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Ten-Year Retrospective Analysis of Continuous Renal Replacement Therapy in Burn Patients: Impact on Survival and Timing of Initiation

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ACDEFG 1 Jerzy Strużyna
ABCDFG 2 Piotr Tomaka
ABCDEF 3 Agnieszka Surowiecka
CDEFG 1 Tomasz Korzeniowski
ABDEF 3 Grzegorz Wilhelm
BCEF 4 Maciej Łączyk
ABDF 4 Ryszard Mądry
BDEF 4 Magdalena Bugaj-Tobiasz
BDEF 3 Sergey Antonov
BDE 4 Łukasz Drozd
BDE 4 Aldona S. Stachura

1 Department of Plastic, Reconstructive Surgery and Burn Treatment, Medical University of Lublin, Lublin, Poland
2 Department of Anesthesiology and Intensive Care, District Hospital, Łęczna, Poland
3 Department of Plastic, Reconstructive Surgery and Microsurgery, Medical University of Lublin, Lublin, Poland
4 East Center of Burns Treatment and Reconstructive Surgery, District Hospital, Łęczna, Poland

Corresponding Author: Tomasz Korzeniowski, e-mail: t.korzeniowski@gmail.com
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Background: Acute kidney injury (AKI) is a common issue in intensive care units and is a potentially lethal consequence of severe burns. In severely burned patients with non-renal indications, renal replacement treatment is frequently used. This study's aim was to compile a 10-year summary of continuous renal replacement therapy (CRRT) experience at a single burn center, including patient outcomes, effectiveness, and potential complications in the context of severe burns.

Material/Methods: This retrospective analysis included the clinical data from 723 burned patients. The data analysis of 300 patients with CRRT therapy included clinical data, laboratory tests, and CRRT parameters. The study group was split into 2 subgroups regarding onset of CRRT: early (up to 7 days after the trauma) and late.

Results: Age, burn extent, length of stay, and inhalation injury all had an impact on survival. Early CRRT was linked to a greater probability of death (*P*<0.005). Upon admission to the burn center, patients with early CRRT exhibited a bigger burn area, higher Baux and SOFA scores, and were younger (*P*<0.05). Sepsis was diagnosed more frequently in the late CRRT group.

Conclusions: Our findings show that patients who require CRRT within the first 7 days following a burn injury have a poorer prognosis; however, this is not due to CRRT's effect, but rather to the trauma's severity. Future studies should explore long-term patient outcomes of CRRT among burn patients.

Keywords: **Burns • Acute Kidney Injury • Sepsis • Continuous Renal Replacement Therapy**

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Introduction

Managing burned patients is a multidisciplinary challenge for burn treatment units. Extensive burn injury leads to severe dysfunction of many organs, including the heart, lungs, digestive system, central nervous system, and kidneys, and often causes multiorgan failure (MOF). Studies conducted in Europe reported MOF as the most significant cause of death, triggered primarily by sepsis [1,2]. The mechanism is very complex, including a multifactorial cascade of pathophysiological consequences. According to an American study of MOF in a group of 821 children, those with renal and liver failure had the worst outcomes. The combination of impaired function of 3 or more organs was always fatal, with no therapeutic success. Early detection of MOF and effective intervention are essential to improve burn care [3].

The incidence of acute kidney injury (AKI) in burn patients is 9-50%. Despite recent increases in survival, post-burn AKI is associated with an extremely poor prognosis, with mortality >80% in those with severe disease. The main factors contributing to the occurrence of AKI are systemic inflammation and hemodynamic alterations [4]. Post-burn AKI is also caused by return of spontaneous circulation (ROSC), the massive release of endotoxins from damaged and non-viable tissues, and iatrogenic factors. AKI is simply defined as an abrupt decline in renal function, and over time, more specific criteria for renal homeostasis disruption to be quantified had to be developed, such as the Acute kidney injury (AKI) criteria, Risk, Injury, Failure, Loss and End-stage renal disease (RIFLE) score, Acute Kidney Injury Network (AKIN) criteria, and the Kidney Disease: Improving Global Outcomes (KDIGO) systems.

In 3-5% of burn patients, biochemical parameters of renal damage reach life-threatening values, requiring renal replacement therapy (RRT) [5,6]. Severe burns have become an independent risk factor in developing AKI, which occurs in approximately 30% of patients hospitalized in intensive care units (ICU) in burn treatment centers [7]. Numerous pathophysiological problems can accompany AKI, ranging from a brief increase in the concentration of biological markers of kidney damage to serious metabolic and clinical diseases. Currently, there is no specific treatment for post-burn AKI; therefore, supportive treatment is used, such as maintaining fluid and electrolyte balance, including RRT when indicated [8].

There is a wealth of research available on RRT, but many inconsistencies remain regarding burns. The variability in RRT implementation and lack of consensus on optimal treatment strategies for post-burn ARF are controversial and are a knowledge gap that needs to be filled.

Therefore, this study aimed to compile a 10-year summary of CRRT experience at a single burn center, including patient outcomes, effectiveness, and potential complications in the context of severe burns.

Figure 1. Severe burned patient included in the study.

Material and Methods

Ethical Statement

This retrospective study adhered to the principles outlined in the Declaration of Helsinki. The Medical University of Lublin Ethics Committee accepted both the study's protocol and the subject's participation (reference number: KE: 0254-245/11/2023). Patient confidentiality was strictly maintained by anonymizing all data before analysis. Due to the retrospective nature of the study, the requirement for informed consent was waived by the Ethics Committee in accordance with local regulations.

Patient and Study Design

The study included 723 patients admitted to the East Centre of Burns Treatment and Reconstructive Surgery's Intensive Care Unit (ICU) from January 2010 to January 2021. Exclusion criteria included minor burns not requiring ICU care and specific dermatological disorders such as toxic epidermal necrolysis (TEN) and Lyell's syndrome. We conducted a retrospective analysis of clinical data from 300 patients who required continuous renal replacement therapy (CRRT) (**Figure 1**).

Data collected at admission included age, sex, burn percentage and depth, and the mechanism of burn trauma. The predominant cause of the burn was determined based on medical history, while the Lund and Browder chart was used to estimate the size of the burn area. The diagnosis of inhalation injury was confirmed by direct examination of the airways (bronchoscopy) in each case. The Baux rule and SOFA score were used to assess burn severity and overall condition, respectively.

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Table 1. KDIGO (Kidney Disease: Improving Global Outcomes) qualification.

Stage of AKI	Serum creatinine level	Diuresis
1	An increase 1.5-1.9 times higher than the baseline value or ≥0.3 mg/dL (≥26.5 µmol/l)	<0.5 ml/kg/h within 6-12 h
2	An increase more than 2-2.9 times higher than the baseline value	<0.5 ml/kg/h ≥12 h
3	An increase ≥3 times higher than the baseline value or creatinine level ≥4 mg/dL (≥353.6 µmol/l)than baseline or the requirement of renal replacement therapy (RRT) initiation	<0.3 ml/kg/h ≥24 h or anuria ≥12 h

Table 2. The RIFLE (Risk, Injury, Failure, Loss and End-stage renal disease) score.

Stage	eGFR and SCr criteria	UO criteria
Risk	An increase in serum creatinine level of 1.5-1.9 times higher than the baseline value or eGFR decreased >25%	An urine output <0.5 mL/body weight/per hour within 6-12 hours
Injury	An increase in serum creatinine level of 2-2.9 times higher than baseline value or eGFR decreased >50%	An urine output <0.5 mL/body weight/per hour within >12 hours
Failure	An increase in serum creatinine level of 3 times higher or >4 mg/dL than baseline or eGFR decreased >75%	An urine output <0.3 mL/body weight/per hour within 24 hours or anuria notice more than 12 hours
Loss	The loss of renal function >4 weeks	
End-stage renal disease	The loss of renal function >3 months	

Sepsis was confirmed with documented infection (at least 2 sets of blood cultures were obtained, drawn from 2 separate venipuncture sites approximately 15 minutes apart). The diagnosis was based on American Burn Association sepsis criteria [9]. SIRS was defined when any 2 of the components were met: temperature above 38°C or below 36°C, heart rate >90 beats per minute (bpm), respiratory rate >20/min or maintenance of Paco2 <32 mmHg, white blood cells count >12 000/mm^3 or <4000/mm^3, or left shift defined as >10% bands [10]. All data were retrieved from the medical records database at the Burn Center.

Acute kidney injury (AKI) was diagnosed according to KDIGO criteria, defined as an increase in serum creatinine by ≥0.3 mg/dl within 48 hours, or ≥1.5 times baseline in the last 7 days, or urine output <0.5 ml/kg/h for 6 hours. AKI severity was categorized into 3 stages based on KDIGO criteria (**Table 1**). Additionally, renal compromise was classified according to RIFLE criteria into Risk, Injury, Failure, Loss, and End-Stage Renal Disease using either estimated glomerular filtration rate (eGFR) and serum creatinine (SCr) levels or urine output (UO) criteria (**Table 2**) [11,12].

Figure 2. Patient during CRRT.

Continuous Renal Replacement Therapy (CRRT)

CRRT was indicated for oliguria (urine output <0.5 ml/kg/h), acidosis (pH <7.15), hyperkalemia (potassium level >6 mEq/L), hyperlactatemia (lactate levels >2 mmol/l), azotemia (BUN >40 mg/dl), volume overload, and septic shock.

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Table 3. Characteristics of the study group.

		Study group
	Number of patients	300
	Age (mean±SD/range)	55±17/13-88
	Sex (%)	M 77%/F 23%
	TBSA Burn% (mean±SD/range)	41±21/4-97
Mechanism of trauma	Scald (N/%)	3 (1%)
	Flame (N/%)	217 (72.34%)
	Electrical (N/%)	6 (2%)
	Burst (N/%)	72 (24%)
	Contact (N/%)	2 (0.66%)
	Inhalation burn (N/%)	168 (56%)
SCORES at the admission	Baux (mean±SD/range)	101±25/41-169
	SOFA (mean±SD/range)	7.4±3.6/0-15
	GCS (mean±SD/range)	14.9±0.6/5-15
	AKIN 0 (%)	40%
	AKIN 1 (%)	50%
	AKIN 2 (%)	7%
	AKIN 3 (%)	3%
	RIFLE "R" (%)	29%
	RIFLE "I" (%)	51%
	RIFLE "F" (%)	20%
Renal function	CRD before (N/%)	12 (4%)
	Late CRRT (N/%)	120 (45%)
	Very early CRRT	88 (29%)
	MAP (mean±SD/range)	83±16/40-133
	Norepinephrine at the admission	51%
Hospitalization	Hours from burn to the admission (mean)	37
	Hours from burn to CRRT (mean)	237
	LOS (mean±SD/range)	36±38 (1-306)
	Mortality (N/%)	207 (69%)

CRD – chronic renal disease; N – number of patients; % – percentage of the study group; LOS – length of hospital stay in days; TBSA – total body surface area; MAP – mean arterial pressure.

Before 2017, CRRT was performed using Ultraflux® AV1000S (Fresenius® Medical Care), and after 2017, Prismaflex® (Baxter®). Regional citrate anticoagulation (RCA) was used in all procedures, which were conducted in continuous veno-venous hemodialysis (CVVHD), hemodiafiltration (CVVHDF), or hemofiltration (CVVH) modes with a blood flow rate of 150 ml/min. Septic patients were treated with the Ultraflux® EMiC®2 filter (**Figure 2**).

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Table 4. Mean values of the laboratory tests taken at the admission.

Parameter	Mean	SD	Range
Creatinine [mg/dl]	1.35	0.18	0.27-5.26
Hemoglobin [g/dl]	12	3.6	5.7-21.7
Hematocrit [%]	36.2	10.19	17.3-67.8
Platelets [×10^3/μl]	255	166	12-1305
Na [mmol/l]	144	14.5	128-178
K [mmol/l]	4.37	0.87	2.55-7.8
P [mg/dl]	4.48	1.71	0.61-10.92
Mg [mg/dl]	2.18	0.5	1.19-4.6
pH	7.33	0.11	6.932-7.6
BE	-2.83	6.29	-35.6
HCO_3^- [mmol/l]	23.09	5.44	1.8-37.3

Patients were categorized into early CRRT (initiated within 7 days of burn injury) and late (CRRT initiated more than 7 days post-injury) groups, following established protocols for identifying early and late AKI [13]. This division facilitated the comparison of outcomes based on the timing of CRRT initiation [14].

Statistical Analysis

Statistical analysis was conducted using Statistica StatSoft Polska version 13.1. A *P* value of <0.05 was considered statistically significant. Descriptive statistics included mean, standard deviation, range, and percentages. The Shapiro-Wilk test assessed the normality of quantitative variables, and homogeneity of variance was evaluated using Levene's and Brown-Forsythe tests. For normally distributed variables with homogeneous variance, the *t* test was employed. The chi-square test and logistic regression analyzed relationships between quantitative variables, while the Mann-Whitney test was used for non-normally distributed variables. Survival analysis was performed using the Cox regression model, and multivariate analysis utilized multiple regression models.

Results

Study Group Characteristics

The CRRT group accounted for 39% of all burn patients treated in the ICU in 2010-2020. The average age was 54 years, with a predominance of men (77%). Those qualified for CRRT had larger burns (41% vs 39%, OR 0.99; CI 0.96-1.02; *P*<0.005) and higher Baux scores (96 vs 92, OR 0.96; CI 0.92-0.99; *P*<0.05). The most common cause of burns was flame (72%) and over half had respiratory injury (56%). The group's features are displayed in **Table 3**.

CRRT

Only 51% of the burned patients had sepsis diagnosed, despite 87% of them presenting SIRS symptoms. AKIN and RIFLE higher scores were associated with sepsis (*P*<0.001). The laboratory results from the patients' admission to the burn unit are listed in **Table 4**. Regarding continuous venovenous hemodialysis, 88% of patients underwent CVVHD and 12% underwent CVVHDF. The total mean dose of CRRT was 34.9 ml/kg/h. Burn patients who required CVVHDF had higher serum sodium levels (155 mmol/l vs 140 mmol/l, *P*<0.001) and lower potassium levels (3.78 mmol/l vs 4.29 mmol/l, *P*<0.001).

Prognosis

The mean time for survivors to receive CRRT after the burn trauma was 213 hours, compared to 52 hours for non-survivors (OR 1; CI 0.99-1, *P*<0.05). The type or the daily dose of CRRT did not differ between the survivors and non-survivors. The period of time between the burn and admission had no impact on mortality. The effects of the RIFLE and the AKIN ranks on survival were not proved by the Cox regression analysis. The multivariate logistic regression analysis showed that age (*P*<0.001; OR 1.48), TBSA (*P*<0.001; OR 1.22) LOS (*P*<0.001; OR 0.66), and inhalation injury (*P*<0.001; OR 1.8) were associated with survival. **Table 5** presents other factors that affected mortality.

Early CRRT (initiated within 7 days of burn injury) was associated with a higher risk of death (*P*<0.005). Although the patients with early CRRT were younger, upon admission to the burn center they had greater burn area and higher Baux and SOFA scores (**Table 6**). Sepsis was diagnosed more frequently in the late CRRT group (*P*<0.001).

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Table 5. Mortality determinants, comparison between survivors and non-survivors.

Parameter	Survivors	Non-survivors	P-value
Age	51	59	p<0.001*
%TBSA	36	43	p=0.009*
Baux index	85	105	p<0.001*
Inhalatory trauma (N)	88	197	p<0.05**
SOFA	3.9	8	p=0.007*
Hemoglobin [g/dl]	11.24	12.3	p<0.05*
Hematocrit [%]	33.8	36.1	p<0.05*
Creatinine [mg/dl]	0.96	1.11	p<0.05*
eGFR [ml/min/1.73 m^2]	90	65	p<0.05*
pH	7.35	7.33	p<0.05*
LOS [days]	56	16	p<0.001*

* Mann-Whitney U Test; ** Chi-square Yates – stat value chi-square checking the significance of parameters.

Table 6. Determinants defined at the admission to the burn unit differentiating early CRRT from late CRRT.

Parameter	Early CRRT	Late CRRT	P-value
Age	54	61	p=0.016*
%TBSA	45.9	30.6	p<0.001*
Baux	99.6	95.3	P=0.014*
SOFA	8.8	5.7	p=0.003*
Hemoglobin [g/dl]	13.8	9	p<0.001*
Hematocrit [%]	40.9	28	p<0.001*
Na [mmol/l]	139	147	p<0.001*
K [mmol/l]	4.22	4	p<0.001*
Mg [mg/dl]	1.98	2.28	p<0.001*
pH	7.289	7.398	p<0.001*
BE	-6.304	0.04	p<0.001*
HCO_3^- [mmol/l]	20.85	25.49	p<0.001*
LOS [days]	8	33	p<0.001*
SEPSIS (%)	37%	68%	p<0.001**

* Mann-Whitney U Test; ** Chi-square Yates – stat value chi-square checking the significance of parameters.

Discussion

For patients treated in the ICU who develop AKI, CRRT is used to replace lost kidney function. The CRRT group of our study had a larger burn area and a higher Baux index, confirming that CRRT is the modality of choice for the treatment of severe AKI in critically ill burn patients [15]. Despite the frequent use of CRRT in burn-related kidney disfunction, the literature is limited on long-term outcomes and prognosis [16]. We observe reduction in burn-related mortality worldwide, largely due to advances in intensive care and the development of specialized burn care teams. Despite the improvement, the mortality rate is still high [17]. Age, TBSA, length of hospital stay (LOS), and inhalation injury were found to be significant predictors of survival in multivariate logistic regression analysis in our findings and are confirmed in other studies [18,19]. This demonstrates the complexity of burn injuries, in which a multitude of factors influence the patient's prognosis and treatment outcome. This is in line with other prognostic tools [20,21].

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Acute kidney injury (AKI) is a common serious complication in patients with severe burns. In our observation, 50% of the patients exhibited a severe impairment of kidney function, as indicated by an Acute Kidney Injury Network (AKIN) score of 1 or above. AKI is traditionally classified into 2 stages: early and late. Early-onset AKI occurs within the first 48 hours of the burn injury. There are many factors which seem to cause AKI in that stage, such as hypovolemia with fluid shifts, poor renal perfusion, oxidative stress, and cardiac factors hypovolemia is considered to be the main reason contributing to the renal insult [22,23]. Rapid fluid shifts from the intravascular to interstitial space and general loss of fluids through the damaged skin and respiratory system results in insufficient filling of the vascular bed. Those changes lead to renal ischemia as blood flow is restricted in a compensatory mechanism for hypovolemia. Cells exposed to oxidative stress tend to produce reactive oxygen species (ROS) that directly damage kidney tubules resulting in reduce effective glomerular filtration rate (eGFR). Despite implementing fluid resuscitation and a normal urine output, AKI can still develop. Fluid shifts during burn resuscitation may be dangerous if over-resuscitation takes place, particularly if they affect facially bound compartments (such as the peritoneal cavity). The development of abdominal compartment syndrome (ACS) is strictly related to intraabdominal hypertension (IAH), which may be a result of fluid oversupply in severely burned patients [24,25]. A greater extent of burn injury is associated with a greater decrease in cardiac output, which seems to be multifactorial [26]. Hypovolemia and increased sympathetic activity suppress the correct function of myocardium, and the molecules released by damaged cells, such as tumor necrosis factor (TNF), seem to have a more direct influence on depression of cardiac function [27]. AKI usually develops when renal flow is significantly decreased as a result of heart impairment and its diminished preload state after thermal injury [18]. AKI appearing in the later stages of treatment can be considered as an integral part of multiorgan failure resulting from sepsis and septic shock, which are seen in up to 87% of cases of AKI in the burn ICU [28,29]. Iatrogenic renal impairment can be also responsible for developing of burn-associated late AKI as a result of chronic exposure to nephrotoxic effects of diuretics and broad-spectrum antibiotics [10,30]. To accurately identify AKI with high sensitivity and specificity and to forecast the prognosis of burn patients, RIFLE and AKIN criteria can be regarded as equivalent [31]. Both have a number of limitations, such as using elevated serum creatinine levels and decreased urine production, but those indicators of renal impairment emerge later on following burn injury [32].

CRRT was needed by39% of the total cohort, or 300 patients, and they were added to a study group. It is widely recognized that the use of CRRT has evolved beyond nephrology to encompass a variety of applications. An example is severe burns with a number of complications such as renal function injury, electrolyte balance disorder, and sepsis, and often a combination of them [33]. CRRT in burns is primarily aimed at maintaining hemodynamic stability and optimal fluid and acid-base balance. Clinical decision-making related to the initiation of CRRT in critically burned patients is complex and still controversial. The choice of method is influenced primarily by the patient's clinical condition, but the experience of the team and the availability of equipment are also important. Because of this, there are many inconsistencies, especially related to CRRT strategy [34,35]. The optimal timing of CRRT initiation remains uncertain. A survey distributed among the members of International Society for Burn Injury revealed that the most frequently used criteria for the diagnosis of AKI were urinary output and creatinine; 43.2% of the respondents use CRRT to treat AKI in burn patients. The timing of starting CRRT was usually based on severe electrolytes' disturbances (81.8%), metabolic acidosis with pH below 7.15 (70.5%), serum creatinine-based thresholds (61.4%), and fluid accumulation thresholds (50%). The most common criterion for discontinuing CRRT was restoration of spontaneous urine output [36,37]. Researchers from Singapore suggest that early CRRT is associated with improved survival in burn victims, but the optimal timing has not been established and data on early CRRT approach are scarce [38]. We divided the study group according to a criterion of 7 days from the time of burn trauma to the start of CRRT in our investigation. The division was done during the analysis of the acquired data. According to available studies, clinical indicators regarding the timing of CRRT initiation are consistent with KDIGO guidelines, including acid-base disturbances, hyperkalemia, volume overload, rhabdomyolysis, and toxins [39,40]. More extensive the burn injury is associated with more intense systemic response and earlier indications for including CRRT, and also with worse a priori prognosis. Deaths associated with indications for early CRTT were due to the injury itself, not because CRRT was started earlier. The topic of optimal timing of CRRT initiation in severely burned patients is an area for future research.

If a burn patient survives initial resuscitation, sepsis becomes the greatest treatment challenge and the primary cause of death in severe burns [41]. In our study, 51% of patients received a sepsis diagnosis, while 87% presented signs of SIRS. We defined sepsis as the presence of SIRS in response to an infection [42]. The observed disparity in the results emphasizes how difficult it is to diagnose sepsis in burn patients because these individuals frequently have systemic inflammatory responses even in the absence of infection-related symptoms. Additional criteria for assessing the intensity of the systemic reaction to burn injuries include quick SOFA (qSOFA) [43] or burn SIRS (bSIRS) [44]. qSOFA is a simplified version of Sequential Organ Failure Assessment score that includes Glascow coma scale (GCS), respiratory rate, and systolic blood pressure [45].

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In our observation, the mean GCS at the admission was 14.9, which might suggest that in our cohort the qSOFA would not properly specify the severity of clinical condition. Yoon et al found that a Sepsis -3 or SOFA mean of 2 or above is a good predictor of sepsis in burn patients, while SIRS diagnosis showed less specificity [46]. In our observation, the mean SOFA at admission was 7.4. Unlike septic SIRS, post-traumatic SIRS is characterized by activation of the inflammatory signaling pathways brought on by damage-associated molecular patterns (DAMPs), which include DAMPs and also the mitochondrial DAMPs (mtDAMPs). Mitochondrial DNA (mtDNA) and mitochondrial formyl peptides (mtFPs) are examples of MtDAMPs [47]. bSIRS differs from SIRS criteria and includes not only abnormal body temperature, tachycardia, and tachypnoe, but also thrombocytopenia, hyperglycemia, and inability to continue enteral feedings over 24 hours. This burn-specific qualification states that to diagnose SIRS in burned patients, more than 3 factors must be present [48,49]. Almost all septic patients have SIRS, but not all SIRS patients are septic. SIRS shows higher sensitivity than qSOFA and bSIRS and may therefore more accurately diagnose sepsis. Clinicians often ignore SIRS, considering it a normal reaction. Therefore, there are cases in which patients with sepsis are missed, even though the sepsis itself is progressing [46]. This corresponds with our results, where only slightly more than half were diagnosed with sepsis, while the mortality rate in the study group was 69%.

The usefulness of CRRT in burn patients experiencing septic shock is still debatable. An Italian study found that CRRT helped to preserve kidney function in burn patients with septic shock and AKI [51]. Another analysis showed that survival decreases when renal replacement therapy is necessary. A single-center study showed that the mortality rate reached 81.5% in a population of 216 burn patients treated with CRRT [50]. On the other hand, most recent studies in critically ill patients with AKI, not only burned patients, agree that CRRT initiation strategy (standard, accelerated, or delayed) has no significant impact on mortality [51,52]. The cited works show discrepancies. Future studies should explore long-term patient outcomes of CRRT among burn victims. There is a clear need for development of uniform standards of treatment, especially a consensus guidance based on research.

Study Limitations

Although the results of our study offer valuable insight into the use of continuous renal replacement therapy (CRRT) in burn patients, it is important to acknowledge several limitations that may impact the interpretation and generalization of the results. It is prone to selection bias because it was a single-center, retrospective study. Indications for CRRT were not clearly defined and the final decision was often subjective, made by the attending physician, which increases the risk of selection bias. Patients with CRRT are a highly diverse group. Regardless of the therapy itself, variations in the degree of injury, time needed to get to the burn treatment facility, volume of fluids transfused, need for intubation, early use of catecholamines or antibiotics, and prior medical issues all can have a distinct effect on the course of the patient's treatment. The ability to apply our findings to the use of CRRT is limited by this constraint.

Conclusions

We report our 10-years' experience with CRRT among severely burned patients. Age and extent of burn and inhalation injury were found to be significant predictors of survival in multivariate logistic regression analysis. We observed that burned patients requiring CRRT in the early period (up to 7 days after the burn injury) have worse prognosis. This may be due to the severity of the trauma in the early CRRT group (greater burn area and higher Baux and SOFA scores). Late CRRT is most often combined with septic complications, as sepsis was diagnosed more frequently in this group.

Prospective randomized multicenter controlled trials (RCTs) are needed to address a number of shortcomings of our retrospective study.

Declaration of Figures' Authenticity

All figures submitted have been created by the authors, who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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