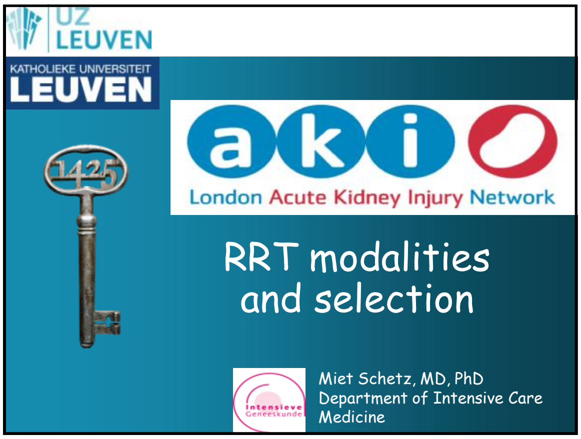
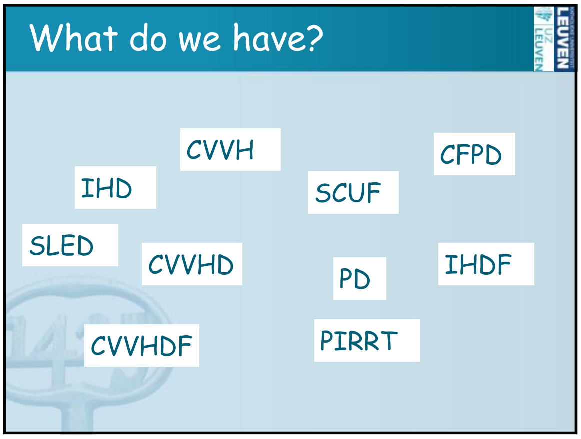
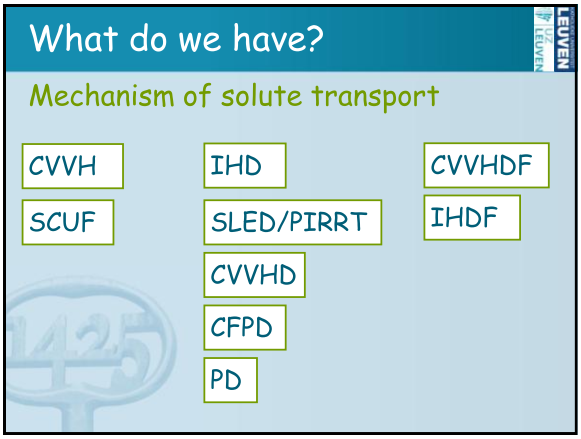

UZ LEUVEN
KATHOLIEKE UNIVERSITEIT LEUVEN
aki
London Acute Kidney Injury Network
RRT modalities and selection
Miet Schetz, MD, PhD
Department of Intensive Care Medicine


What do we have?
CVVH
CFPD
IHD
SCUF
SLED
CVVHD
PD
IHDF
CVVHDF
PIRRT


What do we have?
Mechanism of solute transport
CVVH
IHD
CVVHDF
SCUF
SLED/PIRRT
IHDF
CVVHD
CFPD
PD

What do we have?

Continuous vs intermittent vs hybrid

CVVH

SCUF

CVVHD

CVVHDF

CFPD

IHD

IHDF

PD

SLED/PIRRT

What do we have?

Extracorporeal vs intracorporeal

CVVH

SCUF

IHDF

CVVHDF

IHD

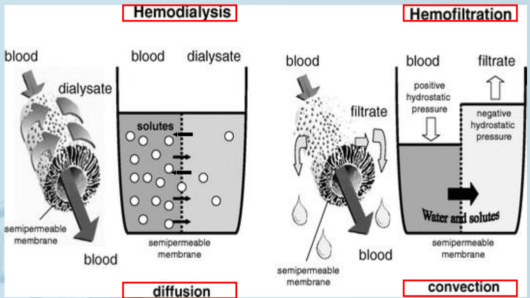
CVVHD

SLED/PIRRT

PD

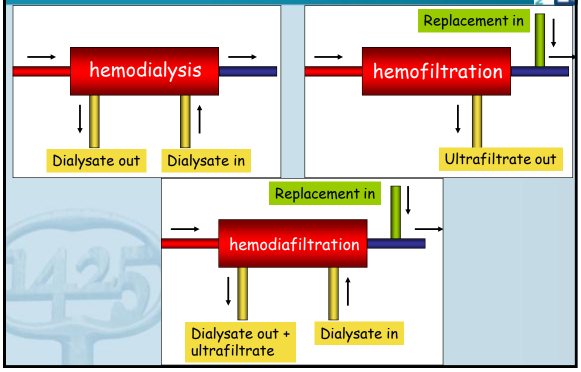
CFPD

Mechanisms of solute transport



Combination = hemodiafiltration

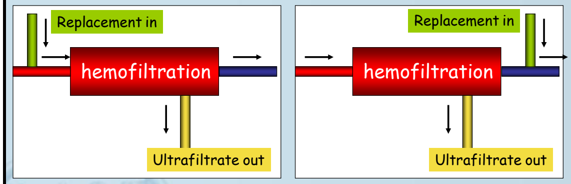
Mechanisms of solute transport



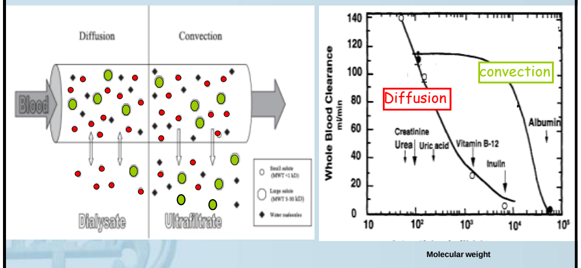
Mechanisms of solute transport

Predilution

Postdilution



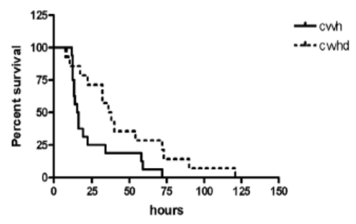
Mechanisms of solute transport



Diffusion or convection?

Prospective randomized cross-over study - n= 15 - CVVH vs CVVHD

Median filter life: CVVHD 37h (19.5-72.5) vs CVVH 19h (12.5-28) p 0.03

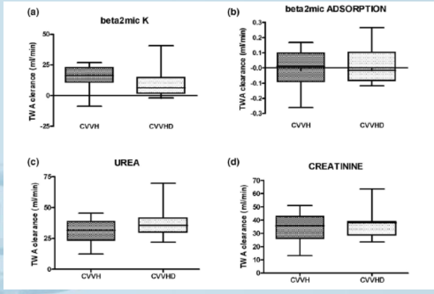


Kaplan-Meier analysis of circuit survival for continuous veno-venous hemofiltration (CVVH) and continuous veno-venous dialysis (CVVHD).

Ricci et al. Crit Care 2006; 10: R67

Diffusion or convection?

Prospective randomized cross-over study - n= 15 - CVVH vs CVVHD



Ricci et al. Crit Care 2006; 10: R67

Diffusion or convection?

Prospective randomized cross-over study - CVVH vs CVVHD

n= 13 - SIRS + AKI

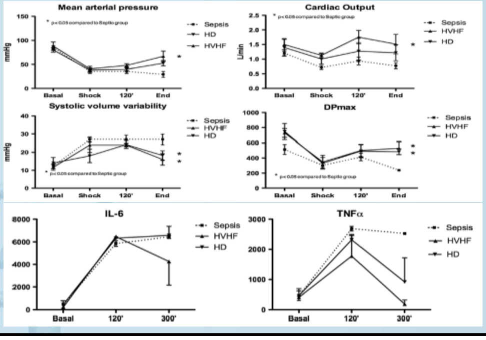
Mediator	CVVH	CVVHD	*p* Value
All Patients (n = 13)	Relative change of plasma concentration		
TNF-α	0.87 ± 0.22[a]	1.23 ± 0.51[a]	.021
IL-6	1.19 ± 0.51	1.57 ± 1.25	NS
IL-10	1.10 ± 0.38	1.11 ± 0.27	NS
sL-selectin	1.03 ± 0.12	0.99 ± 0.04	NS
Endotoxin	1.13 ± 0.43	1.19 ± 0.20	NS

Kellum et al. Crit Care Med 1998; 26: 1995-2000

Diffusion or convection?

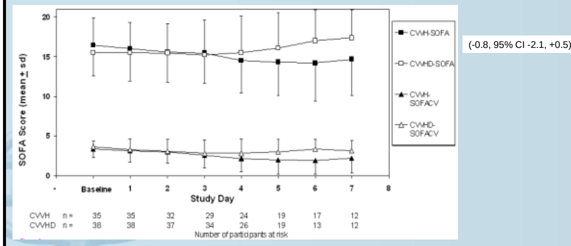
Herrera-Gutièrrez et al. J Trauma Acute Care Surg 2012; 73: 855-60

Animal model of sepsis - CVVH vs CVVHD



Diffusion or convection?

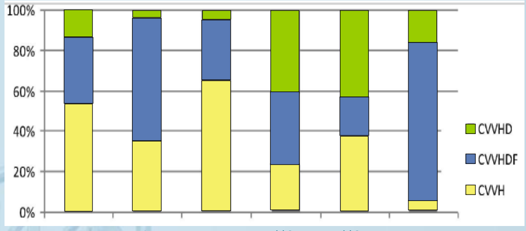
Feasability pilot RCT - CVVH vs CVVHD with similar small solute clearance
n= 78 - AKI + hemodynamic instability
No difference in mortality (C 54% vs D 55%)
dialysis dependence at 60d (C 24% vs D 19%)



Wald et al. Crit Care 2012; 16: R205

Diffusion or convection

Practice patterns based on surveys



	Internat	Aust NZ	UK	US adults	US peds	Can
nICUs	54	34	269	27	13	22

Friedrich et al. Crit Care 2012; 16: R146

Continuous or intermittent?

early years

IHD = standard treatment for AKI in the critically ill - hemodynamic intolerance is perceived as significant problem

1976-1980

CAVH discovered "by accident" and launched as alternative treatment for the hemodynamically unstable patients

1985 and following

further refinement of CRRT with evolution to venovenous techniques and wide acceptance (satisfaction) by intensivists

Advantages of CRRT vs IHD

- Gradual fluid removal
  - more hemodynamic stability -> better renal recovery
  - easier control of fluid balance
- Gradual solute removal
  - no large fluid shifts - dysequilibrium - cerebral edema
  - more efficient solute removal (mobilisation from extra-plasmatic compartment)
- 24h -> More flexibility
- Machines are user-friendly --> ICU nurses
- Hypothermia beneficial in some patients

Disadvantages of CRRT vs IHD

- Need for continuous anticoagulation
- Patient immobilisation
- Interruption for diagnostic and therapeutic procedures
- Less efficient when rapid removal of small toxins is required in life-threatening conditions
- Requirement for specific equipment
- Higher costs

What is the evidence: mortality?

3 meta-analyses of RCTs
OR/RR for mortality with CRRT vs IHD

Bagshaw (9RCTs)	0.99 (0.78-1.26)
Rabindranath (7RCTs)	1.01 (0.92-1.12)
Pannu (7RCTs)	1.10 (0.99-1.23)

Bagshaw et al. Crit Care Med 2008; 36: 610-7
Rabindranath et al. Cochrane Database Syst Rev 2007; (3): CD003773
Pannu et al. JAMA 2008; 299: 793-805

What is the evidence: renal recovery?

3 meta-analyses of RCTs
OR/RR for renal recovery with CRRT vs IHD
(dialysis independence or GFR above 15ml/' at hospital discharge)

Bagshaw (4RCTs)	0.76 (0.28-2.07)
Rabindranath (3RCTs)	0.99 (0.92-1.07)
Pannu (5RCTs)	1.01 (0.92-1.09)

Bagshaw et al. Crit Care Med 2008; 36: 610-7
Rabindranath et al. Cochrane Database Syst Rev 2007; (3): CD003773
Pannu et al. JAMA 2008; 299: 793-805

What is the evidence: hemodynamics?

Study or subgroup Patients with haemodynamic instability	CRRT n/N	IRRT n/N	Weight	Risk Ratio M-H,Random,95% CI
Augustine 2004	0/40	4/40	21.8 %	0.11 [0.01, 2.00]
Uehlinger 2005	20/70	22/55	78.2 %	0.71 [0.44, 1.17]
Total (95% CI)	**110**	**95**	**100.0 %**	**0.48 [0.10, 2.28]**

Study or subgroup Patients with hypotension	CRRT n/N	IRRT n/N	Weight	Risk Ratio M-H,Random,95% CI
John 2001	9/20	6/10	11.8 %	0.75 [0.37, 1.51]
Uehlinger 2005	15/70	8/55	9.5 %	1.47 [0.67, 3.22]
Vinsonneau 2006	61/175	72/184	78.7 %	0.89 [0.68, 1.17]
Total (95% CI)	**265**	**249**	**100.0 %**	**0.92 [0.72, 1.16]**

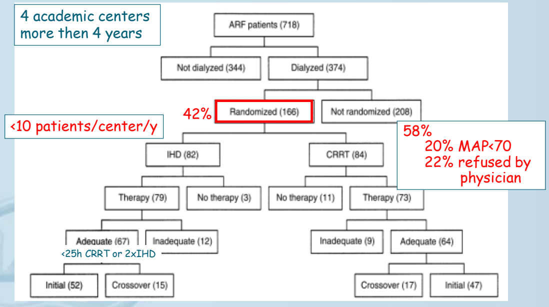
Study or subgroup Patients requiring escalation of pressor therapy	CRRT n/N	IRRT n/N	Weight	Risk Ratio M-H,Random,95% CI
Augustine 2004	5/40	16/40	39.8 %	0.31 [0.13, 0.77]
John 2001	4/20	4/10	28.4 %	0.50 [0.16, 1.59]
Kielstein 2004	5/19	5/20	31.9 %	1.05 [0.36, 3.07]
Total (95% CI)	**79**	**70**	**100.0 %**	**0.53 [0.26, 1.08]**

0.1 0.2 0.5 1 2 5 10
Favours CRRT Favours IRRT

Study or subgroup Dose of norepinephrine	CRRT N	Mean(SD)	IRRT N	Mean(SD)	Weight	Mean Difference IV,Fixed,95% CI
John 2001	20	2.18 (1.79)	10	1.98 (1.68)	7.1 %	0.20 [-1.10, 1.50]
Kielstein 2004	19	0.39 (0.57)	20	0.42 (0.58)	92.9 %	-0.03 [-0.39, 0.33]
Total (95% CI)	**39**		**30**		**100.0 %**	**-0.01 [-0.36, 0.33]**

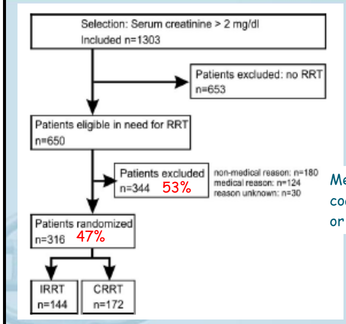
Rabindranath et al. Cochrane Database Syst Rev 2007; (3): CD003773

Results generalizable?



Mehta et al. Kidney Int 2001; 60: 1154-63

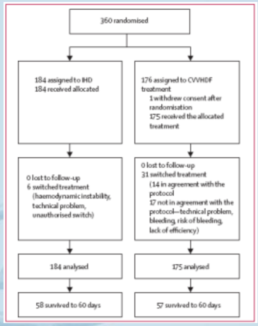
Results generalizable?



Medical reasons =
coagulation disturbances
or hemodynamic instability

Lins et al. Nephrol Dial Transpl 2009; 24: 512-518

Results generalizable?



How many patients were eligible?

Mean = 5 patients /center/year

IHD≠conventional dialysis
(mean 5.2h/day)

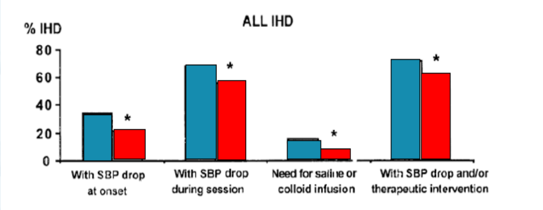
Vinsonneau et al. Lancet 2006; 368: 379-85

Not all IHD is equal

Measures to improve hemodynamic stability during IHD

- Increase duration
- Start without ultrafiltration and slowly increase
- Sequential dialysis and ultrafiltration
- Increase dialysate sodium
- Cool dialysate
- …

Not all IHD is equal



= pre-procedure

= post-procedure

Schortgen et al. Am J Resp Crit Care Med 2000; 162: 197-202

Not all IHD is equal

Continuous RRT

Optimized IHD

Conventional IHD

The spectrum of RRT

Continuous RRT

Hybrid RRT
- SLED
- EDD
- PIRRT
- 6-16h/d
- conventional dialysis machines

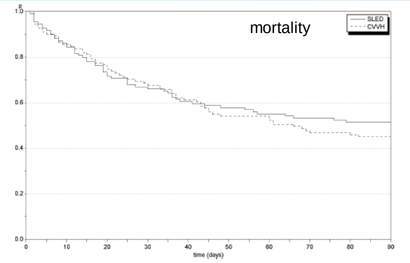
Optimized IHD

Conventional IHD

Hybrid treatments

Prospective randomized study n= 332 surgical ICU + AKI

CVVH vs SLED (badge dialysis)



Schwenger et al. Crit Care 2012; 16: R140

Hybrid treatments

Prospective randomized study n= 332

CVVH vs SLED

Table 3 Primary and secondary outcomes.

	All (n = 232)	SLED (n = 115)	CVVH (n = 117)	P
Death from any cause by day 90	122 (52.6 %)	57 (49.6 %)	65 (55.6 %)	0.434**
Death from any cause up to 30 August 2009	155 (66.8 %)	76 (66.1 %)	79 (67.5 %)	0.926**
In-hospital mortality	119 (51.3 %)	57 (49.6 %)	62 (53.0 %)	0.696**
Mortality in ICU	98 (42.2 %)	49 (42.6 %)	49 (41.9 %)	0.984**
Mechanical ventilation	205 (88.4%)	101 (87.8%)	104 (88.9%)	0.962**
Days of mechanical ventilation	1 9.4 ± 19.7	17.7 ± 19.4	20.9 ± 19.8	0.047*
Days in intensive care unit	21.7 ± 21.1	19.6 ± 20.1	23.7 ± 21.9	0.038*
Recovery of kidney function in days after RRT initiation	10.2 ± 14.5	10.0 ± 15.2	10.5 ± 14.0	0.049*
BP syst pre-treatment (mmHg)	124.8 ± 14.0	125.1 ± 14.6	124.6 ± 13.5	0.434*
BP syst after treatment (mmHg)	126.3 ± 16.4	128.3 ± 17.1	124.3 ± 15.6	0.051*
BP diast pre-treatment (mmHg)	60.7 ± 10.3	60.7 ± 10.7	60.7 ± 10.0	0.420*
BP diast after treatment (mmHg)	61.1 ± 10.7	61.8 ± 11.3	60.3 ± 10.2	0.250*
Hypotensive episodes	1.6 ± 1.5	1.5 ± 1.4	1.8 ± 1.6	0.077*

Schwenger et al. Crit Care 2012; 16: R140

Hybrid treatments

Additional results

More decrease of body temp with SLED

More transfusion in CVVH

More nursing time in CVVH

Higher costs with CVVH

Limitations

Single center surgical ICU

Unblinded

No objective criteria to stop RRT

SLED duration increased from planned 12h to 14.9+/-4.4

CVVH duration was 19.9+/-3.64

Schwenger et al. Crit Care 2012; 16: R140

Continuous, intermittent or hybrid?

This is the wrong question

Each modality has advantages/disadvantages resulting in specific indications

The skills and familiarity of the health care workers with the available techniques and the logistic capacity of the ICU may be more important than the choice of the modality

Indications for CRRT or SLED

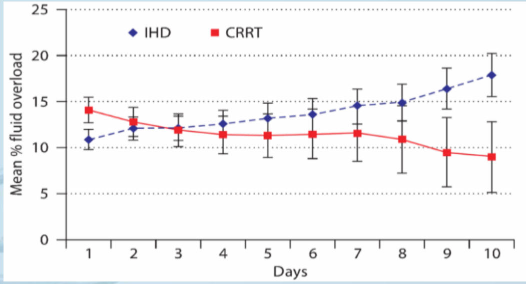
Hemodynamic instability

Important fluid overload

Risk of intracranial hypertension

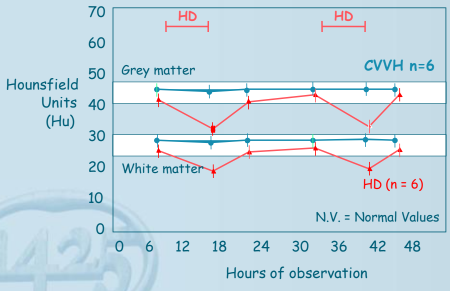
Fluid removal

Fluid removal more easily achieved with CRRT



Bouchard et al. Kidney Intern 2009; 76: 422

Brain injury



Ronco et al, J Nephrol 1999 ;12 : 173-8

Brain injury

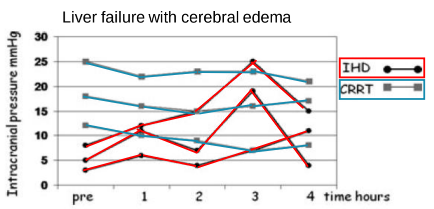


FIG. 2. Changes in mean intracranial pressure during intermittent haemodialysis (IHD) and continuous veno-venous hemodiafiltration (CVVHDF).

Davenport. Semin Dialysis 2009; 22: 165-8

Advantages of IHD: costs

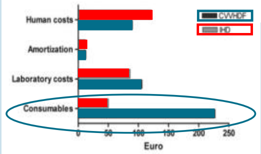
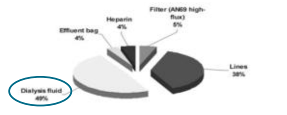


FIG. 2. Distribution of costs for CVVHDF per treatment day and IHD per treatment session.

CVVHDF



IHD

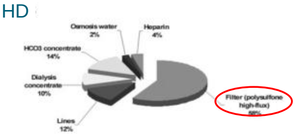
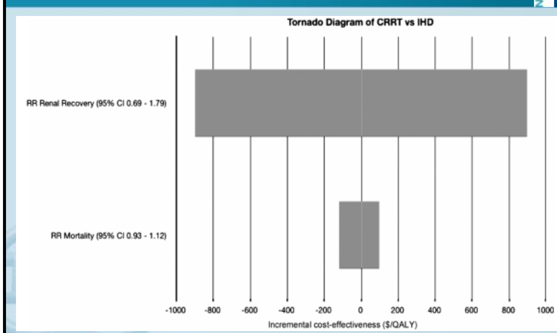


FIG. 1. (A) CVVHDF: expenditures for technical consumables and anticoagulation per treatment day. (B) IHD: expenditures for technical consumables and anticoagulation per treatment session. The numbers behind the segments are the percentage of the total expenditures for consumables.

Farese et al. Artif Organs 2009; 33: 634-40

Advantages of IHD: costs

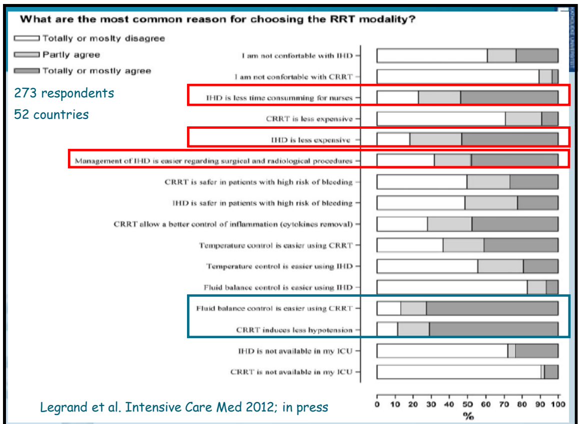


Klarenbach et al. Int J Technol Assess Health Care 2009; 25: 331-8

What are the most common reason for choosing the RRT modality?

273 respondents

52 countries



Legrand et al. Intensive Care Med 2012; in press

Conclusion

Diffusion or convection?

not enough data

Continuous or intermittent or hybrid?

balance advantages -disadvantages

specific indications

local expertise and availability

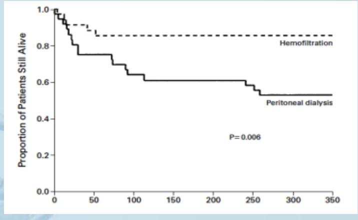
Peritoneal dialysis in AKI?

PRO	CON
no vascular access	catheterproblems (infection)
no anticoagulation	low efficiency
hemodynamic stability	poorly controlable fluid balance
no expensive equipment	needs intact peritoneal cavity
	impaired respiratory mechanics
	protein loss
	hyperglycemia

Peritoneal dialysis

Prospective RCT n= 70 severe sepsis

CVVH vs PD



Phu et al. N Engl J Med 2002; 347: 895-902; 73: S87-S93

Peritoneal dysis

Prospective RCT n= 154 High-volume PD vs daily IHD

Randomisation unclear - 34 patients excluded from final analysis

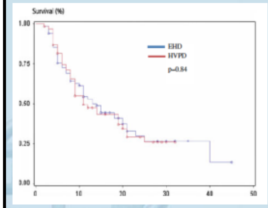
	HVPD (n=60)	DHD (n=60)	P-value
Mortality (%)	58	53	0.48
Recovery of kidney function (%)	83	77	0.84
Duration of treatment (days)	5.5±2.7	7.5±3.1	0.02
Resolution of AKI (days)	7.2±2.6	10.6±4.7	0.04

Gabriel et al. Kidney Intern Suppl 2008; 73: S87-S93

Peritoneal dialysis

Prospective RCT n= 407 High-volume PD vs extended daily dialysis

264 patients excluded from final analysis



	EHD ($n = 82$)	HVPD ($n = 61$)	p value
Mortality (%)	63.4	63.9	0.94
Recovery of kidney function (%)	26.9	29.6	0.11
Resolution of AKI (days)	11 (5.7–20)	9 (5.7–19)	0.58
Need for chronic dialysis (%)	9.7	6.5	0.23
Infectious complications related to dialysis method (%)	19.5	16.3	0.21

Ponce et al. Intern Urol Nephrol 2012; in press

Conclusion

Blood Purification

Blood Purif 2012;34:124–131
DOI: 10.1159/000342088

Published online: October 24, 2012

Tailored Therapy: Matching the Method to the Patient

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.... and to the local expertise and availability