CRRT vs IHD in ICU - a nephrologist point of view

Prof. Robert EKART, MD, PhD

Department of Dialysis, Clinic for Internal Medicine, University Clinical Centre Maribor, Slovenia

Faculty of Medicine, University of Maribor, Slovenia

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INTRODUCTION

- Acute kidney injury (AKI) is a part of the multiple organ dysfunction syndrome in critically ill patients
- AKI develops in 30-60% of patients followed in the ICU, approximately 20% of patients with AKI, and approximately 5% of all ICU patients require renal replacement therapy (RRT)
- The treatment of AKI is based on both conservative measures and timely use of RRT

Heung M, Yessayan L. Crit Care Clin. 2017, 33:365-78.
Truche AS, et al. Intensive Care Med 2016; 42: 1408-17

Which type of renal replacement therapy for AKI treatment in ICU?

CRRT?

IHD?

SLED?

Table 1. Characteristics of different modalities of renal replacement therapy for acute kidney injury in ICU

Characteristics	Intermittent hemodialysis	Sustained low-efficiency dialysis	Continuous renal replacement therapy
RRT duration	Intermittent, three times a week, 3–5 h each session	Intermittent, daily, 6–8 h each session	Continuous until filters are clotted or no need for RRT
Doses	Based on URR and Kt/V_{urea} for quantification		~25 ml/kg/h
Anticoagulation	Short exposure	Extended exposure	Often continuous exposure

Wang AJ, Bellomo R. Curr Opin Crit Care 2018; 24: 437-42

CRRT

The most appropriate modality in ICU for patients with:
- brain edema
- increased intracranial pressure
- acute brain injury
- fulminant hepatic failure
- head trauma

Wang AJ, Bellomo R. Curr Opin Crit Care 2018; 24: 437-42.
Macedo E, Cerda J. Semin Dial 2021; 34:423-31.
Karkar A, Ronco C. Ann Intensive Care 2020; 10:32.

IHD

- Use of higher flow rates than CRRT to maintain fluid, electrolytes and acid-base balance
- For hemodinamically stable patients
- More suited for patients who require faster removal of uremic toxins and control of electrolyte and acid–base disturbance
- The same IHD machine available for several patients in a same day
- Associated with an increased risk of hypotension, renal ischemia

SLED

- Is a modified form of IHD
- An example of hybrid therapy and extended daily dialysis
- In comparison with IHD:
- Lower dialysate (100-350 ml/min)
- Lower blood flow rate (100-200 ml/min)
- Prolonged session duration than traditional IHD (6-12h)

Table 1 | Treatment parameters for current and previous SLED studies

Author (reference)	Kumar *et al.*[4]	Marshall *et al.*[5]	Marshall *et al.*[6]	This study
Treatment name	EDD	SLED	SLEDD-*f*	SLED
Hours/day	7.5	12	8	8
Days/week	6–7	6–7	4–7	6
Blood pump speed (ml/min)	200	100	300	200
Dialysate flow (ml/min)	300	200	200	350
Replacement fluid (ml/min)	—	—	100	17

EDD, extended daily dialysis; SLED, sustained low-efficiency dialysis; SLEDD-*f*, sustained low-efficiency daily diafiltration.

Table 3 | Daily and weekly cost of SLED and CRRT

	SLED ($)	CRRT citrate ($)	CRRT heparin ($)
Supply cost/day	69.75	402.80	334.95
HD RN cost/day	168.75[a]	37.50	37.50
Total cost/day	238.50	440.30	372.45
Total cost/week	1431	3089	2607

CRRT, continuous renal replacement therapy; HD, hemodialysis; RN, registered nurse; SLED, sustained low-efficiency dialysis.
[a]*Note:* Based on one HD nurse treating two patients.

Berbece AN, Richardson RMA. KI 2006;70: 963-8.

STUDIES

CRRT improves renal recovery from acute renal failure

TABLE I Demographics*

	CRRT (n = 65)	*IHD (n = 28)*	*P value*
Time to RRT (hr)	84 (± 80)	68 (± 60)	0.52
Age (yr)	54.7 (± 15.4)	62.6 (± 13.4)	0.02
Gender			
Male	45 (69%)	17 (61%)	0.43
Female	20 (31%)	11 (39%)	
Diagnostic group			
Medical	46 (71%)	17 (61%)	
Surgical	12 (18%)	10 (36%)	0.23
Transplant	7 (11%)	1 (3%)	
APACHE II score	25.1 (± 7.3)	23.5 (± 8.5)	0.37
TISS	47.8 (± 1.3)	37.6 (± 2.0)	0.0001
Mechanical ventilation	65 (100%)	28 (100%)	1.0
Acute lung injury	32 (49%)	6 (21%)	0.01
Admission serum creatinine (μmoL·L^{-1})	289 (± 217)	410 (± 223)	0.02
Vasoactive drugs required	40 (62%)	10 (36%)	0.02

93 ICU pts with AKI

TABLE III Comparison of indications for RRT mode at initiation of RRT

	CRRT (n = 65)	*IHD (n = 28)*	*P value*
Cerebral injury	1 (2%)	0 (0%)	0.51
Hepatic failure	31 (47%)	0 (0%)	0.0001
Dopamine > 5 μg·kg^{-1}·min^{-1}	18 (27%)	6 (18%)	0.53
Epinephrine	15 (23%)	1 (3%)	0.02
Norepinephrine	29 (44%)	5 (15%)	0.014
Cross over to alternate mode of RRT	18 (67%)	0 (0%)	0.002

Jacka MJ, et al. Can J Anesth 2005; 52:327-32

CRRT improves renal recovery from acute renal failure

TABLE IV Multivariable logistic analysis of outcomes

	ICU mortality		*Hospital mortality*		*Renal recovery*	
	*Odds ratio**	*P*	*Odds ratio*	*P*	*Odds ratio*	*P*
pH	18 (8, 30)	0.001	8 (5, 10)	0.003		
Age			0.96 (0.93, 0.99)	0.02	0.89 (0.80, 0.99)	0.03
RRT mode					0.04 (0.004, 0.41)	0.006

*Odds ratio (± 95% confidence limits). ICU = intensive care unit; RRT = renal replacement therapy.

TABLE V

A) ICU survival *vs* RRT mode			
	Survived	*Died*	
CRRT	29 (45%)	36 (55%)	
IHD	20 (71%)	8 (29%)	*P* = 0.02
B) Hospital survival *vs* RRT mode			
	Survived	*Died*	
CRRT	24 (37%)	41 (63%)	
IHD	14 (50%)	14 (50%)	*P* = 0.24
C) Renal recovery *vs* RRT mode			
	Recovered	*Chronic dialysis*	
CRRT	21 (87%)	3 (13%)	
IHD	5 (36%)	9 (63%)	*P* = 0.0003

Jacka MJ, et al. Can J Anesth 2005; 52:327-32

Intensive Care Med (2007) 33:773–780
DOI 10.1007/s00134-007-0590-6

ORIGINAL

Max Bell
SWING
Fredrik Granath
Staffan Schön
Anders Ekbom
Claes-Roland Martling

Continuous renal replacement therapy is associated with less chronic renal failure than intermittent haemodialysis after acute renal failure

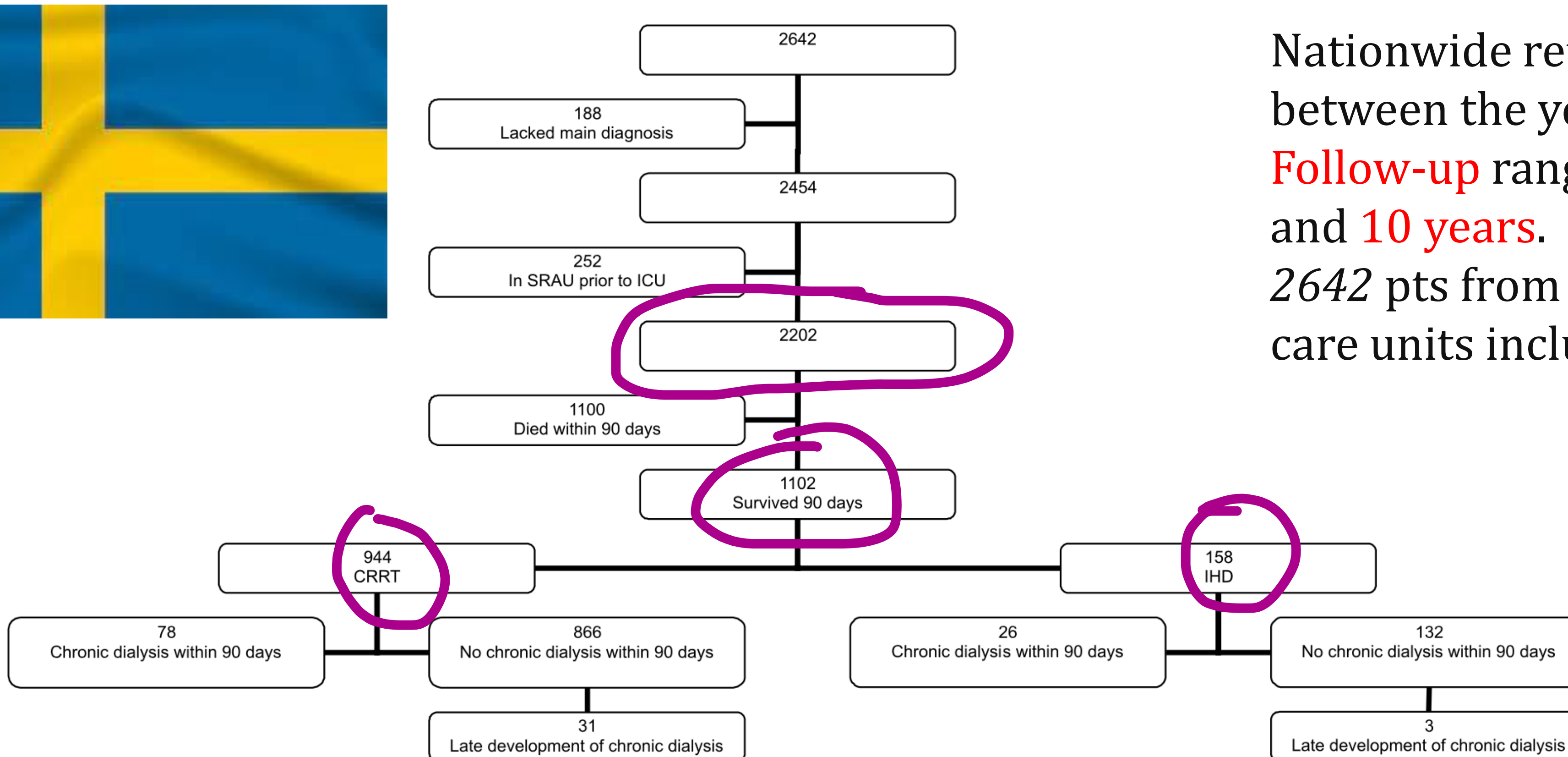

Fig. 1 Flowchart of exclusion criteria and outcome of the cohort

Nationwide retrospective cohort study between the years 1995 and 2004.
Follow-up ranged between 3 months and 10 years.
2642 pts from *32* Swedish intensive care units included, *2202* pts studied.

Intensive Care Med (2007) 33:773–780
DOI 10.1007/s00134-007-0590-6

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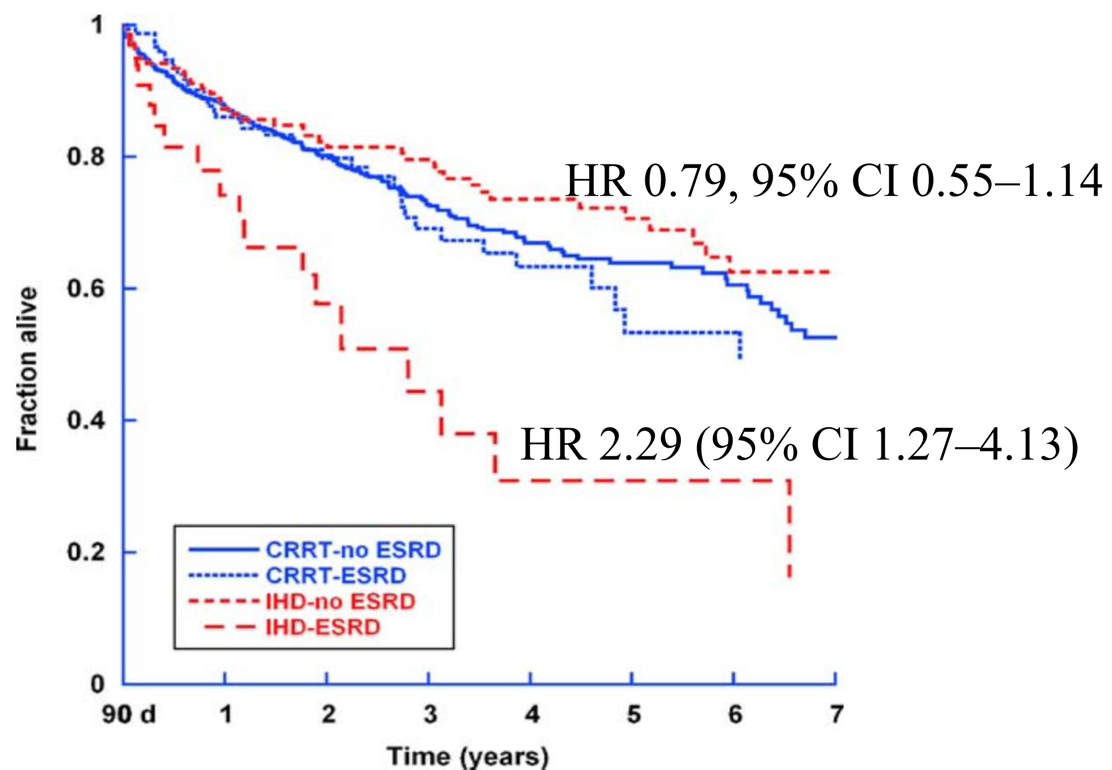


Fig. 2 Kaplan–Meier survival function, all deaths among patients by treatment

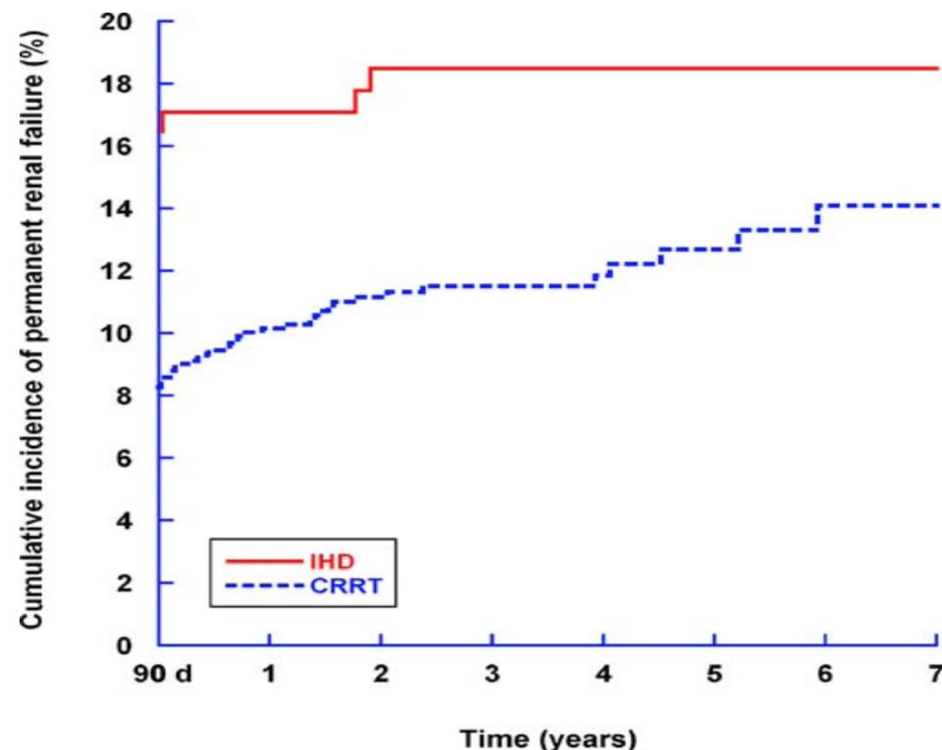


Fig. 3 Cumulative incidence of permanent renal failure among patients surviving 90 days

Patients treated with IHD that ended up with ESRD showed the highest mortality.

A higher risk for ESRD after critical illness for patients treated with IHD than for patients treated with CRRT.

Comparison of the Treatment Efficacy of CRRT and IHD in Patients With AKI admitted to the ICU

120 pts in ICU

Parameters	All Patients (n=120)	IHD (n=80)	CRRT (n=40)	p
Sex: Female; Male	74 (61.7%); 46 (38.3%)	49 (61.3%); 31 (38.7%)	25 (62.5%) 15 (37.5%)	0.894
Age	62.90±13.64	61.41±15.24	65.90±9.13	0.089
SAPS-II	45.05±12.76	43.35±11.11	48.47±15.13	0.038
APACHE II Scores	22.05±6.32	21.06±5.51	24.02±7.38	0.015
SOFA Scores	8.26±2.48	7.91±2.49	8.97±2.35	0.027
Pre-Dialysis				
Mean Arterial Pressure	79.025±15.29	81.75±16.23	73.65±11.62	0.006
Urea (mg/dL)	159.76±66.15	167.18±70.17	144.92±55.13	0.082
Creatinine (mg/dL)	4.09±1.94	4.44±2.09	3.39±1.40	0.005
Sodium (mmol/L)	134.97±6.49	135.08±6.13	134.75±7.24	0.790
Potassium (mmol/L)	4.93±0.94	5.02±1.07	4.73±0.52	0.110
Calcium (mg/dL)	8.36±1.35	8.25±1.42	8.59±1.19	0.198
pH	7.31±0.09	7.29±0.10	7.35±0.07	<0.001
Lactate (mmol/L)	2.33±1.97	2.23±2.22	2.52±1.37	0.448
Bicarbonate (mmol/L)	20.00±4.38	19.59±4.55	20.81±3.95	0.151
Post-Dialysis				
Mean Arterial Pressure	74.49±13.67	75.17±14.67	73.13±11.45	0.442
Urea (mg/dL)	121.08±50.63	115.70±51.21	131.85±48.29	0.100
Creatinine (mg/dL)	3.24±1.46	3.23±1.51	3.27±1.39	0.868
Sodium (mmol/L)	135.80±5.68	136.35±4.73	134.72±7.16	0.140
Potassium (mmol/L)	4.48±0.89	4.48±1.02	4.48±1.02	0.994
Calcium (mg/dL)	8.37±1.01	8.35±1.05	8.43±0,94	0.696
pH	7.32±0.13	7.33±0,14	7.30±0,11	0.338
Lactate (mmol/L)	3.04±3.04	2.88±1.41	3.37±2.10	0.403
Bicarbonate (mmol/L)	21.73±4.14	21.72±4.53	21.75±3.28	0.975
Non-survivor Survivor	80 (66.7%); 40 (33.3%)	53 (66.3%); 27 (33.7%)	27 (67.5%); 13 (32.5%)	0,891
Length of Stay in ICU (days)	12.85±10.23	14.02±10.31	10.50±9.77	0.075

TABLE 1: The demographic, clinical, and laboratory characteristics of the groups during admission to the intensive care unit

Aydin E, et al. Cureus 2022; 14(1): e21707

Comparison of the Treatment Efficacy of CRRT and IHD in Patients With AKI admitted to the ICU

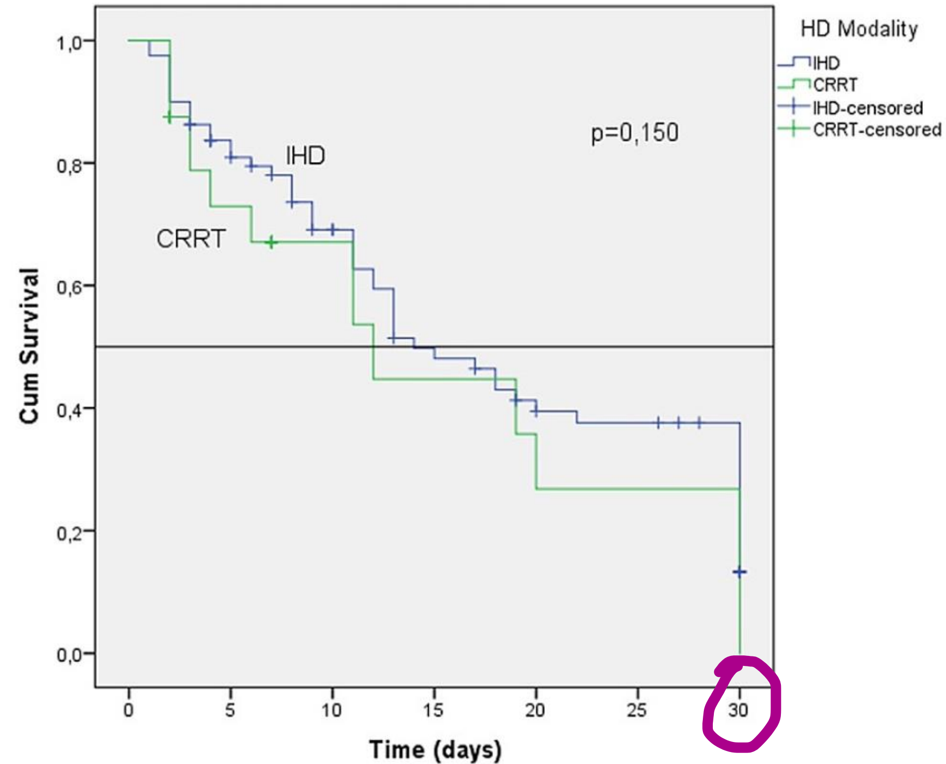


FIGURE 1: Kaplan-Meier survival analysis for hemodialysis modality

	Univariate			Multivariate		
Parameters	OR	95%CI	p	OR	95% CI	p
Age	1.01	0.99 - 1.03	0.183	1.01	0.99 - 1.03	0.116
Sex (Male)	1.19	0.75 - 1.89	0.458	1.32	0.77 - 2.26	0.314
SAPS-II	1.04	1.02 -1.06	<0.001	1.03	1.01 - 1.06	0.007
APACHE II Scores	1.08	1.04 - 1.11	<0.001	1.05	1.01 - 1.09	0.028
SOFA Scores	1.19	1.10 - 1.30	<0.001	1.13	1.02 - 1.26	0.019
RRT Modality (CRRT)	1.36	0.85 - 2.16	0.198	0.87	0.51 - 1.50	0.616

TABLE 2: Univariate and multivariate Cox Regression analysis results to evaluate 30-day mortality risk

Aydin E, et al. Cureus 2022; 14(1): e21707

RESEARCH Open Acce

The effect of continuous versus intermittent renal replacement therapy on the outcome of critically ill patients with acute renal failure (CONVINT): a prospective randomized controlled trial

Joerg C Schefold[1*], Stephan von Haehling[2], Rene Pschowski[1,3], Thorsten Onno Bender[1], Cathrin Berkmann[1], Sophie Briegel[1], Dietrich Hasper[1] and Achim Jörres[1]

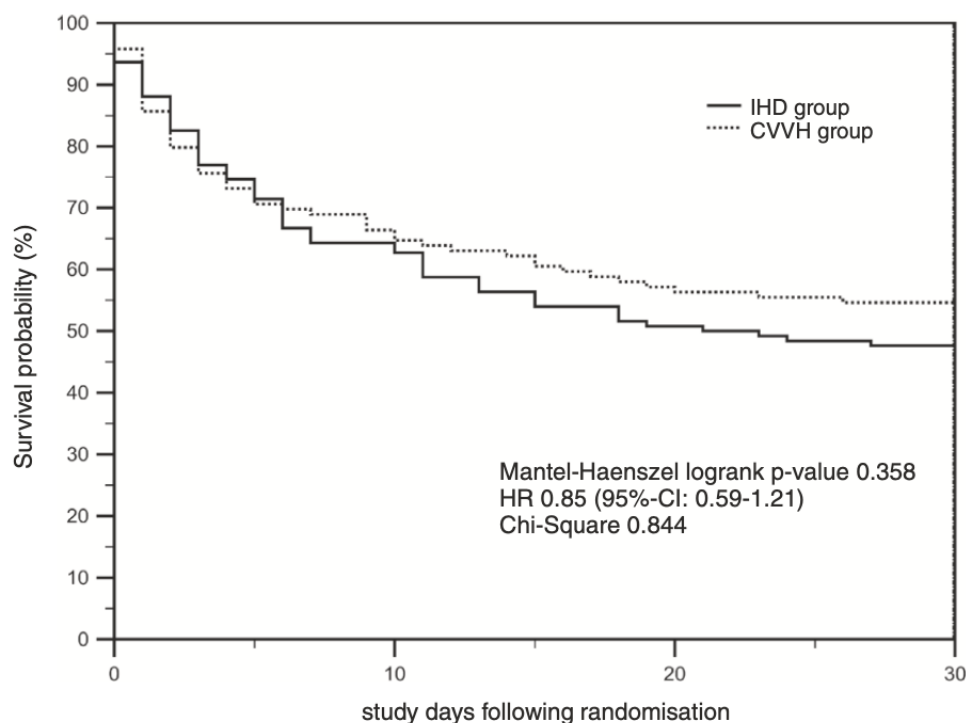
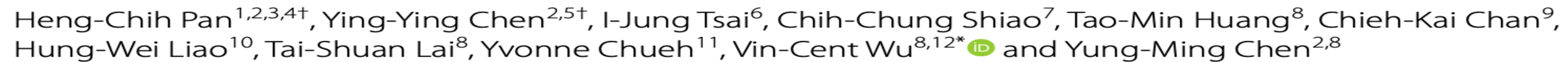


Figure 2 Kaplan-Meier survival estimates for patients randomized to IHD (full line, *n* = 128) and CVVH (dotted line, *n* = 122) are illustrated (total study population). Mantel-Haenszel log-rank *P* value, hazard ratio (HR) including 95% CI and χ^2 is given.

Schefold et al. Critical Care 2014, 18:R11

Accelerated versus standard initiation of renal replacement therapy for critically ill patients with acute kidney injury: a systematic review and meta-analysis of RCT studies


Heng-Chih Pan[1,2,3,4†], Ying-Ying Chen[2,5†], I-Jung Tsai[6], Chih-Chung Shiao[7], Tao-Min Huang[8], Chieh-Kai Chan[9], Hung-Wei Liao[10], Tai-Shuan Lai[8], Yvonne Chueh[11], Vin-Cent Wu[8,12*] and Yung-Ming Chen[2,8]

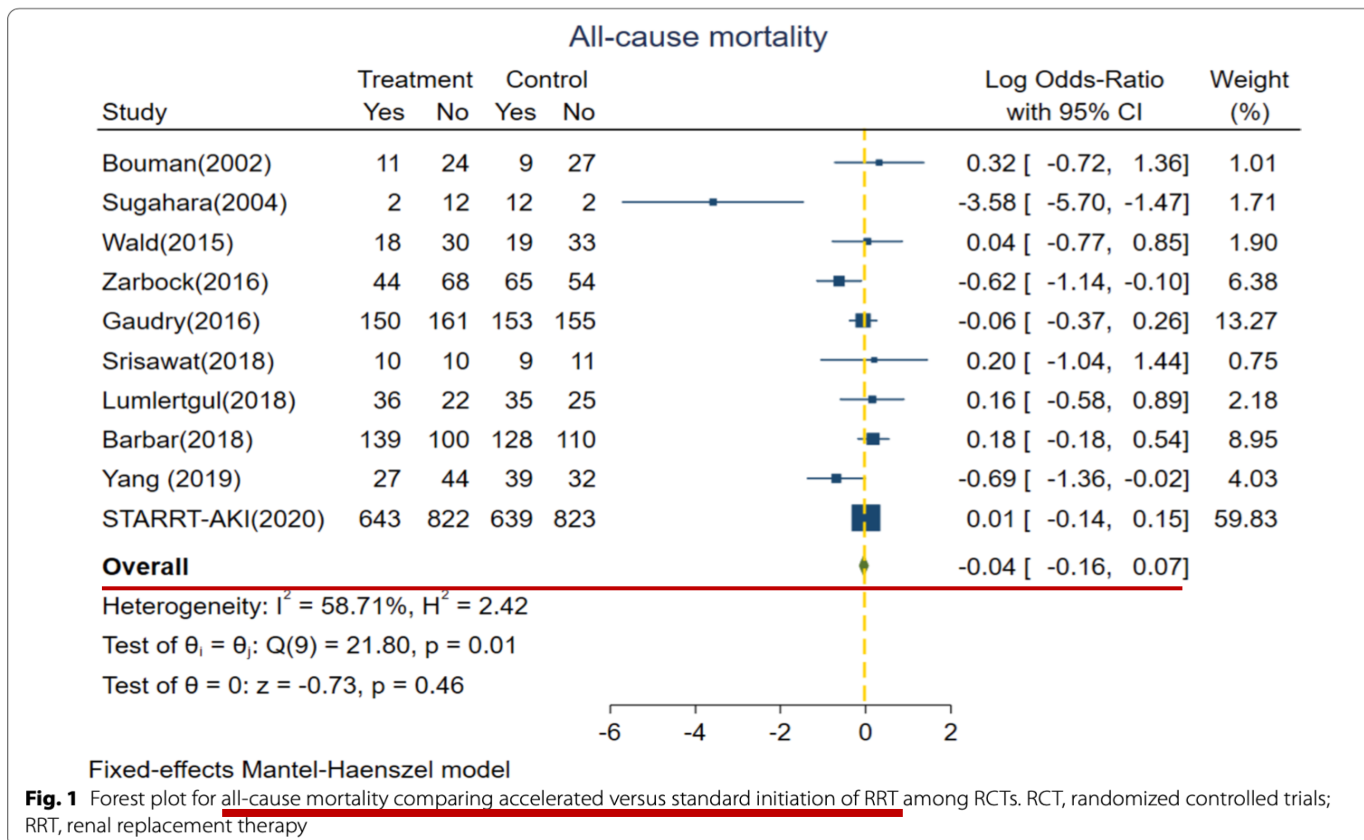


Fig. 1 Forest plot for all-cause mortality comparing accelerated versus standard initiation of RRT among RCTs. RCT, randomized controlled trials; RRT, renal replacement therapy

56 studies
10 RCT
4753 critically ill AKI pts in ICU

Critically ill patients with severe AKI would benefit from accelerated RRT initiation
only if they were surgical ICU patients or
if they underwent CRRT treatment.

Crit Care (2021) 25:5

Extended Daily Dialysis Versus Continuous Renal Replacement Therapy for Acute Kidney Injury: A Meta-analysis

Ling Zhang, MD,[1,2] Jiqiao Yang, MD,[3] Glenn M. Eastwood, MD,[2] Guijun Zhu, MD,[2,4] Aiko Tanaka, MD,[2] and Rinaldo Bellomo, MD, PhD[2]

- primary outcomes were mortality and kidney recovery among patients with AKI
- 7 RCT and 10 observational studies
- from different regions of Asia, North America, Europe, Oceania, and Africa
- The eligible studies were conducted from 2000 to 2014 with a total of **634 patients undergoing EDD** and **574 patients undergoing CRRT**

Am J Kidney Dis. 2015;66(2):322-330

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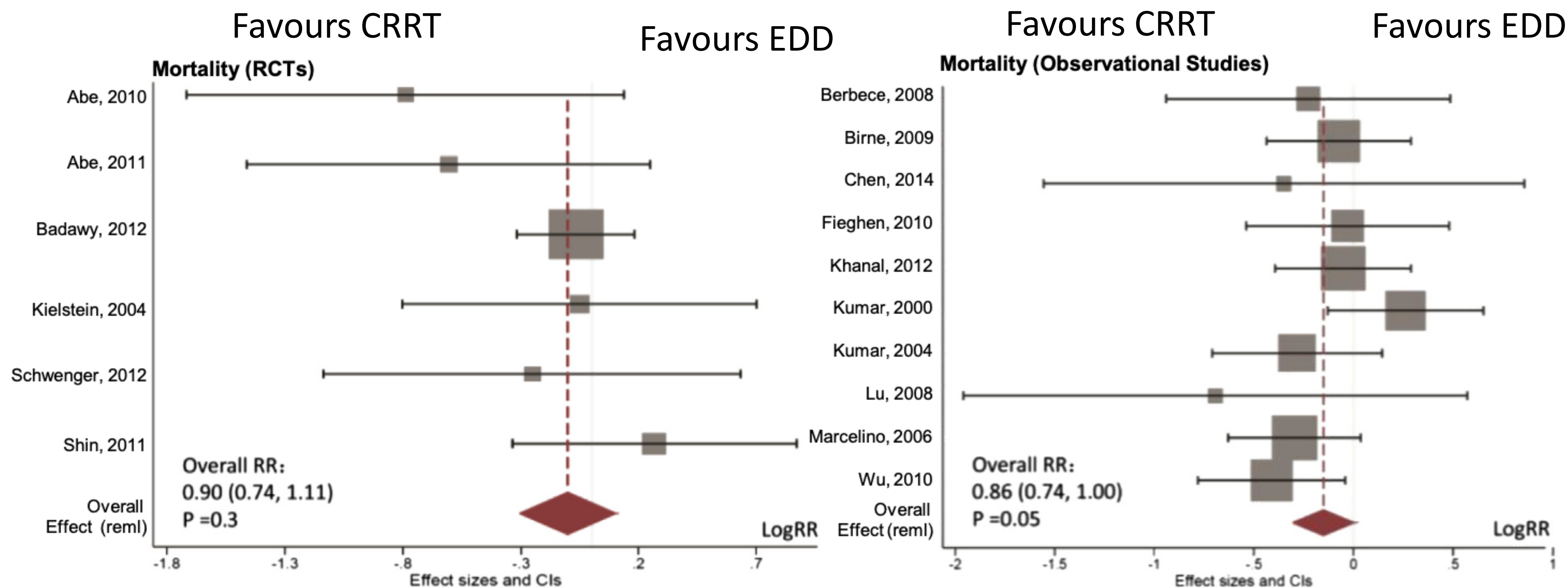

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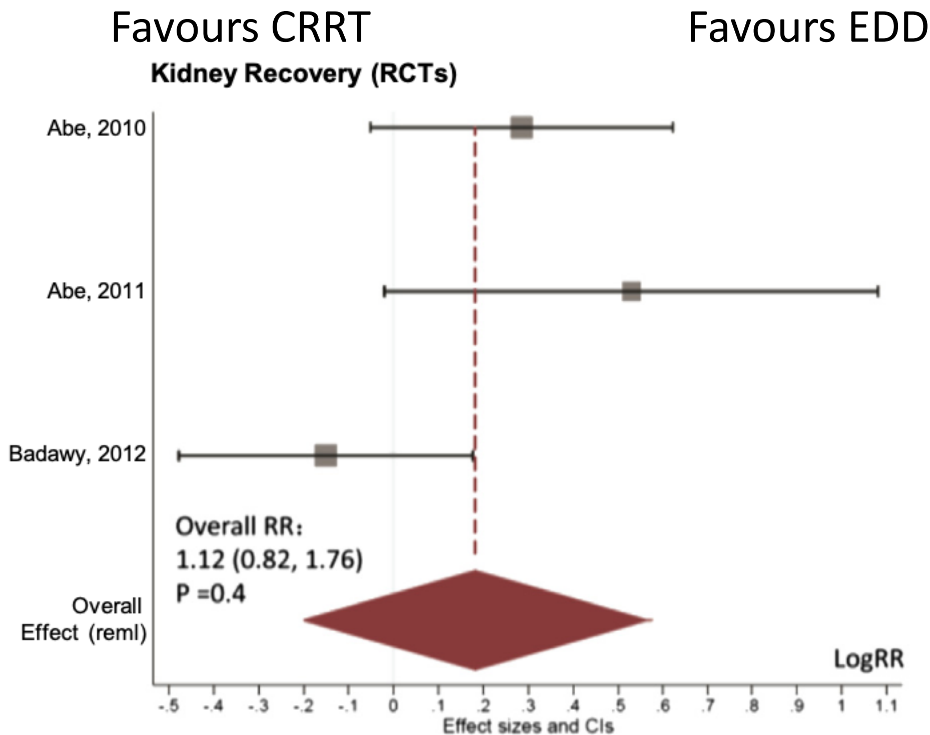

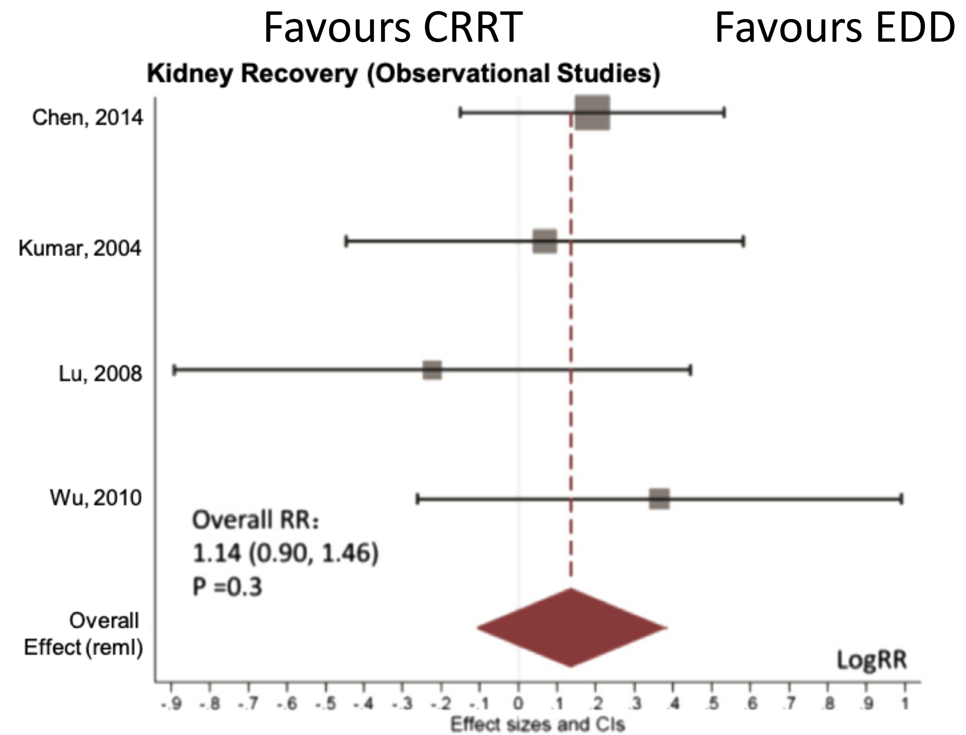

Am J Kidney Dis. 2015;66(2):322-330

CRRT vs. IHD as first RRT modality in severe AKI: AKKI and IDEAL-ICU studies

- AKIKI and IDEAL-ICU trials compared **an early RRT initiation** strategy with a **delayed one**
- **Two multicenter RCT** involving **critically ill** patients with severe AKI
- Patients allocated to the **early strategy** received **RRT less than 12 h** after documentation of severe AKI
- No patient was treated with SLED
- Authors analyzed outcomes according to the first modality used

Gaudry *et al. Critical Care (2022) 26:93*
Gaudry S, et al. N Engl J Med. 2016;375(2):122–33.
Barbar SD, et al. N Engl J Med. 2018;379(15):1431–42.

CRRT vs. IHD as first RRT modality in severe AKI: AKKI and IDEAL-ICU studies

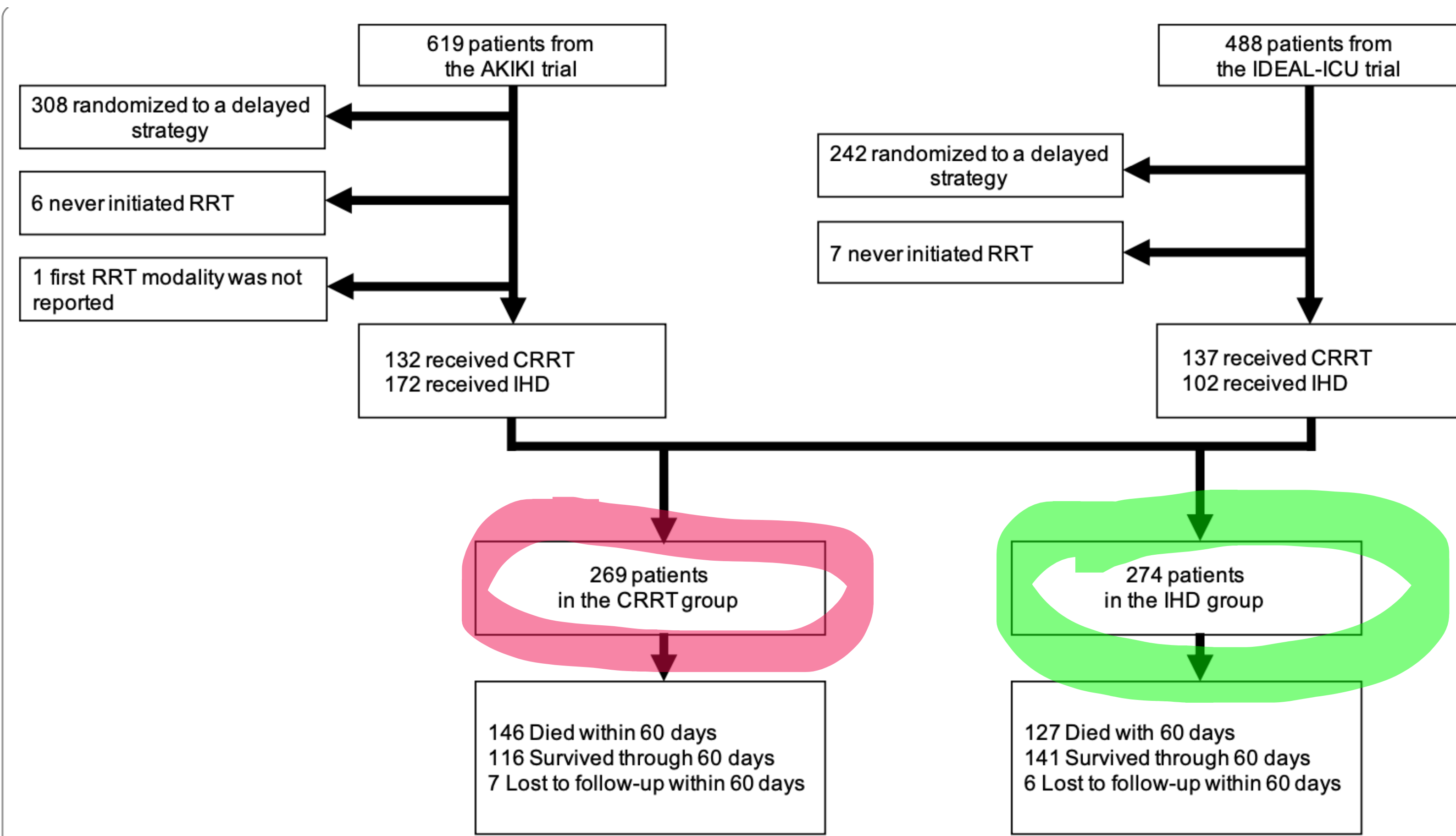

Fig. 1 Study flowchart

Patients have been randomized to receive **either IHD or CRRT within 12 hours** after the documentation of severe AKI.

Gaudry *et al. Critical Care (2022) 26:93*

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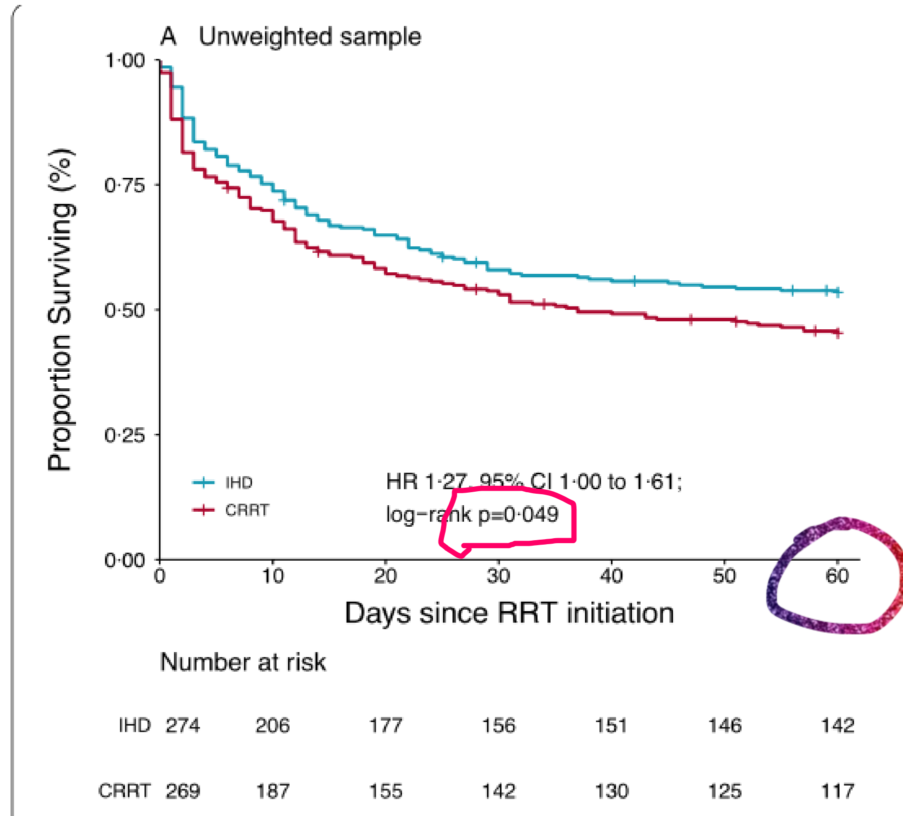

Primary outcome: probability of survival in the unweighted sample

- The Kaplan–Meier death rate at day 60:
- 54.7% in the CRRT group
- 46.5% in the IHD group

Gaudry *et al. Critical Care (2022) 26:93*
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CRRT vs. IHD as first RRT modality in severe AKI: AKKI and IDEAL-ICU studies

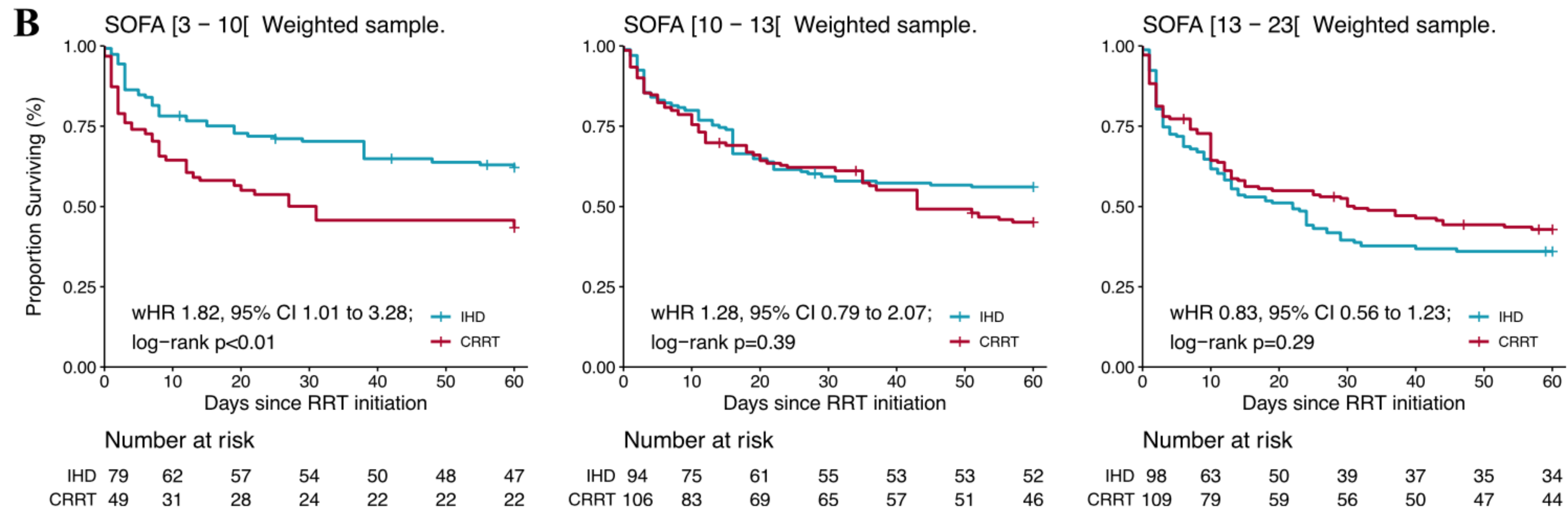


Fig. 3 Treatment effect heterogeneity assessment: Probability of survival in the unweighted samples (**A**) and in the IPTW samples (**B**) stratified by thirds of baseline risk (SOFA score). *HR* hazard ratio, *IHD* intermittent hemodialysis, *CRRT* continuous renal replacement therapy

Probability of survival in the weighted samples

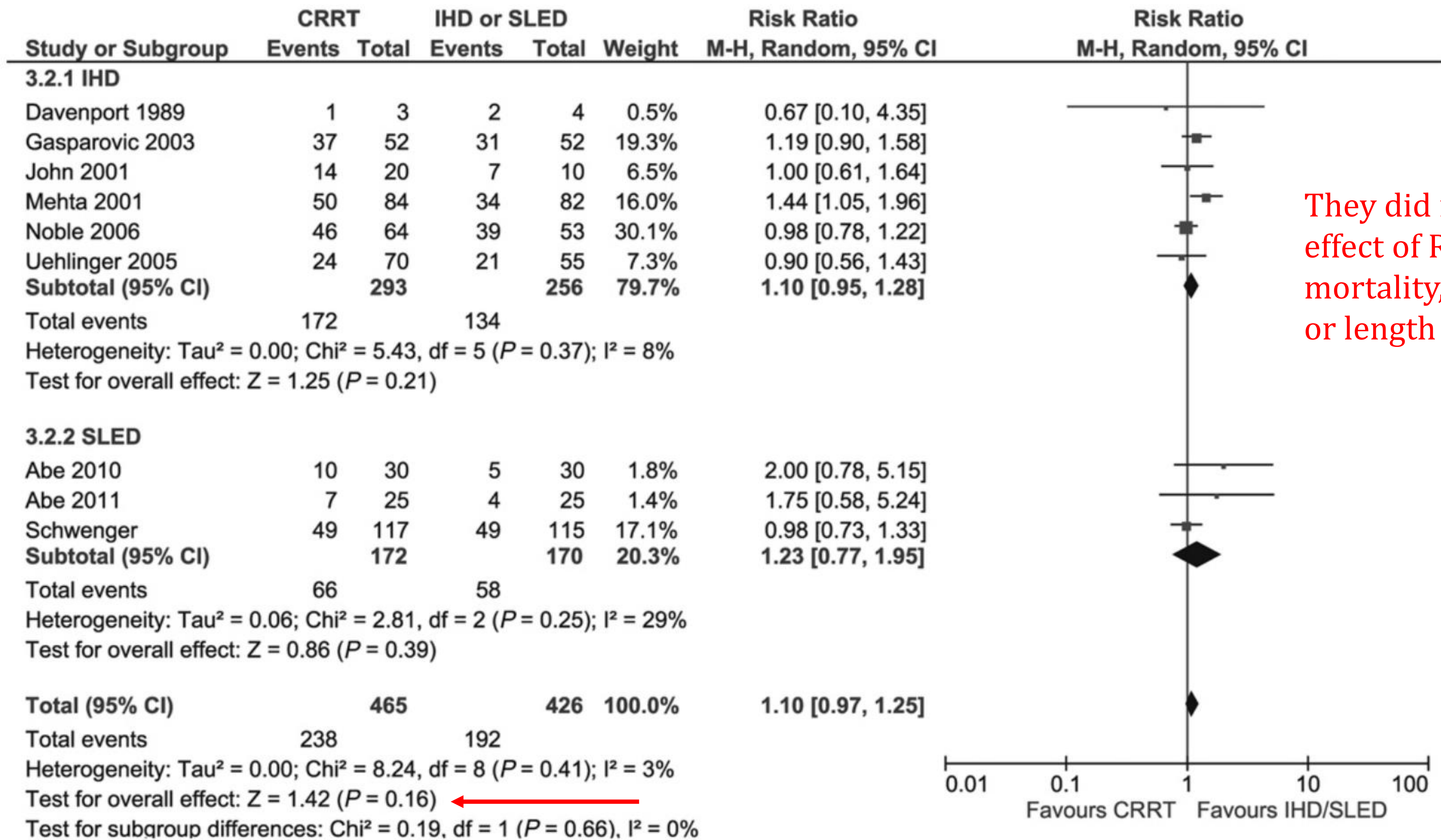
Gaudry *et al. Critical Care (2022) 26:93*
Gaudry S, et al. N Engl J Med. 2016;375(2):122–33.
Barbar SD, et al. N Engl J Med. 2018;379(15):1431–42.

Systematic review and meta-analysis of renal replacement therapy modalities for acute kidney injury in the intensive care unit

Danielle M. Nash, MSc [a,b,*], Sebastian Przech, BSc, MDCM [b,c,d],
Ron Wald, MDCM, MPH, FRCPC [e,f,1], Daria O'Reilly, MSc, PhD [a,g,2]

- 21 eligible studies published from 1989 to 2014 were included
- a total of 5015 participants
- **CRRT *vs* IHD**: 16 studies, 4539 participants
- **CRRT *vs* SLED**: five studies (all RCT), 476 participants
- mean age 31 to 69 years;
- over half the studies had a mean participant age over 60 years;
- females proportion ranging from 24 to 43%;

Journal of Critical Care 41 (2017) 138–44



Study or Subgroup	CRRT Events	CRRT Total	IHD or SLED Events	IHD or SLED Total	Weight	Risk Ratio M-H, Random, 95% CI
3.2.1 IHD						
Davenport 1989	1	3	2	4	0.5%	0.67 [0.10, 4.35]
Gasparovic 2003	37	52	31	52	19.3%	1.19 [0.90, 1.58]
John 2001	14	20	7	10	6.5%	1.00 [0.61, 1.64]
Mehta 2001	50	84	34	82	16.0%	1.44 [1.05, 1.96]
Noble 2006	46	64	39	53	30.1%	0.98 [0.78, 1.22]
Uehlinger 2005	24	70	21	55	7.3%	0.90 [0.56, 1.43]
Subtotal (95% CI)		**293**		**256**	**79.7%**	**1.10 [0.95, 1.28]**
Total events	172		134			
Heterogeneity: Tau² = 0.00; Chi² = 5.43, df = 5 (*P* = 0.37); I² = 8%						
Test for overall effect: Z = 1.25 (*P* = 0.21)						
3.2.2 SLED						
Abe 2010	10	30	5	30	1.8%	2.00 [0.78, 5.15]
Abe 2011	7	25	4	25	1.4%	1.75 [0.58, 5.24]
Schwenger	49	117	49	115	17.1%	0.98 [0.73, 1.33]
Subtotal (95% CI)		**172**		**170**	**20.3%**	**1.23 [0.77, 1.95]**
Total events	66		58			
Heterogeneity: Tau² = 0.06; Chi² = 2.81, df = 2 (*P* = 0.25); I² = 29%						
Test for overall effect: Z = 0.86 (*P* = 0.39)						
Total (95% CI)		**465**		**426**	**100.0%**	**1.10 [0.97, 1.25]**
Total events	238		192			
Heterogeneity: Tau² = 0.00; Chi² = 8.24, df = 8 (*P* = 0.41); I² = 3%						
Test for overall effect: Z = 1.42 (*P* = 0.16)						
Test for subgroup differences: Chi² = 0.19, df = 1 (*P* = 0.66), I² = 0%						

Fig. 3. ICU mortality comparing continuous renal replacement therapy and intermittent hemodialysis/sustained low efficiency dialysis.

They did not identify any clear effect of RRT modality on mortality, dialysis dependence or length of stay.

Nash DM, et al. Journal of Critical Care 41 (2017) 138–44

CHOOSING RRT MODALITY IN ICU- a nephrologist point of view

- Must be patient oriented - patients first!
- Hemodynamic (in)stability, comorbidities?
- Depend of hemodialysis infrastructure
- Depend of dialysis or ICU staff experiences and availability

CONCLUSIONS

- No RRT is ideal for all patients with AKI.
- In the presence of hemodynamic instability in patients with AKI, CRRT is preferable to standard IHD.
- IHD treatment of AKI may delay renal recovery.
- There is lack of solid evidence showing superiority of any mode of RRT in patients with severe AKI in terms of patient survival.

THANK YOU FOR YOUR ATTENTION.