Management of AKI in critically ill patients

09-10-15

Seminar overview

- Introduction
- Definition of AKI
- Classification systems for grading of severity of AKI
- Management of AKI in critically ill patients : indications of RRT
  modes of RRT
  optimal timing of RRT initiation
  suitable mode of RRT

Introduction

- Acute kidney injury (AKI), previously termed as acute renal failure (ARF), is characterized by the rapid and sustained reduction of glomerular filtration rate (GFR) resulting in the retention of nitrogenous (creatinine and urea) and non-nitrogenous metabolic waste products and dysregulation of body fluid volume status, electrolyte and acid-base homeostasis

Classification systems

- **RIFLE (Risk, Injury, Failure, Loss, ESRD) classification :** 2004 by the Acute Dialysis Quality Initiative workgroup
- **Modified RIFLE (AKIN) classification :** ARF replaced by AKI by the Acute Kidney Injury Network (AKIN) in 2007 in an attempt to include the entire spectrum of acute renal dysfunction

Bagshaw SM et al. Can J Anaesth. 2010;57(11):985-998

Bagshaw SM et al. Nephrol Dial Transplant. 2008;23(4):1203-1210

Bellomo R et al. Crit Care 2004;8(4):R204-R212

Ricci Z et al. Kidney Int. 2008;73(5):538-546

Table 1: RIFLE and AKIN classification [1, 25].

RIFLE			AKIN		
Category	Creatinine/GFR	Urine output (UO)	Stage	Creatinine	Urine output (UO)
Risk	Cr increase by x1.5 times or GFR decrease by ≥25%	UO ≤ 0.5 mL/kg/hr for 6 hrs	Stage 1	Cr increase by x1.5 times or ≥ 26 μmol/L	UO ≤ 0.5 mL/kg/hr for 6 hrs
Injury	Cr increase by x2 times or GFR decrease by ≥50%	UO ≤ 0.5 mL/kg/hr for 12 hrs	Stage 2	Cr increase by x2	UO ≤ 0.5 mL/kg/hr for 12 hrs
Failure	Cr increase by x3 times or GFR decrease by ≥75% or Cr ≥ 354 μmol/L (with acute rise ≥ 44 μmol/L)	UO ≤ 0.3 mL/kg/hr for 24 hrs or anuria for 12hrs	Stage 3	Cr increase by x3 or Cr ≥ 354 μmol/L (with acute rise 44 μmol/L) or RRT[1]	UO ≤ 0.3 mL/kg/hr for 24 hrs or anuria for 12 hrs
Loss (outcome)	Persistent ARF = complete loss of renal function > 4 weeks (but ≤3 months)	N/A	Nil		
ESRD (outcome)	Complete loss of renal function > 3 months	N/A	Nil		

RRT: renal replacement therapy.

[1]Patients requiring RRT are automatically considered stage 3 AKIN regardless of stage at time of RRT initiation.

Definition according to guidelines

- The recent Kidney Disease : Improving Global Outcomes (KDIGO) guidelines has defined AKI by any one of the following _

  (1). an increase of serum creatinine by more than 0.3mg/dL within 48 hours,

  (2). an increase of serum creatinine to 1.5 times of baseline within the prior 7 days, or

  (3). an urine volume of less than 0.5ml/kg/h for 6 hours

KDIGO Clinical Practice Guideline for Acute Kidney Injury. Kid Int Supp. 2012;2:124-138

Management of AKI
in
critically ill patients

- The mainstay of treatment for AKI is renal replacement therapy (RRT)
- Paucity of data to guide the optimal timing of initiation of RRT and suitable mode of therapy

Indications and timing of RRT for AKI

- The only absolute indications for RRT in critically ill patients with AKI are metabolic acidosis, hypervolemia, and hyperkalemia not responding to other forms of therapy
- In theory, the early initiation of renal replacement might be beneficial; however data guiding the optimal timing of dialysis in patients with AKI are scarce
- Till date, only 3 RCTs have addressed this issue; others in form of case-control or observational studies

Sugahara S et al. Hemodial Int. 2004;8(4):320-325

Bouman CSC et al. Crit Care Med. 2002;30(10):2205-2211

Recommended relative and absolute indications for RRT in critically ill patients with AKI _ *Gibney N et al. Clinical Journal of the American Society of Nephrology, Vol.3, no.3, pp.876-880, 2008*

Dialysis indication	Criteria	Absolute/relative
Metabolic	Urea > 27 mmol/L	Relative
	Urea > 35.7 mmol/L	Absolute
	Hyperkalaemia > 6 mmol/L	Relative
	Hyperkalaemia > 6 mmol/L plus ECG changes	Absolute
	Dysnatraemia	Relative
	Hypermagnesaemia > 4 mmol/L	Relative
	Hypermagnesaemia > 4 mmol/L plus anuria or areflexia	Absolute
Acidosis	pH > 7.15	Relative
	pH < 7.15	Absolute
Anuria/oliguria	Risk (RIFLE class)	Relative
	Injury (RIFLE class)	Relative
	Failure (RIFLE class)	Relative
	UO < 200 mL for 12 hrs or anuria	Absolute
Uraemic complication	Encephalopathy	Absolute
	Pericarditis	Absolute
	Myopathy	Absolute
	Neuropathy	Absolute
	Bleeding	Absolute
Fluid overload	Diuretic responsive	Relative
	Diuretic resistant (with pulmonary oedema)	Absolute

Study	Methodology	Results	Conclusion
Sugahara S et al. Hemodial Int 2004	• Small study on comparative survival between early and late dialysis • 14 patients received dialysis therapy when urine volume decreased to <30mL/h and another 14 patients received dialysis when urine volume decreased to <20mL/h for 14 days following coronary bypass graft surgery	• 12 of 14 patients who received early dialysis survived whereas only 2 of 14 patients in the late-dialysis group survived (***p*<0.01**)	• Early dialysis may help improve the survival of patients with acute renal failure following cardiac surgery

- **Large reduction in mortality among patients with an earlier initiation (RR, 0.17; 95% CI, 0.05-0.61)**
- **Several markers of poor quality**
- **Definitions of ‘early’ and ‘late’ initiation of dialysis used were unusual and impractical**

Study	Methodology	Results	Conclusion
Bouman CSC et al. Crit Care Med 2002	• 2 center RCT • Total 106 ventilated severely ill patients who were oliguric despite massive fluid resuscitation, inotropic support, and high-dose IV diuretics were randomized into 3 groups : 35 patients were treated with early high-volume hemofiltration (72-96L/24 hours), 35 patients with early low-volume hemofiltration (24-36L/24 hours), and 36 patients with late low-volume hemofiltration (24-36L/24 hours • On average, hemofiltration started 7 hrs after inclusion in the early groups and 42 hrs after inclusion in the late group • 'Early dialysis' was started after 6 hours of urine output <30mL/h	• Median ultrafiltrate rate was 48.2 (42.3-58.7) mL/kg/h in early high-volume hemofiltration, 20.1 (17.5-22.0) mL/kg/h in early low-volume hemofiltration, and 19.0 (16.6-21.1) mL/kg/h in late low-volume hemofiltration • 28-day survival was 74.3% in early high-volume hemofiltration, 68.8% in early low-volume hemofiltration, and 75.0% in late low-volume hemofiltration (***p*=0.80**) • Median duration of renal failure in hospital survivors was 4.3 (1.4-7.8) days in early high-volume hemofiltration, 3.2 (2.4-5.4) days in early low-volume hemofiltration, and 5.6 (3.1-8.5) days in late low-volume hemofiltration (***p*=0.25**) • All hospital survivors had recovery of renal function at hospital discharge, except for 1 patient in the early low-volume hemofiltration group	• 28-day survival and recovery of renal function did not improve using high ultrafiltrate volumes or early initiation of hemofiltration

Timing of Initiation of Dialysis in Critically Ill Patients with Acute Kidney Injury

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PICARD (Program to Improve Care in Acute Renal Disease) Study
Clin J Am Soc Nephrol. 2006;1(5):915-919

- **Multicenter observational study of AKI**
- **Out of total 243 patients who required dialysis for severe AKI, 122 patients belonged to the low degree of azotemia group (BUN≤76mg/dL) and 121 patients to the high degree of azotemia group (BUN>76mg/dL)**
- **The RR for death that was associated with initiation of dialysis at a higher BUN was 1.85 (95% CI, 1.16-2.96)**
- **Risk of death was significantly lower among patients starting RRT with BUN levels ≤ 76mg/dL (adjusted hazard ratio, 0.54; 95% CI, 0.34-0.86)**

- 3 meta-analyses concluded that earlier institution of CRRT or IHD in critically ill patients might be associated with a survival benefit

Karvellas CJ et al. Crit Care 2011;15:R72

Seabra VF et al. Am J Kidney Dis. 2008;52:272-84

Wang X et al. Ren Fail. 2012;34:396-402

Timing of Initiation of Renal Replacement Therapy in Acute Kidney Injury: A Systematic Review and Meta-analysis

Xuan Wang & Wei Jie Yuan

Ren Fail. 2012;34:396-402

- **Study selection : RCTs, prospective or retrospective studies comparing mortality and other clinical outcomes of “early” and “late” RRTs of patients with AKI**
- **15 studies (3 RCTs, 2 prospective and 10 retrospective comparative cohort studies) were finally included**

Results of the meta-analysis

Baseline characteristics of the studies

First author	Publication year	Study design	Mean Age	Male (%)	Total number of patients	Creatinine		Urea	
						Early	Late	Early	Late
Bouman[2]	2002	Randomized	69	59	71	5[a]	6[a]	NR	NR
Durmaz[10]	2003	Randomized	56	77	44	304	286	22.0	18.0
Sugahara[3]	2004	Randomized	64	64	28	256	265	NR	NR
Liu[11]	2006	Prospective	56	68	243	301	415	16.9	41.0
Bagshaw[12]	2009	Prospective	62	65	1237	230	396	15.0	38.8
Gettings[13]	1999	Retrospective	45	79	100	148	238	15.2	33.7
Elahi[14]	2004	Retrospective	70	75	64	328	379	23.9	26.8
Dermirkilic[15]	2004	Retrospective	NR	78	61	NR	NR	NR	NR
Andrade[16]	2007	Retrospective	43	NR	33	583	548	73.9	82.8
Manche[17]	2008	Retrospective	65	NR	71	233	404	14.4	35.2
Iyem[18]	2009	Retrospective	63	37	185	186	256	19.5	24.3
Shiao[19]	2009	Retrospective	66	58	98	292	336	24.6	29.2
Carl[20]	2010	Retrospective	54	67	147	442	514	23.6	48.9
Chou[21]	2011	Retrospective	65	67	370	298	300	28.0	30.0
García-Fernández[22]	2011	Retrospective	68	59	203	139	111	NR	NR

Main characteristics of the studies

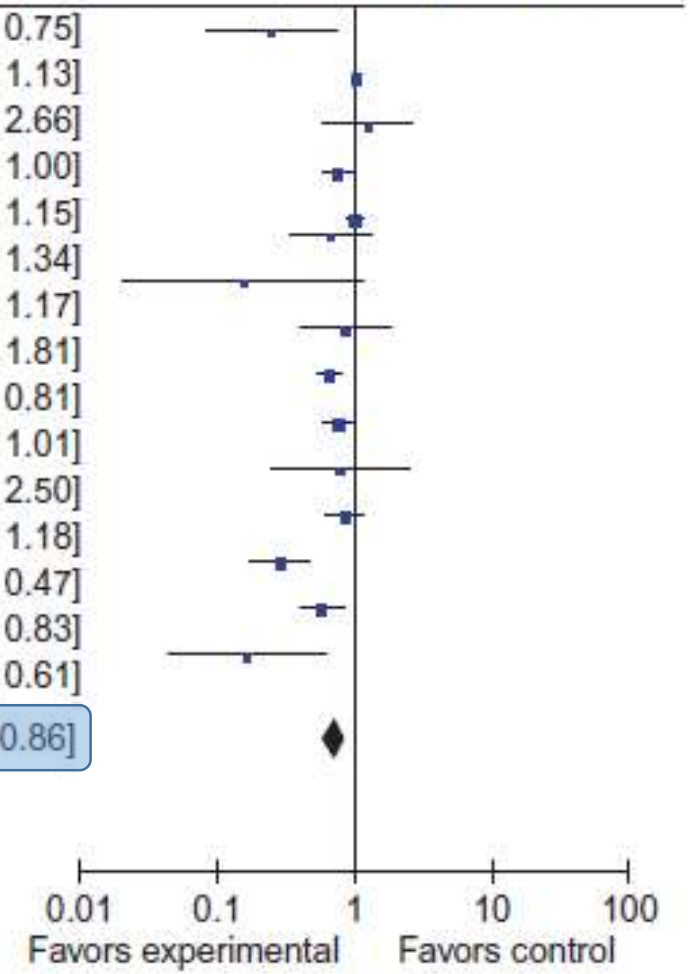
First author	Year	Modality	Population	Definitions of early and late	
				Early	Late
Bouman[2]	2002	CVVH	Cardiac surgery/medical	RRT within 12 h if urine output <30 mL/h	Urea >40 mmol/L or K >6.5 mmol/L
Durmaz[10]	2003	IHD	Cardiac surgery (CABG)	Postoperative sCr increased by 10%	Postoperative sCr increased by 50% or urine output was <400 mL/24 h
Sugahara[3]	2004	CVVH	Cardiac surgery	Urine output <30 mL/h	Urine Output <20 cc/h
Liu[11]	2006	CRRT/IHD	Medical, surgery	Urea <27.1 mmol/L	Urea >27.1 mmol/L
Bagshaw[12]	2009	CRRT/IHS	Medical, surgical	Urea <24.2 mmol/L	Urea >24.2 mmol/L
Gettings[13]	1999	CRRT	Trauma	Urea <21.4 mmol/L	Urea >21.4 mmol/L
Elahi[14]	2004	CVVH	Cardiac surgery	Urine output <100 cc in 8 h	K >6 mmol/L, Cr >250 mmol/L
Dermirkilic[15]	2004	CVVHDF	Cardiac surgery	Cr >400 µmol/L, K >5.5 mmol/L	Oliguria
Andrade[16]	2007	IHD/SLED	Medical (ARDS/sepsis)	On admission	At 24 h
Manche[17]	2008	IHD	Cardiac surgery	Hyperkalemia	Urine output <0.5mL/kg/h
Iyem[18]	2009	CVVH	Cardiac surgery	RRT on admission	After 48 h when anuric
Shiao[19]	2009	CVVH	Surgery/trauma	RIFLE criteria (risk)	RIFLE injury (failure)
Carl[20]	2010	CRRT/IHD	Medical (sepsis)	Urea <35.7 mmol/L	Urea >35.7 mmol/L
Chou[21]	2011	CRRT/SLED	Sepsis	RIFLE criteria (risk)	RIFLE injury (failure)
García-Fernández[22]	2011	CRRT/IHD	Cardiac surgery	≤3 days after cardiac surgery	>3 days after cardiac surgery

- The statistic *p* for heterogeneity is < 0.00001
- Overall 772/1514 patients (51%) died in the “early” RRT group compared with 836/1441 (58%) in the “late” RRT group
- The pooled RR was 0.71 (95% CI, 0.59-0.86) indicating a statistically significant beneficial effect of “early” RRT on mortality; however, internal heterogeneity existed

RR of mortality for the individual studies and pooled analysis

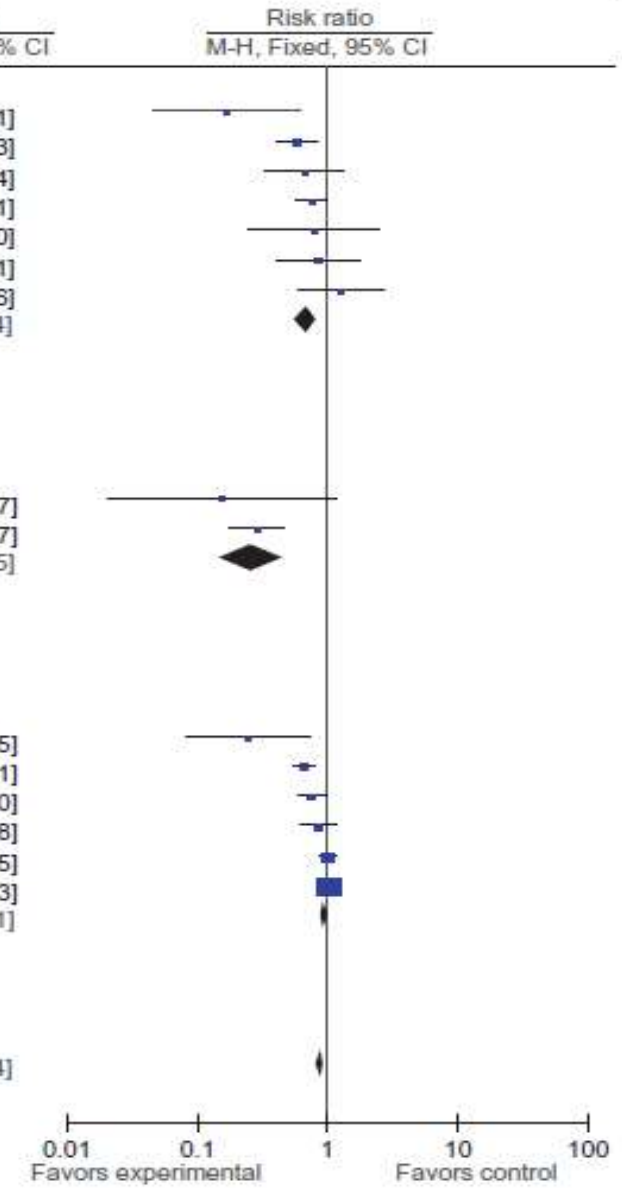
Study or subgroup	Early RRT Events	Early RRT Total	Late RRT Events	Late RRT Total	Weight (%)	Risk ratio M-H, Random, 95% CI
Andrade 2007	3	18	10	15	2.4	0.25 [0.08, 0.75]
Bagshaw 2009	392	618	380	619	12.3	1.03 [0.95, 1.13]
Bouman 2002	11	35	9	36	4.2	1.26 [0.59, 2.66]
Carl 2010	44	85	42	62	10.0	0.76 [0.58, 1.00]
Chou 2011	135	192	124	178	11.8	1.01 [0.88, 1.15]
Dermirkilic 2004	8	27	15	34	4.7	0.67 [0.34, 1.34]
Durmaz 2003	1	21	7	23	0.8	0.16 [0.02, 1.17]
Elahi 2004	8	28	12	36	4.2	0.86 [0.41, 1.81]
García-Fernández 2011	59	111	74	92	11.0	0.66 [0.54, 0.81]
Gettings 1999	25	41	47	59	9.9	0.77 [0.58, 1.01]
Iyem 2009	5	95	6	90	2.2	0.79 [0.25, 2.50]
Liu 2006	43	122	50	121	9.2	0.85 [0.62, 1.18]
Manche 2008	14	56	13	15	6.7	0.29 [0.18, 0.47]
Shiao 2009	22	51	35	47	8.7	0.58 [0.41, 0.83]
Sugahara 2004	2	14	12	14	1.8	0.17 [0.05, 0.61]
Total (95% CI)		1514		1441	100.0%	0.71 [0.59, 0.86]
Total events	772		836			

Heterogeneity: $\tau^2 = 0.07$; $\chi^2 = 67.42$, df = 14 ($p < 0.00001$); $I^2 = 79\%$
Test for overall effect: $Z = 3.55$ ($p = 0.0004$)



RR of mortality in subgroup patients

Study or subgroup	Early RRT Events	Early RRT Total	Late RRT Events	Late RRT Total	Weight (%)	Risk ratio M-H, Fixed, 95% CI
1.1.1 CRRT						
Sugahara 2004	2	14	12	14	1.4	0.17 [0.05, 0.61]
Shiao 2009	22	51	35	47	4.3	0.58 [0.41, 0.83]
Dermirkilic 2004	8	27	15	34	1.6	0.67 [0.34, 1.34]
Gettings 1999	25	41	47	59	4.5	0.77 [0.58, 1.01]
Iyem 2009	5	95	6	90	0.7	0.79 [0.25, 2.50]
Elahi 2004	8	28	12	36	1.2	0.86 [0.41, 1.81]
Bouman 2002	11	35	9	36	1.0	1.26 [0.59, 2.66]
Subtotal (95% CI)		291		316	14.8	0.69 [0.56, 0.84]
Total events	81		136			
Heterogeneity: $\chi^2 = 8.91$, df = 6 ($p = 0.18$); $I^2 = 33\%$						
Test for overall effect: $Z = 3.69$ ($p = 0.0002$)						
1.1.2 IHD						
Durmaz 2003	1	21	7	23	0.8	0.16 [0.02, 1.17]
Manche 2008	14	56	13	15	2.4	0.29 [0.18, 0.47]
Subtotal (95% CI)		77		38	3.2	0.26 [0.15, 0.45]
Total events	15		20			
Heterogeneity: $\chi^2 = 0.45$, df = 1 ($p = 0.50$); $I^2 = 0\%$						
Test for overall effect: $Z = 4.83$ ($p < 0.00001$)						
1.1.3 Mixed						
Andrade 2007	3	18	10	15	1.3	0.25 [0.08, 0.75]
Garcia-Fernández 2011	59	111	74	92	9.5	0.66 [0.54, 0.81]
Carl 2010	44	85	42	62	5.7	0.76 [0.58, 1.00]
Liu 2006	43	122	50	121	5.9	0.85 [0.62, 1.18]
Chou 2011	135	192	124	178	15.1	1.01 [0.88, 1.15]
Bagshaw 2009	392	618	380	619	44.6	1.03 [0.95, 1.13]
Subtotal (95% CI)		1146		1087	82.0	0.94 [0.88, 1.01]
Total events	676		680			
Heterogeneity: $\chi^2 = 25.66$, df = 5 ($p = 0.0001$); $I^2 = 81\%$						
Test for overall effect: $Z = 1.79$ ($p = 0.07$)						
Total (95% CI)		1514		1441	100.0	0.88 [0.83, 0.94]
Total events	772		836			
Heterogeneity: $\chi^2 = 67.42$, df = 14 ($p < 0.00001$); $I^2 = 79\%$						
Test for overall effect: $Z = 3.95$ ($p < 0.0001$)						



Timing of renal replacement therapy initiation by AKIN classification system

Tacyano T Leite[1], Etienne Macedo[2], Samuel M Pereira[3], Sandro RC Bandeira[3], Pedro HS Pontes[3], André S Garcia[3], Fernanda R Militão[3], Irineu MM Sobrinho[3], Livia M Assunção[3] and Alexandre B Libório[1,4,5*]

Critical Care 2013, 17:R62

- **Retrospective analysis of a prospective cohort of consecutive critically ill adult patients (>18 years) undergoing RRT**
- **Diagnosis and severity of AKI was defined by the AKIN classification system, using the worst criteria (SCr increment or reduced UO)**
- **Reference SCr was the lowest achieved during hospital stay before RRT start**
- **Patients initiating RRT < 24 hours after reaching AKIN stage 3 were included in the early RRT group and those after 24 hours in the late RRT group**
- **Total 358 critically ill patients were submitted to RRT; only 150 patients with pure AKI stage 3 were analyzed**
- **Mortality was lower in the early RRT group (51.5 vs 77.9%, p=0.001) with lesser duration of mechanical ventilation, time on RRT, and lesser ICU length of stay**

Factors influencing the decision to start RRT

- Patient factors
  - Kidney function/reserve
  - Comorbid conditions and physiologic reserve
  - Primary diagnosis: severity of illness and trajectory
  - AKI severity and trend
- Physician decision
  - Goals of therapy
  - Relative indications and clinician threshold for initiation
  - Local practice patterns
- Unnecessary procedure
  - Possibility of patient recovering renal function
- Risk associated with RRT procedure
  - Complications associated with catheter placement
  - Hypotension and cardiac events during procedure
  - Fear of prolonging renal injury after initiation of RRT
- Factors affecting implementation
  - Vascular access availability
  - Availability of equipment and personnel
  - Time of decision to initiation (Sundays, late night)
  - Treating physician decision
  - Logistics
    - Process of care
    - Country/institution
    - ICU type
    - Health costs

Modes of RRT

- Current modalities of RRT for AKI include :

  (1). conventional IHD

  (2). continuous RRT

  (3). hybrid treatments (prolonged intermittent RRT)

  (4). high volume peritoneal dialysis
- No single mode is ideal for all patients with AKI
- All have their own advantages and disadvantages

About the different modes of RRT…..

- **Intermittent hemodialysis (IHD) :** performed using venovenous access for a few hours at variable intervals, typically 4 hours, 3-4 times per week
- **Sustained low efficiency dialysis (SLED) or extended daily dialysis :** submodalities of IHD in which the duration of dialysis is extended (6-12 hours), allowing for more gradual removal of solutes and fluid
- **Continuous renal replacement therapy (CRRT) :** performed continuously (approximately 24 hours per day) through arteriovenous or venovenous vascular access, using much slower blood flow rates as compared with IHD, and is typically only delivered in an intensive care setting

About the different modes of RRT…..

- **Peritoneal dialysis (PD) :**

➢ First modality of RRT used for AKI patients

➢ Its practice declined after the advent of hemodialysis

➢ Still frequently used in developing countries because of its lower cost and minimal infrastructural requirements

Modalities of continuous renal replacement therapy (CRRT)

Continuous Venovenous Hemofiltration (CVVHF)

Ultrafiltrate produced is replaced with a replacement solution
- Ultrafiltration in excess of replacement results in patient volume loss
- Solute removal is through convection

Continuous Venovenous Hemodialysis (CVVHD)

Dialysate solution is delivered across membrane countercurrent to blood flow
- Blood flow rates are 100 to 200 mL/min
- Dialysate flow rates are 1 to 2 L/h
- Fluid replacement is not routinely administered
- Solute removal is by diffusion

Continuous Venovenous Hemodiafiltration (CVVHDF)

Dialysate solution is delivered across membrane countercurrent to blood flow
- Typical dialysate flow rates are 1 to 2 L/h
- Ultrafiltration volumes are optimized to exceed desired weight loss and enhance solute clearance from convection
- Fluid losses are replaced in part or completely with replacement solution
- Solute removal is both diffusive and convective

Pannu N et al. JAMA 2008;299(7):793-805

Facts about CRRT

- Provides slower solute clearance per unit of time compared with intermittent therapies, however over 24 hours, the total clearance may exceed that provided by IHD, especially for larger solutes such as cytokines
- Requires continuous anticoagulation, thereby creating the potential for bleeding
- Continuously exposed to an extracorporeal circuit, which might lead to depletion of nutrients, subtherapeutic levels of antimicrobial agents, or infection

Literature

- 3 systematic reviews and meta-analyses concluded that there is no evidence that any single modality of RRT is associated with improved outcomes of patients with AKI

Bagshaw SM et al. Crit Care Med. 2008;36:610-7

Pannu N et al. JAMA 2008;299:793-805

Rabindranath K et al. Cochrane Database Syst Rev. 2007:CD003773

Renal Replacement Therapy in Patients With Acute Renal Failure

A Systematic Review

Pannu N et al. JAMA 2008;299(7):793-805

- **Study selection :** RCTs and prospective cohort studies studying dialytic support in adults with acute renal failure that reported the incidence of clinical outcomes such as mortality, length of stay, need for chronic dialysis, development of hypotension, or filter failure and bleeding complications for anticoagulant comparison
- 173 articles retrieved; 30 RCTs and 8 prospective cohort studies were eligible

Results of the meta-analysis

Characteristics of populations in included studies

Source; Country (Setting)	No.	Mean Age, y	Men, %	APACHE II Score, Mean	Serum Creatinine, mg/dL	Vasopressor Use, %	SIRS, %
Randomized Controlled Trials							
Morgera,[15] 2006; Germany (ICU/ general surgical unit)	28	64	57	26	2.25	NR	100
Saudan,[16] 2006; Switzerland (ICU)	206	63	61	25	4.83	NR	60
Vinsonneau,[17] 2006; France (ICU)	360	65	73	64[c]	4.82	87	63
Kutsogiannis,[18] 2005; Canada (ICU)	30	65	50	NR	3.58	NR	53
Uehlinger,[19] 2005; Switzerland (ICU)	125	67	69	55[c]	3.83	77	46
Augustine,[20] 2004; United States (ICU)	80	61	68	NR	4.80	54	NR
Hein,[21] 2004; Germany (ICU)	26	70	62	77[d]	3.41	NR	12
Kielstein,[22] 2004; Germany (ICU)	40	51	69	33	3.71	100	82
Kumar,[23] 2004; United States (ICU)	54[e]	53	63	30	4.13	NR	NR
Sugahara,[24] 2004; Japan (NR)	28	65	64	19	2.96	NR	NR
Gasparovic,[25] 2003; Croatia (ICU)	104	NR	NR	21	NR	NR	50
Bouman,[26] 2002; Netherlands (ICU)	106	68	59	23	6[f]	NR	NR
Schiffl et,[27] 2002; Germany (ICU)	160[e]	60	55	87[d]	4.74	NR	36
Mehta,[28] 2001; United States (ICU)	166	55	76	25	4.49	NR	NR
John,[29] 2001; Germany (ICU)	30	61	87	34	5.10	NR	100
Pettila,[30] 2001; Finland (ICU)	39	48	82	20	5.07	NR	79
Ponikvar,[31] 2001; Slovenia (ICU)	72	62	76	24	6.51	67	42
Albright,[32] 2000; United States (NR)	66[e]	67	55	22	NR	NR	18
Barenbrock,[33] 2000; Germany (ICU)	117	61	74	26	3.55	NR	45
Gastaldello,[34] 2000; Belgium (hospital)	159	60	69	24	NR	55	57
Ronco,[35] 2000; Italy (ICU)	425	61	56	23	3.59	NR	12

Characteristics of populations in included studies

Source; Country (Setting)	No.	Mean Age, y	Men, %	APACHE II Score, Mean	Serum Creatinine, mg/dL	Vasopressor Use, %	SIRS, %
				Prospective Cohort Studies			
Uchino,[45] 2007; international (ICU)	1218	65	65	48[c]	3.29	74	11
Liu,[46] 2006; United States (ICU)	243	56	61	NR	358	NR	41
Noble,[47] 2006; United Kingdom (ICU)[g]	128	53	71	NR	4.25	NR	45
Swartz,[48] 2005; United States (renal unit)	383	61	59	83[d]	4.46	55	41
Brause,[49] 2003; Germany (ICU)	56	54	50	70[d]	2.96	NR	50
Guerin,[50] 2002; France (ICU)	587	61	70	54[c]	NR	78	NR
Morgera,[51] 1997; Germany (ICU)	84	61	70	21	3.06	NR	45
Neveu,[52] 1996; France (ICU)	169	NR	NR	NR	NR	NR	NR

Characteristics of dialytic support in included studies

Source	Comparison	Intervention					Control				
		Technique (Device)	Membrane Material (Flux)	Buffer	Anti-coagulant	Dosage (Schedule)	Technique (Device)	Membrane Material (Flux)	Buffer	Anti-coagulant	Dosage (Schedule)
Randomized Controlled Trials											
Morgera,[15] 2006	CRRT membrane	CVVHF (NA)	P2SH (high)	B	H	2.5 L/h or 31 mL/kg per h	CVVHF (NA)	PA (high)	B	H	2.5 L/h or 31 mL/kg per h
Saudan,[16] 2006	CRRT technique	CVVHDF (Prisma)	PAN (high)	B/L	NA	42 mL/kg per h or URR 50%	CVVHF (Prisma)	PAN (high)	B/L	NA	25 mL/kg per h or URR 40%
Vinsonneau,[17] 2006	CRRT vs IHD	CVVHDF (Prisma)	PAN (high)	B	H	29 mL/kg per h	IHD (variable)	PAN (high)	B	H	500 mL/min (4 h/alternate d)
Kutsogiannis,[18] 2005	CRRT anti-coagulant	CVVHDF (Prisma)	PAN (high)	B	TC	2 L/h	CVVHDF (Prisma)	PAN (high)	B	H	2 L/h
Uehlinger,[19] 2005	CRRT vs IHD	CVVHDF (Prisma)	PAN (high)	L	H/none	2 L/h or UCl ≈ 30 mL/min	IHD (MiroClav)	PS (high)	B	H/none	UCl ≈ 200 mL/min (3-4 h/session)
Augustine,[20] 2004	CRRT vs IHD	CVVHD (NA)	PS (low)	B	H/none	Kt/V 3.6/wk	IHD (NA)	PS (low)	B	H/none	Kt/V 3.6/wk (3 sessions/wk)
Hein,[21] 2004	CRRT anti-coagulant	CVVHF (BM11/ BM14)	PA (high)	NA	Hi	1-1.5 L/h	CVVHF (BM11/BM14)	PA (high)	NA	H	1-1.5 L/h
Kielstein,[22] 2004	CRRT vs IHD	CVVHF (BM11/ BM14)	PS (high)	B	H	3.2 L/h (1 × 24-h session only)	IHD-extended (Genius)	PS (high)	B	H	URR 53% (12 h/session)
Kumar,[23] 2004	CRRT vs IHD	CVVHD (2008H)	PS/PMMA (high)	NA	H	Mean serum urea 5 mmol/L	IHD-extended (2008H)	PS/PMMA (high)	B	H	Mean serum urea 13 mmol/L (6-8 h/session, 6 sessions/wk)
Sugahara,[24] 2004	CRRT time of dialysis initiation	CVVHD (KM8600)	PAN/ PMMA (high/NA)	L	NA	1 L/h	CVVHD (KM8600)	PAN/PMMA (high/NA)	L	NA	1 L/h

Characteristics of dialytic support in included studies

		Intervention					Control				
Source	Comparison	Technique (Device)	Membrane Material (Flux)	Buffer	Anti-coagulant	Dosage (Schedule)	Technique (Device)	Membrane Material (Flux)	Buffer	Anti-coagulant	Dosage (Schedule)
Gasparovic,[25] 2003	CRRT vs IHD	CVVHF (NA)	PS (NA)	NA	H	18 & 35 mL/kg per h	IHD (NA)	PS (NA)	NA	H/none	NA (3-4 h/session)
Bouman,[26] 2002[a]	CRRT time of dialysis initiation and dose	CVVHF (Diapact/ hemoproces-sor)	CTA (high)	B	H/N/none	48 mL/kg per h	CVVHF (Diapact/ hemoproces-sor)	CTA (high)	B	H/N/none	20 mL/kg per h
Schiffl,[27] 2002	IHD schedule	IHD (MTS2008C)	PS/PAN (high)	B	H/none	NA (alternate days)	IHD (MTS2008C)	PS/PAN (high)	B	H/none	NA (daily)
Mehta,[28] 2001	CRRT vs IHD	CXVHDF (BSM 22/BM-11)	PS/PAN (high)	NA	H	UCI 22 mL/min	IHD (NA)	C/CA/PS/ PMMA/PAN (low/high)	B	H	NA (3-4 h/session)
John,[29] 2001	CRRT vs IHD	CVVHF (BSM 22)	PS (high)	B/L	H	2 L/h	IHD (AK 100)	PS (low)	B	H	NA (4 h/session)
Pettila,[30] 2001	IHD technique	IHDF (AK 100 Ultra)	PA (high)	B	E	164 L dialysate and 4 L ultrafiltration/ session or URR 39.8% (3 h/first session, 4 h/other sessions)	IHD (AK 100 Ultra)	PA (high)	B	E	128 L dialysate and 40 L ultrafiltration/ session or URR 39.9% (3 h/first session, 4 h/other sessions)
Ponikvar,[31] 2001	IHD membrane	IHD (NA)	PAN (high)	NA	H/TC	NA (4-6 h/session)	IHD (NA)	PS (low)	NA	H/TC	NA (4-6 h/session)
Albright,[32] 2000	IHD membrane	IHD (NA)	PS (NA)	B	NA	500-550 mL/min or URR 44% (NA)	IHD (NA)	CA (low)	B	NA	500-550 mL/min or URR 44% (NA)
Barenbrock,[33] 2000	CRRT buffer	CVVHF (NA)	NA (NA)	B	H	1 L/h	CVVHF (NA)	NA (NA)	L	H	1 L/h
Gastaldello,[34] 2000[b]	IHD membrane	IHD (NA)	PS (high)	B	NA	500 mL/min (3 h/daily)	IHD (NA)	PS/CDA (low)	B	NA	500 mL/min (3 h/daily)
Ronco,[35] 2000[c]	CRRT dose	CVVHF (variable)	PS (NA)	L	H	20 mL/kg per h	CVVHF (variable)	PS (NA)	L	H	35 and 45 mL/kg per h

Characteristics of dialytic support in included studies

		Intervention					Control				
Source	Compari-son	Technique (Device)	Membrane Material (Flux)	Buffer	Anti-coagulant	Dosage (Schedule)	Technique (Device)	Membrane Material (Flux)	Buffer	Anti-coagulant	Dosage (Schedule)
Prospective Cohort Studies											
Uchino,[45] 2007	CRRT vs IHD	CVVHF/ CVVHDF/ CVVHD (NA)	NA (NA)	NA	NA	2 L/h	IHD/IHDF/ ISLED/ ISLEDF/IHF (NA)	NA (NA)	NA	NA	NA (3 h/session)
Liu,[45] 2006	Time of dialysis initiation	69% CRRT (NA)	NA (NA)	NA	NA	NA	43% CRRT	NA (NA)	NA	NA	NA
Noble,[47] 2006	CRRT vs IHD	CXVHDF (NA)	PS (high)	B	H/P	NA	IHD (NA)	C (low)	B/A	H	NA (4 h/daily)
Swartz,[48] 2005	CRRT vs IHD	CVVHF/ CVVHDF (NA)	NA (NA)	B	H	NA	IHD (NA)	PS/CTA (high)	B	H	URR 65%-70% (NA)
Brause,[49] 2003	CRRT dose	CVVHF (ADM 08)	PS (high)	L	H	1.5 L/h or BUN 50 mg/dL	CVVHF (ADM 08)	PS (high)	L	H	1 L/h or BUN 70 mg/dL
Guérin,[50] 2002	CRRT vs IHD	CVVHF/ CVVHDF (BSM 22/Prisma)	No cuprophan	NA	NA	NA	IHD (NA)	No cuprophan	NA	NA	NA (NA)

CRRT vs IHD

- The RR of death (latest follow-up from each trial considered) due to CRRT was nonsignificant compared with IHD (RR 1.10; 95% CI, 0.99-1.23, I^2= 0%); results were similar for both ICU and in-hospital mortality

Data from prospective cohort studies were generally consistent with those from trials

- Available RCTs did not suggest that dialytic modality influenced the frequency with which chronic dialysis treatment (implying ESRD) was required in survivors (RR for CRRT vs IHD, 0.91; 95% CI, 0.56-1.49, I^2=0% [5 trials, 308 participants])
- Data from 4 RCTs (643 participants) were inconclusive as to the effect of dialytic modality on hospital length of stay

CRRT vs IHD

- 4 trials (274 participants) measured MAP at various points; in 3 RCTs with no heterogeneity (I^2=0%), the pooled change in MAP from baseline was no different in patients treated with CRRT or IHD (mean decrease in MAP, 2.5 mmHg smaller with CRRT; 95% CI, 1.0 greater to 6.0 smaller)
- The pooled risk of hypotension did not significantly differ between treatments (RR of hypotension with CRRT, 0.87; 95% CI, 0.68-1.12, I^2=0% [2 trials, 389 participants])

CRRT vs IHD

- To summarize the results, data from 9 RCTs suggest no difference in survival between CRRT and IHD, while data from a subset of these RCTs suggest no significant difference in the frequency with which chronic dialysis treatment was required in survivors or in the incidence of hypotension

Techniques for IHD and CRRT

- 1 trial compared hemodiafiltration with hemofiltration in 206 participants treated with CRRT and found a significant reduction in 28-days mortality favouring hemodiafiltration over hemofiltration (RR, 0.63; 95% CI, 0.48-0.82) [however, participants in the hemodiafiltration group received a substantially higher dose of RRT]

Saudan P et al. Kidney Int. 2006;70(7):1312-1317

- In a sensitivity analysis, the pooled results for overall mortality in trials in which the CRRT group used hemodiafiltration exclusively (RR, 1.07; 95% CI, 0.85-1.35; I^2 =62% [3 trials, 650 participants]) did not differ from the findings of the main analysis

SLED vs Other Dialytic Techniques

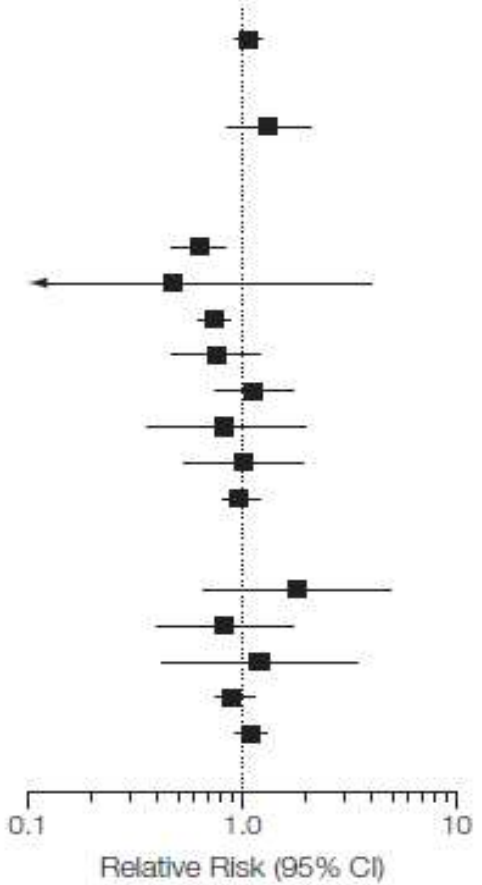
- 2 RCTs compared SLED (6-11h/d;6-7d/wk) with a continuous modality (continuous venovenous hemofiltration or hemodialysis) with respect to the surrogate outcomes of hemodynamic stability and uremic clearance
- No statistically significant differences were found (however, statistical power was low)

Am J Kidney Dis. 2004;43(2):342-349

Int J Artif Organs 2004;27(5):371-379

Pooled effects from RCTs of various interventions on mortality

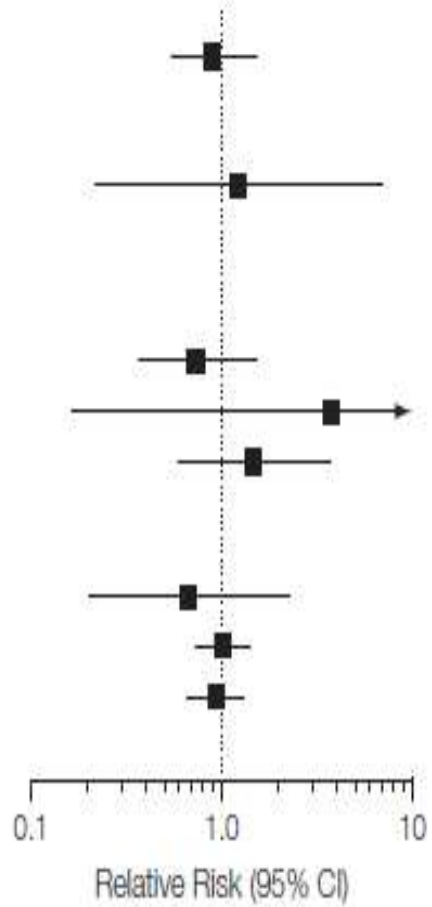
Comparison	References	Mortality, No./Total No. Group 1	Mortality, No./Total No. Group 2	Relative Risk (95% CI)
Continuous renal replacement therapy vs intermittent hemodialysis	17, 19, 20, 23, 25, 28, 29	293/469	254/449	1.10 (0.99-1.23)
Continuous renal replacement therapy vs sustained low-efficiency dialysis	23	20/28	14/26	1.33 (0.87-2.03)
Continuous renal replacement therapy				
Hemodiafiltration vs hemofiltration	30	43/104	67/102	0.63 (0.48-0.82)
Early vs late initiation[a]	24, 26	25/49	32/50	0.48 (0.06-3.97)
Dialysis dose ≥35 vs 20 mL/kg per h	26, 35	138/314	109/181	0.74 (0.63-0.88)
Bicarbonate vs lactate	33	20/61	24/56	0.77 (0.48-1.22)
Trisodium citrate vs heparin	18	13/16	10/14	1.14 (0.76-1.71)
Hirudin vs heparin	21	5/12	7/14	0.83 (0.36-1.95)
P2SH vs polyamide[b]	15	11/18	6/10	1.02 (0.54-1.90)
Polyacrylonitril vs polysulfone	39	69/97	73/100	0.97 (0.82-1.16)
Intermittent hemodialysis				
Hemodiafiltration vs hemodialysis	30	9/21	4/17	1.82 (0.68-4.90)
Daily vs alternate days	27, 44	32/97	45/97	0.83 (0.40-1.72)
Acetate-free vs bicarbonate	37	6/16	4/13	1.22 (0.43-3.42)
High vs low membrane flux	31, 34, 40, 42	76/138	91/149	0.91 (0.74-1.11)
Bioincompatible membrane vs biocompatible membrane	32, 34, 36, 38, 40-42	161/336	173/383	1.11 (0.94-1.31)



CI indicates confidence interval.
[a] Pooled estimate should be viewed with caution (I^2=90%).
[b] P2SH is a newly developed high-flux membrane.

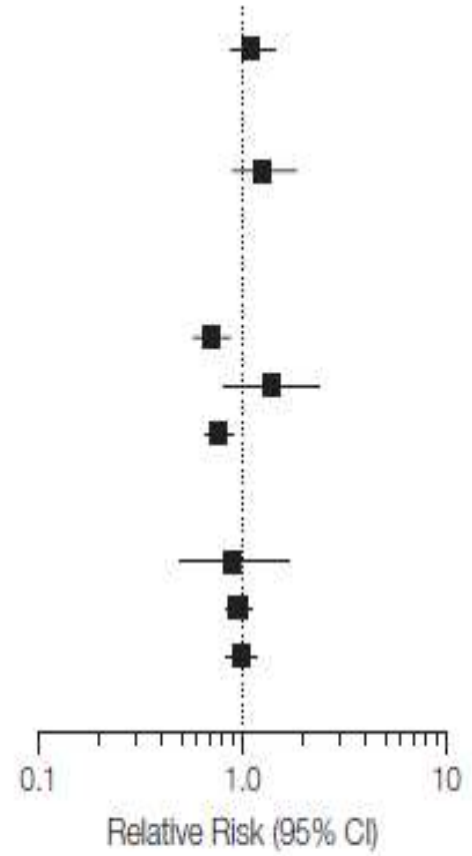
Pooled effects from RCTs of various interventions on chronic dialysis dependence in survivors

Comparison	References	Chronic Dialysis Dependence, No./No. Survived		Relative Risk (95% CI)
		Group 1	Group 2	
Continuous renal replacement therapy vs intermittent hemodialysis	17, 19, 20, 23, 28	19/155	20/153	0.91 (0.56-1.49)
Continuous renal replacement therapy vs sustained low-efficiency dialysis	23	2/8	2/10	1.25 (0.22-7.02)
Continuous renal replacement therapy				
Hemodiafiltration vs hemofiltration	16	3/61	10/35	0.75 (0.37-1.52)
Early vs late initiation	26	1/17	0/22	3.83 (0.17-88.62)
Dialysis dose ≥35 vs 20 mL/kg per h	26, 35	14/182	7/137	1.50 (0.61-3.64)
Intermittent hemodialysis				
Acetate-free vs bicarbonate	37	3/10	4/9	0.68 (0.20-2.23)
High vs low membrane flux	31, 34, 40	34/65	31/54	1.02 (0.75-1.39)
Bioincompatible membrane vs biocompatible membrane	32, 34, 36, 38, 40-42	43/175	57/210	0.94 (0.67-1.32)



Pooled effects from RCTs of various interventions on the composite outcome of chronic dialysis dependence or mortality

Comparison	References	Chronic Dialysis Dependence or Mortality, No./Total No.		Relative Risk (95% CI)
		Group 1	Group 2	
Continuous renal replacement therapy vs intermittent hemodialysis	19, 20, 23, 28	141/222	116/203	1.11 (0.87-1.42)
Continuous renal replacement therapy vs sustained low-efficiency dialysis	23	22/28	16/26	1.28 (0.89-1.83)
Continuous renal replacement therapy				
Hemodiafiltration vs hemofiltration	16	56/104	77/102	0.71 (0.58-0.88)
Early vs late initiation	26	19/35	14/36	1.40 (0.84-2.32)
Dialysis dose ≥35 vs 20 mL/kg per h	26, 35	146/314	197/327	0.77 (0.67-0.90)
Intermittent hemodialysis				
Acetate-free vs bicarbonate	37	9/16	8/13	0.91 (0.50-1.68)
High vs low membrane flux	31, 34, 40	90/112	102/123	0.96 (0.85-1.09)
Bioincompatible membrane vs biocompatible membrane	32, 34, 36, 38, 40, 41	181/310	216/357	1.01 (0.89-1.14)



CVVH vs SLED

Sustained low efficiency dialysis using a single-pass batch system in acute kidney injury - a randomized interventional trial: the REnal Replacement Therapy Study in Intensive Care Unit PatiEnts

Vedat Schwenger[1*†], Markus A Weigand[2†], Oskar Hoffmann[3], Ralf Dikow[1], Lars P Kihm[1], Jörg Seckinger[1], Nexhat Miftari[1], Matthias Schaier[1], Stefan Hofer[4], Caroline Haar[4], Peter P Nawroth[5], Martin Zeier[1], Eike Martin[4] and Christian Morath[1]

Schwenger et al. Critical Care 2012; 16:R140

- **SLED-BD was associated with reduced nursing time and lower costs compared to CVVH at similar outcomes**
- **With limited health care resources, SLED-BD offers an alternative for the treatment of AKI in ICU patients**

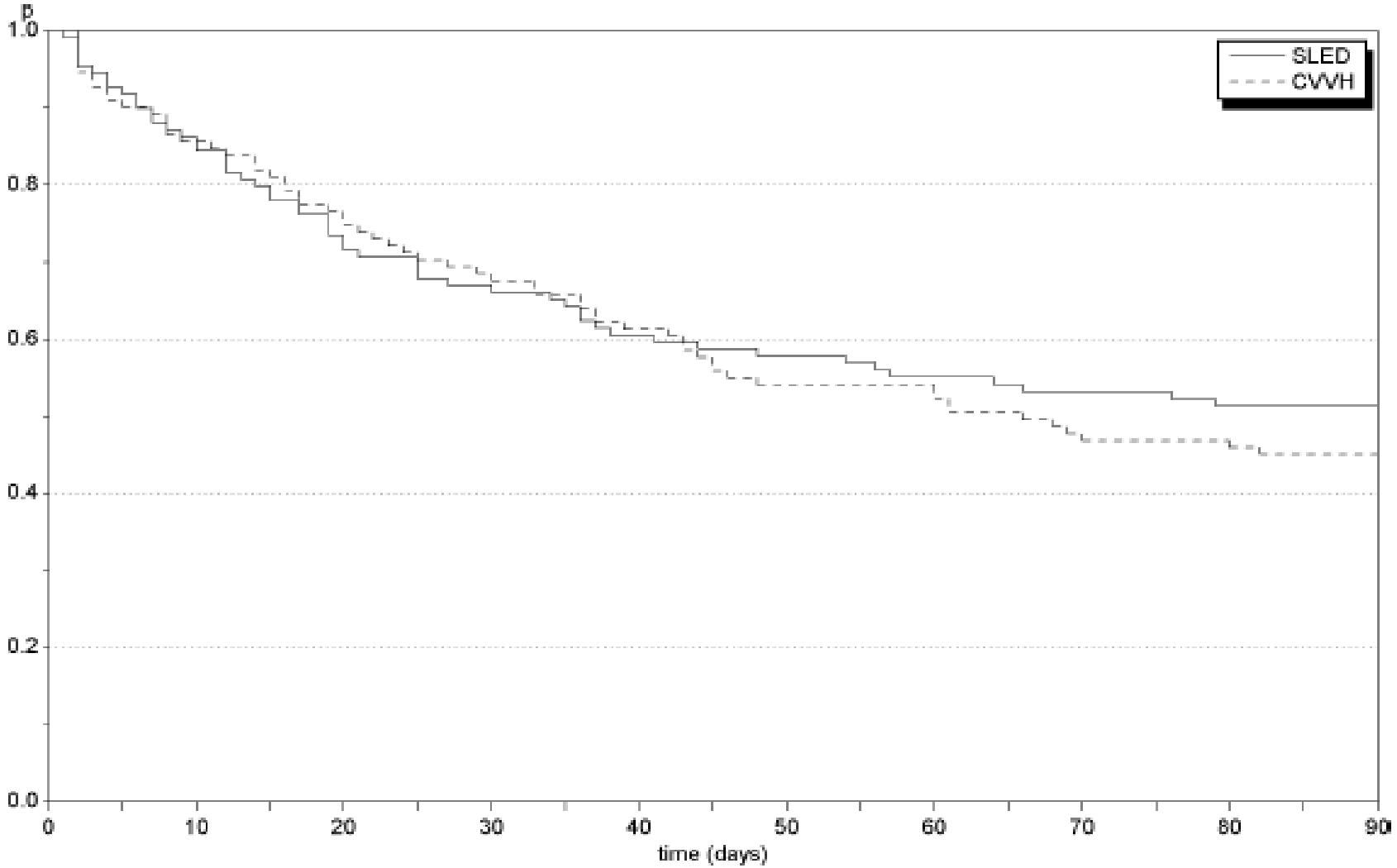
Methodology

- Prospective RCT conducted at a surgical ICU between April 1, 2006 to January 31, 2009; follow-up was assessed until August 30, 2009
- 232 AKI patients who underwent RRT were randomized
- Patients were either assigned to 12-h SLED-BD or to 24-h predilutional CVVH; both therapies were performed at a blood flow of 100-120mL/min
- 115 patients were treated with SLED-BD (total number of treatments, n=817) and 117 patients with CVVH (total number of treatments, n=877)

Results

- 90-day mortality (primary outcome) was similar between both the groups (SLED 49.6% vs CVVH 55.6%; ***p*=0.43**)
- Hemodynamic stability did not differ between the groups
- Patients in the SLED-BD group had significantly fewer days of mechanical ventilation (17.7 ± 19.4 vs 20.9 ± 19.8; ***p*=0.047**) and fewer days in the ICU (19.6 ± 20.1 vs 23.7 ± 21.9; ***p*=0.04**)
- Patients treated with SLED needed fewer blood transfusions (1,375 ± 2,573mL vs 1,976 ± 3,316mL; ***p*=0.02**)
- Patients treated with SLED had a substantial reduction in nursing time spent for RRT (***p*<0.001**) resulting in lower costs

Kaplan-Meier estimates of probability of survival in SLED and CVVH treatment groups during the first 90 days



Peritoneal Dialysis (PD) in AKI

- **PD is not the most efficient therapy** : clearance per exchange can decrease if a shorter dwell time is applied, a lower efficiency can be observed in large-sized and severely hypercatabolic patients, fluid removal can be limited, and there is a high risk of infection and possibility of PD worsening mechanical ventilation, thus impairing respiratory performance
- **5 types of acute PD** : acute intermittent PD (AIPD), continuous flow PD (CFPD), continuous equilibration PD (CEPD), tidal PD (TPD), and high volume PD (HVPD)

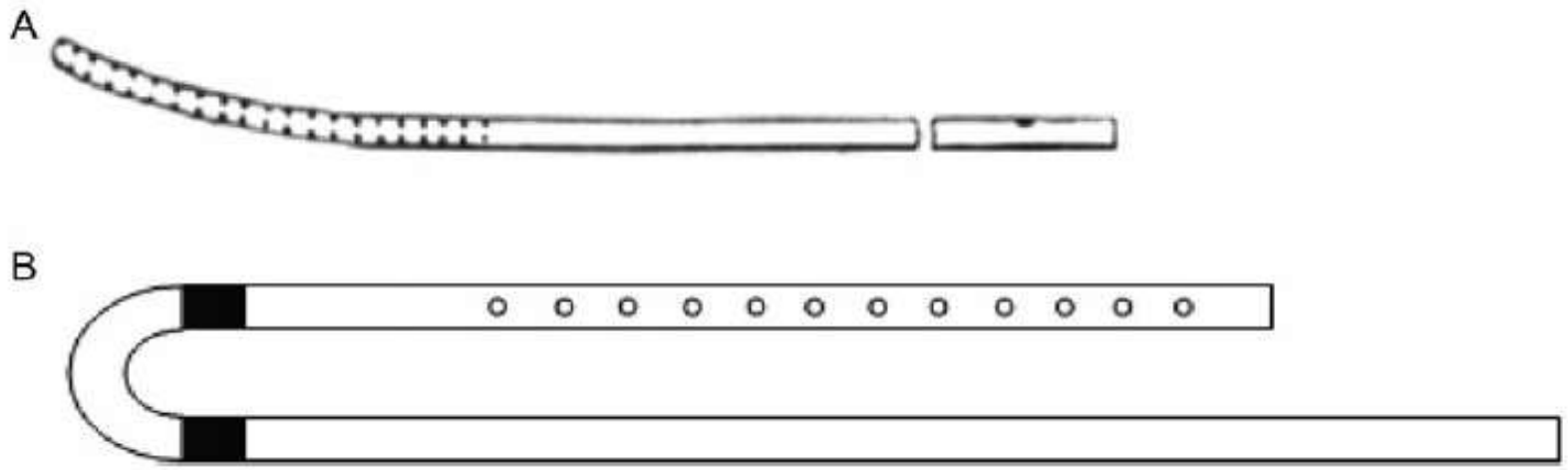
  The urea clearance is 8-12mL/min for AIPD, 15mL/min for TPD, and 30-35mL/min for CFPD

Techniques of PD for AKI

Technique	Description
AIPD	Most often used in the past. Frequent and short exchanges with volumes 1–2 L and dialysate flows of 2–6 L/h. Each session lasts 16–20 h, usually tri-session per week. The solute clearance is likely inadequate due to its intermittent nature.
Continuous equilibration peritoneal dialysis (CEPD)	Long dwells of 2–6 h with up to 2 L of dialysate each (similar to CAPD). The clearance of small molecules may also be inadequate but clearance of middle molecules is possibly higher due to the long dwells.
TPD	Typically involves an initial infusion of 3 L of dialysate into the peritoneal cavity. A portion of dialysate, tidal drain volume (usually 1–1.5 L) is drained and replaced with fresh dialysate (tidal fill volume). The reserve volume always remains in the peritoneal cavity throughout the tidal cycle.
HVPD	Continuous therapy proposed to increase high small solute clearances. Frequent exchanges, usually with cycler (18–48 exchanges per 24 h, 2 L per exchange). The total dialysate volume range from 36 to 70 L a day.
CFPD	In-flow and out-flow of dialysate occurs simultaneously through two access routes. By inflow of 300 mL/min, it is possible to achieve a high peritoneal urea clearance.

Types of PD catheter

- **Rigid catheter :** cheap and easier to insert; however, slightly increased risk of peritonitis, catheter dysfunction and poor dialysate flow when compared with a flexible catheter
- **Flexible catheter :** accommodates a higher dialysate flow rate but is costlier; prevents catheter migration from the pelvis, can be inserted at bedside using a trocar or a peel-away sheath technique



(A) Rigid catheter in PD. (B) Flexible swan neck catheter used in PD.

Use of Peritoneal Dialysis in AKI: A Systematic Review

Chang Yin Chionh,*† Sachin S. Soni,*‡ Fredric O. Finkelstein,§ Claudio Ronco,*‖ and Dinna N. Cruz‖¶

Clin J Am Soc Nephrol. 2013;8:1649-1660

- **Objectives :** to describe outcomes in AKI treated with PD and compare PD with extracorporeal blood purification, such as continuous or intermittent hemodialysis
- Eligible studies were observational cohort or randomized adult population studies on PD in the setting of AKI
- The primary outcome of interest was all-cause mortality
- Secondary outcomes included length of stay, kidney recovery and/or dialysis dependence, and complications related to PD (e.g., peritonitis, hyperglycemia, and hypoalbuminemia) and EBP (e.g., intradialytic hypotension, line sepsis, and bleeding)
- Total 24 articles with 1556 patients was included in this review

Results of the review

Characteristics of eligible studies

Reference	Study Type (Country)	Study Period	Mean Age (yr)	ICU Patients (%)	Sepsis (%)	EBP Used	Mean APACHE II Score	Predominant Causes of AKI (Stated in the Studies)	PD		EBP		Total on RRT	Overall Mortality (%)
									N	Mortality	*N*	Mortality		
Watcharotone (29)	Retr. (Thailand)	January 2005 to December 2009	61.6	69.7	84.8	Int. HD	23.1	Not stated	62	47 (75.8%)	83	52 (62.7%)	145	68.3
George (37)	RCT (India)	June 2005 to June 2008	46.9	100.0	38.0	CVVHDF	18.1	Sepsis (38.0%), prerenal (34.0%), leptospirosis (10.0%), snake bite (6.0%)	25	18 (72.0%)	25	21 (84.0%)	50	78.0
Gabriel (10)	RCT (Brazil)	January 2004 to December 2006	63.4	77.4	44.5	Daily HD	25.1	Sepsis (44.5%), prerenal (39.2%), postsurgery (22.5%)	60	35 (58.0%)	60	32 (53.0%)	120	55.5
Chow A (36)	Pros. (Malaysia)	March 1994 to June 1994	57.7	29.5	41.0	Int. HD, CVVHDF	NA	Prerenal (43.6%), sepsis (41.0%), toxins (10.3%)	9	6 (66.7%)	3	2 (66.7%)	12	66.7
Chow B (36)	Pros. (Malaysia)	November 2004 to February 2005	55.6	13.3	37.9	Int. HD, CVVHDF	NA	Prerenal (53.5%), sepsis (37.9%), toxins (6.2%)	26	12 (46.2%)	4	3 (75.0%)	30	46.7
Mahajan (35)	Retr. (India)	April 2000 to March 2004	66.4	NA	21.6	Int. HD	NA	Prerenal (33.0%), sepsis (21.6%), toxins (16.1%)	95	46 (48.4%)	37	25 (67.6%)	132	53.8

Characteristics of eligible studies

Reference	Study Type (Country)	Study Period	Mean Age (yr)	ICU Patients (%)	Sepsis (%)	EBP Used	Mean APACHE II Score	Predominant Causes of AKI (Stated in the Studies)	PD		EBP		Total on RRT	Overall Mortality (%)
									N	Mortality	*N*	Mortality		
Arogundade (34)	RCT (Nigeria)	December 1998 to February 2001	44.0	NA	17.5	Int. HD	NA	Sepsis (87.5%), obstruction (12.5%)	4	0 (0.0%)	4	0 (0.0%)	8	0.0
Phu (33)	RCT (Vietnam)	1993–1998	35.5	100.0	31.4	CVVHDF	NA	Malaria (68.6%), sepsis (31.4%)	36	17 (47.0%)	34	5 (15.0%)	70	31.5
Bellomo (15)	Retr. (Australia)	1983–1993	58.3	100.0	66.6	HDF, Int. HD	27.3	Sepsis (66.0%)	16	12 (75.0%)	218	139 (63.8%)	234	64.5
Kumar (32)	Retr. (India)	July 1987 to March 1988	46.3	NA	NA	Int. HD	NA	Diarrheal illness (100%)	42	25 (59.5%)	3	2 (66.7%)	45	60.0
Hadidy (31)	Retr. (Serbia)	1980–1986	38.0	NA	NA	Int. HD	NA	Obstruction, surgery, trauma (64.0% of men); pregnancy, GN (56.0% of women)	4	0 (0.0%)	77	26 (33.8%)	81	30.9
Werb (30)	Retr. (Canada)	July 1974 to June 1976	NA	100.0	28.0	Int. HD	NA	Sepsis (28.0%), prerenal (17.0%)	13	9 (69.2%)	19	12 (65.0%)	32	65.5

Characteristics of PD techniques and peritonitis rates

Reference	Access Type	Cycler Based / Manual	Open/Closed Drainage	Buffer	Peritonitis Incidence (%)
Observational studies (PD only)					
Ponce (17)	Tenckhoff	Cycler	Closed	Lactate	12.0
Kilonzo (6)	NA	Manual	NA	NA	11.1
Ponce (18)	Tenckhoff	Cycler	Closed	Lactate	13.1
Hayat (28)	Rigid	NA	NA	NA	NA
Gabriel (27)	Tenckhoff	Cycler	Closed	Lactate	16.7
Chitalia (26)	Rigid	Cycler/manual[a]	Closed	Lactate	3.4
Thongboonkerd (25)	NA	NA	NA	Lactate/ bicarbonate[b]	0.0
Trang (24)	NA	NA	Open	Acetate	8.7
Howdieshell (23)	Tenckhoff	Cycler	Closed	Lactate	40.0
Sonnenblick (22)	NA	NA	Closed	Lactate	27.0
Indraprasit (21)	Tenckhoff	NA	NA	NA	20.0
Ojogwu (20)	NA	NA	NA	NA	NA
Cameron (19)	Rigid	Manual	NA	Lactate	NA
Studies with PD and EBP					
Watcharotone (29)	NA	NA	NA	NA	3.2
George (37)	Rigid	Manual	Closed	Acetate	4.0
Gabriel (10)	Tenckhoff	Cycler	Closed	Lactate	18.0
Chow (36)	NA	NA	NA	NA	NA
Mahajan (35)	Rigid	NA	NA	NA	NA
Arogundade (34)	Tenckhoff	Manual	NA	NA	65.0
Phu (33)	Rigid	Manual	Open	Acetate	2.8 (41.6 cloudy dialysate)
Bellomo (15)	Tenckhoff	Manual	Closed	Lactate	25.0
Kumar (32)	NA	NA	NA	NA	NA
Hadidy (31)	NA	NA	NA	NA	NA
Werb (30)	NA	NA	NA	NA	NA

The peritoneal dialysis techniques are tabulated according to the type of catheters, use of automated cyclers or manual exchanges, drainage system, and dialysate buffer. The peritonitis incidence listed is based on the rates reported in the studies. PD, peritoneal dialysis; NA, not available; EBP, extracorporeal blood purification.

[a]The study compared cycler-based tidal PD with conventional PD using manual exchanges.

[b]The study assessed differences in outcomes between bicarbonate and lactate-based PD fluids in AKI.

Characteristics and dose of EBP techniques

Reference	EBP Mode	Machine	Buffer	Intensity	Dose	Efficiency	Flux	Dialyzer/Membrane
Watcharotone (29)	IHD	NA	NA	NA	NA	NA	NA	NA
George (37)	CVVHDF	2008B; Fresenius, Germany	Acetate	Continuous	K_{urea}=21.72±10.41; K_{Cr}=22.13±9.61	NA	NA	Polysulfone
Gabriel (10)	Daily HD	4008F; Fresenius, Germany	Bicarb	6 times/wk	Kt/V=1.2/session	H	L	Polysulfone (HF 6 or 8)
Chow (36)	HD and/or CVVHDF	NA	NA	NA	NA	H[a]	HD: L; CVVHDF: H[a]	NA
Mahajan (35)	IHD	NA	Bicarb	NA	NA	NA	NA	NA
Arogundade (34)	IHD	COBE Centry 2×	Acetate	Intermittent	K_{Cr}=13.7±39.4	NA	NA	Cuprophane
Phu (33)	CVVHF	BS1 Balancing System; Gambro, Sweden	Lactate	Continuous	25 L/d	H	H	FH-66
Bellomo (15)	HDF	CVVHDF: AK 10; Gambro, Sweden	NA	NA	NA	NA	NA	HD: Cuprophane; CAHDF: AN69S parallel plate filters
Kumar (32)	IHD	NA	NA	NA	NA	NA	NA	NA
Hadidy (31)	IHD	NA	NA	NA	NA	NA	NA	NA
Werb (30)	IHD	Recirculating Single Pass Dialysis Machine; Travenol Laboratories Inc.	NA	NA	NA	NA	NA	Parallel plate filters

Mortality outcome

- **Studies using PD only :**

➢ 13 studies (597 participants) were included, 5 studies conducted predominantly in the ICU setting

➢ The pooled mortality was 39.3%, whereas reported mortality in the individual studies ranged from 1.1% to 100%

Ojogwu Ll. Trop Geogr Med. 1983;35:385-388

Chitalia VC et al. Kidney Int. 2002;61:747-757

Mortality outcome

- **Studies using PD only :**

➢ Studies including lesser number of septic patients had lower mortality rates ranging from 1.1% to 26%

Trang TT et al. Clin Infect Dis. 1992;15:874-880

Chitalia VC et al. Kidney Int. 2002;61:747-757

➢ In one study, 100% mortality was observed for 20 consecutive patients with hypertensive emergency, oliguria, and uremia, mostly reflecting the severity of the underlying condition

Ojogwu Ll. Trop Geogr Med. 1983;35:385-388

Mortality outcome

- **Studies using PD or EBP :**

➢ 11 studies (959 participants) were included, of which 4 studies were conducted only in the ICU and 4 studies were RCTs

➢ 392 patients underwent PD, and 567 patients underwent EBP

➢ For the PD group, reported mortality rates ranged from 25% to 75.8%, except for 2 studies with 0% mortality

Hadidy S et al. Int Urol Nephrol. 1989;21:455-461

Arogundade FA et al. Afr J Med Sci. 2005;34:227-233

Mortality outcome

- **Studies using PD or EBP :**

➢ Mortality for EBP patients ranged from 15% to 84% in individual studies

➢ Pooled mortality was 58% for PD and 56.1% for EBP

➢ Among the observational studies, there was no significant difference in mortality between PD and EBP (odds ratio, 0.96; 95% CI, 0.53-1.71)

Mortality outcome

- Among the RCTs, there was significant intertrial heterogeneity (I^2=73%, p=0.03)

  PD was inferior to continuous venovenous hemofiltration in 1 study, whereas mortality rates were comparable for the other 3 studies

Phu NH et al. N Engl J Med. 2002;347:895-902

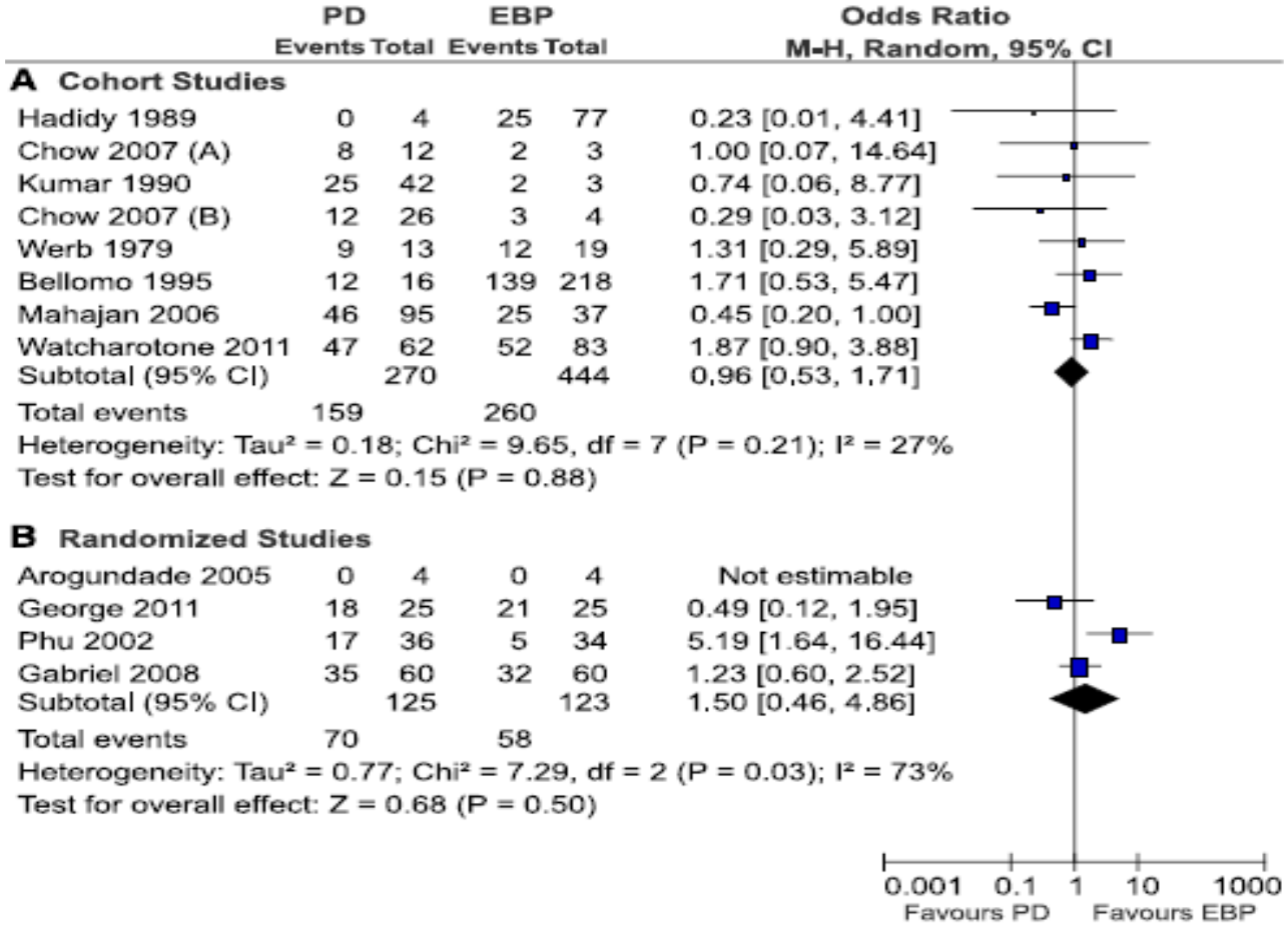
Gabriel DP et al. Kidney Int Suppl. 2008;108:S87-S93

Arogundade FA et al. Afr J Med Sci. 2005;34:227-233

George J et al. Perit Dial Int. 2011;31:422-429

- The first study enrolled patients with severe falciparum malaria compared to the other studies with AKI, which were mainly caused by sepsis or hemodynamic disturbances; these factors likely contribute to the heterogeneity among these studies

Effect of RRT modality on mortality in patients with AKI grouped by study design



Complications related to PD

- 16 studies reported on peritonitis, which was diagnosed based on signs and symptoms (2), positive bacterial culture (5), presence of white cells in the dialysate (2), or unspecified diagnostic criteria;
- Only 1 study had clearly specified criteria for peritonitis (cloudy effluent, >100 white cells/mm^3)

Howdieshell TR et al. Am Surg. 1992;58:378-382

- Overall incidence of peritonitis was 12.4%, and it ranged from 0% to 40% in individual studies
- No data were available on other complications, such as hyperglycemia and hypoalbuminemia

Other outcomes

- 1 RCT observed a significantly shorter duration of dialysis dependence with PD than daily HD (5.5±2.7 vs 7.5±3.1 days; *p*=0.02)

Gabriel DP et al. Kidney Int Suppl. 2008;108:S87-S93

- Another RCT reported that patients treated with PD were more likely to require >1 session of dialysis (PD=70% vs continuous venovenous hemofiltration=37%; *p*=0.04)

Phu NH et al. N Engl J Med. 2002;347:895-902

- The third RCT reported that PD patients required more time on dialysis (PD=20 hours, interquartile range=19 hours vs continuous venovenous hemofiltration=48 hours, interquartile range=74.5 hours; *p*=0.01)

George J et al. Perit Dial Int. 2011;31:422-429

Peritoneal Dialysis in Acute Kidney Injury: Trends in the Outcome across Time Periods

Daniela Ponce*, Marina Berbel Buffarah, Cassiana Goes, André Balbi

PLOS ONE, DOI:10.1371/journal.pone.0126436 May 12, 2015

- **Largest cohort study conducted in a developing country**
- **A Brazilian prospective cohort study, all adult AKI patients on PD were studied from Jan 2004-Jan 2014**
- **Patients were divided into 2 groups according to the year of treatment : 2004-2008 and 2009-2014**
- **Patient survival improved along study periods : compared to 2004-2008, patients treated at 2009-2014 had a RR reduction of 0.87 (95% CI, 0.79-0.98)**
- **The independent risk factors for mortality were sepsis, age >70 years, ATN-ISS > 0.65 and positive fluid balance**

High-Volume Peritoneal Dialysis in Acute Kidney Injury: Indications and Limitations

Daniela Ponce, Marina Nogueira Berbel, Cassiana Regina de Goes, Cibele Taís Puato Almeida, and André Luís Balbi

Clin J Am Soc Nephrol. 2012;7:887-894

- **A prospective cohort study performed on 204 AKI patients who were assigned to high-volume PD (prescribed Kt/V=0.60/session) by flexible catheter and cycler**
- **150 patients (80.2%) were included in the final analysis**
- **An HVPD session was defined as 24 hours with sessions performed 7d/wk**
- **70% patients were in the ICU, and sepsis was the main cause of AKI (54.7%)**
- **BUN and creatinine levels stabilized after 4 sessions at about 50 and 4 mg/dL, respectively**
- **Fluid removal and nitrogen balance increased progressively and stabilized around 1200 mL and -1 g/d after 4 sessions, respectively**
- **Weekly delivered Kt/V was 3.5±0.68**
- **23% patients had renal function recovery, 6.6% patients remained on dialysis after 30 days, and 57.3% patients died**

Take home message

- Early initiation of RRT results in better outcome in critically ill patients
- The mode of RRT to be delivered to each patient should depend on the patient's clinical profile and requirements accordingly
- Early consultation of a Nephrologist should be sought