 0.5 mg/kg/hr
CaCa 0.17 ml/kg/hr

Increase citrate
No citrate side effects



Closed circles cirrhotics

Regional citrate anticoagulation in patients with liver failure supported by a molecular adsorbent recirculating system*

Crit Care Med 2011 Vol. 39, No. 2

Peter Faybik,

4% trisodium citrate infused @ 2-3 mm
blood flow
Post filter iCa levels of 0.2-0.4 mmol/L
CaCl infusion at 0.5 mmol
pre re-infusion of blood
Median subsitution rate 0.9 mmol/L
effluent

	Median (25–75% IQR)
pH	7.33 (7.25–7.38)
$Paco_2$	39.7 (31.7–46.8)
Bicarbonate,mmol/L	18.8 (16.8–23.2)
Base excess, mmol/L	−6.8 (−9.4 to −1.4)
$BE_{Natrium}$, mmol/L	0 (−1.5–1.9)
$BE_{Chloride}$, mmol/L	−4.0 (−6.9 to −2.2)
$BE_{Lactate}$, mmol/L	−3.5 (−10.5 to −0.9)
$BE_{Albumin}$, mmol/L	4.5 (3.6–4.9)
$BE_{Unmeasured\ anions}$,	0.05 (−3.2–1.9)

Table 4. Laboratory parameters before and after MARS treatment (pooled data; n = 77 measurements, n = 20 patients)

	Before MARS Mean ± SD	After MARS Mean ± SD	*p*
Creatinine, mg/dL	1.71 ± 1.04	1.28 ± 0.51	.001
Prothrombin time, %	43 ± 25	43 ± 26	.23
Bilirubin, mg/dL	14.8 ± 8.6	11.8 ± 5.1	.005
Aspartate aminotransferase, U/L	2560 ± 5190	2386 ± 4953	.42
Alanine aminotransferase, U/L	1578 ± 2778	1398 ± 2468	.65
Albumin, mg/dL	25.6 ± 4.1	25.7 ± 4.1	.80
Hemoglobin, mg/dL	9.2 ± 1.6	9.1 ± 1.3	.27
Platelet count	72 ± 47	64 ± 41	.03

Median 20 hours treatment
2 of 77 filters stopped early for bleeding / clotting

	Before MARS Mean ± SD	After MARS Mean ± SD	*p*
pH	7.35 ± 0.08	7.37 ± 0.08	.0005
$Paco_2$, mm Hg	43 ± 12	44 ± 12	.98
Bicarbonate, mmol/L	23 ± 4	24 ± 4	.01
Base excess, (mmol/L	−1.75 ± 5.72	0.59 ± 5.68	.004
$BE_{Natrium}$, mmol/L	0.14 ± 1.81	0.39 ± 1.21	.36
$BE_{Chloride}$, mmol/L	−4.75 ± 3.69	−4.67 ± 3.43	.94
$BE_{Lactate}$, mmol/L	−2.5 ± 3.5	−2.0 ± 3.2	.14
$BE_{Albumin}$, mmol/L	4.40 ± 1.12	4.44 ± 1.17	.65
$BE_{Unmeasured\ anions}$, mmol/L	0.95 ± 3.20	2.43 ± 4.24	.0003
Anion gap, mmol/L	8 ± 4	7 ± 3	.005
$Anion\ gap_{corrected}$, mmol/L	12 ± 4	11 ± 3	.004
$SID_{apparent}$	38.3 ± 4.6	38.9 ± 4.5	.23
$SID_{effective}$	32.3 ± 4.6	33.5 ± 4.1	.02
SIG	6.0 ± 3.0	5.4 ± 3.0	.068

Table 5. Electrolytes before and after MARS treatment (pooled data; n = 77 measurements, n = patients)

	Before MARS Mean ± SD	After MARS Mean ± SD	*p*
Sodium, mmol/L	140 ± 6	141 ± 4	.36
Potassium, mmol/L	4.2 ± 0.4	4.1 ± 0.4	.08
Chloride, mmol/L	107 ± 5	107 ± 4	.29
Magnesium, mmol/L	0.93 ± 0.14	0.94 ± 0.14	.38
Phosphate, mmol/L	1.24 ± 0.5	1.06 ± 0.5	<.0001
Total calcium, mmol/L	2.34 ± 0.32	2.44 ± 0.39	.08
Total calcium$_{corrected}$, mmol/L	2.70 ± 0.31	2.80 ± 0.39	.09
Ionized calcium, mmol/L	1.16 ± 0.15	1.13 ± 0.15	.05
Total calcium/ionized calcium ratio	2.04 ± 0.32	2.17 ± 0.35	.01

MARS, molecular adsorbent recirculating system; Total calcium$_{corrected}$, total calcium corrected f hypoalbuminemia.

Examining those in receipt of RRT

		survivors	non survivors
RRT alone		17	5
NA + RRT		4	9
Vent +RRT		8	18
NA+RRT+vent	28		

50% of cases require RRT

22% survival overall

166

Differences between S and NS

Duration of Rx 6 (3-12) vs 8 (3-14)
D1 urine output 500 (10-1000) vs 285 (0-1000)
D1 lactate 2.2 (1.6-4) vs 3.1(1.8 - 5.5)
D3 lactate 1.8 (1.3-2.5) vs 2.6 (1.8-4.8)

Acute kidney injury in patients admitted to a liver intensive therapy unit. *O'Riordan A*

Period 2000-2007 : 302 ALF managed without OLT

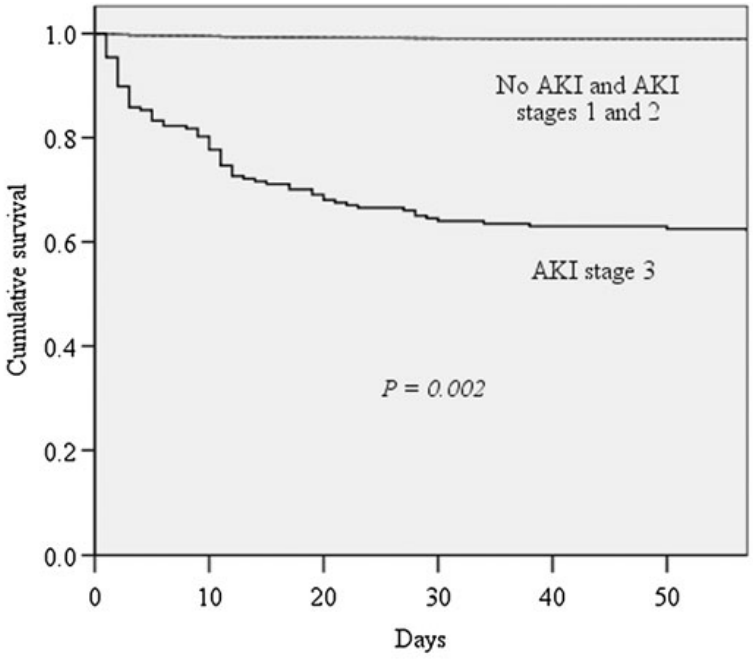
21% did not develop AKI : all survived

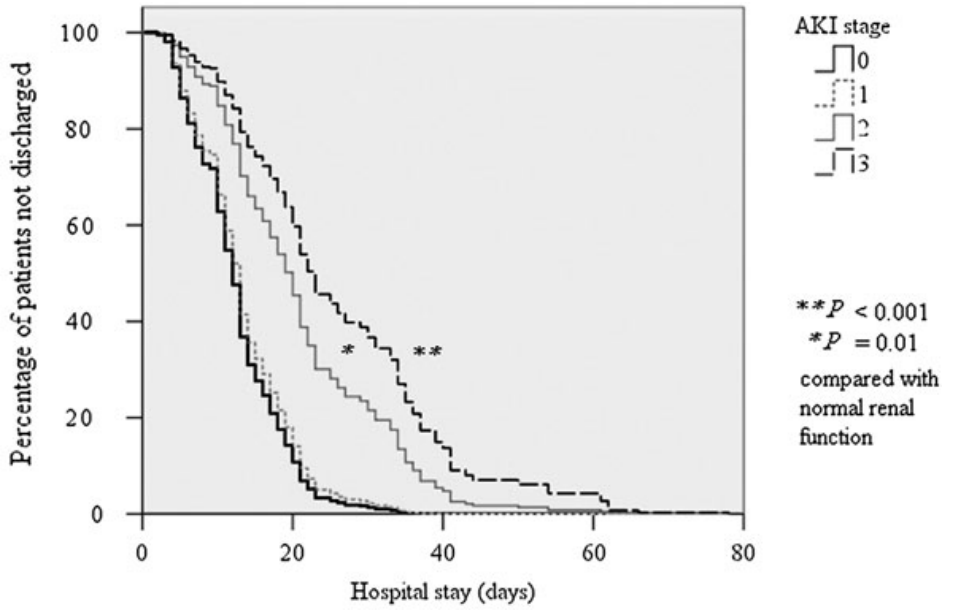
239 with AKI of whom 164 survived

51% return of normal renal function
eGFR > 60 at time of discharge

7% required on going haemodialysis at time of discharge
– lower than perhaps in a general population
At 30 days post discharge of this group eGFR was 20
At 90 days none dialysis dependant and eGFR > 60 (n=5)
AKI univariate factor only re survival

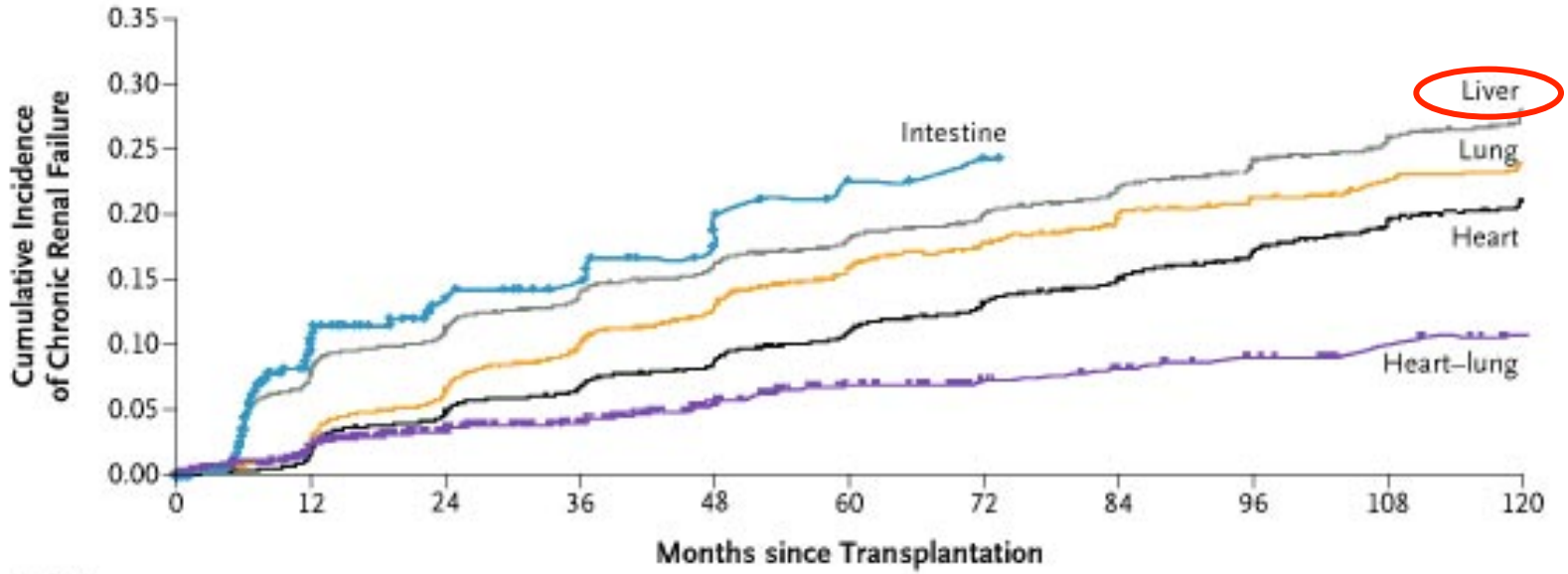
Nephrol Dial Transplant. 2011 Nov;26 (11):3501-8.





AKI only important on univariate not multivariate analysis

Cumulative Incidence of Chronic Renal Failure



No. at Risk											
Heart–lung	576	375	295	219	194	156	133	107	72	46	30
Heart	24,024	19,885	17,238	14,687	12,341	10,022	7997	6104	4526	3096	1991
Intestine	228	152	110	84	57	33	23	13	8	5	5
Liver	36,849	28,495	24,041	19,508	15,724	12,564	9844	7345	5292	3614	2261
Lung	7,643	5,633	4,316	3,184	2,327	1,629	1136	745	468	258	133

N = 69,231 persons who received a transplant in the USA 1990-2000

Ojo AO, et al. *N Engl J Med* 2003;349:931-40.

In summary

- NH4 is cleared by kidneys
- In cirrhosis –
  - high incidence of CRF
  - Over diuresis +++++
- High incidence of CRF post Tx
- In ALF AKI
  - Is a marker of severity of liver injury
  - Except in those with paracetamol induced AKI with minor ALF