Outcomes of acute renal failure patients having received renal replacement therapy in the intensive care unit

Helen Hiu-Lam Wu, Kenny King-Chun Chan, Arthur Chun-Wing Lau, Wing-Wa Yan

Abstract

***Objective*: The aim of the present study was to investigate both the outcomes and prognostic factors of ARF patients requiring RRT in our Intensive Care Unit.**

***Design*: It was a retrospective observational study.**

***Setting*: Pamela Youde Nethersole Eastern Hospital, a 20-bed medico-surgical ICU.**

***Patients and participants*: ARF patients who had received RRT from January 2005 to December 2006 were recruited.**

***Interventions*: The primary outcome was hospital mortality. Secondary outcomes were: dialysis dependency at hospital discharge, ICU and hospital length of stay. Relationship between demographics, premorbidities and clinical parameters with primary outcome was studied.**

***Measurements and results*: One hundred and thirty-five patients were included in the final analysis. Hospital mortality rate was 63.7%. The median survival was 24 days (IQR 7 to 746 days). Mechanical ventilation (HR 2.96, 95% CI 2.04 to 3.89) and hepatorenal syndrome (HR 2.29, 95% CI 1.63 to 2.95) were independently associated with hospital mortality. Dialysis dependency rate after hospital discharge as on day 60 was 4.1%.**

***Conclusion*: ARF in ICU was associated with a high mortality rate which was correlated with hepatorenal syndrome and mechanical ventilation. Most of the hospital survivors were free from dialysis.**

Key words: Acute renal failure, renal replacement therapy, intensive care unit, mortality, hepatorenal syndrome, mechanical ventilation

Introduction

Renal replacement therapy (RRT), including haemodialysis (HD), haemofiltration (HF) and haemodiafiltration (HDF), either continuous or intermittent, is a common treatment modality in the intensive care unit (ICU) for acute renal failure (ARF).

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Materials and methods

Study population

This was a retrospective cohort study performed in the Pamela Youde Nethersole Eastern Hospital (PYNEH) ICU, which is a 20-bed combined medical and surgical ICU. All consecutive admissions to our ICU from 1st January, 2005 to 31st December, 2006 were identified. The study was exempted from Institutional Review Board approval because the data was retrospectively collected, information on individual subjects was not disclosed, and patient intervention was not involved.

All patients who were older than 12 year-old and had been treated with intermittent HD, intermittent HDF, continuous HF or continuous HDF for ARF, which were the modes of

RRT available in our unit, were included. Exclusion criteria were: patients who had received RRT for indications other than ARF for the prevention of contrast nephropathy and drug poisoning; known end-stage renal failure (ESRF) patients who had or had not been receiving chronic renal dialysis before ICU admission; patients having been started on RRT for ARF in other units before ICU admission; patients who had stayed in the ICU for less than 24 hours. End stage renal failure was defined as GFR <15 ml/min/1.73 m2 body surface area estimated by the Cockcroft-Gault equation (1) ie KDOQI stage 5 or dialysis dependency. For patients who had ICU readmission within the study period, only the first admission was included. No additional intervention apart from that performed as usual patient care for this kind of patients was involved for this retrospective study.

Data collection

Retrospective data collection was conducted by case notes review, with supplementary information from the hospital's electronic databases (Clinical Management System [CMS], Clinical Data Analysis and Reporting System [CDARS] and the electronic Patient Record [ePR]). Data collected included demographics data; ICU/hospital admission/discharge dates; comorbidities (cardiac disease, peripheral vascular disease, cerebrovascular accident, dementia, chronic pulmonary disease, connective tissue disease, liver disease, diabetes and chronic renal failure); causes of ARF (sepsis, major surgery, cardiogenic shock, hypovolaemia, hepatorenal syndrome, obstructive uropathy, metabolic cause, rhabdomyolysis and other causes); APACHE II score (2) in the first 24 hour ICU stay; initial mode and duration of RRT and RIFLE classification at start of RRT; other treatment (use of vasopressors, mechanical ventilation); dialysis dependency at ICU/hospital discharge; and long term survival.

Premorbid renal function was recorded and glomerular filtration rate (GFR) was estimated by the Cockcroft-Gault equation. (1) Body weight would be checked for every patient where possible, but where body weight measurement was not feasible in some of the critically ill patients, males were assumed to weigh 70 kg and female 50 kg, except in patients with obviously extreme body sizes. Chronic renal failure was defined as GFR between 15 to 60 ml/min/1.73 m2 body surface area, ie Kidney Disease Outcomes Quality Initiative (KDOQI) classification (3) stages 3 to 4. Patients were assumed to have normal baseline renal function if old blood results were not available and medical history was not suggestive of having chronic renal diseases and there was no radiological or pathological evidence of chronic renal diseases in the admission.

ARF severity was classified using the RIFLE (Risk, Injury, Failure, Loss, and End stage kidney disease) classification (urine output criteria). (4) It was adopted to classify early and late RRT initiation to find out any correlation between timing of RRT initiation and patients' outcomes.

Continuous HF, continuous HDF, intermittent HDF and intermittent HD were the RRT modes available in our unit and they were classified as the continuous and intermittent RRT mode at initiation of dialysis. Initial RRT mode was chosen at the discretion of the attending physician based on clinical judgment. Technical setup for continuous HF, continuous HDF, intermittent HDF and intermittent HD is summarized in **Table 1**.

The primary outcome was hospital mortality. Secondary outcomes were: dialysis dependency at hospital discharge, ICU and hospital length of stay. Relationship between demographics, premorbidities and clinical parameters with above outcome measures were studied.

Data were expressed as number of patients (%) for categorical data or mean±standard deviation (SD) for numerical data unless specified. Fisher's exact test was used for categorical data and Mann-Whitney U test for continuous data in univariate analysis. Cox regression analysis with forward stepwise entry of parameters with p-values ≤ 0.2 in the univariate analysis was performed to look for independent predictors of hospital mortality, and an adjusted hazards ratio with p-value of ≤ 0.05 was considered significant. Absence of death at the time of data collection was taken as censored status. Data analysis was performed by SPSS version 12 (SPSS Inc., Chicago, Ill).

Results

There were 264 patients receiving RRT from 1st January, 2005 to 31st December, 2006. Among these, 111 patients were excluded. Reasons for exclusion were (not mutually exclusive): 3 received RRT for indications other than ARF (eg drug poisoning); 74 had underlying ESRF; 16 patients were started RRT for ARF from other units before ICU

admission; 40 patients stayed in ICU less than 24 hours. Eighteen patients had missing medical records, dialysis record sheet and/or observation charts. Finally, the data of 135 patients were analyzed. **Table 2** shows the demographic variables of our study population.

Outcomes

Seventy-three out of 135 subjects died in ICU (ICU mortality rate 54.1%). Among the 62 ICU survivors, 13 died in hospital after ICU discharge (hospital mortality rate 63.7%). The median survival was 24 days (IQR 7 to 746 days). The following factors were associated with hospital mortality by univariate analysis: history of cerebrovascular accident, diabetes mellitus, chronic renal failure, hepatorenal syndrome, obstructive uropathy, metabolic causes of ARF, RIFLE classification at initiation of RRT, use of vasopressors and mechanical ventilation. Cox regression analysis showed that hepatorenal syndrome and mechanical ventilation were independent factors associated with hospital mortality after adjustment for covariates. The results are summarized in **Table 3** and **Figure 1**.

Among the 62 ICU survivors, 6 patients were dialysis dependent as assessed at ICU discharge. Therefore, ICU discharge dialysis dependency rate was 9.7%. Three of them died in hospital after ICU discharge, 2 remained dialysis dependent and 1 became dialysis-free when they were discharged from hospital. Therefore, the hospital discharge dialysis dependency rate was 4.1%.

Discussion

In summary, hospital mortality for ARF patients receiving RRT was 63.7%. Mortality was associated with hepatorenal syndrome and mechanical ventilation. 4.1% survivors required chronic RRT at hospital discharge. The mean ICU and hospital length of stay were 12.4±13.7 days and 29.7±33.9 days respectively.

Mortality

Despite advances in the management of acute renal failure, critically ill patients with ARF continue to demonstrate high mortality rate as corroborated by our findings. The high ICU and hospital mortality rates in the present study were in accordance with the BEST study. (5) Ympa et al (6) also performed a systemic review for mortality of ARF, summarizing eighty articles with a total 15897 patients. Mortality rates remained high at around 50%, more or less unchanged despite progress in the management of acute renal failure and ICU care.

Two independent factors were found in our study to be associated with hospital mortality, namely, need for mechanical ventilation and hepatorenal syndrome as cause of ARF.

Mechanical ventilation

Both the BEST study (5) and our study demonstrated that the need for mechanical ventilation was one of the independent risk factors for hospital mortality. There are other studies showing similar findings. Hoste et al (7) performed a retrospective cohort study among 185 septic patients with ARF, among which 30% required RRT, in a surgical ICU in a university hospital in Belgium. 77% and 98% of the survivors and non-survivors received mechanical ventilation respectively ($p<0.001$). Lavilla (8) conducted a prospective cohort study which included cancer patients with ARF among which 19% required RRT. Mechanical ventilation was found to be associated with mortality (OR 19.32, 95% CI 10.07-37.08, $p<0.001$).

Several mechanisms were hypothesized to explain this finding. (9) First, mechanical ventilation might affect systemic haemodynamics through its effect on cardiac output. Second, mechanical ventilation could cause baro- and volu-trauma, and generated release of systemic inflammatory mediators which in turn lead to renal impairment. Third, the need for mechanical ventilation was associated with conditions of greater severity, eg respiratory failure due to acute pulmonary edema or pneumonia.

Hepatorenal syndrome

The BEST study (5) also demonstrated that hepatorenal syndrome was independent risk factors for hospital mortality. The pathology involved in the development of hepatorenal syndrome is thought to be an alteration in blood flow and vascular tone that supplies the splanchnic circulation and

the kidneys. (10) The structure of the kidneys are basically normal, and the kidneys often function instantly well if the liver disease is corrected eg by liver transplantation. Hepatorenal syndrome carries a poor prognosis and is usually fatal. (11)

Prognostic scoring system

This study demonstrated that APACHE II score did not correlate with hospital mortality. As the causes of ARF are numerous, APACHE II may not be sufficient to quantify the prognosis of ARF patients. Ahlstrom et al (12) performed a prospective cohort study which included 694 treatment episodes in two ICUs in a university hospital in Finland. ARF was classified using 2 ARF specific scoring systems - the RIFLE and Bellomo scores, (13) and 2 general ICU scoring systems - the admission APACHE II and SOFA scores. (14) They showed that maximum RIFLE score for the first three days in ICU and admission SOFA score were independent predictors of hospital mortality, but not the APACHE II. On the other hand, there were also studies proving the usefulness of APACHE II in this area. Maher et al (15) conducted a retrospective observational study which demonstrated that APACHE II score on admission predicted likelihood of survival of ARF patients well.

Initial mode of RRT

Initial RRT mode was found not to be associated with hospital mortality in our study. The result was similar to many other large trials. (16-20) Uchino et al (16) used the database of the BEST study (5) to enroll 1218 patients treated with CRRT or IRRT for ARF in 54 ICUs in 23 countries. It showed that initial CRRT mode was not a significant predictor of hospital survival. Vinsonneau et al (17) conducted a prospective, randomized, multicentre study and recruited 360 patients from 21 ICUs in France. They were randomized to either the IRRT or CRRT groups. Guidelines were provided to achieve optimum haemodynamic stability and effectiveness of solute removal in both groups. This study showed that the survival rate did not differ between the two groups (32% in IRRT vs 33% in the CRRT group). Guerin's prospective multicentre observational study involved 28 multidisciplinary ICUs in France. (18) There was no statistically significant difference in hospital mortality between the IRRT group and the CRRT group using multivariate logistic regression analysis. The choice between CRRT and IRRT, similar to our study, was based on standard clinical criteria, including haemodynamic instability. But its multicentre involvement could well balance off selection bias due to different practice in individual centre. A multicentre, randomized, controlled trial conducted by Mehta et al (19) comparing intermittent HD vs continuous haemodiafiltration for the treatment of 166 ARF patients in ICUs of four academic medical centers in Southern California who were randomized to either intermittent HD or continuous HDF, also could not prove any survival benefit of continuous HDF compared with intermittent HD. Marcello (20) performed a systemic review and meta-analysis in which six randomized controlled trials were identified. It also showed no difference in mortality with the use of different RRT modality.

Timing of RRT initiation

There are debates concerning the optimal timing for initiation of RRT for ARF. Theoretic advantages of early initiation include correction of fluid status, acid-base and electrolytes disturbance. However, this has to be balanced against the risk of hypotension, dialyzer bio-incompatibility, risks associated with anticoagulation, infection and mechanical complications during creation of vascular access.

No correlation between time of RRT initiation and hospital mortality was found in this study. In fact, there are controversies in this area with some published literatures demonstrated improved patient's outcomes after early RRT initiation (21,22) while others did not. (23) The Program to Improve Care in Acute Renal Disease (PICARD) study, (24) which was an observational study from five American academic medical centers, found that initiation of dialysis at higher BUN concentration was associated with increased 60 days mortality (relative risk of death 1.85; 95% CI 1.21 to 3.20). The PICARD study differed from ours in several aspects: early and late RRT initiation was defined by blood BUN concentration at the start of dialysis, patients who were admitted with GFR <30 ml/min/1.73 m2 and those with chronic renal failure were eliminated. It was hypothesized that exclusion of this very ill group, which may not benefit much from early RRT initiation or other invasive treatment, was responsible for the result.

Seabra et al (22) conducted a meta-analysis with the primary analysis including 4 RCTs and 1 quasi-RCT with a total of 270 patients. Early RRT was associated with a 36% mortality risk reduction (RR 0.64, 95% CI 0.40 to 1.05, p=0.08). The secondary analysis included 18 comparative cohort studies with a total of 2108 patients. Early RRT was associated with a 28% mortality risk reduction (RR 0.72, 95% CI 0.64-0.82, p<0.001). However, the studies differed considerably in patient selection, baseline disease severity, definitions for early RRT, modality used and duration of follow up in this meta-analysis.

On the other hand, Bouman et al (23) found that 28-day survival did not improve with early initiation of haemofiltration. It was a randomized controlled trial involving 2 ICUs in the Netherlands. In this study, early dialysis was started after 6 hours of urine output less than 30 ml/h. It was found that survival at 28 days did not improve with early initiation of haemofiltration.

In conclusion, whether early RRT initiation is associated with improved outcomes in ARF patients is still controversial. Adequately powered randomized controlled trial is needed to address this question in the future. In real life, the timing of RRT initiation often cannot be controlled solely by intensivists. It is also affected by the time the patient presented themselves to the hospital and the stage of illness at which ICU was consulted by the general ward.

Dialysis dependency

Our ICU and hospital discharge dialysis dependency rate were 9.7% and 4.1% respectively. This result was better than other studies which quoted rates ranging from 10% to 35%, (5,19-21,25,26) despite the fact that we had an older study population and a higher proportion of chronic renal failure patients. Possible reasons for the difference included variability in baseline patient characteristics and indications to adopt long-term dialysis. In our unit, for patients with multiple comorbidities and poor ability for activities of daily living, we would discuss with patients or their relatives to choose not to adopt such long-term therapy, and such option was regarded a better option for these patients with poor prognosis to reduce suffering.

These are the results of some published literature concerning renal recovery after ARF. In the BEST study, (5) the dialysis dependency at hospital discharge was 13.8% (95% CI 11.2%-16.3%). The study conducted by Uchino et al (16) had hospital discharge dialysis dependency rates of 14.5% and 33.8% among the CRRT and IRRT groups respectively. Metha (19) found that 7% IRRT and 14% CRRT patients depended on dialysis at hospital discharge. Morgera et al (27) conducted a single-centre prospective cohort study which included 979 ARF patients treated with CRRT. It was found that 10% survivors required chronic dialysis 5 years after hospital discharge. The review performed by Bagshaw et al (28,29) showed that recovery to independence from RRT was expected in 60-70% survivors by 90 days.

In summary, our hospital mortality for ARF patients requiring RRT was similar to the published literature. Hepatorenal syndrome and mechanical ventilation were independent risk factors associated with hospital mortality. No correlation was found between hospital mortality and initial RRT mode, timing of RRT initiation and APACHE II score during the first 24 hours ICU admission, with which the published literature result were controversial. Most survivors were dialysis independent.

Limitation

As this was an observational study, drawing cause-and-effect conclusion between various factors and the outcomes was difficult. Also, it was only a single-centre study, the result may not be generalizable as different centers could have different approaches in the management of ARF. RRT dosage was not available due to the retrospective nature of the study, as detailed recording of RRT duration, dialysate/blood flow in the medical records could not be obtained. Also, patient could also be switched to other mode of RRT in the course without a pre-specified protocol, which further complicated the process of dosage estimation. Although 71.3% of our study population received only one mode of RRT in ICU, this could have affected the correlation between initial mode of dialysis and ARF outcomes where only initial mode was adopted in the analysis. Some clinical events like transient hypotension during RRT had not been accurately recorded. Use of diuretics in either ICU or general ward was not recorded, which could affect the RIFLE classification before RRT initiation.

Conclusion

Our study showed that ARF patients requiring RRT in ICU was associated with high hospital mortality, which was independently associated with hepatorenal syndrome and mechanical ventilation. We should therefore think carefully before starting RRT for patients with decompensated liver function resulting in renal and respiratory failure in the future, unless definitive treatment for the liver disease is available. Most survivors were free from dialysis at hospital discharge.

Table 1. Technical setup of continuous HF, continuous and intermittent HDF and intermittent HD in our ICU

	CVVH	CVVHDF	iHDF	iHD		
Dialyzer	APS 650	M100	APS 650	Terumo E12	EE 12	AM-BO-WET 650
Hollow fibre membrane	Asahi polysulfone	Acrylonitrile (AN69)	Asahi polysulfone	Excebrane (modified regenerated cellulose+Vit E)	Excebrane	Cuprammonium rayon (modified regenerated cellulose)
Effective surface area (m2)	1.3	0.9	1.3	1.2	1.2	1.3
In vitro ultrafiltration rate (ml/mmHg/hr)	63.1	27.7	63.1	9.9	16.6	7.8
Blood flow rate (ml/min)	120-150	120-150	150-200	150-200		
Dialysate flow rate (ml/min)	Not applicable	25	300-400	300-400		
Duration/session (hr)	Not applicable	Not applicable	7	4		
Replacement fluid flow rate (L/hr)	Post-dilution (1.8)	Post-dilution (1.0)	Pre-dilution (3.0)	Not applicable		
Anticoagulation	Regional citrate	Regional citrate	Systemic heparin	Systemic heparin or regional citrate		

Table 2. Demographics of study population

	All patients (n=135)	Survivors (n=49)	Non-survivors (n=86)
Age (years)	69.9±13.7	69.4±14.3	70.2±13.5
APACHE II	31.7±8.9	31.1±7.7	32.1±9.6
APACHE II predicted risk of death	0.6±0.2	0.7±0.3	0.7±0.3
Male [n (%)]	88 (65.2)	29 (59.2)	59 (68.6)
Comorbidities [n (%)]			
Cardiac disease	26 (19.3)	8 (16.3)	18 (20.9)
Cerebrovascular event	10 (7.4)	1 (2.0)	9 (10.5)
Dementia	1 (0.7)	1 (2.0)	0 (0)
Chronic pulmonary disease	7 (5.2)	1 (2.0)	6 (7.0)
Liver disease	12 (8.9)	3 (6.1)	9 (10.5)
Diabetes	49 (36.3)	24 (49.0)	25 (29.1)
Chronic renal failure	99 (73.3)	41 (83.7)	58 (67.4)
- KDOQI stage 3	63 (46.7)	24 (49.0)	39 (45.3)
- KDOQI stage 4	36 (26.7)	17 (34.7)	19 (22.1)
Subspecialties [n (%)]			
Medical	71 (52.6)	27 (55.1)	44 (51.2)
Surgical	49 (36.3)	17 (34.7)	32 (37.2)
Neurosurgical	2 (1.5)	0 (0.0)	2 (2.3)
Orthopaedics	7 (5.2)	3 (6.1)	4 (4.7)
Oncology	2 (1.5)	0 (0.0)	2 (2.3)
Obstetrics & gynaecology	3 (2.2)	1 (2.0)	2 (2.3)
Psychology	1 (0.7)	1 (2.0)	0 (0)
Reasons to start RRT* [n (%)]			
Sepsis	97 (71.9)	32 (65.3)	65 (75.6)
- Pneumonia	51 (37.8)	15 (30.6)	36 (41.9)
- GI	20 (14.8)	7 (14.3)	13 (15.1)
- Hepatobiliary	11 (8.1)	3 (6.1)	8 (9.3)
- UTI	12 (8.9)	7 (14.3)	5 (5.8)
- Others**	21 (15.6)	9 (18.4)	12 (14.0)
Major surgery	39 (28.9)	11 (22.4)	28 (32.6)
Cardiogenic shock	15 (11.1)	6 (12.2)	9 (10.5)
Hypovolaemic shock	13 (9.6)	6 (12.2)	7 (8.1)
Hepatorenal syndrome	5 (3.7)	0 (0)	5 (5.8)
Obstructive uropathy	6 (4.4)	4 (8.2)	2 (2.3)
Metabolic	45 (33.3)	22 (44.9)	21 (24.4)
Rhabdomyolysis	9 (6.7)	2 (4.1)	7 (8.1)
Other causes***	6 (4.4)	2 (4.1)	4 (4.7)
Vasopressors [n (%)]			
- Yes	110 (81.5)	36 (73.5)	74 (86.0)
- No	25 (18.5)	13 (26.5)	12 (14.0)
Mechanical ventilation [n (%)]			
- Yes	109 (80.7)	33 (67.3)	76 (88.4)
- No	26 (19.3)	16 (32.7)	10 (11.6)
Time of RRT initiation [n (%)]			
- Risk	29 (21.5)	13 (26.5)	16 (18.6)
- Injury	15 (11.1)	8 (16.3)	7 (8.1)
- Failure	91 (67.4)	28 (57.1)	63 (73.3)
ICU LOS (days)	8.0 (4.0-15.0)	8.0 (4.0-15.0)	8.5 (3.8-17.3)
Hospital LOS (days)	20.0 (9.0-37.0)	33.0 (19.0-70.0)	13.0 (6.8-26.0)
Duration of RRT (days)	4.0 (1.0-8.0)	4.0 (1.0-8.5)	4.0 (2.0-8.0)

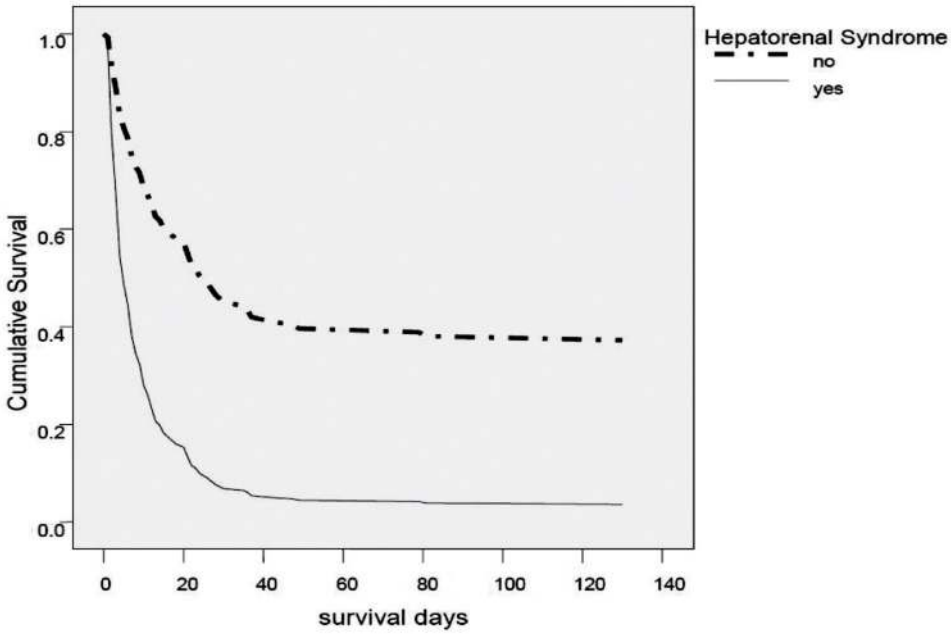
Legend: * Reasons not mutually exclusive; ** 1 leptospirosis, 3 necrotizing fasciitis, 1 septic arthritis, 1 spontaneous bacterial peritonitis, 1 line sepsis, 1 infective endocarditis, 1 Klebsiella and 1 E. coli septicaemia with foci of infection unknown, 1 cellulitis, 1 perineal abscess, 9 septic shock of unknown cause; *** 1 malignant hypertension, 5 causes of ARF unknown

Table 3. Univariate and multivariate survival analysis of factors associated with hospital survival

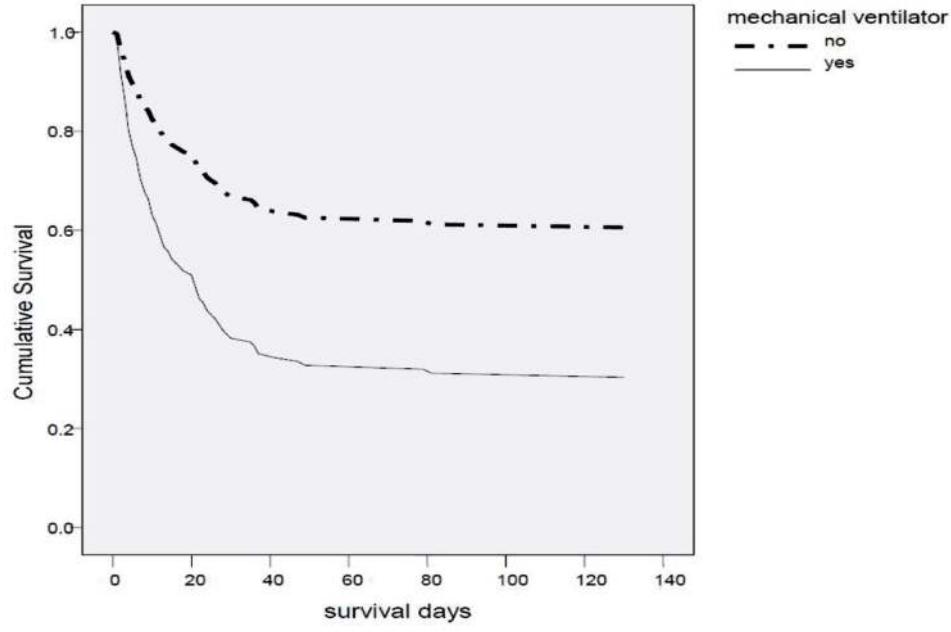
	Subgroup	Hospital survival rate (%)	P value	Hazards ratio (95% CI) Multivariate survival analysis	P value
Gender	Male Female	29/88 (33.0%) 20/47 (42.6%)	0.348		
Age (mean±SD)	Survived Died	69.4±14.3 70.2±13.5	0.559		
APACHE II (mean±SD)	Survived Died	31.1±7.7 32.1±9.6	0.266		
Past medical history					
Cardiac disease	Yes No	8/26 (30.8%) 41/109 (37.6%)	0.651		
Cerebrovascular accident	Yes No	1/10 (10.0%) 48/125 (38.4%)	0.093		
Chronic pulmonary disease	Yes No	1/7 (14.3%) 48/128 (37.5%)	0.422		
Liver disease	Yes No	3/12 (25.0%) 46/123 (37.4%)	0.535		
Diabetes	Yes No	24/49 (49.0%) 25/86 (29.1%)	0.026		
Chronic renal failure	Yes No	40/99 (40.4%) 9/36 (25.0%)	0.110		
Causes of ARF					
Sepsis	Yes No	32/97 (33.0%) 17/38 (44.7%)	0.235		
Major surgery	Yes No	11/39 (28.2%) 38/96 (39.6%)	0.241		
Cardiogenic shock	Yes No	6/15 (40.0%) 43/120 (35.9%)	0.780		
Hypovolaemic shock	Yes No	6/13 (46.2%) 43/122 (35.3%)	0.546		
Hepatorenal syndrome	Yes No	0/5 (0.0%) 49/130 (37.7%)	0.159	2.96 (2.04 to 3.89)	0.022
Obstructive uropathy	Yes No	4/6 (66.7%) 45/129 (34.9%)	0.189		
Metabolic	Yes No	22/43 (51.2%) 27/126 (29.4%)	0.021		
Rhabdomyolysis	Yes No	2/9 (22.2%) 47/126 (37.3%)	0.487		
Initial mode of RRT	Intermittent Continuous	22/77 (28.6%) 27/58 (46.6%)	0.857		
RIFLE at RRT initiation	Risk+injury Failure	21/49 (42.9%) 28/49 (57.1%)	0.060		
Mechanical ventilation	Yes No	33/109 (30.3%) 16/26 (61.5%)	0.006	2.29 (1.63 to 2.95)	0.014
Vasopressors	Yes No	36/110 (32.7%) 13/25 (52.0%)	0.105		
Mean±SD					
Urea (mmol/L) at ICU discharge	Survived Died	15.1±8.3 16.6±12.9	0.602		
Creatinine (μmol/L) at ICU discharge	Survived Died	230.0±145.1 240.3±182.1	0.813		

Figure 1. Kaplan-Meier curves of independent factors associated with hospital mortality (n=135)

1a. According to hepatorenal syndrome



1b. According to use of mechanical ventilation



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