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Original Article

Application of continuous renal replacement therapy for acute kidney injury in elderly patients

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Abstract: This study aims to analyze the factors that affect the prognosis of continuous renal replacement therapy (CRRT) in elderly patients with acute kidney injury (AKI). Data obtained from 41 elderly patients with AKI who underwent CRRT in our department between January 2001 and December 2010 was retrospectively evaluated in this study. The enrolled patients were 80 to 100 years old, with a mortality of 60.98%. The mean Acute Physiology and Chronic Health Evaluation II (APACHE II) score was 27.8±5.6 points, and the mean risk coefficient was 0.80±0.10. The APACHE II score of the survival group was significantly higher than that of the death group. The comparisons of therapeutic dosages between <25 mL/(kg·h) and 25-50 mL/(kg·h), and between 25-50 mL/(kg·h) and >50 mL/(kg·h) all had no statistical significance. The prognosis of CRRT and the number of involved organs were related to the APACHE II score. Logistic regression analysis revealed that the number of involved organ, APACHE II score, mechanical ventilation, and hypoalbuminemia were the major risk coefficients that affected the prognosis of patients with bedside hemofiltration. The turnover of elderly CRRT patients was related to the number of involved organs, APACHE II score, mechanical ventilation, hypoalbuminemia, and other factors. The APACHE II score was the important reference index of CRRT starting time and could predict mortality risk.

Keywords: Continuous renal replacement therapy, acute kidney injury, elderly, prognosis

Introduction

Currently, continuous renal replacement therapy (CRRT) has progressed significantly. It is used not only in patients with renal failure but also as an important auxiliary treatment of multiorgan dysfunction syndrome (MODS), especially in patients with acute kidney injury (AKI) [1-4]. However, CRRT in elderly AKI patients is associated with high mortality. Moreover, a consensus has not been reached as to the timing of initiating CRRT and the factors that influence its efficacy in clinical practice [5, 6].

In recent years, experience with bedside CRRT for elderly AKI patients has been accumulated. This retrospective study was conducted to identify the factors that affect the prognosis of elderly AKI patients who had undergone bedside CRRT.

Methods

Patient selection

Forty-one elderly patients with critical illnesses who were admitted in the geriatric ward of the PLA General Hospital between January 2000 and December 2010 and met the inclusion criteria with complete data underwent bedside CRRT, including 37 men and 4 women, aged 80 to 100 years (mean, 88.65±4.76 years). According to the RIFLE hierarchical diagnostic criteria of AKI, developed by the Acute Dialysis Quality Initiative Group in 2002 [5], AKI was divided into the following 5 stages: first stage, exposure to risk of renal dysfunction (R); second stage, injury to the kidney (I); third stage, failure of kidney function (F); fourth stage, loss of kidney function (L); fifth stage, end-stage kidney disease stage. The cases in this research were all in the second or third stage. Among the patients, the primary diseases were the following: 1 case of intestinal obstruction, 1 case of colorectal cancer, 2 cases of biliary tract infection, 1 case of acute pancreatitis, 1 case of liver cancer associated with kidney syndrome, 1 case of bladder cancer, 1 case of contrast-induced nephropathy, 1 case of nephrotic syndrome, 1 case of multiple myeloma, 3 cases of diabetic nephropathy, 2 cases of malignant primary hypertension, 4 cases of myocardial infarction associated with heart failure, and 22 cases of lung infection. This study was conducted in accordance with the declaration of Helsinki. This study was conducted with approval from the Ethics Committee of Chinese PLA General hospital. Written informed consent was obtained from all participants.

Inclusion criteria

AKI was defined as follows: in 48 h, serum creatinine increased to 0.3 mg/dL (25 mmol/L), or 50% higher than the baseline, and/or urine output decreased to <0.5 mL/(kg·h) and continued for >6 h [7]. An MODS diagnosis referred to the score criteria for sequential organ failure assessment (SOFA) established by the European Society of Intensive Care Medicine. A single-organ dysfunction score ≥3 could be judged as indicative of organ failure. MODS was defined when sequential or simultaneous failure of 2 or more organs occurred [8]. Except for patients with urinary tract obstruction or other reversible factors that lead to decreased urine output, patients with progressive chronic renal failure should be excluded.

Data collection

The relative information was collected from the PLA General Hospital medical records database. The following indicators were recorded 24 h before CRRT: 1) general information, including age, sex, body mass index, primary disease, complications, and turnover; vital signs, including temperature, respiratory rate, mean arterial pressure, and urine output; 2) laboratory examination parameters: blood routine, liver and kidney function, electrolytes, and blood gas analysis; 3) Acute Physiology and Chronic Health Evaluation II (APACHE II) score and mortality risk coefficient [ln (R/1-R) = -3.517 + (APACHE II score × 0.146) - 0.885), with R as the risk coefficient] were calculated based on the above-mentioned data combined with those reported in the literature [9, 10] to evaluate disease severity. The SOFA score was used to verify the number of organs involved [8].

The calculation of the actual mortality was in accordance with the commonly used statistical survival time of patients with critical illnesses, whether they survived after 4 weeks of CRRT set as the criteria. According to survival status, 16 patients were assigned to a survival group and 25 patients were assigned to a non-survival group. The baseline characteristics of the 2 groups were compared.

Bedside hemofiltration treatment

The Seldinger technique was performed to establish temporary vascular access through femoral or jugular vein catheterization. Four patients underwent femoral vein catheterization, and 37 patients underwent internal jugular vein catheterization. Gambro Prisma (Campbell, Sweden) or Fresenius-4008 (Fresenius, Germany) was used, with a M100 polyacrylonitrile membrane filter (1.2 m^2; Gambro, Sweden) or AV600 polysulfone membrane filter (1.35 m^2; Faison Eustace, Germany). The operations were all performed at the bedside, with continuous venovenous hemofiltration method, and in 5 cases, the procedures were performed simultaneously with continuous venovenous hemofiltration. Hemodialysis was performed through the displacement liquid line or by using basic replacement fluid (batch No. H20080452; Chengdu Qingshan Likang Pharmaceutical Co., Ltd. Chengdu, China). The replacement fluid was diluted before the instrument, and the flow rate was set at 2-4 L/h according to the condition. Blood flow was set at 125-250 mL/min. Ordinary heparin or no heparin was administered according to the patient's condition. The amounts of ultrafiltration and other supplements such as electrolytes and carbonate were adjusted according to the patient's clinical situation and need.

Statistical analysis

The SPSS 15.0 statistical software was used. The measurement data were expressed as x±s. In the intergroup comparison, one-sample t test was used; count data were expressed as frequency. In the ratio comparison, the chi-square test was used; and in the risk coefficient analysis, Pearson and Spearman correlations and non-conditional logistic regression analysis were used. A P<0.05 was considered as statistically significant.

Results

Basic data

Forty-one patients were enrolled in the study; 16 in the survival group and 25 in the non-survival group, with a total mortality rate of

Table 1. Comparison of clinical features of elderly AKI patients in the 2 groups

	Survival group (16 cases)	Death group (25 cases)	P
Age (years)	88.56±5.81	88.72±4.09	0.918
Gender (M/F)	15/1	22/3	0.948
APACHE II score (points)	26.25±3.46	32.36±2.83	0.000
Main reason of AKI [cases (%)]			0.00
Prerenal	6 (37.5)	2 (8.0)	
Renal	9 (56.2)	23 (92.0)	
Postrenal	1 (6.3)	0	
Serum creatinine (μmol/L)	468.8±132.7	515.6±153.6	0.323
Serum urea nitrogen (mmol/L)	25.7±11.1	29.6±12.6	0.123
Bicarbonate (mmol/L)	17.5±7.4	15.5±6.6	0.372
Hemoglobin (g/L)	11.3±2.5	9.5±3.3	0.070
Plasma albumin (g/L)	33.5±10.7	26.6±10.5	0.040
Total bilirubin (mmol/L)	10.8±5.6	11.3±7.6	0.822
Mechanical ventilation [cases (%)]	11 (68.8)	22 (88.0)	0.452

Table 2. APACHE II score comparison of different turnover patients

APACHE II score	Survival group (16 cases)	Death group (25 cases)	Death risk coefficient	Actual mortality rate (%)
≤25	6	0	0.60±0.08	0
26~30	*9*	*8*	*0.78±0.03*	*47.05*
31~35	1	12	0.87±0.02	92.30
≥36	0	5	0.92±0.01	100.00

60.98%. The distribution of the AKI causes between the 2 groups was statistically significant ($P<0.01$). Of all the factors in the survival group, 37.5% and 56.2% were prerenal and renal factors, respectively. Meanwhile, in the non-survival group, the renal factors accounted for the main reasons (92.0%), with prerenal factors accounting for only 8.0%. The serum albumin level in the survival group was higher than that in the non-survival group ($P<0.01$). The number of involved organs in the non-survival group was significantly more than that in the survival group ($P<0.05$). No statistical significance was observed in age, sex, urine output, and levels of serum creatinine, urea nitrogen, bicarbonate ions, hemoglobin, and total bilirubin between the 2 groups ($P>0.05$; **Table 1**).

APACHE II score

The APACHE II score of the 41 elderly AKI patients was 27.8±5.6 points, the risk coefficient was 0.80±0.10, and the actual mortality rate was 60.97%. The APACHE II scores of the non-survival and survival groups were 32.36±2.83 and 26.25±3.46 points, respectively, showing significantly higher scores in the non-survival group than in the survival group ($P<0.05$). The patients were grouped according to APACHE II scores; the higher the score, the greater the risk coefficient and the actual mortality rate. The results indicated that the risk coefficient in each group was closely related to the actual mortality rate (**Table 2**).

Number of organs with dysfunction or failure

The numbers of involved organs in the patients in the survival group were as follows: 6 cases with 2 involved organs, 7 cases with 3 involved organs, and 3 cases with 4 involved organs. In the death group, the numbers were as follows: 5 cases with 3 involved organs, 11 cases with 4 involved organs, and 9 cases with 5 involved organs. The more involved organs, the greater risk of death. The number of involved organs in the non-survival group was significantly more than that in the survival group, with statistically significant difference ($P<0.05$).

Treatment dosage

The impact of the therapeutic dosage on the turnover was assessed based on the different mean filtration rate of the replacement fluid during the bedside hemofiltration. The mean dosage in the survival group was higher than that in the non-survival group, with no significant difference between the replacement fluid dosage of 25-50 mL/(kg·h) and <25 mL/(kg·h) ($P=0.222$). The difference was not statistically significant between the replacement fluid dosage >50 mL/(kg·h) and 25-50 mL/(kg·h) (**Table 3**), whereas the difference was statistically significant between the replacement fluid dosage <25 mL/(kg·h) and >50 mL(/kg·h) ($P<0.05$).

Table 3. Replacement fluid dose on the bedside CRRT effect

Replacement fluid dose [ml/(kg.h)]	Survival group (16 cases)	Death group (25 cases)	X^2	P
<25	2 (12.5)	11 (44.0)	—	—
25~50	6 (37.5)	11 (44.0)	0.644	0.222
>50	8 (50.0)	3 (12.0)	2.396	0.122

Table 4. Risk coefficients analysis of bedside CRRT prognosis

Risk coefficient	R	P
Age	0.040	0.803
APACHE II score	0.690	0.000
Involved organ numbers	0.664	0.000
Whether there was original Kidney injury or not	0.025	0.877

Correlation and regression analysis of prognostic risk coefficients

The acute and chronic risk coefficients that might have affected the prognosis of the 41 patients were analyzed. The Pearson and Spearman correlation analyses revealed that the prognosis of the elderly AKI patients with bedside hemofiltration was significantly correlated with the number of involved organs and APACHE II score but was not related to age and the absence or presence of original kidney injury (**Table 4**). The unconditional logistic regression analysis revealed that APACHE II score, number of involved organs, mechanical ventilation, and serum albumin level were independent risk coefficients that affected the CRRT-related prognosis of the elderly AKI patients (**Table 5**).

Discussion

The mortality of the patients with severe AKI is as high as 50-70%, and strategies to lower this rate have gained increasing attention. The introduction and development of bedside CRRT represent an important step to the treatment of patients with critical illnesses. Only 6 patients with severe elderly AKI underwent CRRT in the 1980s; 27, in the 1990s; and 66, in the last 10 years. Although the management strategies and renal replacement technology for patients with critical illnesses have been greatly improved, the mortality of patients undergoing bedside CRRT for AKI is still high and the consumption of medical resources is huge [11, 12]. The Chinese General Hospital of the Nanjing Military Region [13] reported that the mortality of elderly MODS patients who had undergone CRRT reached 57.1%. In this study, the results also showed that the mortality of the elderly AKI patients who had undergone bedside CRRT was also as high as 60.97%. Improving bedside hemofiltration treatment levels is a serious challenge for nephrologists.

Identifying the appropriate timing to initiate the treatment is crucial for the improvement of CRRT prognosis. Currently, the indications of bedside hemofiltration are mostly based on previous experience with treatment of ESRD patients, including those with recurring hyperkalemia, refractory volume overload, sustained severe metabolic acidosis, and severe uremic symptoms. As for the elderly AKI patients, because of the lack of absolute standards, either the degree of azotemia or AKI duration is difficult to validate as an indicator of treatment initiation [14, 15]. In our study, the APACHE II score was demonstrated as an indicator of treatment timing and as a prognostic predictor. It is an authoritative scoring system for assessing the severity of critical illness. It could combine the basic and acute physiological indicators of chronic diseases for fast calculation, with results within 24 h; in addition, it could change with changes in the illness conditions [9, 10]. This study showed the various degrees of risk according to APACHE II score as follows: 6 cases, ≤ 25 points with a risk coefficient of 0.60±0.08 (all survived); 17 cases, 26 to 30 points with a risk coefficient of 0.78±0.03 and actual mortality rate of 47.05%; 13 cases, 31 to 35 points, with a risk coefficient of 0.87±0.02 and actual mortality rate of 92.31%; 5 cases, ≥ 36 points with a risk coefficient of 0.92±0.01 and actual mortality rate of 100%. The risk coefficient in each group was closely related to the actual mortality rate. With the increasing APACHE II score, the risk coefficient also increased, as well as the actual mortality rate. Therefore, this study suggests that elderly AKI patients should be assessed using the APACHE II scoring system and dynamically observed for disease severity, with the aim of identifying the proper timing of starting CRRT. A score <25 points was a good indicator, which

Table 5. Regression analysis of risk coefficients of bedside CRRT prognosis

Risk coefficient	Regression coefficient (B)	Standard error (SE)	Wald statistic	P	Exp (B)
involved organ numbers	0.92	5.10	1.00	0.024	0.125
APACHE II score	1.79	3.89	1.00	0.048	0.029
Mechanical ventilation	1.25	0.52	4.05	0.030	0.280
Serum albumin	1.08	0.39	2.65	0.040	0.320
Age	0.11	3.76	1	0.053	1.232

might generate better results; when the score was >30 points, the mortality was high; when the score was >35 points, the patient died within 2 d even if CRRT was performed once or twice. Assessment of the patient's APACHE II score could provide a basic understanding of the patient's prognosis. Furthermore, the more organs are involved, the higher the mortality rate; when 5 or more organs were involved, the patients almost died. Therefore, when the patient's disease was predicted to be irreversible through CRRT, CRRT should not be blindly implemented. This would not only increase the suffering of patients and their families but also increase medical costs and medical resource consumption.

The influence of hemofiltration dosage on prognosis remains controversial. Some studies thought that relatively large dosages would have better survival rates [16-19], whereas other studies considered that increasing the therapeutic dosage would not improve efficacy. In particular, in patients with high disease severity scores, no correlation was observed between prognosis and dialysis dosage [20, 21]. This study showed that when the replacement fluid dose was compared between 25-50 mL/(kg·h) and >50 mL/(kg·h), and between <25 mL/(kg·h) and 25-50 mL/(kg·h), no statistically significant differences were observed in the effects on prognosis. When the comparison of the replacement fluid dosage was between <25 mL/(kg·h) and >50 mL/(kg·h), a significant difference was observed. Because of the limited sample size, the selection of the replacement fluid dosage was limited by the comprehensive situation of the patient and the comparability was poor. For clinical practice, we summarized that in elderly patients, the replacement fluid dosage of bedside CRRT should be appropriately increased to 25-35 mL/(kg·h); a dosage <25 mL/(kg·h) would have poor effect, and blindly increasing the dosage might not be able to achieve better results. In addition, the patients in this research were elderly, the ages were not very different, and the number of cases was small; therefore, the prognosis was not related to age.

Because the elderly AKI patients were old, their physical function and immunity decreased. Consequently, the disease was normally complex, accompanied by various complications, generating adverse effects on the prognosis. In this study, through the analysis of the risk factors that could affect the prognosis of elderly AKI patients undergoing CRRT, we revealed that the number of involved organs, APACHE II score, mechanical ventilation, and low albumin level were the major risk factors of death in the patients. When CRRT was performed for elderly AKI patients, the aforementioned risk factors should be considered for correct assessment of disease status.

Disclosure of conflict of interest

All authors have no conflict of interest regarding this paper.

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