Renal Replacement Therapy Modality in the ICU and Renal Recovery at Hospital Discharge*

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Objectives: Acute kidney injury requiring renal replacement therapy is a major concern in ICUs. Initial renal replacement therapy modality, continuous renal replacement therapy or intermittent hemodialysis, may impact renal recovery. The aim of this study was to assess the influence of initial renal replacement therapy modality on renal recovery at hospital discharge.

Design: Retrospective cohort study of all ICU stays from January 1, 2010, to December 31, 2013, with a "renal replacement therapy for acute kidney injury" code using the French hospital discharge database.

Setting: Two hundred ninety-one ICUs in France.

Patients: A total of 1,031,120 stays: 58,635 with renal replacement therapy for acute kidney injury and 25,750 included in the main analysis.

Interventions: None.

Measurements Main Results: PPatients alive at hospital discharge were grouped according to initial modality (continuous renal replacement therapy or intermittent hemodialysis) and included in the main analysis to identify predictors of renal recovery. Renal recovery was defined as greater than 3 days without renal replacement therapy before hospital discharge. The main analysis was a hierarchical logistic regression analysis including patient demographics, comorbidities, and severity variables, as well as center characteristics. Three sensitivity analyses were performed. Overall mortality was 56.1%, and overall renal recovery was 86.2%. Intermittent hemodialysis was associated with a lower likelihood of recovery at hospital discharge; odds ratio, 0.910 (95% CI, 0.834–0.992) *p* value equals to 0.0327. Results were consistent across all sensitivity analyses with odds/hazards ratios ranging from 0.883 to 0.958.

Conclusions: In this large retrospective study, intermittent hemodialysis as an initial modality was associated with lower renal recovery at hospital discharge among patients with acute kidney injury, although the difference seems somewhat clinically limited. (*Crit Care Med* 2018; 46:e102–e110)

Key Words: acute kidney injury; continuous renal replacement therapy; intermittent hemodialysis; renal recovery; renal replacement therapy modality

Acute kidney injury (AKI) requiring renal replacement therapy (RRT) is a major concern in ICUs. Reported prevalence is approximately 13.5%, with a mortality rate of 50–60% (1, 2), and 15–30% of survivors remain dialysis dependent (2–4). RRT can be administered according to two modalities: continuous RRT (CRRT) or intermittent hemodialysis (IHD). CRRT and IHD have been extensively compared, and neither has proven superiority in terms of mortality (5, 6). However, dialysis dependence after severe AKI is recognized as a major issue as it negatively impacts the quality of life of patients (7), is associated with long-term mortality, and increases costs (8–10). Hemodynamic instability, inflammation, and fluid overload are thought to be involved in dialysis dependence following AKI (11–14). It is accepted that CRRT enhances hemodynamic tolerance and hence facilitates fluid removal and metabolic control (6, 14–16), yet IHD is less expensive, easier to perform, and requires less anticoagulation (17, 18).

Several observational studies have suggested an association between CRRT and improved renal recovery (19–24). Unfortunately, randomized trial data are limited and do not fully confirm these findings (14, 25–30). A meta-analysis did find a benefit of CRRT; however, the effect was largely driven by observational data (31). Most retrospective studies on this topic lack robust adjustment for illness severity, a variable likely to greatly influence the choice of RRT modality. In addition, published randomized trials were not designed with renal recovery as a main outcome. A large trial comparing IHD with CRRT, which would be adequately powered to demonstrate a difference in renal recovery, is highly unlikely in the near future. In the context of these conflicting results, we aimed to assess the influence of initial RRT modality on renal recovery at hospital discharge among critically ill patients with AKI requiring RRT, using a large French nationwide database.

METHODS

Design and Participants

This was a retrospective cohort study using the French hospital discharge database ("programme de médicalisation des supports d'information" [PMSI]). The study population included all patients admitted to an ICU between January 1, 2010, and December 31, 2013, who required RRT for AKI. RRT was identified based on selected Common Classification of Medical Acts (CCMA)–defined procedures. For patients with multiple stays, we considered all stays that met the inclusion criteria. All patients alive at hospital discharge were included in the main analysis. Patients with terminal or stage 5 chronic kidney disease (CKD; creatinine clearance < 15 mL/min), as well as those less than 18 years old and stays with missing data, were excluded.

Database Description

The PMSI is a nationwide database of hospitalizations based on the French diagnosis-related groups. PMSI is described elsewhere as a reliable database for epidemiologic studies (32). This database relies on mandatory data collection and aims to measure the activity of all facilities in France. Each patient is identified with a unique anonymous number. Information provided includes administrative, sociodemographic, medical, and economic data. Each hospital stay is associated with a primary diagnosis linked to the reason of admission and secondary diagnoses, all of which are coded according to *International Classification of Diseases,* 10th Edition. Surgical and supportive care procedures are defined according to the CCMA. According to French law, no patient approval or local ethics committee authorization was required for this study. Approval for the database analysis was obtained from the national data protection commission ("Commission nationale de l'informatique et des libertés"; number 1559750).

Definition of Exposure and Renal Recovery

All stays for which a "RRT procedure for AKI" during the ICU was coded were extracted. Stays were divided into two groups according to the initial RRT modality (IHD or CRRT). RRT technique (diffusive or convective), dialysis dose, or frequency for IHD were not available. In France, Slow Long Extended Daily Dialysis is a marginal practice and is coded as IHD. Follow-up started upon RRT initiation and ended at patient discharge or death. Renal recovery was defined as no RRT for AKI greater than 3 days before hospital discharge. Patients with a RRT procedure code less than or equal to 3 days preceding hospital discharge were considered to have not recovered.

Adjustment Variables

We extracted multiple clinical variables in order to characterize the study population. Primary diagnosis and secondary diagnoses were extracted to assess premorbid conditions (diabetes, arterial hypertension, chronic heart failure, and non end-stage CKD). Stay characteristics (surgical procedure during the stay, time between ICU admission and first RRT session, and hospital length of stay) were also extracted. Critical illness severity was determined according to Simplified Acute Physiology Score (SAPS) II score, presence of sepsis, and need for vasopressors or mechanical ventilation on the first day of RRT. Center characteristics were taken into account: type (public/private), number of beds, annual number of RRT treatments, and available RRT modalities.

For multivariate analyses, variables were chosen according to three steps: their significance in univariate analyses, their clinical relevance, and their coding quality. The following variables were retained in the final model: age, gender, nonterminal CKD, SAPS II, vasopressors, invasive mechanical ventilation, sepsis, center size, annual number of patients treated, and initial RRT modality.

Statistical Analysis

Univariate analyses were performed to identify adjustment variables. The Kolmogorov-Smirnov test was used to assess the distribution normality of continuous variables. Continuous variables were expressed as medians and interquartile ranges. Categorical variables were expressed as proportions. Comparisons of stays were based on chi-square or Fisher exact test for categorical data as appropriate and on Wilcoxon test for continuous data.

The main analysis was a hierarchical logistic regression analysis (PROC GLIMMIX, SAS Institute, Cary, NC) performed to identify predictors of renal recovery. To control for the potential effects of clustering, we also included center as the hierarchical level. Variables with a p value of greater than 0.05 were eliminated. The variable SAPS II was forced into the model.

Three sensitivity analyses were conducted. 1) We generated a propensity score using the initial mode of RRT as the dependent variable and 1:1 ratio matching year by year. All variables found to be significant in the univariate analyses (IHD vs CRRT) were considered as candidates. The following variables were selected in the final propensity score: age, nonterminal CKD, SAPS II, use of vasopressors, invasive mechanical ventilation, sepsis, center size, and timing for RRT initiation. The main analysis was repeated using the propensity score. 2) We restricted the analyses to patients with a single RRT modality during their hospital stay. 3) We assessed the association of initial mode of RRT with renal recovery through the approach described by Fine and Gray (33), which extends the Cox model to competitive risk data. We generated a propensity score, using the same methodology as the first one, within the whole population including patients who died in hospital. Then, we matched patients using this propensity score and ran a competitive risk analysis on the matched population to assess renal recovery with death as a competitive factor.

All statistical analyses were performed using SAS v9.3 (SAS Institute). Statistical significance was accepted when the p value was less than 0.05.

RESULTS

ICU Stay Characteristics

Within the study period, we identified 1,031,120 ICU stays. RRT was provided in 73,144 (7%) of these; 58,635 stays (6%) (57,171 individual patients) met the inclusion criteria (**Fig. 1**). Among the 58,635 included stays, hospital mortality was 56%: 45% in the IHD group versus 61% in the CRRT group ($p < 0.0001$).

Among survivors, 9,699 (38%) received IHD and 16,051 (62%) received CRRT as the initial modality. Patients in the IHD group had a higher prevalence of nonterminal CKD (17.1% vs 12.2%; $p < 0.0001$) and arterial hypertension (38.7% vs 35.8%; $p < 0.0001$). Conversely, those in the CRRT group had a higher frequency of sepsis (40.3% vs 28.0%; $p < 0.0001$) and greater severity indexes: SAPS II score (55.0 vs. 51.0; $p < 0.0001$), vasopressor use (66.4% vs 41.3%; $p < 0.0001$), and need for invasive mechanical ventilation (68.4% vs 46.3%; $p < 0.0001$) (**Table 1**).

Center Characteristics

This study involved 291 centers. Most included stays took place in public centers (91.3%), with greater than or equal to 450 beds (65.3%), greater than or equal to 50 patients receiving RRT for AKI per year (65.3%), and with both modalities at disposal (95.3%) (Table 1).

Renal Recovery

In the IHD group, 8,178 (84.3%) experienced renal recovery versus 14,006 (87.2%) in the CRRT group ($p < 0.0001$). Differences between patients who recovered and those who did not are shown in **Table 2**.

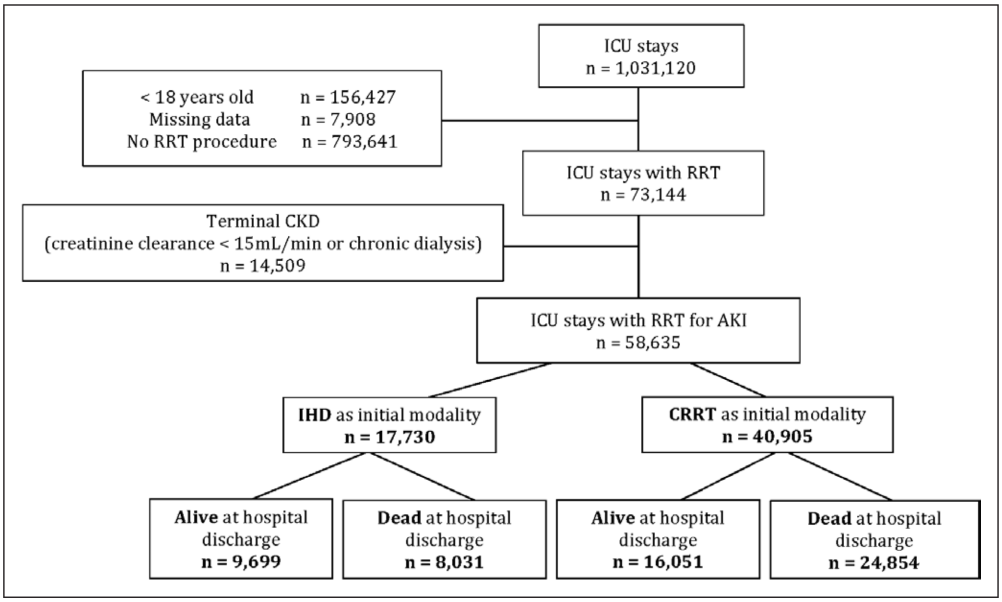

Figure1. Study flow chart. AKI = acute kidney injury, CKD = chronic kidney disease, CRRT = continuous renal replacement therapy, IHD = intermittent hemodialysis, RRT = renal replacement therapy.

After correcting for baseline variables, IHD remained associated with a lower likelihood of renal recovery, odds ratio (OR), 0.910 (95% CI, 0.834–0.992) p value equals to 0.0327 (**Table 3**). Renal recovery was greater among patients who required vasopressors, OR, 1.211 (95% CI, 1.106–1.325) p value of less than 0.0002, or mechanical ventilation, OR, 1.528 (95% CI, 1.392–1.677) p value of less than 0.0001, at the time of RRT initiation, as well as for those with sepsis, OR, 1.471 (95% CI, 1.351–1.601) p value of less than 0.0001. Renal recovery was lower in patients treated in smaller

TABLE 1. Patient Characteristics and Center Description Among 58,635 Stays With Renal Replacement Therapy for Acute Kidney Injury

	All Patients (*n* = 58,635)			Survivors (*n* = 25,750)		
Variables	**Initial IHD (*n* = 17,730)**	**Initial CRRT (*n* = 40,905)**	***p***	**Initial IHD (*n* = 9,699)**	**Initial CRRT (*n* = 16,051)**	***p***
Patients						
Age (yr), median (Q1–Q3)	66.0 (56.0–76.0)	67.0 (57.0–76.0)	0.2478	64.0 (54.0–75.0)	64.0 (54.0–74.0)	0.0026
Men, *n* (%)	11,536 (65.1)	27,049 (66.1)	0.0128	6,145 (63.4)	10,506 (65.5)	< 0.0001
Diabetes, *n* (%)	4,361 (24.6)	9314 (22.8)	< 0.0001	2,599 (26.8)	4,129 (25.7)	0.0577
Arterial hypertension, *n* (%)	6,385 (36.0)	13,565 (33.2)	< 0.0001	3,750 (38.7)	5,746 (35.8)	< 0.0001
Heart failure, *n* (%)	3,721 (21.0)	9209 (22.5)	< 0.0001	1,910 (19.7)	3,323 (20.7)	0.0510
Nonterminal chronic kidney disease, *n* (%)	2,655 (15.0)	4291 (10.5)	< 0.0001	1,663 (17.1)	1,956 (12.2)	< 0.0001
Class 1	63 (0.4)	136 (0.3)		41 (0.4)	63 (0.4)	
Class 2	105 (0.6)	222 (0.5)		70 (0.7)	115 (0.7)	
Class 3	519 (2.9)	900 (2.2)		301 (3.1)	412 (2.6)	
Class 4	441 (2.5)	706 (1.7)		283 (2.9)	329 (2.0)	
Unknown	1,527 (8.6)	2,327 (5.7)		968 (10.0)	1,037 (6.5)	
Stays						
Hospital length of stay (d), median (Q1–Q3)	20.0 (9.0–38.0)	18.0 (6.0–37.0)	< 0.0001	25.0 (13.0–44.0)	32.0 (17.0–54.0)	< 0.0001
Surgical procedure, *n* (%)	6,092 (34.4)	17,251 (42.2)	< 0.0001	3,268 (33.7)	7,284 (45.4)	< 0.0001
Interval between ICU admission and first RRT (d), *n* (%)			< 0.0001			< 0.0001
0	8,301 (46.8)	20,198 (49.4)		4,902 (50.5)	8,174 (50.9)	
1–3	5,612 (31.7)	12,145 (29.7)		3,023 (31.2)	4,694 (29.2)	
4–10	2,264 (12.8)	4,876 (11.9)		1,054 (10.9)	1,748 (10.9)	
> 10	1,553 (8.8)	3,686 (9.0)		720 (7.4)	1,435 (8.9)	
Severity						
Simplified Acute Physiology Score II, median (Q1–Q3)	56.0 (44.0–72.0)	61.0 (47.0–78.0)	< 0.0001	51.0 (40.0–64.0)	55.0 (43.0–68.0)	< 0.0001
Vasopressors, *n* (%)	9,575 (54.0)	30,884 (75.5)	< 0.0001	4,001 (41.3)	10,651 (66.4)	< 0.0001
Mechanical ventilation, *n* (%)	10,421 (58.8)	31,763 (77.7)	< 0.0001	4,495 (46.3)	10,981 (68.4)	< 0.0001
Sepsis, *n* (%)	6,340 (35.8)	18,243 (44.6)	< 0.0001	2,719 (28.0)	6,462 (40.3)	< 0.0001
Center size (no. of beds), *n* (%)			< 0.0001			< 0.0001
< 250	1,609 (9.1)	5,856 (14.3)		752 (7.8)	2141 (13.3)	
250–449	3,483 (19.6)	10,253 (25.1)		1,919 (19.8)	4,125 (25.7)	
≥ 450	12,638 (71.3)	24,796 (60.6)		7,028 (72.5)	9,785 (61.0)	

(*Continued*)

TABLE 1. Patient Characteristics and Center Description Among 58,635 Stays With Renal Replacement Therapy for Acute Kidney Injury

	All Patients ($n = 58,635$)			Survivors ($n = 25,750$)		
Variables	Initial IHD ($n = 17,730$)	Initial CRRT ($n = 40,905$)	p	Initial IHD ($n = 9,699$)	Initial CRRT ($n = 16,051$)	p
Annual no. of RRT, *n* (%)				< 0.0001		<0.0001
< 18	823 (4.6)	2371 (5.8)		377 (3.9)	879 (5.5)	
18–29	1,110 (6.3)	4,761 (11.6)		574 (5.9)	1,838 (11.5)	
30–49	3,393 (19.1)	8,764 (21.4)		1,820 (18.8)	3,452 (21.5)	
≥ 50	12,404 (70.0)	25,009 (61.1)		6,928 (71.4)	9,882 (61.6)	
Available technique, *n* (%)				< 0.0001		< 0.0001
IHD only	706 (4.0)	N/A		294 (3.0)	N/A	
CRRT only	N/A	2,183 (5.3)		N/A	920 (5.7)	
IHD and CRRT	17,024 (96.0)	38,722 (94.7)		9,405 (97.0)	15,131 (94.3)	

CRRT = continuous renal replacement therapy, IHD = intermittent hemodialysis, N/A = not applicable, RRT = renal replacement therapy.

centers (< 250 beds), OR, 0.659 (95% CI, 0.530–0.818) *p* value equals to 0.0008, and for patients with non–end-stage CKD, OR, 0.607 (95% CI, 0.537–0.686) *p* value equals to 0.0008. The final predictive model is presented in **Appendix 1** (Supplemental Digital Content 1, http://links.lww.com/CCM/C961).

Sensitivity Analyses

Propensity Score. A total of 8,408 CRRT patients were matched to 8,408 IHD patients, year by year. After matching, standardized differences were less than 0.2 for all variables used (**Appendix 2**, Supplemental Digital Content 1, http://links.lww.com/CCM/C961); differences between matched and nonmatched patients are shown in **Appendix 3** (Supplemental Digital Content 1, http://links.lww.com/CCM/C961). After inclusion of the propensity score in the statistical model constructed for the main analysis, IHD was associated with a lower renal recovery at hospital discharge, OR, 0.883 (95% CI, 0.798–0.975) *p* value equals to 0.0144, (Table 3).

Patients Treated With One Modality Only. A total of 21,204 patients (82.3%) were treated with only one modality. Differences between patients who switched from one modality to the other and those who did not are shown in **Appendix 4** (Supplemental Digital Content 1, http://links.lww.com/CCM/C961). In this subanalysis, the association between IHD and dialysis dependence was still observed, OR, 0.893 (95% CI, 0.810–0.986) *p* value equals to 0.0244 (Table 3).

Whole Population and Death as a Competitive Risk. A total of 16,413 CRRT patients were matched to 16,413 IHD patients including those who were dead at hospital discharge. After matching, standardized differences were less than 0.2 for all variables used (**Appendix 5**, Supplemental Digital Content 1, http://links.lww.com/CCM/C961). Differences between matched and nonmatched patients are shown in **Appendix 6** (Supplemental Digital Content 1, http://links.lww.com/CCM/C961). In this subanalysis, the association between IHD and dialysis dependence was still observed, hazard ratio (HR), 0.958 (95% CI, 0.919–0.997) *p* value equals to 0.0375 (Table 3). The cumulative prevalence of survival and renal recovery at 90 days was higher for CRRT (**Fig. 2**).

DISCUSSION

In this nationwide cohort study, the largest to date on this topic, IHD as initial RRT modality was associated with a lower rate of renal recovery than CRRT at hospital discharge. However, with OR/HR point estimates ranging from 0.883 to 0.958, in a study performed on a very large adjusted cohort, the clinical effect is probably modest.

CRRT and IHD have been widely compared using mortality as a primary endpoint, and meta-analyses have failed to demonstrate a difference in this regard (5, 6). Randomized controlled trials also failed to show a difference regarding renal recovery, yet they were largely underpowered to detect a difference in renal recovery rates (14, 25–30). Concomitantly, numerous observational studies have reported an association between CRRT and renal recovery (19–24). Bell et al (19) retrospectively compared 2,642 patients between 1995 and 2004 and found that renal recovery rate was significantly higher in the CRRT group: OR, 2.60 (95% CI, 1.5–4.3). The main limit was the lack of adjustment regarding premorbid kidney condition, and the association could have been confounded by a different baseline risk for CKD. Schneider et al (31) performed a meta-analysis including all studies reporting renal recovery data. Pooled data suggested an association between IHD and dialysis dependence, relative risk, 1.73 (95% CI, 1.35–2.20; $I^2 = 44\%$). Wald et al (24), in a matched cohort study of 4,008 critically ill patients, found a significantly higher rate of chronic dialysis in patients who initially received IHD, HR, 0.75 (95% CI, 0.65–0.87; $p < 0.0001$). In this study, premorbid state was well balanced between groups

TABLE 2. **Differences Between Patients Who Recovered Renal Function at Hospital Discharge and Those Who Did Not (Patients Alive at Hospital Discharge)**

Variables	Recovery (*n* = 22,184; 86.2%)	No Recovery (*n* = 3,566; 13.8%)	*p*
Patient characteristics			
Age, mean (SD), (yr)	62.9 (15.0)	60.9 (15.7)	< 0.0001
Men, *n* (%)	14,381 (64.8)	2,270 (63.7)	0.1803
Diabetes, *n* (%)	5,888 (26.5)	840 (23.6)	< 0.0001
Arterial hypertension, *n* (%)	8,299 (37.4)	1,197 (33.6)	< 0.0001
Heart failure, *n* (%)	4,495 (20.3)	738 (20.7)	0.5600
Nonterminal chronic kidney Disease, *n* (%)	2,935 (13.2)	684 (19.2)	< 0.0001
Class 1	91 (0.4)	13 (0.4)	
Class 2	160 (0.7)	25 (0.7)	
Class 3	622 (2.8)	91 (2.6)	
Class 4	477 (2.2)	135 (3.8)	
Unknown	1585 (7.1)	420 (11.8)	
Technique, *n* (%)			< 0.0001
IHD	8,178 (36.9)	1,521 (42.7)	
IHD then CRRT	1,130 (5.1)	191 (5.4)	
IHD only	7,048 (31.8)	1,330 (37.3)	
CRRT	14,006 (63.1)	2,045 (57.3)	
CRRT then IHD	2,816 (12.7)	409 (11.5)	
CRRT only	11,190 (50.4)	1,636 (45.9)	
Severity of illness			
Simplified Acute Physiology Score II, mean (SD)	55.3 (19.2)	53.3 (19.4)	< 0.0001
Vasopressors, *n* (%)	12,986 (58.5)	1,666 (46.7)	< 0.0001
Mechanical ventilation, *n* (%)	13,754 (62.0)	1,722 (48.3)	< 0.0001
Sepsis, *n* (%)	8,261 (37.2)	920 (25.8)	< 0.0001
Centers description (*n* = 291), *n* (%)			
Public	20,218 (91.1)	3,306 (92.7)	0.0015
Center size (no. of beds), *n* (%)			< 0.0001
< 250	2,397 (10.8)	496 (13.9)	
250–449	5,199 (23.4)	845 (23.7)	
≥ 450	14,588 (65.8)	2,225 (62.4)	
Annual no. of renal replacement therapy, *n* (%)			0.0092
< 18	1,054 (4.8)	202 (5.7)	
18–29	2,077 (9.4)	335 (9.4)	
30–49	4,495 (20.3)	777 (21.8)	
≥ 50	14,558 (65.6)	2,252 (63.2)	
Available technique, *n* (%)			0.0023
IHD only	252 (1.1)	42 (1.2)	
CRRT only	756 (3.4)	164 (4.6)	
IHD and CRRT	21,176 (95.5)	3,360 (94.2)	

CRRT = continuous renal replacement therapy, IHD = intermittent hemodialysis.

TABLE 3. Multivariate Analyses of the Influence of Intermittent Hemodialysis Versus Continuous Renal Replacement Therapy on Renal Recovery at Hospital Discharge

Variables	OR (95% CI)	*p*
Main analysis (*n* = 25,750)	0.910 (0.834–0.992)	0.0327
Propensity score (*n* = 16,816)	0.883 (0.798–0.975)	0.0144
Only one modality (*n* = 21,204)	0.893 (0.814–0.986)	0.0244
Variables	**Hazard Ratio (95% CI)**	***p***
Mortality as a competitive risk (*n* = 32,826)	0.958 (0.919–0.997)	0.0375

OR = odds ratio.

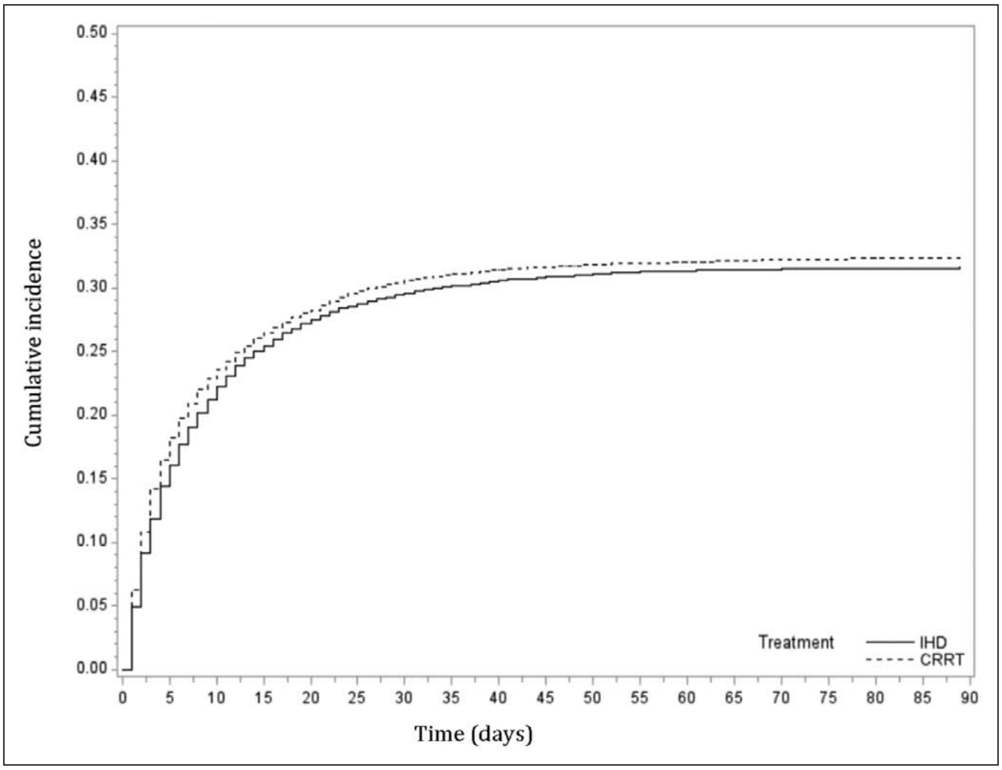

Figure 2. Cumulative incidence of survival and renal recovery at 90 d. CRRT = continuous renal replacement therapy, IHD = intermittent hemodialysis.

although adjustment on severity was limited. Conversely, Liang et al (34) analyzed 638 patients who underwent RRT for AKI. After adjustment, no significant difference was found between CRRT and IHD. However, in this cohort study with a relatively small sample size, patients were allocated to RRT modality mainly according to hemodynamic stability. Unstable patients were more frequent in the CRRT group, and adjustment for severity was questionable. Thus, limiting IHD use in unstable patients could have artificially decreased the effect on renal recovery. Recently, Truche et al (35) retrospectively assessed the impact of RRT modality on mortality and renal recovery in 1,360 patients. Benefit of CRRT was only found in patients with higher weight gain at RRT initiation.

The main analysis herein focused on hospital survivors. However, in a cohort with an overall mortality rate of 56%, it appears difficult to exclude a certain degree of bias as CRRT was applied to more severe patients. To minimize this bias, a sensitivity analysis was performed extending the analysis to the whole population, considering death as a competitive risk factor. In this analysis, the effect was still found. Thus, CRRT patients seem to experience better renal recovery despite higher illness severity. In addition, to correct for factors influencing the propensity of a patient to receive CRRT, the analysis was repeated including a propensity score, which did not alter the main findings. Furthermore, as the initial modality might not correspond to the dominant modality, a sensitivity analysis restricted to patients who received a single RRT modality was performed, and IHD remained associated with a lower renal recovery.

The pathophysiologic hypothesis that IHD can worsen kidney condition in the context of critical illness ensues from several observations. Hemodynamic stability is more difficult to provide with IHD (6, 14, 16). Animal models have also demonstrated loss of renal blood flow autoregulation in AKI, and any further hypotension impacts nephrons cells limiting recovery (36, 37). It is also possible to observe fresh tubular damage on renal biopsies from patients receiving IHD (38). In addition, it is also recognized that CRRT enables better and more progressive fluid removal (6, 22), and fluid overload at initiation of RRT is associated with worse renal recovery (11, 12). Another hypothesis is that higher middle molecular weight molecules clearance might have anti-inflammatory properties and increase recovery (39, 40). However, this must be balanced by the theoretical advantages of IHD: small solute removal in acute life-threatening conditions, restriction of bleeding complications, limitation of expenses, and practicality and flexibility of application.

This study has several limitations. The retrospective design does not allow adjustment for all potential factors implicated in RRT modality choice; only a prospective randomized methodology could have achieved this. Furthermore, several variables are lacking in the database, such as AKI stage, intradialytic variables, membrane used, convective or diffusive technique, dialysis dose reached, and RRT indication. Another point to consider is that data are highly dependent on the accuracy of physician's coding, and it is possible that some variables could have been undercoded. However, French clinicians are required to code procedures daily, and this coding is linked to hospital billing. SAPS II, RRT, vasopressor use, and mechanical ventilation are therefore known to be well coded because they are mandatory to receive full reimbursement. Furthermore, despite the clinical relevance of the 3-day cutoff to define renal recovery, some patients considered as recovered might have been treated with RRT after discharge. However, the reported renal recovery rates are consistent with published medical literature (2–4).

The large number of patients involved represents the strength of this study. To the best of our knowledge, this is the largest study ever conducted on this topic. Collecting data from various centers (public/private, large/small) avoids a potential "center-effect" on renal recovery. In addition, French data are of great interest because the amount of IHD use is greater than in other countries, and French recommendations do not exclude IHD for hemodynamically unstable patients. Furthermore, the adjustment on severity is very robust, as previous studies were lacking a validated severity score and vasopressor or mechanical ventilation use on RRT initiation. Indeed, severity seems to be a key factor influencing the choice of modality. Furthermore, adjustment on preexisting CKD is of great interest as such patients are known to often require RRT for less severe conditions and have lower trend to recover (4). Finally, the main result was explored by three sensitivity analyses, which led to the same finding.

In conclusion, in this large retrospective study, initial treatment with IHD was associated with lower renal recovery than CRRT at hospital discharge. Although the difference is statistically significant, it remains somewhat clinically limited. This finding seems to be consistent with emerging results from other groups around the world and should be a consideration when choosing RRT modality for AKI in the ICU.

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