Blood Purification

Blood Purif 2015;40:1–37
DOI: 10.1159/000431262

Published online: June 4, 2015

Abstracts are available online only, free of charge,
at www.karger.com/doi/10.1159/000431262

Selected Abstracts from the

33rd Vicenza Course on Critical Care Nephrology

Vicenza, June 9–12, 2015

KARGER

Basel · Freiburg · Paris · London · New York · Chennai · New Delhi ·
Bangkok · Beijing · Shanghai · Tokyo · Kuala Lumpur · Singapore · Sydney

Blood Purification

1

Association between Time to Reperfusion and Acute Kidney Injury among ST Segment Elevation Patients Undergoing Primary Percutaneous Intervention

Yacov Shacham, Eran Leshem-Rubinow, Yaron Arbel, Gad Keren, Arie Roth, Arie Steinvil

Department of Cardiology, Tel-Aviv Sourasky Medical Center Affiliated to the Sackler Faculty of Medicine, Tel-Aviv University, Tel-Aviv, Israel

Background: Time to reperfusion and acute kidney injury (AKI) are powerful prognostic markers in ST segment elevation myocardial infarction (STEMI) patients undergoing percutaneous coronary intervention (PCI), however no information to date is present regarding the association between time to reperfusion and AKI. We evaluated whether time to reperfusion predicts the risk of AKI among STEMI patients undergoing primary PCI.

Methods: Medical records of 417 patients admitted to our department between January 2006 and July 2013, for STEMI and treated with primary PCI were reviewed. Patients' were stratified by time to reperfusion tertiles and their records were assessed for the occurrence of AKI following PCI.

Results: Mean age was 61 ± 13 years and 346 (83%) were male. The cut-off points for the time to reperfusion tertiles were <120 minutes, 120–300 minutes, and >300 minutes. Patients having longer time to reperfusion had more AKI complicating the course of STEMI (3% vs. 11% vs. 13%, p = 0.007) and had significantly higher serum creatinine change throughout hospitalization (0.13 mg/dl vs. 0.18 mg/dl vs.0.21 mg/dl p < 0.001). In a multivariable logistic regression model time to reperfusion emerged as an independent predictor of AKI (OR 1.001, 95% CI 1.000–1.001, p = 0.04).

Conclusion: Longer time to reperfusion in is an independent risk factor for the development of AKI in STEMI patients undergoing primary PCI.

2

C-Reactive Protein and the Risk of Acute Kidney Injury among ST Elevation Myocardial Infarction Patients Undergoing Primary Percutaneous Intervention

Yacov Shacham, Eran Leshem-Rubinow, Arie Steinvil, Gad Keren, Arie Roth, Yaron Arbel

Department of Cardiology, Tel-Aviv Sourasky Medical Center Affiliated to the Sackler Faculty of Medicine, Tel-Aviv University, Tel-Aviv, Israel

Purpose: Elevated periprocedural high sensitive C-reactive protein (hs-CRP) have been shown to be associated with an increased risk for acute kidney injury (AKI) in non-myocardial infarction (MI) patients undergoing percutaneous coronary intervention (PCI), however no information to date is present regarding its predicting role for AKI in MI patients. The aim of the study was to evaluate whether admission serum hs-CRP levels may predict risk of AKI among ST elevation MI (STEMI) patients undergoing primary PCI.

Methods: Medical records of 562 patients admitted to our department between January 2006 and July 2013, for STEMI and treated with primary PCI were reviewed. Serum hs-CRP levels were determined from blood samples taken prior to PCI. Patients were stratified according hs-CRP tertiles. Patients were assessed for the occurrence of AKI following PCI, in hospital adverse outcomes as well as all-cause mortality up to 5 years.

Results: According to the admission hs-CRP values patients were divided into 3 groups: group 1: hs-CRP <2.1 mg/l (n = 187), group 2: hs-CRP 2.1–7.9 mg/l (n = 188) and group 3: hs-CRP >7.9 mg/l (n = 187). Patients with higher admission hs-CRP had significantly increased rate of AKI following PCI (16% vs. 6% vs. 5%, p = 0.001), more in hospital complications and higher long term mortality rate (7.6% vs. 3.2% vs. 2.0%; p = 0.01). In a multivariable logistic regression model admission hs-CRP was an independent predictor for AKI (OR 2.9, 95% CI 1.28–6.54, p = 0.01).

Conclusion: Admission serum hs-CRP is associated with an increased risk for AKI in STEMI patients undergoing primary PCI.

KARGER 125

0253–5068/15/0401–0001$39.50/0

E-Mail karger@karger.com
www.karger.com/bpu

3

Crush Syndrome – The Impact of Early Intervention on the Course of the Disease

Anda Grigane, Eva Bormane

Riga East Clinical University Hospital, Clinic of Nephrology and Renal Replacement Therapy, Latvia

Patient, 33 years old male, was brought to the hospital with Emergency Medical Service from the supermarket in Riga, where he as a rescuer had suffered from injury when the roof of this building collapsed. He had spent ~6 hours under the ruins of the building. On admission he complained about pain in both his legs and back pain. He was immediately examined in the emergency department and as there was a fluid in his abdominal cavity in US examination, the operation – explorative laparotomy – was performed without any pathological finding. Locally there was a marked tension of his left thigh muscles, skin bullae and microcirculation failure with deterioration in spite of hydration therapy.

First fasciotomies in his left thigh were done ~3.5 h after admission which included opening of the fascial spaces and partial resection of damaged muscle tissue, and following reoperations due to bleeding. ~16 h after hospitalization due to AKI with anuria, hyperkalaemia and acidosis (both metabolic and respiratory) CVC was implanted and CRRT (CVVHD) was started. The procedure was performed with a high flux dialyzer with dialysate flow 2000 ml/h, with predilution 500 ml/h without heparin anticoagulation because of the bleeding risk. Patient received CRRT for 77 h which afterwards was continued with IHD every day (for 20 days).

Gradually his renal function recovered. He had a prolonged and serious treatment in our microsurgery centre with several reoperations on his left leg, had massive transfusions of different blood components (FFP, EM, TM, cryoprecipitate). He had spent in total 2 months in a hospital and was discharged with completely normal kidney function for further rehabilitation.

Aims of Presentation

- Favourable outcome of a potentially life-threatening disease.
- The impact of early intervention on the course of the disease.

4

Peritoneal Dialysis in Treating Acute Kidney Injury on Chronic Kidney Disease with Delayed Renal Function Recovery

Hao Yan, Wei Fang, Qin Wang, Minfang Zhang, Zanzhe Yu, Zhaohui Ni

Department of Nephrology, Renji Hospital, School of Medicine, Shanghai Jiao Tong University, Shanghai, China

Objectives: This preliminary study was aimed to investigate the effect of peritoneal dialysis (PD) on outcomes of acute kidney injury (AKI) on chronic kidney disease (CKD) with delayed renal function recovery.

Methods: We analyzed the characteristics and outcomes of the patients initializing PD in our center between January 2013 and December 2014 due to AKI on CKD. Careful medical history review and comprehensive clinical investigation were performed to identify cases of AKI on CKD. Data were censored at 20th Mar 2015.

Results: A total of 11 patients were included in the study. There were 7 males, and the mean age was 56.7 ± 22.1 years. All the patients had preexisting CKD (stage 1–3). Three patients had renal biopsy and the diagnosis was Henoch-Schonlein purpura nephritis, membranous nephropathy and focal segmental proliferative glomerulonephritis, respectively. Four patients were diagnosed as ischemic nephropathy, diabetic nephropathy, ANCA-associated systemic vasculitis, and solitary kidney respectively according to clinical investigations. The underlying CKD causes of the other 4 patients were unknown. The causes of AKI included progression of primary renal disease, infections, congestive heart failure, and deep venous thrombosis. At the initiation of renal replacement therapy, serum creatinine was 832 ± 406 (range 238–1500) μmol/l; daily urine volume was 650 ± 310 (300–1200) ml; GFR was 7.7 ± 3.9 (4.0–15.5) ml/min; APACHE II score was 25.0 ± 4.6 (18–32); Charlson comorbidity score was 5.6 ± 2.1 (3–9). Temporal IHD or CRRT was performed in 6 patients before PD. All the PD catheters were inserted by open surgery technique. Two patients were taking immunosuppressive agents while they were on PD. By the end of the study, PD vintage was 180 ± 155 (10–552) days, and 7 (63.6%) patients terminated PD because of renal function recovery and 1 (9.1%) patient died. Two (18.2%) patients had catheter malposition and omental wrap and received laparoscopic reposition. Four patients experienced 4 episodes of peritonitis (peritonitis rate 1/16.5 patient-months) and all the episodes were cured.

Conclusion: PD is an effective mode of renal replacement therapy for AKI on CKD with delayed renal function recovery, while PD-related complications could be common with multifactorial reasons. Large scale and well-designed study is needed to further confirm our results.

5

The Effect of Biomarkers on the Cause of Different Diagnosis in Acute Kidney Injury Patients

Lu Ren-hua, Yan Yu-cheng, Che Miao-lin, Wang Jun-lin, Wu Qing-wei, Xu Xiao-ping, Dia Hui-li, Zhang Wei-ming, Ni Zhao-hui

Department of Nephrology, RenJi Hospital, School of Medicine, Shanghai Jiao Tong University, Shanghai, China

Objective: To investigate the value of biomarkers in diagnosing the cause and renal injury location of acute kidney injury (AKI) patients.

Methods: A total of 103 hospitalized patients with AKI were enrolled prospectively. According to the main cause of AKI, the etiology of AKI can be divided into PRE-AKI, Renal Parenchymal AKI including Acute Tubular Necrosis (ATN), Acute Glomerular Vascular injury (AGV) and Acute Interstitial Necrosis (AIN), and POST-AKI. Blood and urine samples were collected when patients were diagnosed AKI. ELISA was used to detect the concentration of urinary biomarkers including neutrophil gelatinase-associated lipocalin (NGAL), Interleukin-6 (IL-6) and IL-18. Colorimetric method was used to measure the lever of urinary N-acetyl-β-D-

Table 1. Baseline data in different cause of AKI (for Abstract 5)

	PRE-AKI (n = 34)	ATN (n = 31)	AGV (n = 15)	AIN (n = 14)	POST-AKI (n = 9)
Sex (n, %)	27 (74.9%)*, #	21 (67.7%)*, #	7 (46.7%)	5 (35.7%)	7 (77.8%)*, #
Age (years)	60.9±14.8*	55.1±23.1*	34.6±14.7	52.3±12.6*	62.2±9.5*
Baseline Scr (umol/l)	90.7±48.6	99.6±31.7	92.6±22.0	95.5±18.7	86.4±31.5
CKD (n, %)	2 (5.9%)	2 (6.5)	0 (0%)	0 (0%)	0 (0%)
Hypertension (n, %)	11 (32.4%)	10 (32.3%)	5 (33.3%)	4 (28.6%)	2 (22.2%)
Diabetic (n, %)	3 (8.8%)	4 (12.9)	2 (13.3%)	2 (14.3%)	1 (11.1)
Extra-organs failure (n, %)	28 (82.4%)	16 (51.6%)△	3 (20.0%)△	2 (14.3%)△	2 (22.2%)△
Spesis (n, %)	2 (5.9%)	6 (19.4%)△	0 (0%)	0 (0%)	0 (0%)

* vs. AGV $p < 0.05$; # vs. AIN $p < 0.05$; △ vs. PRE $p < 0.05$.

Table 2. The levels of biomarkers between different causes of AKI patients (for Abstract 5)

Biomarkers	PRE-AKI (n = 34)	ATN (n = 31)	AGV (n = 15)	AIN (n = 14)	POST-AKI (n = 9)
sCr (μmol/l)	245.44±167.59	449.83±244.95*	437.44±240.92*	462.84±325.35*	470.16±263.18*
sCysC (mg/l)	2.95 (2.51, 4.50)	3.91 (2.76, 5.53)*	3.53 (1.83, 4.58)	2.11 (1.29, 3.88)#, △	1.98 (0.91, 3.50)#, △
Urinary protein (mg/dl)	38.39±55.91#, △	96.80±135.23△	242.50±168.35	32.50±30.82△	0.00
uRBP (μg/ml)	202.38 (93.57, 237.60)	199.60 (30.23, 270.07)	215.59 (123.78, 543.10)	205.77 (55.82, 443.97)	289.34 (71.66, 607.38)
uNAG (U/l)	34.02 (21.61, 59.74)	36.75 (25.54, 59.74)	44.28 (32.51, 61.37)	31.20 (20.55, 77.78)	59.74 (30.88, 98.32)
uIL-6 (pg/ml)	0.57 (0.33, 2.20)#	2.07 (0.50, 2.20)	0.66 (0.43, 6.90)	0.46 (0.31, 1.24)#	1.68 (0.51, 5.77)
uNGAL (μg/ml)	41.77 (8.38, 157.72)	98.37 (20.92, 243.31)	19.55 (3.93, 48.31)#	20.70 (4.92, 35.91)#	23.09 (3.19, 43.64)#
uIL-18 (pg/ml)	351.62±212.11	320.94±91.0	182.87±44.33	580.29±385.81	521.10±357.15

* vs. PER $p < 0.05$; # vs. ATN $p < 0.05$; △ vs. AGV $p < 0.05$.

Table 3. The levels of biomarkers between renal parenchymal AKI patients who were diagnosed by renal biopsy (for Abstract 5)

Biomarkers	ATN (n = 10)	AGV (n = 10)	AIN (n = 9)
sCr (μmol/l)	426.73±211.0	390.78±157.59	396.56±294.95
sCysC (mg/l)	3.08 (2.43, 4.53)	3.60 (2.26, 4.00)	1.66 (0.96, 2.11)#, *
Urinary protein (mg/dl)	119.38±161.48	241.67±208.37	22.50±28.06*
uRBP (μg/ml)	240.24±45.64	298.64±262.47	161.12±154.46
uNAG (U/l)	28.21±17.48*	62.47±33.50	34.92±27.06*
uIL-6 (pg/ml)	2.58 (0.50, 5.81)	3.12 (0.44, 12.14)	0.45 (0.21, 1.14)
uNGAL (μg/ml)	97.68±87.74*	36.27±21.62	15.44±14.20#
uIL-18 (pg/ml)	147.19 (113.76, 210.51)	117.28 (92.0, 449.0)	114.90 (92.07, 153.75)

* vs. AGV <0.05; # vs. ATN $p < 0.05$.

glucosaminidase (NAG). Turbidimetry and enzymic method were applied to examine the concentration of serum Cystatin C (Cys C). The levels of biomarkers between different causes of AKI patients were compared. Area under the receiver operating characteristic (ROC) curve (AUC) in these biomarkers was used to evaluate the sensitivity and specificity in diagnosing the cause and renal injury location of AKI.

Results: Mean age of 103 hospitalized AKI patients was (54.28±19.05) years old and ratio of male to female was 1.86 to 1. The concentration of serum Cys C in PRE-AKI patients was sig-

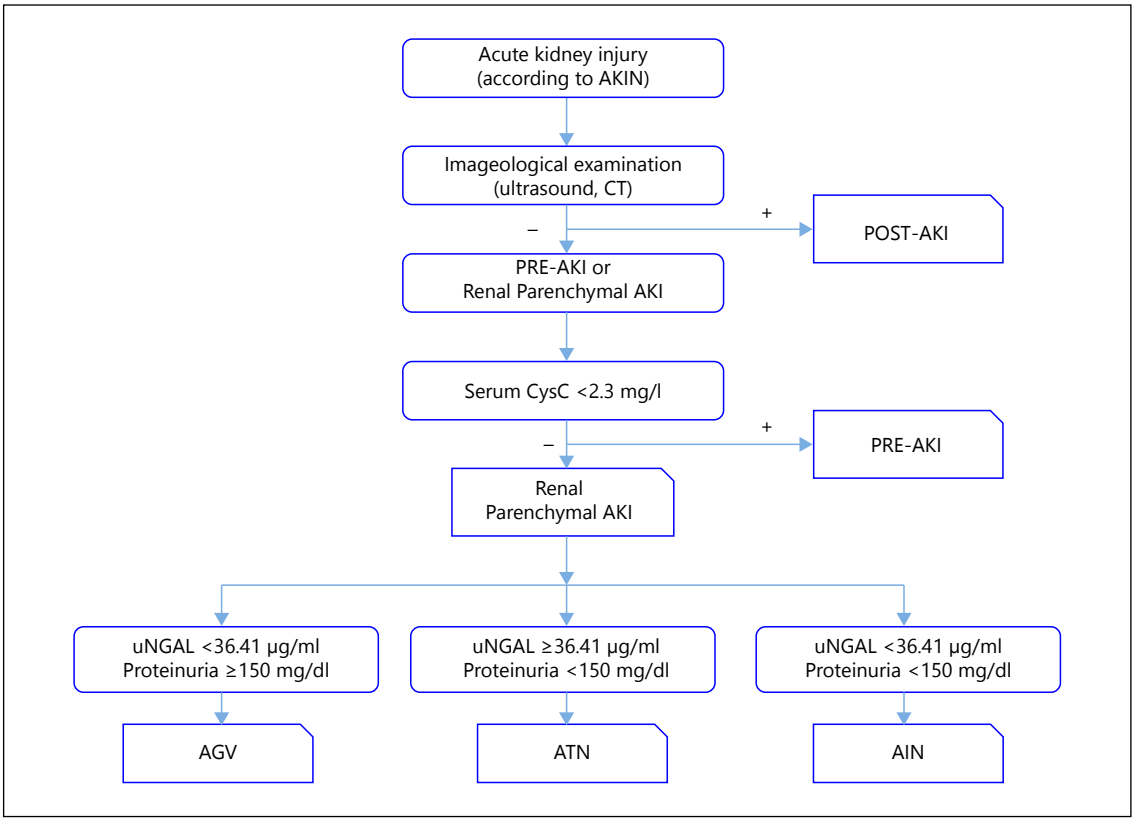


Fig. 1. The program of AKI etiology diagnosis (for Abstract 5).

nificantly lower than that of Renal Parenchymal AKI patients [2.95 (2.51, 4.50) mg/l vs. 3.85 (2.62, 5.66) mg/l, p = 0.041]. The urinary protein and IL-6 in ATN patients were significantly higher than PRE-AKI patients [96.80 ± 135.23 mg/dl vs. 38.39 ± 55.91 mg/dl, P = 0.041 and 2.07 (0.50, 2.20) pg/ml vs. 0.57 (0.33, 2.20) pg/ml, P = 0.001, respectively]. In Renal Parenchymal AKI patients, the lever of urinary protein in AGV patients was significantly higher than ATN and AIN patients (P = 0.011 and P = 0.003). Meanwhile, the concentration of urinary NGAL in ATN patients was higher than AGV and AIN patients (Both P < 0.0001). The area under the ROC curve of using Serum Cys C to diagnosis Renal Parenchymal AKI was 0.626 (95% CI 0.515–0.737, P = 0.038). The AUC of using urinary NGAL to diagnosis ATN was 0.684 (95% CI 0.563–0.806, P = 0.004). The AUC of using urinary protein to diagnosis AGV was 0.843 (95% CI 0.688–0.997, P = 0.001).

Conclusions: According to the different characteristics of biomarkers in AKI, we might be able to use biomarkers to diagnose the cause and renal injury location of AKI. More study with large samples should be done for further estimation of the results.

6
Prognostic Value of Urine NGAL (uNGAL), IL 18 (uIL18) and Urine Protein to Creatinine Ratio (prot/cr) in Critical Patients at the Admission to an Intensive Care Unit (ICU)

Marta Chicot, Diego Anibal Rodriguez-Serrano, Raquel Ferreiro, Laura Salanova, Enrique Cereijo, Carmen Bernis

CIFRA–C.Madrid, ICU, Nephrology, Biochemistry, HU Princesa, Madrid, Spain

Introduction: Acute kidney injury (AKI) in ICU remains common and tightly associated with mortality. NGAL and IL 18 are promising biomarkers for early AKI detection. However a routine biochemical parameter, the prot/cr ratio has been proposed also as a predictor for AKI and mortality.

Objective: To estimate the diagnostic accuracy of uNGAL, IL 18 and urine protein/creatinine at the admission to an adult general ICU for early detection of AKI and 30 days mortality.

Methods: We conducted a prospective observational study of 181 consecutive adult patients admitted to a general ICU (64% males, age 63.4 + 14). The study was approved by the institutional review board. AKI was defined by KDIGO criteria. Clinical information: Gender, age, cause for admission, APACHE, SAPS, Charl-

Table 1. (for Abstract 6)

	AKI (n = 35)	No AKI (n = 143)	
Age, years	68.5±12.3	62.1±15.2	P < 0.01
SAPS	49.9±18.1	32.5±15.7	P < 0.001
APACHE	23.4±9	15.6±6.8	P < 0.001
Charlson	5.5±2.3	4.2±2.5	P < 0.01
NGAL, ng/ml	410±547	106±261	P < 0.001
IL 18, ng/ml	195.7±264	103±332	P < 0.05
Pr/cr	0.65±1.2	0.59±1.7	Pns
Basal MDRD	67±21	90±28	P < 0.001

son index, need for RRT, 30 days mortality. Samples: uNGAL, u IL18, urine prot/cr ratio, at the admission in the ICU, Creatinine daily till 96 h, weekly and discharge creatinine. NGAL was done by Standardized Clinical Platform ARCHITECT assay, (Abbott Diagnostics). IL 18 was done by ELISA (Human IL-18 instant NN267). Statistical analysis: SPSS17 was used.

Results: 38 patients (21%) developed AKI, and 35 (19.3%) died. AKI patients had higher mortality (14/38, (38.8%)) vs. non-AKI (21/143 (14.6%)) p < 0.001, longer ICU and hospital length of stay.

Conclusions: Urine NGAL and IL18 at admission in ICU can predict AKI. Pr/cr at admission was not related with AKI development. AKI group had higher SAPS, APACHE and Charlson index.

7

Ebola-Virus and Glycoprotein Elimination by Lectin Affinity Plasmapheresis

S. Büttner[1]*, *B. Koch*[1]*, *O. Dolnik*[2], *M. Eickmann*[2], *T. Freiwald*[1], *S. Rudolf*[1], *S. Becker*[2], *C. Ronco*[3], *H. Geiger*[1]

[1]Medical Clinic III, Department of Nephrology, University Hospital Frankfurt, Goethe University, Frankfurt am Main, Germany; [2]Institute of Virology, Philipps University, Marburg, Germany; [3]Department of Nephrology, Dialysis and Transplantation, International Renal Research Institute of Vicenza (IRRIV), San Bortolo Hospital, Vicenza, Italy

Introduction and Aims: In severe viral diseases viraemia is associated with unfavorable outcome. Additionally enveloped viruses like Ebola, SARS, HIV and Hepatitis B/C are facilitating many of their destructive features, especially immune evasion, by shedding and secreting glycoproteins (GP). In October 2014 we treated a patient with severe Ebola Virus disease (EVD) caused by a Zaire strain (EBOV) with Lectin Affinity Plasmapheresis (LAP). LAP combines plasma separation with virus and GP capture by Galanthus nivalis agglutinin in the extracapillary spaces of the plasmafilter. We evaluated viral and GP removal by LAP.

Methods: (1) LAP was performed using the Hemopurifier® (Aethlon Medical, San Diego, US) which was incorporated in the arterial line upstream of a commercially available dialyzer within the multiFiltrate Ci-Ca® device (Fresenius Medical Care, Bad Homburg, Germany) using CVVHDF with regional citrate anticoagulation. (2) After treatment the device was examined at the National EBOV Reference Laboratory at Phlipps University in Marburg, Germany. The eluted RNA was used for reverse transcription, and quantitative real-time PCR. In addition eluates were used for SDS gel electrophoresis followed by Western blotting with anti-GP1 and anti-GP2 antibodies.

Results: LAP was performed safely on EVD day 13 (6.5 hours). The treatment was well tolerated with no adverse events. There was no clotting, hemolysis or anaphylactic reaction noted during the single 6.5 hour treatment period. As shown by Western blotting circulating GP were removed in addition to the elimination of 253,160,000 EBOV copies. The EBOV-IgG-titer did further increase after the LAP treatment, and viral load measurements during the treatment phase did show a 3-fold decrease. After day 13 the patient had improved steadily and finally fully recovered.

Conclusions: Here we describe for the first time the successful use of the Hemopurifier® in the treatment of severe EVD in a critically ill patient and provide a proof of concept for Ebola virus capture. Additionally we showed that LAP also addresses GP. This data warrants further examination of LAP in diseases caused by enveloped viruses.

8

Acute Kidney Injury in Neurocritical Care – Risk Factors, Impact and Outcome

B. Koch[1], *A. Stadler*[1], *F. Finkelmeier*[2], *C. Mayer*[3], *H. Geiger*[1], *O. Jung*[1], *S. Büttner*[1]

University Hospital Frankfurt, Goethe University, [1]Medical Clinic III, Department of Nephrology, [2]Department of Neurosurgery, [3]Department of Neurology, Frankfurt am Main, Germany

Background: Acute kidney injury (AKI) is a severe complication in medical and surgical intensive care units (ICU) accounting for their patients' high morbidity and mortality. Incidence, risk factors and prognostic impact of AKI are well established in this setting. Data concerning the neurocritically ill patient are lacking. The aim of this study was to determine the incidence of AKI and identify risk factors in this special population.

Methods: Patients admitted to a neurocritical care unit (NCCU) at our hospital between 2005 and 2011 with a stay above 48 hours were analyzed retrospectively for incidence, cause, impact and outcome of AKI (AKIN stage ≥2).

Results: Within 7 years 681 patients were included (mean age 60.7 ± 15.8 years, 55.4% male). Most frequent diagnosis was intracerebral hemorrhage (48.5%) followed by cerebral neoplasm (14.5%) and ischaemic stroke (14.2%). Except for stroke, none of the underlying diseases were associated with AKI. Chronic renal failure (CKD) was known in 57 patients (8.4%). AKI incidence was 11.6%. Conservative treatment was sufficient in 43 patients (54.4%). 36 patients (45.6%) developed dialysis dependent AKI. Sepsis was the main cause of AKI (>50%). Independent risk factors for AKI were CKD (OR 12.65; 95% CI 6.34–25.24; p < 0.0001), infection (OR 2.84; 95% CI 1.12–7.17; p = 0.027) and nephrotoxic medication (OR 2.10; 95% CI 1.17–3.76; p = 0.013). Surgical intervention or contrast medium were not associated with NCCU AKI. 2 patients (5.6%) did not recover from AKI. Risk of dying corre-

lates with severity of AKI (no AKI 13.3%, conservative treatment 28%, hemodialysis 50%). Dialysis dependent AKI increased the odds for dying (OR 4.51; 95% CI 1.50–13.50; p = 0.007).

Conclusion: Despite a different spectrum of underlying diseases causes and course of AKI in the setting of neurocritical follows known rules. The main cause for AKI in this setting is sepsis, frequently caused by ventilator associated pneumonia, and is associated with a high mortality. Interestingly exposure to contrast dye is not associated with AKI in this setting.

9

Acute Kidney Injury (AKI) in the Elderly

Dharshan Rangaswamy, K.R. Nishanth, Ravindra A. Prabhu, Aswani S. Mareddy, Shankar P. Nagaraju

Kasturba Medical College, Department of Nephrology, Manipal, India

Introduction and Aims: The elderly are at increased risk for acute kidney injury (AKI) due to decreased renal reserve and comorbidities. We studied the etiology, course and outcome of AKI in the elderly at a tertiary center in India.

Methods: After approval from institutional ethics committee a prospective study of elderly (age ≥60 years) patients with AKI as per RIFLE (Risk, Injury, Failure, Loss of kidney function, End stage renal disease) criteria was done over one year. Patients were followed up till renal recovery or for 3 months after discharge. Chronic kidney disease (CKD) stage 5 was excluded. Where not available baseline serum creatinine was calculated using the standard MDRD formula assuming baseline glomerular filtration as 75 ml/min/1.73 m^2. Data was analyzed on SPSS version 16 with percentage comparison using chi square and means by student t test (p value <0.05 significant).

Results: Of 124 elderly patients with AKI, baseline characteristics are shown in table 1 and etiological distribution in figure 1. Most i.e. 75 (60.5%) were in Failure category of RIFLE. Tropical infections in 25 (19.8%) and sepsis in 24 (19%) were the commonest causes of AKI. True hypovolemia in 20 (16.1%) was the main cause of prerenal AKI. Complications and outcomes are as per table 2. The commonest complication was metabolic acidosis in 76 (61.2%). Complications, requirement of renal replacement therapy and intensive care, and mortality was significantly higher in Failure category (p < 0.05). On univariate analysis, risk factors associated with high mortality were oliguria at presentation, uncompensated metabolic acidosis, presence of multiorgan dysfunction (MODS), hospital acquired AKI and age ≥75 years. On multivariate analysis uncompensated metabolic acidosis and age ≥75 years were significant risk factors for mortality. Of those who recovered 7 (5.6%) had CKD on follow up.

Conclusion: AKI in elderly in India is most commonly due to intrinsic renal causes resulting from sepsis or tropical infections and usually presents in RIFLE Failure category. Common complications are metabolic acidosis and hyperkalemia with an increase in complications with severity of RIFLE class. Increasing age and uncompensated metabolic acidosis are risk factors for mortality with about 5.6% progressing to CKD.

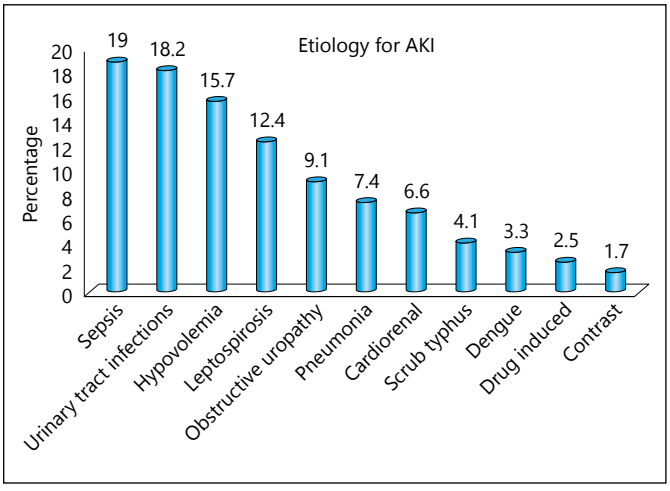


Fig. 1. (for Abstract 9).

Table 1. Baseline characteristics as per RIFLE criteria (for Abstract 9)

Characteristics	Total (%)	Risk (%	Injury (%)	Failure+ (%)	p value
Number	124	7 (5.6)	42 (33.9)	75 (60.5)	
Age (years)*	69.6±7.6	73.5±5.85	68.5±6.6	70.1 ±8.27	0.23
Male gender	80 (64.5)	3 (42.9)	31 (73.8)	46 (61.3)	0.162
Preexisting Chronic kidney disease	16 (12.9)	2 (28.6)	5 (11.9)	9 (12)	0.461
Sr. Creatinine at admission (mg/dl)*	3.60 ±1.88	1.9±0.81	2.26±0.33	4.55±0.25	0.000
Intensive care requirement	57(46)	0 (0.00)	20 (47.6)	37 (49.3)	0.041
Co-morbidities	35 (28.2)	7 (100)	30 (71.4)	51 (68.2)	0.017
Multiorgan dysfunction	49 (39.5)	0 (0.00)	12 (28.6)	37 (49.3)	0.01
Oliguria	53 (42.7)	0 (0.00)	14 (33.3)	39 (52)	0.016

*Mean ± SD. + In failure category two progressed to loss and one progressed to end stage renal disease.

Table 2. Complications and outcome as per RIFLE criteria (for Abstract 9)

	Total (%)	Risk(%)	Injury(%)	Failure(%)	p value
Number of patients	124	7	42	75	
Hyperkalemia	69 (55.6)	0 (0.0)	15 (35.7)	54 (72)	0.014
Metabolic acidosis	76 (61.2)	0 (0.0)	18 (42.8)	58 (77.4)	0.044
Volume overload	37 (29.8)	1 (14.3%)	10 (23.8)	26 (36.1)	0.124
Uremic encephalopathy	38 (30.6)	0 (0.0)	8 (19)	30 (40.0)	0.001
Requirement for HD	43 (34.7)	1 (14.3)	6 (14.3)	36 (48.0)	0.010
Mortality at 3 months	33 (26.6)	0 (0.0)	9 (21.4)	24 (32)	0.046

10

High Cut-Off Hemodiafiltration for Myoglobinuric AKI in the ICU

Vladimir Premru, Jakob Gubenšek, Bojan Knap, Andreja Marn, Rafael Ponikvar

University Medical Center Ljubljana, Slovenia

Dialytic removal of middle-molecular toxins such as myoglobin from the circulation in rhabdomyolysis patients with myoglobinuric acute kidney injury (Mb-AKI) can be greatly enhanced by the use of high cut-off (HCO) membranes. The impact of such treatment on clinical outcomes of Mb-AKI has not been demonstrated. We report here on our 4-year experience with high cut-off haemodiafiltration procedures (HCO HDF) in the treatment of Mb-AKI in the intensive care unit (ICU).

In this period, 46 ICU patients (39 male, 7 female) with Mb-AKI were treated with HCO HDF (18 in the cardiovascular surgery, 10 in other surgical ICU, 16 in the internal medicine ICU, and 2 in the infectious disease ICU). Mean age of the patients was 57 (range 91.7–13.9) years. According to diagnoses, patients had on average 3.1 acute disorders, and AKI was mostly multifactorial with rhabdomyolysis playing a dominant role. Main causes of Mb-AKI were abdominal aorta surgery for dissection/aneurysm in 10 patients, peripheral artery occlusion/surgery in 6, coronary bypass surgery in 2, acute myocardial infarction in 2, and late post heart-transplant complications in 2, massive pulmonary embolism in 2, multiple trauma in 4, abdominal surgery in 3, primary sepsis in 3, non-traumatic crush in 9, burns and uterine rupture in 1 patient each. Eighty-seven HCO HDF were performed. On average, each patient had 1.9 (range 1–6) HCO HDF procedures, mostly followed by 4.7 (range 0–26) conventional HD procedures in the next 10 (range 1–61) days. Only 3 procedures were performed with heparin anticoagulation, and the rest with regional citrate. Line clotting occurred twice. A mean reduction ratio of 0.77 was achieved for myoglobin in the mean procedure duration of 7.5 hours. Blood electrolytes and acid-base balance were reasonably well maintained with adjustments of the dialysis fluid/infusate composition. Albumin loss in dialysate was replaced within the procedure by i.v. albumin infusion, mean blood albumin levels increasing slightly from 26.3 g/l to 28 g/l (NS). Mean blood pressure (BP) lowered during the procedure, and returned to slightly higher than initial levels thereafter. BP was low already at the start in 23 procedures. Hypotension lower than 100 mm Hg systolic BP was observed in the mid-course of 46 procedures, and at the end in 15 procedures. Five patients experienced circulatory failure and disturbed ventricular rhythm during the HCO HDF, of whom 2 died after unsuccessful resuscitation. Eight others died within the following 24 hours. These deaths were considered to be the consequence of extreme vulnerability of these patients and not related to the procedure. Ten other patients died later (2–66 days, mean 8 days from the start of HCO HDF) while still dialysis dependent. Six others died dialysis-free at 5 to 64 days, mean 37 days from the start. Overall, 26 patients (56.5%) died. Multi-organ failure was common, and half of the deaths was attributed to sepsis. Only 8 of the 26 cardiovascular (surgical and non-surgical) patients with Mb-AKI survived. Among 9 other surgical patients 6 survived. None of the 3 patients with primary sepsis survived. Contrary to that, 7 of the 10 patients with the (more isolated) non-traumatic crush survived. During an average 28 days in the ICU, 8 of the 20 survivors completely regained their renal function, 7 had considerable residual kidney injury, and 5 were still dialysis dependent.

Our observations are in agreement with most published data, confirming that though technically efficient and feasible, HCO HDF had no apparent impact on the outcome of ICU patients with rhabdomyolysis and AKI in the context of multiple vital derangements.

11

Rescue Ultrafiltration in Acute Heart Failure Hospitalizations

P. Klin[1], *L. Gutierrez*[2], *C. Zambrano*[1], *F. Zeppa*[1], *A. Bilbao*[1], *F. Klein*[3], *P. Raffaele*[2]

[1]Intensive Care Telemetry Unit, [2]Nephrology, Dialysis and Renal Transplantation Unit and [3]Intensive Care Unit, University Hospital, Favaloro Foundation, Buenos Aires, Argentina

Loop diuretics (LD) are considered the mainstay treatment for patients (P) hospitalized for acute decompensated heart failure (ADHF). Despite pharmacologic treatment, a substantial proportion of P do not achieve negative fluid balance during hospitalization. Ultrafiltration (UF) has been proposed for negative fluid balance in this setting to relieve pulmonary and systemic congestion, but emphasis has been put in comparing UF as pre-emptive ther-

apy with LD, while rescue UF (R-UF) strategy has not been fully addressed.

Aims: We sought to assess prevalence and impact of R-UF on outcome in P admitted for NYHA class III/IV ADHF.

Methods: R-UF was indicated in P with persistent fluid overload refractory to medical therapy with LD, IV vasodilators and inotropic challenge with clinical signs of hypoperfusion and least one of the following: severe ventricular dysfunction or pulmonary hypertension or new organ failure development.

A total of 652 consecutive P admitted for ADHF between July 2011 and April 2015 were included in the analysis. R-UF was considered in P who developed Diuretic Resistance (RESIST) under optimal treatment. Demographic and clinical variables were compared according to R-UF indication. In-hospital and 180-day outcomes were reported for both groups. P under chronic dialysis and those who received a heart transplant were excluded from this analysis.

Results: Although a total of 62 P (9.8%) developed RESIST, R-UF was indicated in 22 P (3.4%). Although both groups did not differ in terms of gender o previous cardiac disease, R-UF P were younger (65 ± 14 vs. 72 ± 14 years old; p = 0.03); had more frequently diabetes mellitus (50 vs. 28.2%; p = 0.03), anemia (83 vs. 39%; p < 0.001) and previous chronic kidney disease CKD) (71 vs. 31%; p < 0.001). They received higher Furosemide dose previous to admission (80 vs. 51 mg/day; p < 0.001).

Clinical evidences of hypoperfusion (28 vs. 9%; p = 0.01) and right-sided heart failure at admission (47 vs. 25%; p = 0.03) were more frequent in R-UF. These P had lower blood pressure (113 vs. 137 mm Hg; p = 0.01) and serum sodium levels at baseline (133 vs. 136 mEq/L, p = 0.04). Admission serum creatinine (2.4 vs. 1.2, p < 0.001) and urea (102 vs. 58 mg/dl, p < 0.001) were higher in P who received R-UF. There were no differences in BNP levels (p = NS). Neither type of cardiac disease, left ventricular ejection fraction nor liver function tests differed between groups (p = NS). R-UF had higher right ventricular systolic pressure (55 vs. 47 mm Hg; p = 0.02) and central venous pressure (17 vs. 12 mm Hg, p = 0.01).

In-hospital events as worsening heart failure (36 vs. 15%, p = 0.01), need for inotropic support (59 vs. 15%; p < 0.001) and prolonged length of stay (LOS) >7 days (72 vs. 36%; p = 0.001) were more frequently observed in R-UF. LOS was longer (12 vs. 7 days; p < 0.001). Chronic dialysis was frequently observed in R-UF survivors (46%) at discharge.

In-hospital mortality (36 vs. 9.4; p = 0.001; OR 5.3; 95% CI 2.2–13) and 6-month mortality (45 vs. 25%; p = 0.04; OR 2.4; 95% CI 1.02–5.7) were higher in R-UF, but early and 6-month readmission rates did not differ at 180-d (p = NS for both).

Previous CKD (Wald 7.9; HR 4.7; 95% CI 1.6–14; p = 0.005), Anemia (Wald 9.7; HR 7.8; 95% CI 2.1–28; p = 0.002) and Inotropic requirements (Wald 11.8; HR 6.2; 95% CI 2.2–17; p = 0.001) were independent predictors of R-UF development.

Conclusion: Near thirty percent of P develop Diuretic resistance during ADHF admissions and may beneficiate from rescue UF. It identified a subset of P with poorer outcome, including a greater event rate during admission, early and mid-term mortality.

Previous CKD, Anemia and hemodynamic instability independently predicted Rescue UF need in ADHF hospitalizations.

12

Cardiorenal Syndrome in Acute Decompensated Heart Failure: How Valuable Is Each Ingredient?

Pablo Klin[1], *Luis Gutierrez*[2], *Carola Zambrano*[1], *Federico Zeppa*[1], *Luis Varela Falcón*[1], *Andrés Bilbao*[1], *Francisco Klein*[3], *Pablo Raffaele*[2]

[1]Intensive Care Telemetry Unit, [2]Nephrology, Dialysis and Renal Transplantation Unit, [3]Intensive Care Unit, Favaloro Foundation, Buenos Aires, Argentina

Introduction and Aims: Cardiorenal syndrome (CRS) is considered a serious and prevalent event in acute decompensated heart failure (ADHF) setting. Current accepted definition is an increase in serum creatinine (SCr) ≥0.3 mg/dl during ADHF hospitalization. However, improving renal function and diuretic resistance seem to be expression of renal damage, too. We sought to assess prevalence and impact of these three variables of CRS on outcome in P admitted for NYHA class III/IV ADHF.

Methods: Based on serum creatinine changes and diuresis, three variables were identified: creatinine increase ≥0.3 mg/dl (INCREASE) or decrease ≥0.3 mg/dl (DECREASE) or diuresis resistance (DR). CRS was diagnosed when one of the previous 3 criteria was reached. DR was diagnosed when urine output adjusted by mg of IV furosemide was below pre-established value. CRS different variables were analyzed separately. Demographic, clinical and biochemical data were recorded. In-hospital and 6 month mortality, readmission and combined death or readmission rates were analyzed for each criterion.

Results: A total of 710 consecutive P were admitted due to ADHF between July 2011 and April 2015. Mean age was 70 ± 16 years old, while 58% were males. Previous renal dysfunction was present in 31%, diabetes in 28%, hypertension in 70%. INCREASE, DECREASE and DR were identified in 31.5, 16.9 and 9.4%, respectively.

DR identified different short and mid-term mortality populations (in-hospital mortality: 51.6 vs. 22.3%; OR 3.7; 95% CI 2.2–6.3; p < 0.001 and 6-month mortality: 35.9 vs. 7.6%; OR 6.8; 95% CI 3.7–12.3; p < 0.001). DECREASE tended to identify populations with different readmission risk (26.7 vs. 19.4%; OR 1.51; 95% CI 0.95–2.4; p = 0.08). All evaluated criteria predicted combined death or readmission end point: INCREASE (45.1 vs. 37.2%; OR 1.39; 95% CI 1.001–1.92; p = 0.05), DR (65.6 vs. 36.8%; OR 3.2; 95% CI 1.9–5.6; p < 0.001) and DECREASE (49.1 vs. 37.8%; OR 1.67; 95% CI 1.2–2.2; p = 0.001).

Conclusion: CRS was frequent in ADHF admissions and strongly related to poor prognosis. Optimal outcome discrimination may not be reflected by individual CRS diagnostic criteria. Only diuretic resistance identifies short and mid-term mortality. All three criteria predicted death or readmission.

13

Cardiorenal Syndrome in Acute Decompensated Heart Failure: A Recipe for the Unmet Needs ?

Pablo Klin[1], *Luis Gutierrez*[2], *Carola Zambrano*[1], *Federico Zeppa*[1], *Luis Varela Falcón*[1], *Andrés Bilbao*[1], *Francisco Klein*[3], *Pablo Raffaele*[2]

[1]Telemetric Intensive Care Unit, [2]Nephrology, Dialysis and Renal Transplantation, [3]Intensive Care Unit, University Hospital, Favaloro Foundation, Buenos Aires, Argentina

Admissions for acute decompensated heart failure (ADHF) adversely affect patient (P) prognosis. In this population, renal dysfunction (RD) is an already known predictor of poor outcome.

Aims: According to our daily practice, we propose a new classification for cardiorenal syndrome (CRS) based on pathophysiological mechanisms of renal injury and heart failure phenotype. Linking renal and heart dysfunctions mechanisms might aid in clinical decision making.

Methods: CRS was defined as an increase or decrease of serum creatinine ≥0.3 mg/dl from baseline, or diuretic resistance. CRS was classified in 3 groups due to:

A) Renal ischaemia, caused by hypoperfusion; B) secondary to right-sided heart failure and an increased intra-abdominal pressure (IAP); C) intra-renal damage secondary to aggressive diuresis or modification of intra-renal hemodynamics (early initiation of renin-angiotensin-aldosterone inhibitors). Those P with length of stay (LOS) below 2 days, who received a Heart transplant and those under chronic Dialysis were excluded from this analysis.

Results: A total of 720 consecutive P were admitted between July 2011 and April 2015. RD was detected in 30.7% p at admission, while 69% were hypertensive, 27% diabetics and 35% had atrial fibrillation. A total of 30% of P were octogenarians. According to our CRS definition, 45% developed CRS: 12% corresponded to type A, 38% to type B and 50% to type C. Hospital mortality was 10.5%.

Group A had lower left ventricular ejection fraction (27 vs. 40%; $p = 0.002$), more frequently admitted with anemia (57 vs. 38%; $p = 0.02$), corresponded to idiopathic cardiomyopathy (30 vs. 8.7%; $p < 0.001$) and had signs of hypoperfusion at admission (62 vs. 11%; $p < 0.001$). Diuretic resistance (55 vs. 6%; $p < 0.001$) and worsening heart failure (55 vs. 15%; $p < 0.001$) were more frequent in this group. Accordingly, these P often received inotropic drugs (84 vs. 20%; $p < 0.001$) and rescue ultrafiltration (26 vs. 2.1%; $p < 0.001$). Additionally, type A tended to require chronic dialysis during follow up (p = NS). These P had the highest length of stay (LOS) (15 vs. 6 days; $p = 0.02$), in-hospital mortality (39.5 vs. 8.6%; OR 6.9; 95% CI 3.4–14; $p < 0.001$) and early readmission rates (62 vs. 22%; OR 6; 95% CI 1.35–26; $p = 0.02$).

Group B had prior RD (59 vs. 26%; $p < 0.001$), cholestasis (90 vs. 80%; $p = 0.02$), lower T3 at admission (0.62 vs. 0.74 mg/dl; $p < 0.001$), right-sided heart failure (35 vs. 23%; $p = 0.01$), elevated IAP at admission (88 vs. 58%; $p = 0.01$) and tended to develop severe hyponatremia (<125 mEq/L) during hospitalization (18 vs. 9.6%; $p = 0.13$). These P had the highest 6-m readmission rate (27.5 vs. 19%; OR 1.6; 95% CI 1.02–2.5; $p = 0.04$).

Finally, group C identified older (74 vs. 68 years old; $p < 0.001$), hypertensive P (systolic arterial pressure at admission 144 vs. 130 mm Hg; $p < 0.001$). This group had the lowest in-hospital mortality (5.6 vs. 11.6%; OR 0.45; 95% CI 0.22–0.92; $p = 0.02$).

There were no differences in admission doses of Furosemide (p = NS), while group A had the highest at discharge (64.6 ± 26 vs. 45 ± 27 mg/day; $p = 0.02$) and C the lowest (49 ± 27 vs. 59 ± 37 mg/d; $p = 0.01$).

Conclusion: The classification identified 3 different groups with distinctive clinical features and prognosis. Identifying a link between renal and cardiovascular dysfunctions might aid in decision making. Considering CRS as a retrospective diagnosis, recognition of different mechanisms that lead to renal dysfunction in ADHF would allow early implementation of personalized therapies to improve adverse prognosis.

14

Peritoneal Ultrafiltration for Refractory Fluid Overload and Ascites Due to Pulmonary Arterial Hypertension

F. Husain-Syed[1,2], *M.J. Muciño-Bermejo*[2], *C. Ronco*[2], *S. Lopez-Giacoman*[2], *L.I. Bonilla* [2], *S. De Rosa*[2], *S. Samoni*[2], *W. Seeger*[1], *H.W. Birk*[1]

[1]Department of Internal Medicine II, Division of Nephrology and Intensive Care Medicine, University Clinic Giessen and Marburg (UKGM) – Campus Giessen, Giessen, Germany, [2]Department of Nephrology, Dialysis and Transplantation, International Renal Research Institute of Vicenza (IRRIV), San Bortolo Hospital, Vicenza, Italy

Removal of fluid overload is a demanding challenge in the management of severe pulmonary hypertension (PH) and congestive hepatopathy in patients with ascites and diuretic resistance. Venous congestion and ascites-induced increased intra-abdominal pressure are essential in progression to chronic kidney disease, recurrent hospitalization, morbidity and mortality. Patients with PH present strong hemodynamic fluctuations having a narrow window for fluid balance, as extremes can be associated with worsened renal and right ventricular function. In addition to that, many patients with PH cannot tolerate extracorporeal ultrafiltration. Peritoneal dialysis (PD), a well-established, hemodynamically tolerated treatment for outpatients may be the best option to control fluid status, even in non-end stage renal disease.

We present the case of a patient hospitalized for over 3 months due to ascites induced refractory volume overload with the need of IV diuretics and daily chronic renal replacement therapy, finally treated with peritoneal ultrafiltration (PUF). We report the treatment benefits on fluid balance, cardiorenal and pulmonary function, as well as its safety. In conclusion, we report a case in which PUF was an efficient treatment option for refractory ascites in patients with PH and congestive hepatopathy.

15

Successful Management of Severe Hypernatraemia, Rhabdomyolysis and Acute Kidney Injury with Hyper-Osmolar Dialysate Solutions in Continuous Renal Replacement Therapy

M. De Francesco[1], *M. Conti*[2], *S. Pianca*[1], *P. Merlani*[2], *K. Schönholzer*[1]

[1]Division of Nephrology and Dialysis, Department of Internal Medicine, Civic Hospital of Lugano, Lugano, Switzerland; [2]Intensive Care Unit, Department of Intensive Care Medicine, Civic Hospital of Lugano, Lugano, Switzerland

Severe hypernatremia causes hyperosmolarity and cellular dehydration developing clinical manifestations as nausea, vomiting, muscle weakness, irritability and lethargy which can progress to confusion, coma and even death [1]. Rhabdomyolysis is a life-threatening condition characterized by muscle necrosis and leakage of muscle constituents into the plasma and it may lead to acute kidney injury (AKI).

We report a case of severe hypernatraemia associated with rhabdomyolysis and AKI treated by continuous renal replacement therapy (CRRT).

A 69-year-old woman, was admitted at our emergency room for an altered level of consciousness. She was found on the floor of her home by the rescue team and probably she had poor oral fluid intake in the last few days.

In the medicine intensive care unit 0.9% sodium chloride was initially given intravenously for hydration and to correct slowly hypernatremia. The serum sodium level increased from 179 mmol/l to 183 mmol/l in the first 12 h, most likely due to decreased urine output up to anuria complicated with hyperkalemia and metabolic acidosis. In order to gradually correct sodium concentration, we decided to start CRRT. We chose CVVHD as renal replacement modality to correct hypernatremia by diffusion. We used a Multifiltrate-System extracorporeal blood circuit (Fresenius Medical Care, Bad Homburg, Deutschland), a hemofilter Ultraflux® AV1000S (Fresenius Medical Care, Bad Homburg, Deutschland) with high membrane area (2.1 m^2), across a 12.12-Fr dual lumen catheter placed in the right femoral vein. The blood flow rate was 150 ml/min and the dialysate flow rate was 1500 ml/h. Initially, commercial solution for CVVHD, Multibic® (Fresenius Medical Care, Bad Homburg, Deutschland) with sodium concentration of 140 mmol/l was adjusted by adding 11.7% sodium chloride. We obtained a sodium concentration of 178 mmol/l in the dialysate solution. The serum sodium level decreased from 183 mmol/l to 176 mmol/l after 12 hours CVVHD treatment. During the first 48 hours we performed CVVHD sessions for 8 h daily in order to achieve a gradual reduction of osmolality.

Successively, we extended the time of CRRT and we adjusted sodium concentration in the dialysate solution with a 4 mmol/l targeted reduction of sodium concentration every 12 h. This resulted in progressive and slow correction of hypernatremia 9 days later (fig. 1), according to current standard recommendations [2], without the development of cerebral edema or neurological sequelae. The choice of CVVHD as treatment modality in this case has been also due to the objective of reducing albumin loss, related to an higher mortality risk in intensive care patients [3].

CVVHD with high cut-off could be considered a feasible strategy treatment of severe hypernatremia in patients suffering from oliguric or anuric AKI who cannot tolerate intermittent hemodialysis [4]. In accord with other recent reports [5], this treatment solution can be efficacy also in rhabdomiolysis; in this clinical context, CVVHD with high cut-off filter and high membrane area can be a successful therapeutic compromise between maximal myoglobin removal, minimal albumin loss and diffusive correction of hypernatremia.

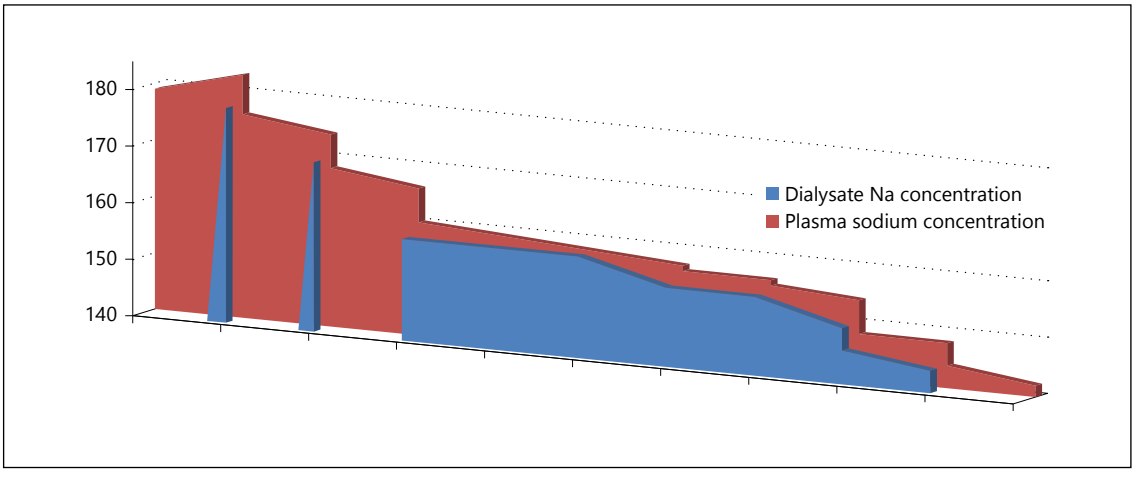


Fig. 1. Plasma sodium concentration (red) and dialysate sodium concentration (blue) during CVVHD in the time (for Abstract 15).

References

1 Arieff AI: Central nervous system manifestations of disordered sodium metabolism. Clin Endocrinol Metab 1984;13:269–294.
2 Bagshaw SM, et al: Disorders of sodium and water balance in hospitalized patients. Can J Anesth 2009;56:151–167.
3 Jellinge ME, Henriksen DP, Hallas P, Brabrand M: Hypoalbuminemia is a strong predictor of 30-day all-cause mortality in acutely admitted medical patients: a prospective, observational, cohort study. PLoS One 2014;9:e105983.
4 Ostermann M, et al: Management of sodium disorders during continous haemofiltration. Crit Care 2010;14:418.
5 Buyun WU, Dehua GONG, Daxi JI, Bin XU, Zhihong LIU: Clearance of myoglobin by high cutoff continuous veno-venous hemodialysis in a patient with rhabdomyolysis: a case report. Hemodial Int 2015;19:132–145.

16

Epidemiology, Risk Factors, Clinical Outcomes and Role of Urinary Neutrophil Gelatinase-Associated Lipocalin (uNGAL) in Patients with Type 1 Cardiorenal Syndrome (CRS1): A Prospective Study from a Developing Country

Rajeevalochana Parthasarathy, Dharshan Rangaswamy, Ravindra A. Prabhu, Shankar P. Nagaraju

Kasturba Hospital, Department of Nephrology, Manipal University, India

Introduction and Aims: Acute cardiac dysfunction precedes a decrease in kidney function and progression of kidney disease in CRS1. Conversely, renal dysfunction is a potent predictor of cardiovascular complications and mortality. We conducted a prospective study to determine the incidence, risk factors and short term mortality (within 3 months) of CRS1 and to study the role of uNGAL and uNGAL to creatinine ratio as an early biomarker in predicting CRS1.

Methods: A prospective observational cohort study was carried between January-June 2013. All consecutive patients admitted with Acute coronary syndrome (ACS) and/or Acute decompensated heart failure (ADHF) were studied at admission and till 3 months or death. Standard demographic, clinical, physiological and complications data was recorded. Random urine samples of 105 consecutive patients at admission were analyzed by Biovendor ELISA for uNGAL and urine creatinine by Jaffe method. AKI was classified based on serum creatinine levels, as proposed by the KDIGO Criteria. ACS was further categorized as ST segment elevated myocardial infarction (STEMI), non STEMI and unstable angina. KILLIP classification was used to categorize patients with heart failure. Patents <18 years, known malignancies, sepsis, urinary tract infection, chronic kidney disease (CKD) stage 5 and patients with chronic heart failure were excluded. Data was analyzed on SPSS version 16. Cox regression analysis was used to evaluate the independent correlates of AKI. Hospital survival rate was calculated using the Kaplan-Meier method. Two-tailed p values <0.05 were considered statistically significant.

Results: Of 235 patients who were included in the study 146 (62%) developed CRS1. Patients who developed CRS1 were older 62.9 ± 13.8 years (p = 0.001) with preexisting diabetes, prior diuretic use and an ejection fraction of <50% on ECHO. Patients with ADHF (73%) had higher incidence of CRS1 compared to patients with ACS (58.4%), however it was not statistically significant (p = 0.243). Among ACS, patients with NSTEMI had a higher incidence of CRS1 (p = 0.04). The median day (interquartile range) for development of AKI was 1 (0–12), with 37.7% patients requiring renal replacement therapy (RRT). CRS1 patients on RRT had a high mortality rate (69%), with no significant difference in outcomes based on the modality of RRT. On Cox regression analysis, a higher KILLIP score, preexisting CKD, hyponatraemia, hypoalbuminaemia, inotropic requirement and eGFR <60 ml/min at presentation were independent risk factors for development of CRS1. Duration of hospital stay, eGFR and mortality at the end of 3 months was significantly higher in patients with CRS1 (38.3% v/s 10.1%, p = 0.001). The area under the receiver operating characteristics curve for the absolute values of uNGAL and uNGAL to creatinine ratio was 0.675 and 0.72 respectively. The absolute NGAL values or NGAL to creatinine ratio at admission are not sensitive biomarkers in predicting CRS1 in our setting. uNGAL to creatinine ratio and not an absolute value of uNGAL could significantly predict in hospital and short term mortality at 3 months (p = 0.036) and had a good correlation with the recovery of AKI (p = 0.035).

Conclusion: Incidence of CRS1 in India is very high with an increased mortality among patients requiring RRT. Higher KILLIP class at presentation and NSTEMI were associated with an increased incidence of CRS1. uNGAL or NGAL to creatinine ratio is not a sensitive marker in predicting the development of CRS1.

17

Effectiveness of the Palindrome Tunneled Catheter in Achieving an Adequate Diffusive and Convective Dialysis Doses: A 3 Year Single-Center Prospective Study

M. Montomoli[1], *P. Molina*[1], *B. Vizcaíno*[1], *S. Beltrán*[1], *C. Castro*[1], *M. González-Moya*[1], *J.L. Górriz*[1], *L.M. Pallardó*[1], *F. Maduell*[2]

[1]Dr. Peset University Hospital, Valencia, Spain; [2]Clinic University Hospital, Barcelona, Spain

Objective: Acute Kidney Injury (AKI) without renal function recovery is one of the leading causes of beginning of dialysis with permanent tunneled catheter as vascular access, until the creation and maturation of native arteriovenous fistula (AVF). In addition to major complications as thrombosis or infection, the poor function of the catheter due to flow and recirculation problems is one of the main cause of unplanned catheter removal, This issue is often managed increasing the length of dialysis sessions for achieving adequate dialysis dose. As opposed to usual HD catheters with a staggered tip design, Palindrome catheters (PC) have a symmetric tip design, providing better flow rates and lower risk of recirculation even if reversal of the lumens is performed to correct inad-

Table 1. (for Abstract 17)

Parameters	AVF (n = 7,888)	PC (n = 1,628)	p
Recirculation rate (%)	13±4	16±9	0.083
Qb achieved (ml/min)	368±33	338±39	<0.001
PA (mm Hg)	–183±49	–221±36	<0.001
PV (mm Hg)	154±35	176±33	<0.001
Kt (l)	60.2±6.8	55.7±7.1	<0.001
% Kt >45 l	98%	93%	<0.001
Convective volume (l)	27.1±4.0	22.5±4.3	<0.001
% Conv. vol. >18l	98%	90%	<0.001

equate inflow. The present study assessed the effectiveness of the Palindrome catheter compared to AVF in achieving adequate dialysis dose in a 4-hour HD session regimen.

Methods: This single-center, prospective, observational, non-inferiority study enrolled all HD subjects with PC (n = 23) or AVF (n = 44), attending our Unit from January 2012 to December 2014 with a 4-hour thrice weekly HD regimen. Patients with other tunneled cuffed catheter or other HD regimen were excluded. Primary outcomes were the measurement of recirculation rate and the proportion of HD sessions which a goal of Kt of at least 45L, and an effective convective volume of at least 18L, with each one of the different vascular access. Recirculation rate and Kt were assessed in every session of dialysis by thermodilution and the conductivity-based online clearance measurement, respectively. A target blood flow rate of 400 ml/min and a FX100 Helixone dialyzer were prescribed in all the *sessions*.

Results: 9516 sessions were analyzed (PC: 1628.17%; AVF: 7888, 83%) and the median follow-up time was 347 (146–521) days. The recirculation rate was similar in both groups (Table). Although the dialysis parameters were better in the AV fistula group, more than 90% of the sessions performed with Palindrome catheter achieved the target of adequate *diffusive and convective dialysis doses.*

Conclusion: AVF remains the preferred *choice* as vascular access but in the case there have to start hemodialysis with a catheter, the use of a PC, in 4-hour thrice weekly HD patients, could avoid to increase the length of the dialysis sessions in majority of patients, even when convective therapies are performed and the lines connection are reversed. Randomized trials with dialysis dose as primary endpoint are warranted to confirm these findings.

18

Outcomes of Renal Survival after Acute Kidney Injury Requiring Dialysis

S. González-Sanchidrián[1,2], *S. Aresu*[1], *M.J. Muciño-Bermejo*[1], *E. Tonini*[1], *J.L. Deira*[2], *P.J. Labrador*[2], *J.R. Gómez-Martino*[2], *C. Ronco*[1–3]

[1]International Renal Research Institute of Vicenza (IRRIV), Vicenza, Veneto, Italy; [2]Nephrology University, San Pedro de Alcántara Hospital, Cáceres, Extremadura, Spain; [3]Department of Nephrology, Dyalysis and Transplantation, San Bortolo Hospital, Vicenza, Veneto, Italy

Background: The incidence of Acute Kidney Injury (AKI) requiring dialysis is increasing globally and it is usually associated to Chronic Kidney Disease (CKD) and high mortality. Long-term data on recovery of renal function after AKI is still lacking.

Objectives: The objective was to evaluate the long-term overall survival and Glomerular Filtration Rate (GFR) improvement after an episode of AKI requiring dialysis.

Materials and Methods: Retrospective study including two nephrology units. 151 adult patients who presented AKI and received Renal Replacement Therapy (RRT) were enrolled in a period of two years. We excluded patients admitted to the critical care unit and transplanted patients. Baseline renal function, mortality and GFR improvement were evaluated.

Results: The incidence of AKI requiring dialysis was $10.5/10^5$ population/year.

Mean age was 70.5 ± 15.24 years, the 60.26% were males. The renal status before AKI was known in 116 patients (76.82%): 9.5% stage 1, 25% stage 2, 34.5% stage 3, 24.1% stage 4 and 6.9% on stage 5. Median Baseline Creatinine (bCr) and Baseline Glomerular filtration Rate (bGFR) were 1.4 mg/dl and 46.13 mg/dl respectively. Cause of AKI: renal disease (64.9%), prerrenal (22.52%) and obstructive (7.9%). Patient's characteristics: 72.2% were hypertensive, 38.4% diabetics, 35.8% dyslipemics, 31.8% obese, 20.5% smokers. The median number of dialysis sessions required to the resolution of AKI was 2 (IQR 1.6). After one year of follow-up we completed the monitoring of 94 patients: 64.89% was dead, 24.5% was alive without need of RRT and the 10.6% was alive on dialysis. Patients with bGFR >60 ml/min prior to AKI episode had a slower but sustained improve in the GFR through the follow-up in comparison to patients with bGFR <60 ml/min.

Conclusions: Patients with AKI requiring RRT have high long-term mortality but few require maintenance dialysis. GFR improvement occurs later in patients with GFR >60 ml/min prior to AKI episode but nearer to the basal GFR respect to patients with a previous diminished GFR in which the recovery was incomplete.

19

The Role of Electronic Alert Systems to Detect Renal Dysfunction in Hospital Patients. DETECT-H Project

S. González-Sanchidrián[1,2], P.J. Labrador[2], J.P. Marín[1], M.C. Jiménez[1], S. Polanco[1], M.E. Davin[1], I. Castellano[1], J.R. Gómez-Martino[2]

[1]Nephrology University, San Pedro de Alcántara Hospital, Cáceres, Extremadura, Spain; [2]International Renal Research Institute of Vicenza (IRRIV), Vicenza, Veneto, Italy

Background: Renal dysfunction is an important factor in hospitalized patients' management.

Objectives: The aim of our study was to analyse the prevalence of chronic kidney disease (CKD) and acute kidney injury (AKI) in our hospital, length of stay and in-hospital mortality.

Materials and Methods: To improve renal dysfunction detection rates we developed a fully automated, electronic alert system which identifies all cases of reduced glomerular filtration rate (GFR) according to CKD-EPI formula in patients over 14 years. Patients admitted to our nephrology department and on dialysis were excluded. Detected patients were studied. CKD and AKI were defined according to KDIGO guidelines. Baseline serum creatinine was the lowest level between 0.5–6 months before admission. Length of stay and in-hospital mortality was recorded.

Results: Between January and June 2014, 11,022 completed adult patient admission episodes occurred. The number of alerts issued was 1.241 (11.3% of admissions), from 1.079 patients (13.1% multiple admissions). Median age 77 years (IQR 70–81), 53.9% men. Renal function before admission was present in 1.042 patients (84%), only 31.9% had reflected previous medical history of CKD. AKI was present in 846 admission episodes (69.9% of alerts and 7.7% of overall admissions): stage 1: 49.7%, stage 2: 24.5%, stage 3: 25.8%. AKI episode was specified to be suffered in 33.2% patients at discharge. Length of stay in overall admissions was 5.31 days. Median length of stay for patients detected with CKD but without AKI, or AKI stage 1, 2 and 3 respectively was 6 (3–10), 8 (5–13), 8 (6–14) and 10 (5–19) days; $p < 0.001$. Global in-hospital mortality for all detected patients was 14.9% (185 patients). In-hospital mortality for patients with CKD but without AKI, or AKI stage 1, 2 and 3 respectively was 4.3%, 10.9%, 22.7% and 33.9%. In-hospital mortality in patients with AKI requiring dialysis was 57.1%, $p < 0.001$.

Conclusions: Electronic alerts is an effective tool to detect in-hospital renal dysfunction patients. Renal dysfunction prevalence was over 10% in-hospital admissions and AKI prevalence out of nephrology unit was 7.7%. CKD is an underestimated pathological entity, only one third of affected patients. In-hospital AKI was recognized in less than a half of episodes. Nevertheless, AKI is associated with a poor in-hospital prognostic and a longer in-hospital stay. Renal dysfunction (CKD and AKI) is an undervalued clinical condition for rest of clinicians, recorded in one third of clinical history and at discharge.

20

Missed Opportunities for Investigation of AKI in ICU

A. El-Solia, M. Ostermann

Guy's & St. Thomas Hospital, London, United Kingdom

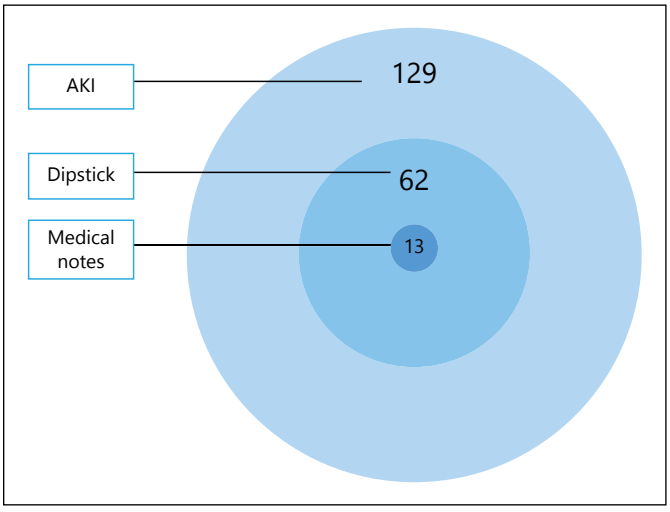
Introduction: It is estimated that 30–60% of patients in the intensive care unit (ICU) develop acute kidney injury (AKI). In most cases, AKI is multifactorial and related to haemodynamic factors, sepsis and drug toxicity. However, a proportion of patients have primary renal disorder which may need specific therapies. In 2014, the National Institute for Health and Care Excellence (NICE) in the UK recommended that all patients with suspected or confirmed AKI should have a urine dipstick. This recommendation was subsequently considered to be a quality indicator.

Objectives: To determine the proportion of critically ill patients with AKI in whom a urine dipstick was performed and acted upon during a 3-month period in 2015.

Methods: We retrospectively screened all admissions to two mixed ICUs in a large University Hospital in Central London between January – March 2015 and identified patients with AKI as defined by the KDIGO criteria. We reviewed the electronic notes of AKI patients and recorded whether a urine dipstick had been performed after the onset of AKI. We also reviewed the entries by the medical team and recorded whether they had specifically requested a urine dipstick and whether they had acknowledged the results after it had been performed.

Results: During a 3-month period, 275 patients were admitted to ICU. Following exclusion of 16 patients [anuria (n = 8), patients on chronic dialysis (n = 7), known history of renal disease (n = 1)], 259 were analysed.

129 patients (49.8%) fulfilled the criteria for AKI of whom 62 (48%) had a urine dipstick performed and recorded in the results section of the electronic notes. In 21 patients, the urine dipstick was significantly abnormal [presence of blood + protein ≥+3 (n = 5), presence of protein ≥+2 (n = 17) and nitrite positive (n = 8)]. The electronic notes of only 13 patients contained an acknowledgement of the urine dipstick by the medical team (figure 1).



Color version available online

Fig. 1. (for Abstract 20).

Conclusion: In critically ill patients with AKI, urine dipstick is a neglected diagnostic investigation. More education is necessary to incorporate simple tests like urine dipstick into the routine diagnostic work-up of AKI.

Grant Acknowledgement: The work was undertaken during an ERA-EDTA Young Fellowship.

21

Effects of Single-Pass Albumin Dialysis (SPAD) in Patients with Hepatorenal Dysfunction after Cardiac Surgery Intervention

A. Nogaibayeva[1], *B. Bekishev*[1], *F. Kacheganov*[1], *S. Bekbosynov*[2], *I. Vakhrushev*[3], *M. Makhmutov*[3]

[1]National Research Cardiac Surgery Centre, Astana, Republic of Kazakhstan; Extracorporeal Hemocorrection Department, [2]Cardiac Surgery Department No 2, [3]ICU, Astana, Republic of Kazakhstan

Background: Patients with advanced cardiac cirrhosis are at high risk of progressing hepatorenal dysfunction after cardiac surgery operation and cardiopulmonary bypass.

Case Report: A 24-years-old male was operated because of constrictive pericarditis in 2005. In spite of it cardiac insufficiency has been progressing (dispnea, oedemas, oliguria, cardiac cirrhosis Child-Pugh class B). The basic level of total bilirubin was 53.4 μmol/l, direct – 21.1 μmol/l, serum creatinine – 96.4 μmol/l before reoperation.

On the second day after operation (mitral valve plastic, subtotal pericardectomy with cardiopulmonary bypass) and intraoperating bleeding, there were anuria, hyperbilirubinemia (total bilirubin – 87.3 μmol/l, direct – 19.3 μmol/l), increasing of serum creatinine – 161.8 μmol/l. The 1st procedure hemofiltration (predilution 5,000 ml/hour, without anticoagulants, duration – 5 hours) was stopped because of bleeding.

SPAD initiated on the 3rd day after operation because of acute on chronic liver failure (AoCLF) and acute kidney injury (AKI) progression (total bilirubin – 92.7 μmol/l, direct – 39.8 μmol/l, serum creatinine – 221 μmol/l).

To obtain the albumin dialysate solution for use in SPAD: 1000 ml human albumin 10% were mixed with 4000 ml dialysis solution for hemofiltration; the result was an albumin solution of 2.5%. The same standard dialysis solution was used in the hemodiafiltration circuit. The albumin solution passed the filter at a rate of 700–1,000 ml/h; substitute rate was at 1,000 ml/h with ultrafiltration rate 100–200-0.0 ml/hour. 2 SPAD sessions were carried out for 7 hours and were alternated with 13–38 hours of hemodiafiltration. Total time of procedure was 60:37 hours/min.

Results: After procedures total bilirubin decreased till 47.9 μmol/l and direct till 32.8 μmol/l, creatinine – 112.3 μmol/l. Diuresis 150–100 ml/hour occurred at the 39th hours of procedure without stimulation by diuretics. In 6 days after SPAD total bilirubin reached 32.9 μmol/l and direct – 24.6 μmol/l, serum creatinine – 77.8 μmol/l.

Conclusions: This case showed the effectiveness of SPAD early initiation in patients with hepatorenal disfunction after cardiac surgery operation. Procedure doesn't need expensive additional equipment and disposables. Also early start of treatment required less volume of albumin.

22

Role of Extracorporeal Therapies in the Management of Critically Ill Patients with Fluid Overload

Erwin Otero Garcés[1], *Guillermo Pinzón Velásquez*[2]

[1]Specialist in Internal Medicine, Nephrology and Intensive Care, Master of Medical Sciences – Nephrology – Federal University of Rio Grande do Sul, Brazil, and Graduate professor of Internal Medicine at the Universidad Libre and Universidad Metropolitana, Barranquilla, Colombia; [2]Master in Research, Specialist in Internal Medicine and Critical Nephrology, University Foundation of Health Sciences, Specialist in Teaching and University Research, Sergio Arboleda University, Graduate Professor of Internal Medicine at the Fundación Universitaria de Ciencias de la Salud – San Jose Hospital and San José Childrens Hospital, Bogotá, Colombia

Summary: Excess body water or fluid overload, is a clinical problem that occurs quite frequently in the intensive care unit, negatively affecting the clinical course of these patients; when the pharmacological approach is not sufficient to maintain adequate water balance extracorporeal therapy techniques emerge as a useful and safe alternative for the management of this medical situation.

Introduction: Patients in the ICU, due to their critical condition, often need the administration of large amounts of intravenous fluids, both in the form of colloids and crystalloids *(water resuscitation)*, to improve tissue perfusion. A lack of clear hemodynamic criteria to stop this therapeutic measure leads the patient to a state of fluid overload, which can adversely affect the clinical course, if this medical situation is not reversed quickly. The following case report shows how the critical condition of the patient justified the use of extracorporeal therapy to achieve this goal and modify the patient's prognosis.

Case Presentation: Male patient, 32 years old, electively admitted to the institution to conduct intramedullary tumor resection, anterior approach, as well as fusion of C-2, with exploration of intrathoracic vessels. He presents increased bleeding during surgery, prolonging the surgical procedure more than 12 hours, which required the administration of large amounts of intravenous fluids, in the form of crystalloids, colloids and blood products (packed red blood cells and fresh frozen plasma), while infusion of vasopressors in increasing doses (dopamine 18 mcg/kg/min and noradrenaline 0.3 mcg/kg/min) in order to maintain pressure values in limit of normal, the patient is admitted to the intensive care unit (ICU) for monitoring and management of immediate postoperative.

Due to persistent shock state during the first 24 hours of ICU stay, with evidence of bleeding, administration of more volume (crystalloid and blood products) became necessary in an attempt to improve the hemodynamic condition and restore the dysfunc-

Table 1. Lab follow-up ICUs (for Abstract 22)

	Outset	Day 1	Day 2	Day 3	Day 4
Hemoglobin (gr/dl)	11.3	7.2	8.9	7.6	9
Hematocrit	33	15	28.4	24.7	22
Leucocytes (mm^3)	19,440	28,000	30,500	34,780	34,670
PMN	16,700	21,500	26,800	28,900	31,150
Lymphocytes	1,500	2,500	2,400	2,000	2,200
Creatinine (mg/dl)	0.6	0.81	0.75	0.7	0.6
BUN	15	19	19.1	18	23
Calcium (mg/dl)	5	7.56	8.7	9.15	8.2
Glucose (mg/dl)	241	114	180	199	126
Potassium (meq/l)	3.6	4.95	4.9	4.95	5.2
Sodium (meq/l)	145	133	134	139	140
Urea	56	54	41	54	63.5
Magnesium (mg/dl)	1	2.08	2.2	2.09	1.8
Total Cholesterol (mg/dl)	93	ND	ND	ND	ND
TP	18.5	25	21	19	12
TPT	32	54	45	32	29

tion is necessary hematologic patient (table 1); Oxygenation indices in the first 72 hours of ICU management continue to decline and an evident deterioration of gas exchange is observed, with severe and refractory hypoxemia *(PaO_2/FiO_2 of 80)* , despite adjustments in ventilatory parameters *(FiO_2 100% and 20 cmH_2O PEEP),* the concomitant appearance of alveolar infiltrates bilaterally in the chest (figure 1) X-rays; hemodynamic monitoring with a Swan-Ganz catheter, showing a state of fluid overload, central venous pressure (CVP) pressure of 25 mm Hg and pulmonary artery occlusion (PAOP) of 30 mm Hg, reflecting the accumulated water balance of over 40 liters.

The initial medical management requires increasing the volume diuretic, starting with furosemide bolus (1 mg/kg/dose) and then infused at a rate of 20 mg/hour, with little clinical response, obtaining a maximum of 1.5 ml/kg/hour. Given the state of fluid overload the patient with serious repercussions in oxygenation and poor response observed with the use of intravenous diuretic maximum dose, preserving renal function tests, it was decided to use a method of extracorporeal purification to remove excess body water.

To this end, the insertion of a temporal high flow catheter *(Mahurkar®)* installed in the right femoral vein was performed, and using a Genius® 90 machine, *(Fresenius Medical Care AG, Bad Homburg, Germany* [1]*)* in SCUF mode for daily sessions for 4 days. The parameters used for therapy were: 100–120 Blood Flow cc/min Ultrafiltration rate: 10 cc/min, polysulfone filters (FX60 *Fresenius Medical Care).* No anticoagulant was used in the circuit; the initial goal was to maintain ultrafiltration between 7 and 8 liters a day.

Continuity of therapy is assessed on the second day due to the remarkable improvement in ventilatory parameters and prescribes the second session thereby increasing the net rate of UF to 8000 cc; Laboratory studies show no changes in renal function (table 1). Once 20 hours were completed and as recommended by the literature (many schemes have used time to 24 hours) it is suspended and reassessed the next day.

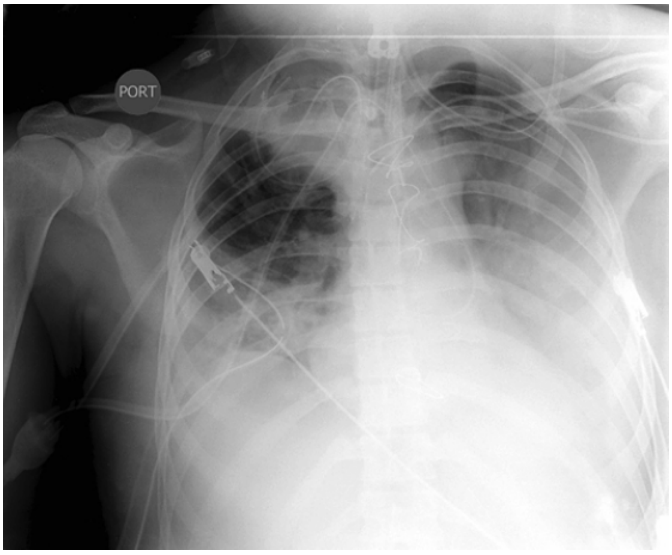


Fig. 1. Chest X-Rays before beginning extracorporeal therapy (for Abstract 22).

During a general service review the need to continue for an additional 24 hours in two sessions SCUF 12 hours each was considered, reaching a negative water balance at the fourth session and completing 30 liters (figure 1).

With this type of therapy a negative water balance is quickly reached, with disappearance of infiltrates on control chest X-rays (figure 2), enabling progress in ventilator weaning, shortening the time on mechanical ventilation, and overall time of stay in the UCI.

Discussion: Water replacement or hydric resuscitation, is an effective therapeutic measure in some specific clinical situations

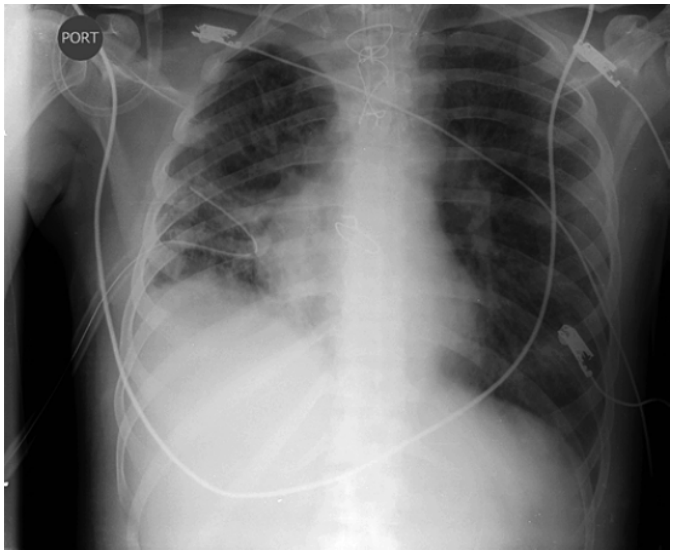
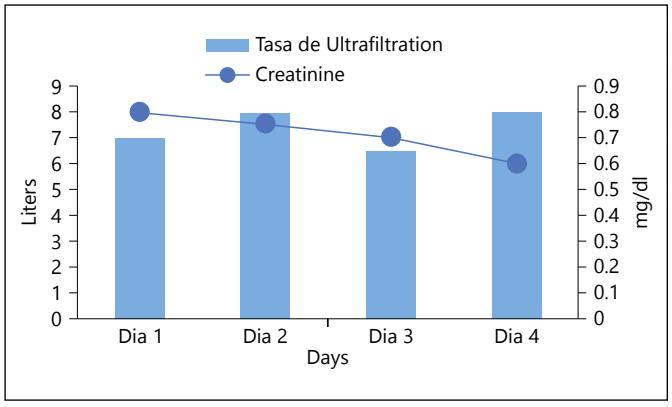


Fig. 2. Chest X-Rays 72 hours after beginning extracorporeal therapy (for Abstract 22).



Graph 1. Renal function and Ultrafiltration volume per session (for Abstract 22).

and it can save the patient's life [1]. The lack of clear, reported in the literature criteria to guide the administration of intravenous fluids [2–4] after the initial hydric resuscitation leads to accumulation of water in the body, producing a clinical condition known as syndrome of fluid overload. This excess water in the body can have a deleterious effect on the evolution critically ill clinic [5, 6] patients, mainly surgical ones [7, 8], increasing mortality significantly in some populations studied [9, 10]. Studies have shown that even small increases in water total body, over 10% relative to the dry weight of the patient are associated with worse outcomes, and that a higher percentage of water retention, leads to increased mortality [11].

Excess body water accumulates in all organs and tissues, and is responsible for dysfunction or failure of many of these organs observed in the critically ill patient [12]. The lungs, due to their anatomical characteristics, is especially susceptible to excess fluid accumulation, both at the interstitial and alveolar levels, resulting in pulmonary edema [13, 14], affecting the proper gas exchange, and producing a state of severe hypoxemia, which is partly responsible for the multiple organ dysfunction syndrome. In the patient with acute respiratory distress [15] syndrome, mechanical ventilatory support is essential [16–19]. Studies have shown that a strategy of water restriction and removal of excess body water, which is known as extravascular lung water (EVLW), reduces the time on mechanical ventilation [20–23] and improves survival rates [24–28]. The use of pharmacological measures such as the use of furosemide is indicated, but in some cases where the response to diuretic use is limited or sometimes inadequate [29, 30] and the patient's condition is very severe, using some method of extracorporeal therapy is justified in order to achieve rapid negative water balance thus improving oxygenation rates.

The use of different methods or types of extracorporeal therapies in the critically ill patient is not new, today a wide variety of medical devices is available, and they can provide a great help when giving support to most organs [31–40]. The goal of these therapeutic measures is to gain the necessary time so that the dysfunctional or failing organ recovers, while its functions are supplemented with a minimum of complications associated with performing the procedure. The intensive care unit is where patients with multiple organ failure are commonly found. Due to acute and potentially reversible conditions, it becomes the ideal scenario for the use of these therapies, which is why the specialist in this area must know and be familiar with the various methods and devices available for this purpose.

In the report above it is evident that the use of an extracorporeal purification technique without a classic indication for the same, which has led to change the term 'renal replacement' with 'renal support' [41–43] is indicated, as it enabled the physicians to quickly and safely remove excess body water, despite the serious hemodynamic compromise, observing an immediate improvement in oxygenation indices, reducing the time on mechanical ventilation, time in ICU and modifying a favorable clinical evolution. A major concern when considering the use of such therapies is clotting or thrombosis of the extracorporeal circuit. In this specific patient, due to bleeding complications presented in its immediate post-surgical, the use of anticoagulation heparins was contraindicated and the use of regional citrate anticoagulation was not available at the institution, the recommendation of periodically washing the circuit with saline bolus were followed, which was effective in preventing system coagulation [44]; an aspect to highlight is the benefits of the Genius® (Fresenius Medical Care, Bad Homburg, Germany) system because the shorter length of the lines of the extracorporeal circuit and fewer connections between the different components that are part of it decreases the risk of coagulation [45, 46], allowing for the adequate performance of extracorporeal therapy, meeting the objectives thereof.

The use of this therapeutic measure, although expensive when compared with the use of diuretic, is in the end is better from an economic point of view, because by reducing the time on mechanical ventilation and time of stay in ICU, it is more cost-effective, without mentioning the other possible complications, such as infection, whose risk increases directly as the patient remains hospitalized longer in the ICU.

Conclusion: Extracorporeal therapies have proven useful and safe in the management of critically ill patients in fluid overload syndrome, with severe impact on oxygenation, as described above, the rapid removal of excess body water guarantees less time on mechanical ventilation, favorably modifying these patients' prognosis.

References

1 Rivers E, Nguyen B, Havstad S, Ressler J, Muzzin A, Knoblich B, et al: Early goal-directed therapy in the treatment of severe sepsis and septic shock. N Engl J Med 2001;345:1368–1377.
2 House AA, Haapio M, Lentini P, Bobek I, de CM, Cruz DN, et al: Volume assessment in mechanically ventilated critical care patients using bioimpedance vectorial analysis, brain natriuretic Peptide, and central venous pressure. Int J Nephrol 2011;2011:413760.
3 Marik PE, Monnet X, Teboul JL: Hemodynamic parameters to guide fluid therapy. Ann Intensive Care 2011;1:1.
4 Durairaj L, Schmidt GA: Fluid therapy in resuscitated sepsis: less is more. Chest 2008;133:252–263.
5 Bouchard J, Mehta RL: Fluid balance issues in the critically ill patient. Contrib Nephrol 2010;164:69–78.
6 Payen D, de Pont AC, Sakr Y, Spies C, Reinhart K, Vincent JL: A positive fluid balance is associated with a worse outcome in patients with acute renal failure. Crit Care 2008;12:R74.
7 Brandstrup B, Tonnesen H, Beier-Holgersen R, Hjortso E, Ording H, Lindorff-Larsen K, et al: Effects of intravenous fluid restriction on postoperative complications: comparison of two perioperative fluid regimens: a randomized assessor-blinded multicenter trial. Ann Surg 2003; 238:641–648.
8 Lowell JA, Schifferdecker C, Driscoll DF, Benotti PN, Bistrian BR: Postoperative fluid overload: not a benign problem. Crit Care Med 1990;18: 728–733.
9 Arikan AA, Zappitelli M, Goldstein SL, Naipaul A, Jefferson LS, Loftis LL: Fluid overload is associated with impaired oxygenation and morbidity in critically ill children. Pediatr Crit Care Med 2012;13:253–258.
10 Teixeira C, Garzotto F, Piccinni P, Brienza N, Iannuzzi M, Gramaticopolo S, et al: Fluid balance and urine volume are independent predictors of mortality in acute kidney injury. Crit Care 2013;17:R14.
11 Bouchard J, Soroko SB, Chertow GM, Himmelfarb J, Ikizler TA, Paganini EP, et al: Fluid accumulation, survival and recovery of kidney function in critically ill patients with acute kidney injury. Kidney Int 2009;76: 422–427.
12 Cordemans C, De L, I, Van RN, Schoonheydt K, Dits H, Huber W, et al: Fluid management in critically ill patients: the role of extravascular lung water, abdominal hypertension, capillary leak, and fluid balance. Ann Intensive Care 2012;2(suppl 1):S1.
13 Sibbald WJ, Anderson RR, Holliday RL: Pathogenesis of pulmonary edema associated with the adult respiratory distress syndrome. Can Med Assoc J 1979;120:445–450.
14 Snapper JR, Brigham KL: Pulmonary edema. Hosp Pract (Off Ed) 1986; 21:87–88, 101.
15 Ranieri VM, Rubenfeld GD, Thompson BT, Ferguson ND, Caldwell E, Fan E, et al: Acute respiratory distress syndrome: the Berlin Definition. JAMA 2012;307:2526–2533.
16 Fan E, Needham DM, Stewart TE: Ventilatory management of acute lung injury and acute respiratory distress syndrome. JAMA 2005;294:2889–2896.
17 Amato MB, Barbas CS, Medeiros DM, Magaldi RB, Schettino GP, Lorenzi-Filho G, et al: Effect of a protective-ventilation strategy on mortality in the acute respiratory distress syndrome. N Engl J Med 1998;338:347–354.
18 Hickling KG: Ventilatory management of ARDS: can it affect the outcome? Intensive Care Med 1990;16:219–226.
19 Marini JJ, Gattinoni L: Ventilatory management of acute respiratory distress syndrome: a consensus of two. Crit Care Med 2004;32:250–255.
20 Stewart RM, Park PK, Hunt JP, McIntyre RC Jr, McCarthy J, Zarzabal LA, et al: Less is more: improved outcomes in surgical patients with conservative fluid administration and central venous catheter monitoring. J Am Coll Surg 2009;208:725–735.
21 Wiedemann HP: A perspective on the fluids and catheters treatment trial (FACTT). Fluid restriction is superior in acute lung injury and ARDS. Cleve Clin J Med 2008;75:42–48.
22 Upadya A, Tilluckdharry L, Muralidharan V, Amoateng-Adjepong Y, Manthous CA: Fluid balance and weaning outcomes. Intensive Care Med 2005;31:1643–1647.
23 Wiedemann HP, Wheeler AP, Bernard GR, Thompson BT, Hayden D, deBoisblanc B, et al: Comparison of two fluid-management strategies in acute lung injury. N Engl J Med 2006;354:2564–2575.
24 Mitchell JP, Schuller D, Calandrino FS, Schuster DP: Improved outcome based on fluid management in critically ill patients requiring pulmonary artery catheterization. Am Rev Respir Dis 1992;145:990–998.
25 Humphrey H, Hall J, Sznajder I, Silverstein M, Wood L: Improved survival in ARDS patients associated with a reduction in pulmonary capillary wedge pressure. Chest 1990;97:1176–1180.
26 Neamu RF, Martin GS: Fluid management in acute respiratory distress syndrome. Curr Opin Crit Care 2013;19:24–30.
27 Schuller D, Mitchell JP, Calandrino FS, Schuster DP: Fluid balance during pulmonary edema. Is fluid gain a marker or a cause of poor outcome? Chest 1991;100:1068–1075.
28 Simmons RS, Berdine GG, Seidenfeld JJ, Prihoda TJ, Harris GD, Smith JD, et al: Fluid balance and the adult respiratory distress syndrome. Am Rev Respir Dis 1987;135:924–929.
29 Ellison DH: Diuretic resistance: physiology and therapeutics. Semin Nephrol 1999;19:581–597.
30 Asare K: Management of loop diuretic resistance in the intensive care unit. Am J Health Syst Pharm 2009;66:1635–1640.
31 McCunn M, Reed AJ: Critical care organ support: a focus on extracorporeal systems. Curr Opin Crit Care 2009;15:554–559.
32 Cooper DS, Jacobs JP, Moore L, Stock A, Gaynor JW, Chancy T, et al: Cardiac extracorporeal life support: state of the art in 2007. Cardiol Young 2007;17(suppl 2):104–115.
33 Gramaticopolo S, Chronopoulos A, Piccinni P, Nalesso F, Brendolan A, Zanella M, et al: Extracorporeal CO_2 removal – a way to achieve ultraprotective mechanical ventilation and lung support: the missing piece of multiple organ support therapy. Contrib Nephrol 2010;165:174–184.
34 Yap HJ, Chen YC, Fang JT, Huang CC: Combination of continuous renal replacement therapies (CRRT) and extracorporeal membrane oxygenation (ECMO) for advanced cardiac patients. Ren Fail 2003;25:183–193.
35 Oppert M, Rademacher S, Petrasch K, Jorres A: Extracorporeal liver support therapy with Prometheus in patients with liver failure in the intensive care unit. Ther Apher Dial 2009;13:426–430.
36 Rifai K, Tetta C, Ronco C: Prometheus: from legend to the real liver support therapy. Int J Artif Organs 2007;30:858–863.
37 Schmid C, Philipp A, Mueller T, Hilker M: Extracorporeal life support – systems, indications, and limitations. Thorac Cardiovasc Surg 2009;57: 449–454.
38 Cruz D, Bellomo R, Kellum JA, de CM, Ronco C: The future of extracorporeal support. Crit Care Med 2008;36(4 suppl):S243–S252.
39 Bouchard J, Khosla N, Mehta RL: Emerging therapies for extracorporeal support. Nephron Physiol 2008;109:85–91.
40 Bouchard J, Macedo E, Mehta RL: Renal support in critically ill patients with acute kidney injury. N Engl J Med 2008;359:1959–1960.
41 Mehta RL: Indications for dialysis in the ICU: renal replacement vs. renal support. Blood Purif 2001;19:227–232.
42 Ricci Z, Romagnoli S, Ronco C: Renal support. Minerva Anestesiol 2011; 77:1204–1215.

43 Schetz M: Non-renal indications for continuous renal replacement therapy. Kidney Int Suppl 1999;(72):S88–S94.
44 Garces EO, Victorino JA, Veronese FV: [Anticoagulation in continuous renal replacement therapies (CRRT)]. Rev Assoc Med Bras 2007;53:451–455.
45 Davenport A: Extracorporeal anticoagulation for intermittent and continuous form of renal replacement therapy in the intensive care unit. In: Patrick Murray, Hugh Brady, Jesse Hall, editors. Intensive Care NEPHROLOGY. London and New York: Taylor & Francis Group; 2006, pp 239–262.
46 Gainza F, Quintanilla N, Lampreable I: Anticoagulación y accesos vasculares en las técnicas de depuración extracórporeas. Depuración Extrarrenal en el Paciente Grave. Philadelphia: Elsevirer – Masson; 2004, pp 161–182.

23

Early Nephrology Consultation and Outcomes in the Intensive Care Unit

Hector Toledo[1], *Laura Muralla-Sil*[1], *Ulises Ceron-Diaz*[1,2], *Ricardo Martinez-Zubieta*[1,2], *Jose J. Zaragoza*[1,2]

[1]Intensive Care Unit, Hospital Español de Mexico, Mexico City, Mexico; [2]ARUAL Medicina de Reanimacion, Society, Mexico City, Mexico

Introduction: Acute kidney injury is a common problem among critically ill [1, 2]. An integrated approach is necessary and collaboration between various specialties is essential [3]. Optimal timing for nephrology consultation by the critical care physician is still debated, although early consultation has been related to better outcomes [4]. We studied patients with early nephrology consultation defined by a maximum renal Sequential Organ Failure Assessment (SOFA) sub score in the Intensive Care Unit (ICU) of 1 and 2 and described their outcomes.

Methods: We retrospectively analyzed a prospectively obtained database of patients admitted to the ICU from September 2009 to February 2015. We included patients in which the highest SOFA renal sub score was 1 and 2 (i.e. maximum creatinine during ICU stay 1.2–3.4 mg/dl). We sought to test for differences in demographics and outcomes between those who were evaluated by a nephrologist in the ICU and those who were not. Variables with p value less than 0.2 in alpha level and those considered meaningful variables were incorporated into a multivariate analysis. Primary outcome was hospital mortality. Secondary outcomes were hospital stay, ICU mortality, ICU stay and readmissions.

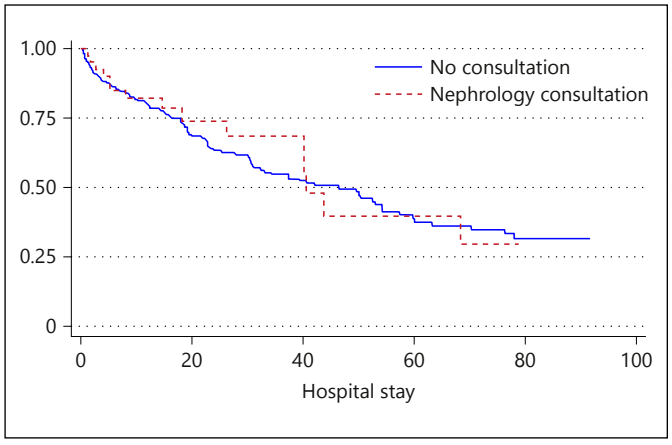
Results: In total 1899 patients were admitted into the ICU in the mentioned period. We excluded 64 who were transferred to another hospital. Of the remaining, 540 patients reached a renal SOFA sub score of 1 or 2, 40 were evaluated by a nephrologist and 500 were not. Those patients evaluated had more often a medical diagnosis rather than a surgical one, had higher renal SOFA sub score and were more commonly readmitted into the ICU in the same hospitalization. After adjustment by multivariate analysis, those evaluated by a nephrologist were more readmitted into the ICU (table 1). Hospital mortality (figure 1), hospital stay, ICU mortality and ICU stay were not different between both groups.

Conclusion: Evaluation by a nephrologist in those patients with a maximum SOFA score in the ICU stay of 1 or 2 was not

Table 1. Patients characteristics (for Abstract 23)

Variable	Non evaluated (n = 500)	Evaluated (n = 40)	Total (n = 540)	P value	P value multivariate analysis
Demographics					
Age	73.5 (58–83)	71 (61–83)	73 (58–83)	0.95	
Female gender	190 (38%)	21 (52%)	211 (39%)	0.09	0.26
Maximum SOFAs	7 (4–10)	7 (4–10.5)	7 (4–10)	0.8	
Maximum RSOFA	1 (1–2)	2 (1–2)	1 (1–2)	0.04	0.14
Full code (No DNR)	475 (95%)	37 (92%)	512 (94%)	0.51	
Mortality % saps3	34 (15–59)	41 (23–71)	34 (16–61)	0.08	<0.001
Surgical	90 (18%)	1 (2.5%)	91 (16%)	0.008	0.67
Cardiac surgery	28 (5.6%)	1 (2.5%)	29 (5.3%)	0.71	
MV	348(69%)	30 (75%)	378 (70%)	0.301	
NIMV	110 (22%)	13 (32%)	123 (22%)	0.168	0.48
Outcomes					
Hospital mortality	167 (33%)	15 (37%)	182 (33%)	0.605	0.64
Hospital stay	13 (7–22.5)	17 (8.5–40)	13.3 (7–23)	0.06	0.15
ICU mortality	100 (20%)	11 (27%)	111 (20%)	0.308	0.82
ICU stay	3 (1.7–6.7)	4.4 (1.8–10)	3 (1.7–6.8)	0.103	0.10
Readmission to ICU	26 (5.2%)	6 (15%)	32 (5.9%)	0.02	0.01

SOFAs = Sequential organ failure assessment score; RSOFA = renal sequential organ failure assessment score; DNR = do not resuscitate order; MV = mechanical ventilation; NIMV = non-invasive mechanical ventilation; ICU = intensive care unit.



Color version available online

Fig. 1. Kaplan-Meier survival estimates (for Abstract 23).

related with better predefined outcomes. Notably, nephrology consultation was related with higher rate of readmission to the ICU.

References

1 Qianyi P, Lina Z, Yuhang A, Lemeng Z: Epidemiology of acute kidney injury in intensive care septic patients. Chin Med J (Engl) 2014;127:1820–1826, DOI: 10.3760/cma.j.issn.0366–6999.20140387.

2 Bellomo R, Ronco C, Kellum JA, Mehta RL, Palevsky P: Acute renal failure – definition, outcome measures, animal models, fluid therapy and information technology needs: the Second International Consensus Conference of the Acute Dialysis Quality Initiative (ADQI) Group. In: Crit Care (London, England) 2004;8:R204–R212, DOI:10.1186/cc2872.

3 Khwaja A: KDIGO clinical practice guidelines for acute kidney injury. Nephron Clin Pract 2012;120:c179–c184.

4 Renhua L, Miaolin C, Junlin W, et al: The level of the biomarkers at the time of nephrology consultation might predict the prognosis of acute kidney injury in hospitalized patients. Blood Purif 2014;38:89–95, DOI: 10.1159/000362865.

24

Protocolized Strategy for Early and Fast Fluid Removal after Reanimation. A Pilot Prospective Study

M. Espinoza, P. Mercado, A. Salazar, J. Graf

Department of Critical Care Medicine, Clinica Alemana de Santiago, Universidad del Desarrollo, Santiago de Chile, Chile

There is a well defined relation between positive fluid balance and bad outcome in a series of clinical situations. However still many patients get overhydrated during reanimation of an acute critical illness. For those patients it is desirably to correct the overhydration. The purpose of this study is to describe the feasibility and security of a protocol of early and fast fluid removal in overhydrated patients after completing reanimation. This is a prospective study. Patients included were those in mechanical ventilation, with a accumulated positive fluid balance (APFB) >5 liters, with edema. Competed reanimation was defined as absence of clinical hypoperfusion, lactate <2.2 mM/L, SvO_2 >70%, norepinephrine dose stable below 0.1 mcg/kg/min. Negative fluid balance was induced with furosemide or hemofiltration, with a target of removing at least 75% of the APFB in 48 h. We registered volume removed, weight, renal function, blood electrolytes, hemodynamics at 0, 1, 2 and 7 days. Protocol was stopped if the patient showed evidence of hypoperfusion or needed increase of vasopressor. Furosemide we used as an iv bolus and continuous infusion. A KCl solution and iv water were added to prevent or correct hypokalemia and dysnatremia.

We analyzed 25 patients, mean age 61 + 24 years, stay in ICU 2 days (1–8), APFB 9.8 + 3.4 L, APACHE II 18 (14–27), SOFA 5 (3–11). In 20 fluid removal was obtained with furosemide, 5 CVVH. In average, 8.3 + 3 L were removed. In 1 patient the protocol was stopped for evidence of hypoperfusion. At 48 h of observation, there were no changes in creatinine, BUN or bicarbonate. There was a slight decrease in sodium and an increase in pH and potassium. Cardiac output decrease from 6.6 + 0.2 to 5.2 + 0.2 LPM ($p < 0.01$) There were no significant changes in Stroke volume, lactate, SvO_2 and AV delta of PCO_2.

We conclude that is possible and safe the early and rapid removal the APFB after reanimation, without inducing renal failure, electrolyte imbalance or circulatory alterations.

25

Pro-Apoptotic and Pro-Inflammatory Effects of Plasma of Patients with Cardiorenal Syndrome Type 1 on Human Renal Tubular Epithelial Cells

G.M. Virzi[1,2], A. Brocca[1,2], M. de Cal[1,2], C. Castellani[3], C. Bolin[4], M. Fedrigo[3], M.L. Valente[3], G. Thiene[3], A. Angelini[3], G. Vescovo[4], C. Ronco[1,2]

[1]Department of Nephrology, St. Bortolo Hospital, Vicenza, [2]International Renal Research Institute Vicenza, [3]Department of Cardiac, Thoracic and Vascular Sciences, University of Padua, [4]Internal Medicine, St. Bortolo Hospital, Vicenza, Italy

Background: Cardiorenal Syndrome Type 1 (CRS1) is a specific condition which is characterized by a rapid worsening of cardiac function leading to AKI. CRS Type 1 pathophysiology is complex and unclear as it involves several interrelated factors. It is postulated that the concurrent dysfunction of heart and kidneys is due to a cellular and molecular crosstalk between these organs. Key physical, chemical and biological processes may be involved. Furthermore, an immune-mediated damage, an alterations in the immune response with apoptosis, cytokine-release and changes in immune cell functions, have been hypothesized as a potential mechanisms involved in the pathogenesis of CRS. The pathophysiology of CRS1 is widely studied, although the mechanisms by which renal tubular epithelial cells (RTCs) cease to proliferate and embark upon terminal differentiation, following the initial insult of heart failure (HF), remain a key target.

This study seeks to provide insight into the pathophysiological pathways in CRS1; we evaluated *in vitro* the effects of CRS1 plasma on RTCs.

Methods: We enrolled 40 acute HF patients and 15 controls (CTR) without HF or acute kidney injury (AKI). 11/40 HF patients exhibited AKI at the time of admission for HF or developed AKI during hospitalization and were classified as CRS1. *In vitro*, cell viability, DNA fragmentation and caspase-3 levels were investigated in RTCs incubated with HF, CRS1, and CTR plasma. We assessed inflammatory cytokines and NGAL expression at gene and protein level.

Results: The mean age of 11 patients with CRS1 was 74.0 ± 13.1 years and 45% of these patients were male. The median baseline SCr of CRS1 patients was 0.96 mg/dl (IQR 0.88–1.02), the median eGFR was 62 ml/min/1.73 m^2 (IQR 55–75). The mean age of 29 patients with HF was 73.6 ± 9.5 years and 58% of these patients were male. The median baseline SCr of HF subjects was 0.98 mg/dl (IQR 0.87–1.15), the median eGFR was 67 ml/min/1.73 m^2 (IQR 53–82). We observed a marked pro-apoptotic activity and a significantly increased *in vitro* level of apoptosis in RTCs incubated with plasma from CRS1 patients compared to HF and CTR ($p < 0.01$). The increase of apoptosis was also confirmed by Caspase-3 concentration. Expression of IL-6, IL18 and NGAL were analyzed by qRT-PCR using mRNAs prepared from RTCs incubated with different plasma. In the CRS1 group, mRNA expression of IL-6, IL-18 and NGAL resulted significantly higher in RTCs incubated with CRS1 plasma compared with those incubated with plasma from HF and CTR ($p < 0.01$). IL-6, IL-18, NGAL, RANTES levels were significantly higher in RTCs supernatant incubated with CRS1 plasma compared with HF patients and CTR plasma ($p < 0.01$). However, TNF-α and sICAM levels in supernatant were similar in CRS1 and HF groups.

Conclusion: *In vitro* exposure to plasma from CRS1 patients altered the expression profile of RTCs characterized by increases in pro-inflammatory mediators, release of tubular damage markers, and apoptosis.

26

Complementarity of Renal Replacement Therapy

M.M. Papaginovic Leiva, M.E. Nicolini, P. Martinez Allo, M. Serrano, E.R. Mojico, R.D. Martinez*

Nephrology and Dialysis Department, Churruca's Hospital, Buenos Aires, Argentine

Acute kidney injury is a frequent complication in hospitalized patients and even more in those ones in critical conditions showing greater predisposition because of pre-existing renal disease, which increase the risk of morbidity and mortality in the short and long term (hospital mortality of 50–80%).

It is the dynamic status of the patient that requires the appropriate therapeutic treatment according to their clinical situation. The choice of different methods and the optimal dose in renal replacement therapies (RRT) can improve outcomes. Herein lays the importance of the use of different therapies for renal support complementary and not exclusive.

Our case demonstrates the management of a critically ill patient with multiple complications; applying different of renal replacement method according to the clinical situation. Over nine months of hospitalization, alternate types of RRT were used, continuous and intermittent ones, reassessing the daily requirements for both the modality indication and prescription.

Clinical Case: Female patient, 33 years old with history of arterial hypertension of 1 year of evolution, without adherence to treatment. She was admitted in intensive care unit because of acute lung edema Hypertension, oliguria and renal failure.

The patient presented multiple complications, hypovolemic shock, retroperitoneal hematoma which led to left radical nephrectomy, hemothorax, and surgical site infection. After that presented reversible posterior leukoencephalopathy with blindness and psychiatric disorders and multiple organ failure (MOF).

We prescribed hemodiafitration (CVV HDF), hemofiltration (CVVHF) with manual technique and with PRISMA, intermittent hemodialysis (IHD),extended hemodialysis (EHD), plasmapheresis, according to hemodynamic status, Fluid overload and/or biochemical parameters.

Conclusion: The purpose of this presentation is to highlight through a clinical case, the complementarity importance on of different RRT modalities. Despite that survival rate remains low in critical illness, the amelioration of patients adjusting RRT to clinical status plays an important rol. We can observe that the combination of different renal support therapies can be applied on the same patient obtaining better results.

27

The Importance of Simulation-Based Continuous Renal Replacement Therapy Training in Nurse Education

S. De Rosa, F. Ferrari, S. Samoni, G. Villa, M. Neri, M. Sartori, S. Lopez-Giacoman, I. Bonilla Resendiz, F. Husain-Syed, C. Ronco

Department of Nephrology, Dialysis and Transplantation, International Renal Research Institute of Vicenza (IRRIV), San Bortolo Hospital, Vicenza, Italy

Introduction: Over the last years, many technical advances have been made in the delivery of continuous renal replacement therapy (CRRT). However, little attention has been given on the optimal care delivery model for CRRT. Optimal care delivery model for CRRT relies on expert bedside nursing staff to maintain prescribed therapy, troubleshoot technical issue and ensure patient safety. CRRT in the intensive care unit (ICU) requires a theoretical and practical training through educational process able to replicate clinical practices in a safe environment. Simulation-based learning in nurse education could be an effective teaching and learning method: in particularly, critical care nurses are a potential receptive professional group for CRRT training. The purpose of this review is to analyze the quantitative evidence of educational strategy in nursing training for CRRT.

Methods: A review of quantitative studies published between 1996 and January 2014 was undertaken using the following databases: CINAHL Plus, ERIC, Embase, Medline, SCOPUS, ProQuest, ProQuest Dissertation and Theses Database. The primary

search terms were 'human simulation CRRT' and 'nursing training CRRT'. All articles identified were English-language, full-text papers. We also searched the reference lists of identified articles for further relevant papers and the websites of relevant nursing organizations.

Results: Six studies were included in the review. Two of the studies indicate that education, continuing competence, prevention and management of adverse events, such as bleeding and filter clotting, are the major issues related to CRRT nursing. One of these two studies showed the importance to establish training programs and to define the role of teaching nurse. One quasi-experimental study showed the introduction in nursing education of self-learning manuals as useful aids and catalysts to achieve more effective and satisfying learning experiences. Two observational studies evaluated the impact of a program designed to improve CRRT stability on unexpected circuit clotting and the effectiveness of CRRT delivery with an ICU bedside nurse delivery model for CRRT, while comparing circuit patency and circuit exchange rates. One prospective quality controlled observational study evaluated the importance of simulation–based educational model in nursing training for CRRT with a significant and sustained improvement in the delivery of CRRT demonstrating by marked increase in filter lifespan.

Conclusion: Simulation-based learning in nursing education could be a valid teaching and learning strategy. Highest level nurse to the bedside represented by a nephrology–critical care nurse can help to fil the gaps in delivering CRRT practice. Additional studies are needed to support simulation-based learning in nursing education.

28

Renal Graft Outcome and Recipients' Survival in Patients with History of Cardiac Surgery

S. Lopez-Giacoman[1,2], L. Bonilla-Resendiz[2,3], S. Samoni[2], F. Husain-Syed[2], S. De Rosa[2], C. Estremadoyro[2], C. Ronco[2], F. Rodríguez-Castellanos[1]

[1]Department of Nephrology, Instituto Nacional de Cardiologia, México City, México; [2]Department of Nephrology, Dialysis and Transplantation, International Renal Research Institute of Vicenza (IRRIV), San Bortolo Hospital, Vicenza, Italy; [3]Department of Internal Medicine, General Hospital 'Dr. Manuel Gea González', Secretaría de Salud, México City, México

Introduction: Given the advances in medical technologies related to kidney transplantation (KT), the post-transplant graft survival rate and quality of life have improved significantly. Nevertheless, attention has transferred to improving long-term outcomes in kidney transplant recipients and, in particular, the high rate of cardiovascular (CV) death with a functioning graft. Only a few studies address renal graft and recipient survival in patients with a history of cardiac surgery (HCS), which is of special interest as pre-transplant CV disease contributes to such poor prognosis at least in part. We focused on 7 kidney transplant recipients with a HCS.

Methods: Between January 1995 and May 2013, our center performed 600 KT, including 7 cases with HCS (coronary artery bypass grafting [CABG] or cardiac valve replacement [CVR]). The patients with HCS were compared to 21 without HCS. We documented baseline renal function parameters (at discharge of KT) and at 6 and 12 months of follow-up. In patients with HCS, we analyzed echocardiographic parameters before and 1 year after KT.

Results: In the cohort with HCS, age was significantly higher (45.7 ± 17.3 vs. 31.8 ± 11.7 years), and diabetes was the main etiology of ESRD (57.1%). Concerning cardiac surgery procedures, 57.1% of these patients underwent CABG and 42.9% CVR (one case with three cardiac valve replacements). The median time between cardiac surgery and the first KT was 8 months (IQR 7-20). At 12 months of follow-up, serum-creatinine values did not differ significantly between both cohorts (1.4 ± 0.12 vs.1.5 ± 0.4 mg/dl in HCS and none-HCS cohort, respectively). 1-year and graft survival in both cohorts was 100%. In the HCS-group, left ventricular ejection fraction increased before and one year after KT (45.3 ± 13.5 to 51.3 ± 18.5%, p = NS).

Conclusion: In dialysis patients, the estimated 2-year survival after CABG is 56.4% and 54% after CRV. In dialysis patients undergoing KT and HCS, Debska et al. reported a 1-year survival of 93.8% in 16 recipients. Regarding this, we found a 1-year graft and recipient survival of 100%. Furthermore kidney allograft function was comparable between both groups at the time of follow-up, thus it is likely that patients with HCS have a favorable long-term prognosis. In conclusion, we consider KT as a safe and important prognostic procedure in patients with HCS, and encourage further studies to confirm that patients with HCS should be included in American KT programs.

29

Positive Cumulative Fluid Balance as a Risk Factor for the Development or Progression of Acute Kidney Injury in Patients Admitted to the Intensive Care Unit of the General Hospital 'Dr. Manuel Gea Gonzalez'

Luis Ignacio Bonilla-Reséndiz[1,2], María Fernanda Golzarri[1], Salvador López-Giacoman[2,3], Andoreni Bautista-Ocampo[1], Claudio Ronco[2,4], Guillermo Cárdenas-Membrila[5]

[1]Department of Internal Medicine, General Hospital 'Dr. Manuel Gea González', Secretaría de Salud, México City, México; [2]International Renal Research Institute Vicenza (IRRIV), San Bortolo Hospital, Vicenza, Italy; [3]Department of Nephrology, National Institute of Cardiology, Secretaría de Salud, México City, México; [4]Department of Nephrology, Dialysis and Transplantation, San Bortolo Hospital, Vicenza, Italy; [5]Department of Critical Medicine, Division of Intensive Care Unit, General Hospital 'Dr. Manuel Gea González', Secretaría de Salud, México City, México

Introduction: During the last years, the importance of fluid overload as a risk factor for mortality and worse outcomes has been consistently documented in critically ill patients with acute kidney injury (AKI) in the intensive care unit (ICU). However, the evidence of the relationship between positive fluid balance and risk

for development and/or progression of AKI has not been clearly described. We hypothesized that positive cumulative fluid balance (CFB) is a risk factor for development or progression of AKI in critically ill patients of a general ICU in a single center in Mexico City.

Methods: Records of all the patients admitted to ICU of the General Hospital 'Dr. Manuel Gea Gonzalez' from May 2013 till April 2014 were retrospectively evaluated. After applying exclusion criteria, 138 records remained for complete analyses. We calculated the CFB by the sum of the daily intakes and outputs recorded during the whole stay of the patient in ICU, insensible losses were taken into account. Daily records of serum creatinine were evaluated and development of AKI was defined by the RIFLE criteria. Progression of AKI was defined as the change to a worse grade of the RIFLE criteria at any time during the ICU stay. CFB was evaluated at the day of discharge and was defined as positive when it exceeded 5,000 cc. Balances between 0 cc and 4,999 cc were considered 'neutral' and balances below 0 cc were considered 'negative'. Baseline characteristics and outcomes were compared using t-test, Mann-Whitney and X^2 tests. To test the association of positive CFB with AKI development or progression, we performed a logistic regression analysis, adjusting for age, sepsis, shock, nefrotoxic drugs and APACHE score as confounders.

Results: Of the 138 evaluated patients, 90 (65.2%) developed AKI during the ICU stay. Positive CFB was identified in 28 patients, 26 (92.9%) of these patients developed AKI. 110 patients had neutral or negative CFB, 64 (58.2%) of these patients developed AKI. 92.9% of patients with positive CFB developed AKI compared to 58.2% of patients with neutral or negative CFB ($p < 0.001$). None of the 90 patients with AKI suffered progression of AKI. The unadjusted odds ratio for developing AKI with positive CFB of ≥5,000 cc was 9.3 (95% CI 2.1–41.4). Death occurred in 32 (23.2%) of the 138 patients. The median CFB of the survivors was –1,824 cc (IQR –9,790 to 630), compared to a median of 5,920 cc (IQR 1,574–12,720) in the non survivors ($p < 0.001$). After adjusting for confounders, positive CFB remained a significant risk factor for developing AKI (OR 18.9, 95% CI 2.03–176.29).

Conclusion: In a cohort of critically ill patients admitted to ICU, positive cumulative fluid balance of 5,000 cc or more was a risk factor for the development of AKI and was associated with increased mortality, however positive CFB does not seem to increase the risk of progression of AKI during the ICU stay. Further, larger studies are needed to confirm whether the reduction in fluid accumulation could have a significant impact on development of AKI and mortality.

30

Hypertension as a Risk Factor for Renal Impairment in General Population: A Cross-Sectional Survey Through the Italian Pharmacy Network

M. Sartori[*,1,2,4], *M.P. Rodighiero*[1], *S. Cattin*[1,4], *E. Tonini*[1], *S. De Rosa*[1], *F. Husain-Syed*[1], *A. Fontanesi*[2], *M. Tirapelle*[2], *F. Cracco*[2], *V.M. Ballici*[2], *E. Pietrogrande*[2], *E. Ioverno*[3], *M. Valente*[3], *A. Dacomo*[1], *M. Zancato*[4], *C. Ronco*[1]

[1]International Renal Research Institute of Vicenza (IRRIV), Pharmacology Section, and Department of Nephrology, San Bortolo Hospital, Vicenza, Italy; [2]Federfarma Vicenza Association and Order of Vicenza Pharmacists, Vicenza, Italy; [3]Order of Vicenza Physicians, Vicenza, Italy; [4]University of Padua, Department of Pharmaceutical and Pharmacological Sciences, Padua, Italy

Background: The changing age structure of the population has highlighted the phenomenon of chronic diseases, such as arterial hypertension (AH) and chronic kidney disease (CKD). Therefore we have designed cross-sectional survey through the pharmacy network in order to assess risk factors, in particular AH for renal impairment in general population of northeastern area of Italy (Vicenza).

Objectives: The main aim of this study was to estimate patients with undiagnosed AH in the area under investigation. In addition, we assessed hypertensive patients that were out of pharmacology therapeutic goal and the knowledge of AH as a risk factor for CKD in general population.

Participants, Setting and Measurements: The survey was carried out between October 2014 and February 2015 by the Department of Nephrology, Dialysis and Transplantation, St. Bortolo Hospital (Vicenza, IT) in collaboration with community-pharmacists (CP). 35 CP participated without financial compensation, based on commitment and willingness. The survey was conducted on general population (n = 2036): 94.4% Caucasian and 5.6%, non-Caucasian, age ≥18 years old, 39.1% male and 60.9% female. The survey was based on risk factors for CKD, the population's knowledge of AH as risk factor for CKD, and included a single measurement of blood pressure (BP).

Results: 28.61% of participants were undiagnosed hypertensive. Furthermore, 57.6% of the patients undergoing antihypertensive pharmacology treatment did not reach the therapeutic goal. The BP measurement differed among age ($p < 0.01$) but no in gender. A large percentage of population did not recognize AH as a risk factor for CKD (46.3%). The latter was statistically significant in both age and gender ($p < 0.01$).

Conclusion: AH as a risk factor for renal impairment demands more attention in the primary care setting, both in patients undergoing antihypertensive pharmacology treatment and in general population. Additional work is needed to determine factors, which contribute to the unacceptable high antihypertensive treatment failure. Screening programs should be periodically performed in the general care setting in order to identify undiagnosed hypertensive patients. Furthermore, the awareness of AH as a risk factor for development of CKD should be raised to obtain high compliance in prevention and pharmacology treatment.

31

Rebound Kinetics of Linezolid after High Adsorption Clearance during Continuous Veno-Venous Hemofiltration by Miniaturize Dialysis *in vitro* System

*Marco Sartori**,[1–3], *Arianna Loregian*[2], *Silvana Pagni*[2], *Silvia De Rosa*[1], *Fiorenza Ferrari*[1], *Mirella Zancato*[3], *Giorgio Palù*[2], *Claudio Ronco*[1]

[1]International Renal Research Institute of Vicenza (IRRIV), Pharmacology Section, and Department of Nephrology, San Bortolo Hospital, Vicenza, Italy; [2]Department of Molecular Medicine and [3]Department of Pharmaceutical and Pharmacological Sciences, University of Padua, Padua, Italy

Background: Patients with severe sepsis or septic shock often develop acute kidney injury requiring Continuous Veno-Venous Hemofiltration (CVVH). The antimicrobial therapy response of these patients is high affected to the clearance resulting from extracorporeal blood purification treatment. In this setting the pharmacokinetic profile of Linezolid (LZD) could be modified by CVVH. Therefore we performed an *in vitro* study to evaluate LZD removal by CVVH.

Methods: A sham hemofiltration (SHF, Q_B = 30 ml/min; Q_{UF} = 2 ml/min) was set up with polysulfone hemofilter (0.25 m^2; cut-off 50.000 Da) as miniaturize CVVH circuit (CARPEDIEM, Bellco, Mirandola, IT). We separately circulated, into the system for 240 min, blood diluted with frozen plasma (n = 3; Hct 30%, 552.67 ± 7.02 ml) and saline solution (n = 3; 0.9% NS, 2000 ml). Each vehicle (blood and NS) was spiked with LZD at usually clinical peak level and packed into the bag as reservoir. LZD baseline levels were 11.75 ± 0.08 and 17.24 ± 0.54 mg/l for blood and NS, respectively. LZD samples (blood or NS) were collected from arterial, venous and ultrafiltrate lines at 10, 20, 60, 120 and 240 min from the beginning of the experiment. LZD sample levels were measured by High Performance Liquid Chromatography. We used the results to estimate pharmacokinetic parameters.

Results: LZD baseline level decreased rapidly during the first ten min of SHF both in NS and blood. Later, LZD levels gradually rose in arterial, venous and ultrafiltrate lines. There was a rapid adsorption of LZD onto polysulfone membrane followed by LZD release from the membrane itself. We observed the maximum LZD mass adsorption of 2.92 ± 2.08 and 2.64 ± 0.24 mg in NS and blood, respectively, on mass balance analysis. However, at the end of experiments the total LZD mass adsorbed onto the filter were 1.21 ± 1.04 mg in NS and 1.96 ± 0.17 in blood (figure 1).

Conclusion: This *in vitro* study suggests that LZD has a complex pharmacokinetic profile during the first hours of CVVH with polysulfone membrane. After rapid adsorption a redistribution phenomenon occurred. The rebound of LZD concentration should be take into account when therapeutic drug monitoring will be performed after one hour in order to identify the LZD peak plasma level for maximizing the efficacy. The LZD peak sample should be taken at least after four hours.

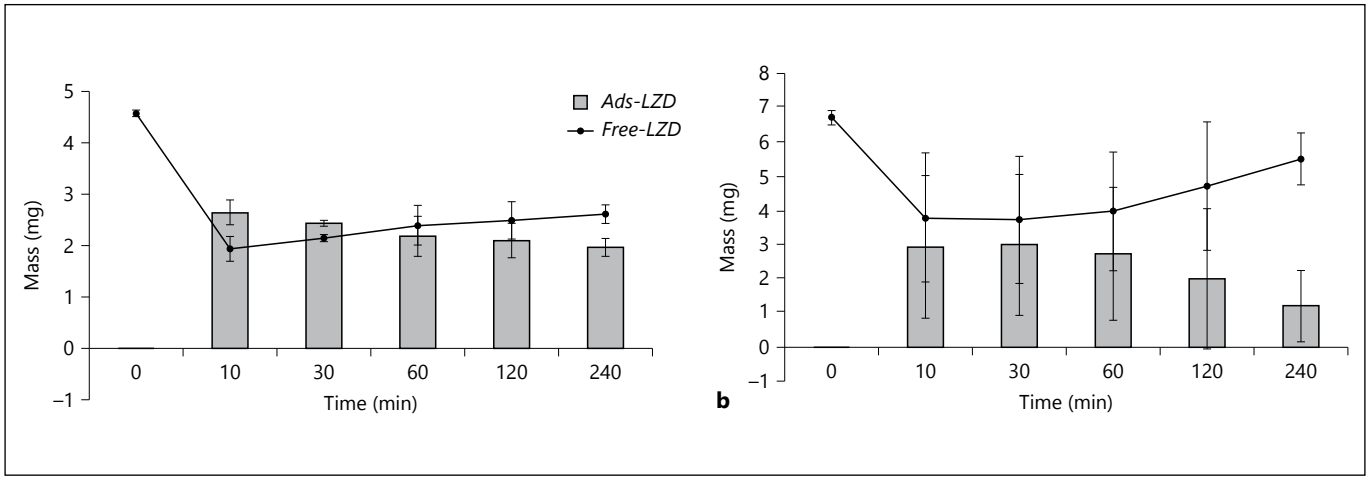


Fig. 1. Kinetics adsorption profile of Linezolid during the experiment. *Ads-LZD* is the amount of Linezolid mass [mg] adsorbed onto the polysulfone membrane at different time points; *Free-LZD* is the Linezolid mass [mg] in solution into the vehicle (Blood or NS) at different time points; **a** indicates blood experiments whereas **b** NS experiments (for Abstract 31).

32

Evaluation of Lixelle S-35 Cartridge β2-Microglobulin Removal in Two Chronic Hemodialysis Patients

Marco Sartori[*,1,2], *Sara Samoni*[1], *Federico Nalesso*[1], *Alessandra Brendolan*[1], *Mauro Neri*[1], *Francesco Garzotto*[1], *Silvia De Rosa*[1], *Davide Giavarina*[1], *Mirella Zancato*[2], *Claudio Ronco*[1]

[1]International Renal Research Institute of Vicenza (IRRIV), Pharmacology Section, and Department of Nephrology, San Bortolo Hospital, Vicenza, Italy; [2]University of Padua, Department of Pharmaceutical and Pharmacological Sciences and Department of Molecular Medicine, Padua, Italy

Background: Several adsorption medical devices have been developed for removing middle-high molecular weight solutes. Lixelle is a sorbent used to treat dialysis-related amyloidosis (DRA) due to β2-microglobulin (β2-MG) deposit. The aim of this study was assess the impact of Lixelle S-35 coupled with High-FluxDialysis (HFD) vs. online Hemodiafiltration (OL-HDF) on 2 patients.

Methods: We selected two patients with β2-MG plasma levels over 15 mg/l and regularly treated with OL-HDF. *Case 1.* Male, 57 years old with body mass index (BMI) 35.5 Kg/m^2. We collected blood samples previous and after pre/post-reinfusion OL-HDF (n = 3). Then the patient was shifted to HFD+Lixelle S-35 (n = 3; Q_B = 380 ml/min; Q_D = 500 ml/min; DBW = 2.87 ± 0.42 Kg). *Case 2.* Male, 72 years old, BMI 26.8 Kg/m^2. We collected blood samples previous and after post-reinfusion OL-HDF (n = 3). Then the patient was shifted to HFD+Lixelle S-35 (n = 3; Q_B = 300 ml/min; Q_D = 500 ml/min; DBW = 3.1 ± 0.53 Kg). In both cases, we compared the data obtained in each treatment.

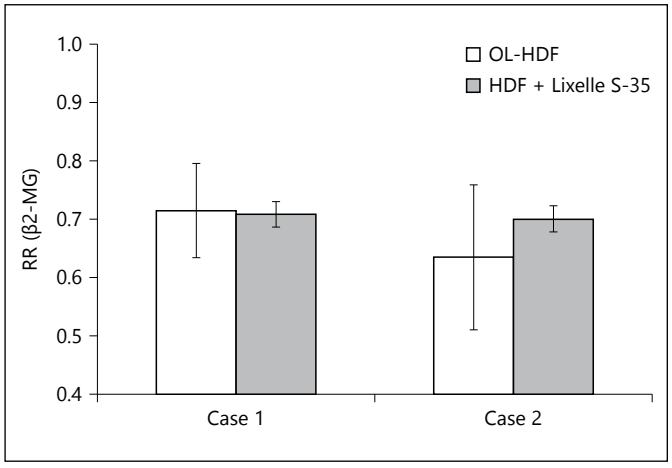


Fig. 1. β2-Microglobulin Removal Rate comparison. Case 1. pre/post-reinfusion OL-HDF vs. HFD+Lixelle S-35; Case 2. post-reinfusion OL-HDF vs. HFD+Lixelle S-35; RR is the β2-MG removal rate: [1-($\beta2MG_{POST}/\beta2MG_{PRE}$] where $\beta2MG_{PRE}$ and $\beta2MG_{POST}$ were β2-MG levels before and after extracorporeal blood purification treatment (for Abstract 32).

Results: *Case 1.* Before and after pre/post-reinfusion OL-HDF and HFD+Lixelle S-35, β2-MG levels were 18.26 ± 3.91 and 5.00 ± 0.18, 27.34 ± 1.45 and 7.96 ± 0.77 mg/l, respectively. There was no difference between pre/post-reinfusion OL-HDF (71.48%) and HFD+Lixelle S-35 (70.90%) β2-MG removal rate (figure 1). *Case 2.* Before and after post-reinfusion OL-HDF and HFD+Lixelle S-35β2-MG levels were 13.68 ± 4.10 and 4.66 ± 0.24, 17.23 ± 1.55 and 5.13 ± 0.60 mg/l, respectively. There was difference between post-reinfusion OL-HDF (63.44%) and HFD+Lixelle S-35 (70.09%) β2-MG removal rate. We did not observe any adverse reactions and/or side effects potentially related to Lixelle S-35 (e.g. thrombocytopenia, anemia etc.), nor during neither among treatments.

Conclusion: Findings suggest that HFD+Lixelle S-35 seems to be more efficient in β2-MG removal than post-reinfusion OL-HDF, whereas no differences have been found with pre/post-reinfusion OL-HDF. To our knowledge, this is the first comparison of HFD+Lixelle S-35 vs. pre/post-reinfusion OL-HDF and post-reinfusion OL-HDF.

33

The Critically Ill Patient: Ethical Challenges

Carlotta Caprara[1], *Valentina Corradi*[1], *Fiorenza Ferrari*[1], *Nereo Zamperetti*[2], *Elisa Scalzotto*[1], *Claudio Ronco*[1]

[1]Department of Nephrology Dialysis and Transplantation, International Renal Research Institute Vicenza (IRRIV), St. Bortolo Hospital, Vicenza, Italy; [2]Service for Quality, Accreditation and Patients' and Health Care Workers' Safety, St. Bortolo Hospital, Vicenza, Italy

Clinical research in the Intensive Care Units (ICU) poses unique scientific and ethical challenges. Potential participants in critical care studies are to be considered particularly vulnerable. They may lack sufficient capacity to make informed decisions about trial participation, their health care proxies may lack legal authority to enroll them in research trials or may not know their true involvement, and the life-threatening nature of the illness may make them or their surrogates more susceptible to therapeutic misconception.

It is necessary to ensure that science and knowledge can progress while respecting the ethical principle of autonomy, which is usually the best way to respect the dignity and interests of that person. However, critically ill patients are rarely conscious and able to comprehend or communicate clearly.

Nevertheless, critically ill patients are particularly interesting due to their clinical characteristic associated to emergency. Unfortunately it is difficult to create animal models with comparable characteristics or identify other type of patients with the same peculiar clinical picture. Therefore it is important to going on this research field.

What About Solutions Around the World?

Emergency research is possible only if informed consent is waived. Recent legislations have specifically addressed this issue, both in the US and in Europe.

In almost all of the European Union member states, prior consent by a legal representative is used as a substitute for informed

patient consent for non-urgent medical research. In acute emergency research deferred consent (patient and/or proxy) is accepted as a substitute in approximately half of the member states.

The identification of Substitute Decision Maker (SDM) for and the conduct of research using alternate consent models in patients lacking decision-making capacity vary across jurisdictions.

Scales DC and colleagues proposed 5 different options to approach this problems: No research while patient is incapable; advanced consent prior to critical illness and/or eligibility; waiver of need for informed consent (following approval by institutional review board); enrolment followed by delayed/deferred consent by patient once capacity is regained; consent from substitute decision-maker (SDM).

What About Italy?

Waiting for law in force in May 2016 (already approved) regulating clinical research in ICU, also for unconscious patients, a lot of decisions are left to local Ethics Committee.

This leads to global inconsistencies about enrollment of patients and approved studies, even if national guide lines are present. The hot point is that rules are not laws and every local Ethics Committee have their own ethic interpretation.

As a consequence, at the present time in Italy the destiny of a research protocol in unconscious patients depends on how local Ethics Committees understand and apply the law.

Since common guide lines are already been stipulated (January 2005),why do not all local Ethics Committee follow it? It is a dream all local Ethic Committee don't interpret subjectively the guide lines?

34

Correction of Serum Creatinine for Fluid Overload Improves the Diagnosis of Acute Kidney Injury in Critically Ill Patients: Preliminary Results

Sara Samoni[1,2], *Valentina Vigo*[3], *Luis Ignacio Bonilla-Reséndiz*[1], *Salvador Lopez-Giacoman*[1], *Silvia De Rosa*[1], *Ilaria Petrucci*[2], *Mario Meola*[2], *Federico Nalesso*[1,4], *Alessandra Brendolan*[1,4], *Carlo Donadio*[3], *Claudio Ronco*[1,4]

[1]International Renal Research Institute (IRRIV), San Bortolo Hospital, Vicenza, Italy; [2]Institute of Life Sciences, S. Anna School of Advanced Studies, Pisa, Italy; [3]Experimental Medicine, University of Pisa, Italy; [4]Department of Nephrology, San Bortolo Hospital, Vicenza, Italy

Background: Fluid overload is a frequent condition in critically ill patients. It occurs in the first hours after Intensive Care Unit (ICU) admission as a consequence of resuscitation practices or of fluid administration during surgery.

Fluid overload increases the volume of distribution of creatinine, thus decreasing serum creatinine (sCr) concentration, which may contribute to delay the diagnosis of Acute Kidney Injury (AKI) and to underestimate its severity. For this reason, some authors have suggested a formula to correct sCr according to fluid balance.

Objective: Our aim was to assess the incidence of AKI based on corrected creatinine according to a formula based on total body water (TBW) estimated by bioimpedance.

Methods: This is a prospective, dual-center study. Body fluid status was assessed in 40 adult patients during the first 24 hours after admission to a general ICU. Total body Bioelectric Impedance Analysis (BIA) was performed using a single frequency tetrapolar analyzer, to evaluate TBW (kg) and the hydration scale with vectorial analysis (BIVA). Patients were considered eligible if: (i) baseline sCr levels were available (within 3 months before admission) and (ii) BIVA hydration level was more than 81% of lean body mass, indicating moderate to severe hyper-hydration. We applied the following correction formula: (measured sCr*TBW)/(0.6*Body Weight). Acute Kidney Injury was diagnosed from sCr increase, according to KDIGO criteria, before and after creatinine correction.

Results: Twenty-six patients (61.5% male; median age 76.5 years) were considered eligible for the study. The average baseline value of sCr was 0.93 ± 0.36. Twenty-four hours after admission, sCr was 1.18 ± 0.85. The average increase of uncorrected sCr value was 0.24 ± 0.63. After correcting creatinine for fluid overload, the average value of sCr was 1.33 ± 0.89 with an increase of 0.40 ± 0.66.

The incidence of AKI was 38.4% and 42.3%, respectively before and after correction. Taking into account measured sCr, 34.6%, 0% and 3.8% of patients developed AKI stage I, II and III. After correcting creatinine for TBW overload, the percentages of patients with stage I, II and III of AKI were 26.9%, 11.5% and 3.85% of patients.

Conclusion: AKI is a common, severe, and often unrecognized comorbidity in critically ill patients. Besides correction for fluid balance, we suggest the utilization of TBW estimated by BIA to early diagnose AKI in hyper-hydrated patients. Further studies, including more patients, are needed to assess the correlation of AKI diagnosed with our formula with major outcomes.

35

Non-Hepatic Hyperammonemia: A Case Report

S. De Rosa[1], *F. Ferrari*[1,2], *M. Sartori*[1], *S. Samoni*[1], *A. Rigobello*[2], *N. Mozzo*[2], *A. Carrada*[2], *L. Fornasier*[2], *S. Marafon*[2], *R. Bonato*[2]

[1]International Renal Research Institute of Vicenza, San Bortolo's Hospital, Vicenza; [2]Department of Anaesthesia and Intensive Care Medicine, San Bortolo Hospital, Vicenza,Italy

Background: Hyperammonemia usually develops because of acute liver failure or chronic liver disease, but may occur also in the absence of hepatic disease (non-hepatic hyperammonemia, NHH). NHH is characterized by a sudden increase in plasma ammonia levels in the absence of any identifiable causes, which frequently results in intractable coma and high mortality. Urea cycle disorders rarely cause NHH in adults in whom the liver cannot handle an increased nitrogen load (e.g. protein load, increased metabolism) and usually present with much higher ammonia levels This case report aimed to investigate the early diagnosis and treatment of NHH.

Methods: To analyze the clinical characteristics and laboratory results of a man admitted to our Intensive Care Unit (ICU) on February, 2015. Reports on NHH were searched and the clinical and laboratory characteristics of reported cases were summarized.

Results: Our report describes the case of a 53-year-old male who presented to the emergency room with nausea, heartburn for the past two days and acute mental status changes the day before hospital admission. He was hospitalized to the neurology ward. Sepsis parameters, cerebrospinal fluid examination and brain magnetic resonance imaging were normal. An initial diagnosis of autoimmune encephalitis was based on electroencephalography showing generalized slowing waves. Treatment with clonazepam, carbamazepine, and corticosteroids was started without improvement of clinical condition, at which point the patient was transferred to the ICU. Metabolic evaluation confirmed hyperammonemia (up to 546 umol/l) without signs or biochemical evidence of hepatic failure. Pharmacologic, microbial, and autoimmune causes for hyperammonemia were excluded. The patient ultimately required continuous veno-venous hemodiafiltration to decrease his ammonia but without success. Unfortunately, he died after one days.

Conclusions: In the minority of hyperammonaeic patients without severe liver disease, other unusual non-cirrhotic causes should be considered, such as an occult late onset, inborn error of metabolism or intake of certain drugs. This rare report of NHH illustrates how careful investigation should be done to diagnose and treat this fatal condition.

36

CKD-EPI and Hypertension Predicting Acute Kidney Injury after Cardiac Surgery: The Tree Decision Model

S. Lopez-Giacoman[1,2], C. Garza-Garcia[1], J.L. Salas-Pacheco[3], L.I. Bonilla[4], F. Husain-Syed[2], E.F. Rodriguez[1], C. Ronco[2], M. Madero[1]

[1]Department of Nephrology, National Institute of Cardiology, Secretary of Health, México City, México; [2]Department of Nephrology, Dialysis and Transplantation, International Renal Research Institute of Vicenza (IRRIV), San Bortolo Hospital, Vicenza, Italy; [3]Department of Echocardiography, National Institute of Cardiology, Secretary of Health, México City, México; [4]Department of Internal Medicine, General Hospital 'Manuel Gea Goanzalez', México City, México

Introduction: Acute kidney injury after cardiac surgery (CS-AKI) is a common complication, associated with increased morbidity and mortality. Accurate prediction of AKI is crucial as it provides an opportunity to develop strategies for early diagnosis and treatment. Different prediction models have been developed to identify high-risk patients that may develop CS-AKI. Nonetheless the performance of these models may not be optimal regarding our population, as most of the models have been developed in patients undergoing coronary artery bypass graft (CABG) surgery. The aim of this study was to develop a clinical model to predict postoperative AKI by incorporating the effect of all of its major risk factors.

Methods: We conducted a prospective, observational, and longitudinal analysis of adult patients who underwent cardiac surgery requiring cardiopulmonary bypass and aortic cross clamp. AKI was defined by the AKIN classification, and severe AKI was considered AKIN stage 2 or 3. Patients were followed up to 96 hours after surgery or earlier if discharged from the intensive care unit. We analyzed age, sex, body mass index (BMI), co-morbidities, previous cardiac surgery, left ventricular ejection fraction, arterial hypertension (HTN), New York Heart Association classification, type of procedure, cardiopulmonary bypass time, cross clamp time and bleeding complications.

Results: In total, 347 patients who underwent cardiac surgery were analyzed. Median age was 53 ± 14.8 years, 58% of the population were male, median CKD-EPI was 84.4 ± 21.4 ml/min. 70% of the patients underwent valvular cardiac surgery, here aortic valve replacement was the most frequent procedure (63%). During the first 96 hours after procedure, 143 subjects (41.2%) developed AKI and 51 patients (16.1%) had severe AKIN, respectively. We developed a clinical risk score algorithm based on a three decision model. This method split the samples into 3 different groups based on interactions between key discriminating variables. High-risk patients with an incidence of 30% included those with history of HTN, valvular surgery and CKD-EPI less than 79.5 ml/min; middle-risk patients with an incidence of 13.5% included those who underwent CABG surgery and had a history of HTN; the low-risk group with an incidence of 3.9% corresponded to those patients with CKD-EPI higher than 79.5 ml/min and without history of HTN. The accuracy of this model was 80%. According to multivariate analysis, high-risk patients had an OR 2.8 (CI 95%, 1.2 to 5.9) with a p value = 0.003 for the development of severe AKI. In contrast, being a low-risk patient had a protective effect for AKI development with and OR 0.41 (CI 95%, 0.2 to 0.87) and p value = 0.017. Our model AUC was 0.66, with a sensibility of 62% and specificity of 67%.

Conclusions: Based on a three decision algorithm, we found that the use of a simple clinical model in patients undergoing cardiac surgery may have the same or even more accurate performance for prediction of severe AKI development compared with other clinical scores. The advantage of our clinical tree decision model lies in its easier feasibility and need of few variables of patients undergoing valvular surgery. In conclusion, the combination of risk factors during the pre-operative (GFR by CKD-EPI), trans-surgical (extracorporeal circulation and clamp time) and early post-operative period provides an improved recognition of patients who are likely to develop AKI after cardiac surgery. This may allow early preventive and therapeutic measures, along with interventions that end up in an optimal use of human and economic resources.

37

Utility of Back-Calculating Baseline Creatinine with MDRD for Diagnosis of Cardiorenal Syndrome Type 1

Elisa Scalzotto[1], *Luis Ignacio Bonilla-Reséndiz*[1,2], *María Fernanda Golzarri*[3], *Sara Samoni*[1], *Faeq Husain-Syed*[1], *Flavio Mistrorigo*[4], *Grazia Maria Virzì*[1], *Nadia Aspromonte*[5], *Roberto Valle*[6], *Valentina Corradi*[1], *Carlotta Caprara*[1], *Alice Parise*[1], *Rossella Torregrossa*[1], *Alessandra Brendolan*[1], *Dinna Cruz*[1], *Claudio Ronco*[1]

[1]Department of Nephrology Dialysis and Transplantation International Renal Research Institute Vicenza (IRRIV), St. Bortolo Hospital, Vicenza, Italy; [2]National Institute of Cancerology, Secretaría de Salud, México City, México; [3]Department of Internal Medicine, General Hospital 'Dr. Manuel Gea González', Secretaría de Salud, México City, México; [4]Department of Cardiolgy, St. Bortolo Hospital, Vicenza, Italy; [5]Department of Cardiology, St. Filippo Neri Hospital, Roma, Italy; [6]Department of Cardiology, Chioggia Hospital, Venezia, Italy

Introduction: The cardiorenal syndrome (CRS) classification includes a vast array of acute and chronic conditions, where the primary failing organ can be either the heart or the kidneys. In particular, type 1 includes acute cardiovascular disease scenarios leading to acute kidney injury (AKI). Several methods have been proposed to achieve early detection of CRS; neutrophil gelatinase-associated lipocalin (NGAL) is a well-recognized plasma and urinary biomarker that can predict and diagnose AKI development. In many cases, AKI is underdiagnosed in patients with acute cardiac dysfunction, taken into account that the baseline serum creatinine (sCr) is unknown, and first day measurement of sCr is taken as baseline value. We hypothesized that by back-calculating baseline sCr using MDRD formula, more cases of AKI associated with acute cardiac dysfunction could be identified.

Material and Methods: This prospective multicenter study was conducted on 144 individuals with acute heart failure admitted to the Coronary Intensive Care Unit (CICU) from January 2010 to December 2011 in three Italian centers. The following variables were obtained: gender, age, sCr at day of admission and at 48 hours and plasma NGAL at 48 hours. The presence of AKI, defined according to the KDIGO AKI Guidelines, was assessed 48 hours after admission. Plasma NGAL was measured at the same time; we used a cut-off value ≥150 ng/ml for classifying patients with AKI. The presence of AKI was evaluated by three different methods; comparison between baseline estimated creatinine using back-calculating MDRD and measured sCr at 48 hours, comparison between admission measured sCr and sCr at 48 hours and plasma NGAL at 48 hrs. We compared the prevalence of AKI detected by every method.

Results: We enrolled for study 144 individuals, the mean age of patients was 66 years (SD ±19.9 y), 109 (75.7%) were male and 35 (24.3%) were female. The median back-calculated baseline creatinine was 1.04 mg/dl (IQR 0.99–1.08), the median measured SCr at admission was 0.88 mg/dl (IQR 0.76–1.1). At 48 hours, the median measured sCr was 0.89 mg/dl (IQR0.79–1.1) and for NGAL 113 ng/dl (IQR 68.3–192.5). At 48 hours 53 (36.8%) of the patients were classified as AKI by plasma NGAL ≥150 ng/dl. According to KDIGO definition, taking in account back-calculated baseline creatinine AKI was identified in 31 (21.5%) of patients, and according to measured sCr, AKI was present in 7 (4.9%) of the patients. At 48 hours of admission, plasma NGAL diagnosed 36.8% of patients with CRS type 1, compared to 21.5% ($p = 0.01$) with back-calculated creatinine and 4.9% ($p < 0.001$) with measured sCr. A receiver operator characteristic (ROC) curve was generated, and the area under the curve (AUC) for the estimated creatinine change was 0.759 (95% CI 0.673–0.845). A less optimal performance was seen with the measured sCr change, resulting in an AUC 0.508 (95% CI 0.402–0.614) (fig. 1).

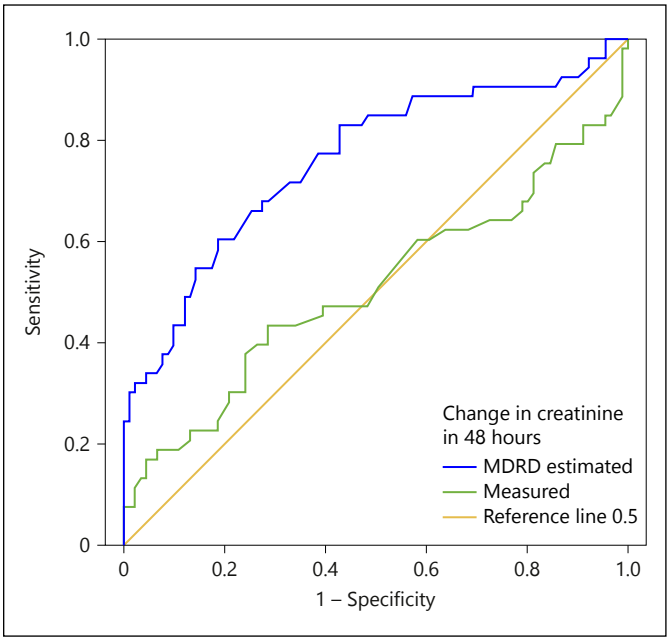


Fig. 1. ROC curve for sensibility and specificity of AKI detection with back-calculated baseline creatinine vs. measured creatinine at first 24 hrs of admission to CICU. State Variable: AKI diagnosed with plasma NGAL ≥150 ng/dl (for Abstract 37).

Conclusions: Classification of AKI with back-calculating baseline creatinine with MDRD formula diagnosed more patients with CRS type 1 compared to measured sCr. Plasma NGAL measurement with a cut-off value of ≥150 ng/dl identified the most patients with CRS type 1. We suggest that back-calculating MDRD baseline creatinine should be applied to classify AKI when plasma NGAL is not available in order to identify more patients with CRS type 1. More studies are needed in order to make a clear cut-off value for plasma NGAL in this type of patients.

38

Prognostic Implication of Plasma Procalcitonin and IL-6 in Predicting Mortality and Renal Failure after Cardiac Surgery

Alessandra Brocca[1,2,4], *Grazia Maria Virzì*[1,2], *Maria Jimena Muciño-Bermejo*[1,2], *Davide Giavarina*[3], *Massimo de Cal*[2], *Tommaso Hinna Danesi*[5], *Maria Rosa Carta*[3], *Loris Salvador*[5], *Claudio Ronco*[1,2]

[1]IRRIV-International Renal Research Institute Vicenza, [2]Department of Nephrology, Dialysis and Transplantation, San Bortolo Hospital, Italy; [3]Clinical Chemistry and Haematology Laboratory, San Bortolo Hospital, Italy; [4]Department of Medicine DIMED, University of Padova Medical School, Italy; [5]Department of Cardiac Surgery, San Bortolo Hospital, Vicenza, Italy

Background: Accurate evaluation of the risk for adverse outcomes and mortality is crucial to clinical decision-making in patients submitted to a cardiac surgery. Procalcitonin levels has been reported to be related to the development of postoperative complications, including postoperative myocardial infarction, SIRS, and respiratory failure. Furthermore, in cardiopulmonary bypass (CPB), it was observed the rises in the pro-inflammatory cytokines, such as TNF-α, IL-6 and IL-8 and the correlation between the magnitude of cytokine response and the severity of organ injury.

The aim of this study was to evaluate the usefulness of IL-6 and Procalcitonin postoperative levels in predicting mortality and renal complications in cardiac surgery patients.

Methods: 122 cardiac surgery patients were enrolled. Procalcitonin and IL-6 concentrations were measured in the second postoperative day (POD) and their levels were evaluated versus a number of conditions and endpoints, including kind of cardiac surgery, mortality, length of ICU stay and composite renal, respiratory and cardiovascular outcomes.

Results: There was no significant difference in Procalcitonin or IL-6 levels among surgery type defined groups and between the ECC duration. Neither Procalcitonin nor IL-6 concentrations seem to be good predictors of bleeding and the length of ICU stay. IL-6 was observed to be a better predictor of mortality than Procalcitonin ($p < 0.05$). Patients with adverse renal outcome have significantly higher Procalcitonin levels ($p < 0.05$).

Conclusion: In this pilot study, we observed the utility and power of IL-6 to predict mortality in this small group; so we may speculate that IL-6 could be an effective biomarker. It is possible that a combination of Procalcitonin for predicting renal outcome and IL-6 for predicting mortality in an inflammatory multi biomarker panel as opposed to a single biomarker should be taken as 'add-value' rather than a 'unique-predicting' data.

39

Definitions and Conceptualization of Dose in Continuous Renal Replacement Therapy

Mauro Neri[1], *Gianluca Villa*[1,3], *Francesco Garzotto*[1,2], *Zaccaria Ricci*[4], *Anna Lorenzin*[1], *Marco Sartori*[1], *Alessandra Brendolan*[1,2], *Federico Nalesso*[1,2], *Monica Zanella*[1,2], *Claudio Ronco*[1,2]

[1]Internation Renal Research Institute of Vicenza, [2]Nephrology, Dialysis and Transplantation, San Bortolo Hospital, Vicenza, Italy; [3]Department of Human Health Science, Section of Anesthesia and Intensive Care, University of Florence, Florence, Italy; and [4]Department of Pediatric Cardiac Surgery, Bambino Gesù Children's Hospital, Rome, Italy

Background: During the last decades, increasing attention has been paid to the quantification of the dose to deliver during an extracorporeal continuous renal replacement therapy (CRRT) in patients with acute kidney injury (AKI). Although the literature almost agrees in the identification of an appropriate value to achieve, there is no strict consensus about definitions and formulas of dose. *Dose* identifies the dialysis efficiency and in particular the amount of blood cleared of waste products and toxins by extracorporeal circuit. However, different and more specific measures of adequacy and dose should be considered during a CRRT, in order to clarify and simplify the clinical evaluation before, during and after the treatment.

Methods: Urea is usually considered as marker for uremic toxins and is often used to quantify the treatment dose. However, during CRRT, a different approach based on the evaluation of flows into the machine could be an easier and more reproducible method to estimate the dose.

Results: We defined 7 concepts of dose: *target prescribed dose* is the target clearance prescribed by clinicians to achieve in the patient; *target delivered dose* is the clearance set in the RRT machine and is based on flows and parameters; *current dose* is the instantaneous clearance calculated in the machine; *cumulative dose* is the clearance obtained considering the current dose applied over the total treatment session time; *estimated dose* is the weighted-mean clearance that will be theoretically obtained at the end of the treatment session time; *current delivered dose* is the instantaneous clearance based on patient's blood concentration; *delivered dose* or *real delivered dose* is the weighted-mean of current delivered dose over total treatment session time.

Conclusions: A standardized definition of different concepts of dose in CRRT can help physicians, nurses and users to manage the extracorporeal therapy in the most rigorous way.

40

Baseline Creatinine and AKI: A Still Actual Debate

C. Estremadoyro[1,2], *S. Aresu*[2,3], *A. Casas*[2], *S. Lopez-Giacoman*[2], *C. Ronco*[2]

[1]Department of Nephrology Hospital Barros Luco, Santiago Chile; [2]International Renal Research Institute Vicenza (IRRIV), San Bortolo Hospital, Vicenza, Italy; [3]Department of Nephrology Hospital Brotzu, Cagliari, Italy

Introduction: Acute kidney injury (AKI) is a frequent complication in hospitalized patients, diagnosis is based in serum creatinine (sCr) increase from baseline, or decrease urinary output. Standard definition for baseline creatinine does not exist, leading to heterogeneity across research studies and the potential misinterpreting of the true stage of AKI in hospitalized patients.

The aim of this study is to evaluate the applicability of the BCr use in daily clinical practice, confronting the different estimating methods with the real BCr and evaluating the differences between the three classification methods.

Methods: Retrospective observational study conducted in Nephrology department San Bortolò Hospital in Vicenza, Italy. Included adult patients throw out 2013. Demographic data, clinical information and laboratory values were collected using SINED MEDWARE software. We defined AKI by RIFLE, AKIN and KDIGO and did comparison among them. For the study we defined Baseline Cr (BCr) pre AKI Cr limited 1 year before. Admission Cr (ACr) Cr at admission. Maximum Cr (MCr) the maximum Cr during the hospitalization. Discharge Cr (DCr) Cr at discharge. Minimum Cr (mCr) minimum Cr in the 12 months follow-up. Back-calculation with the MDRD formula (eCr75) supposing all patients had a GFR of 75 ml/min eCr75 = (75/[186 × (age –0.203) × (0.742 for women) × (1.21 for black people)])–0.887. The follow-up period was one year after admission.

Results: We analyzed 87 patients with AKI at admission or during the hospitalization, median age was 75 years, 61% were male, AKI etiology was 39%, 41%, 15% y 4.6%, pre-renal, renal, post-renal and unknown respectively. Dehydration (24%) was the main etiology.

We analyze the 36 (41%) known BCr of this 50% had CKD in those we analyzed the corresponding eBCr with the 4 methods, ACr and DCr reach an overestimation error the 1200% and 600%. In the other hand mCr has a median error tending to 0% and error distribution is small eCr75 underestimates BCr.

We divided BCr known population by CKD pre-AKI episodes in 2 groups by CKD stage: stage 1–2, stage 3–4. In the same CKD groups we evaluated MCr: the median was similar in both groups but stage 1–2 had a higher variability in MCr values from 1.7 to 13.9 mg/dl. Stage 3–4 MCr values varied from 3.2 to 11 mg/dl. Besides we evaluated the concordance among different classification criteria for AKI, 14 patients classified in stage 1 by KDIGO/AKIN, RIFLE classifies 11 patients (78%) in stage 1; 2 patients (13%) in stage 2 and 1 patient is not classified, of the 5 patients classified in stage 2 by KDIGO/AKIN, RIFLE classifies all in stage 2, of the 3 patients classified in stage 3 by KDIGO/AKIN, RIFLE classifies 2 (6%) in stage 1, 1 (3%) in stage 2 and 14 (42%) in stage 3 and 16 (48%) were not included as AKI.

Conclusions: BCr is fundamental to make AKI diagnosis. Unfortunately this value is often not available and clinicians have to estimate it to divide unknown CKD from AKI. This study shows that in AKI patients the mCr had better correlation with the BCr. In other way eCr75 and ACr had poor correlation with BCr, confirming what was stated in other studies.

Even though mCr has the minor error in estimating BCr, it is available only delayed in time so it is not helpful in the clinical practice when we have to decide if it is AKI or not, but it becames a fundamental point in the follow-up; Also seem that DCr could be helpful because it is only slightly higher than the real BCr but it is earlier available.

Other methods and classification criteria to diagnose AKI will be necessary, biomarkers will be the future and research should implement this way of diagnosis, hoping this technique will be soon available for daily clinical practice.

41

The (DoReMIFA) Dose Response Multicenter Investigation Fluid Assesment: Fluid Accumulation and CRRT Initiation

F. Garzotto[1,2], *M. Ostermann*[3], *M.E. Herrera-Gutiérrez*[4], *D. Martín-Langerwerf*[5], *L. Cachafeiro*[6], *R. Robert*[7], *A. Marinho*[8], *A. Lorenzin*[2], *D. Marcelli*[9], *C. Tetta*[10], *C. Ronco*[1,2]

[1]St. Bortolo H, Nephrology and IRRIV, Vicenza, Italy; [2]St. Bortolo Hospital, IRRIV, Vicenza, Italy; [3]Guy's & St. Thomas NHS Foundation, Dp. Adult Critical Care, London, United Kingdom; [4]Department of Critical Care Medicine, University Hospital Carlos Haya, Málaga, Spain; [5]Hospital Universitario del Vinalopó, Servicio de Medicina Intensiva, Elche, Spain; [6]H. La Paz, Servicio de Medicina Intensiva, Madrid, Spain; [7]CHU de Poitiers, Service de Réanimation Médicale, Poitiers, France; [8]H. Do Porto, Dp. Anestesia e Cuidados Intensivo, Porto, Portugal; [9]Fresenius Medical Care, MBA Int. Hospital and Healthcare Management, Bad Homburg, Germany; [10]Fresenius Medical Care, EMEA LA Medical Board, Vaiano Cremasco, Italy

Introduction: Acute kidney injury (AKI) is associated with high mortality and significant health resource utilization. 5–6% of ICU patients also requires renal replacement therapy (RRT). Recent data highlight the importance of fluid balance in patients with AKI. Moreover dangerous thresholds (10% and 20%) are associated with increasing mortality. In general, a positive cumulative fluid balance portends higher morbidity and an increased risk for worse clinical outcome. Fluid balance should be recognized as a potentially modifiable biomarker and determinant of clinical outcome in these patients.

Methods: We developed an observational, prospective, multicenter study (DoReMIFA) on critical ill patients. Of the 1636 patients recorded we calculated the daily percentage of FluidOverload (FO%) as the cumulative daily Fluid Balance (intake-out) on patient weight. The maximum (M_FO%) has been extracted among 4 categories: Overall, no AKI, AKI (RRT not included), RRT patients. We also analyzed the mortality among these groups. Results are reported as median, 25 and 75 percentiles and non-

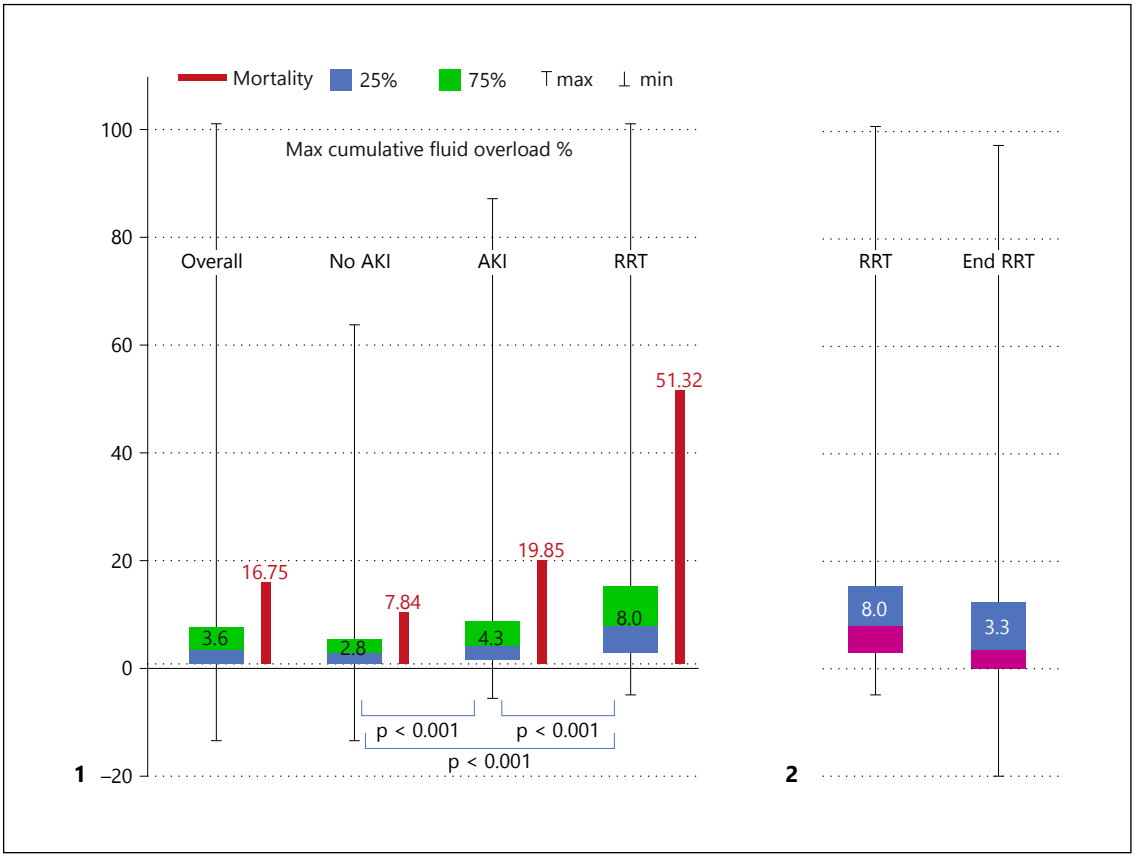


Fig. 1, 2. (for Abstract 41).

parametric Kruskal-Wallis test with Bonferroni correction has been applied.

Results: Our results show an higher percentage of patients treated with CRRT (11.5%) if compared with literature (5–6%). As show in figure 1 the M_FO% is appreciably low in each group. None of the 75 percentile exceed the 20% with the worst value (15.2%) reached by RRT group. M_FO% is under 20% and 10% respectively on 94.1% and 82.0% of all patients. M_FO% significantly characterize the 3 groups ($p < 0.001$). At the end of the CRRT (figure 2) median FO% decrease to 3.3% from 8.0% ($p < 0.05$). Mortality is strongly correlated with the median M_FO% value.

Conclusion: A relatively high level of cumulative FO% characterized the RRT population (Median 8%, IRQ: 2.8%–15.2%). Nevertheless CRRT was also effectively used to reduce FO% while Mortality (51.3%) remains high for overloaded patients.

A high number of patients treated with extracorporeal therapies and an overall low fluid accumulation seems to reflect, for the first time, a careful and accurate fluids management in all the ICUs.

42

In vitro Test of a New Membrane for CVVHD with CARPEDIEM

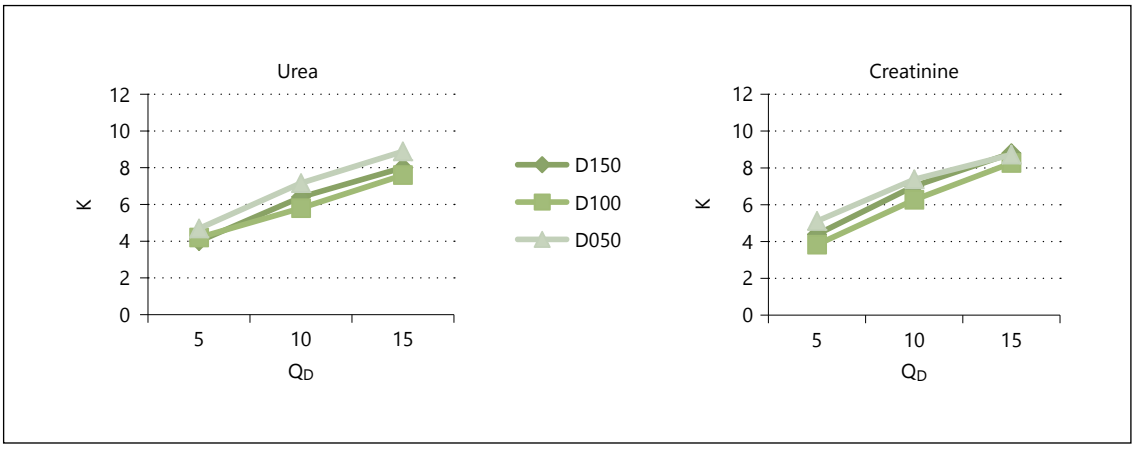
Anna Lorenzin[1], *Dario Galeano*[1], *Stefania Aresu*[1], *Francesco Garzotto*[2], *Claudio Ronco*[2]

[1]International Renal Research Institute of Vicenza (IRRIV), Italy; [2]International Renal Research Institute of Vicenza (IRRIV) and St. Bortolo Hospital Vicenza, Italy

Introduction: Historically, peritoneal dialysis were considered the renal replacement therapy of choice for acute kidney injury in neonates. Thanks to the development of new devices, designed specifically for small infants (<10 kg), Continuous Renal Replacement Therapies CRRT are now becoming a common clinical practice in the pediatric intensive care units. Following this trend, specific circuits/filters have been conceived to implement a CVVHD treatments of CRRT with the CARPEDIEM machine, to date set up only for CVVH treatments.

We tested a prototype kit with an handmade dialyzers, to evaluate the performance of the therapy in terms of urea and creatinine clearance.

Blood Purif 2015;40:1–37
DOI: 10.1159/000431262



Color version available online

Fig. 1. Example of clearances of urea and creatinine obtained with a Q_P = 20 ml/min and different Q_D (5, 10, 15 ml/min) three different size of the filter (for Abstract 42).

Table 1. Flow rate configuration of the in vitro test (for Abstract 42)

Q_P (ml/min)	Q_D (ml/min)	Q_{EFF} (ml/min)
30	5	5
20	5	5
10	5	5
30	10	10
20	10	10
10	10	10
30	15	15
20	15	15
10	15	15

Methods: We performed in vitro tests with plasma, comparing the three different size of the filter available (handmade filters with surface are of 0.10 m^2, 0.20 m^2, 0.35 m^2). A CVVHD treatment, in co-current configuration, was carried out using the infusion pump as dialysate pump and ultrafiltration pump as effluent pump. Every test was performed with a scheduled combination of plasma flow rate (Q_P) and dialysate flow rate (Q_D) (see table 1) to obtain different clearances in various conditions; the effluent flow rate Q_{EFF} was adjusted to have 0 ml/min of ultrafiltration. The samples were collected in the plasma bag, before starting the treatment (single pass), and in the venous line every Q_P and Q_D changes. Sample time interval of 8 minute was established for the system stabilization with the lowest flow configuration. We computed the clearances from the samples concentration of urea and creatinine.

$$K = Q_P \frac{(C_i - C_o)}{C_i}$$

Results: Figure 1 shows the comparison of the clearances obtained with the three dialyzers in the different flow rates configurations. The filters efficiency increases with the increase both of the flow rates Q_P and Q_D.

Discussion: CVVHD with CARPEDIEM machine seems to be effective for diffusion transport of small molecular weight solutes, according with the neonate clinical needs.

43

In-vitro Evaluation of NGAL Extracorporeal Removal during Hemodialysis with High Cut-Off Membrane

Gianluca Villa, Mauro Neri, Marco Sartori, Sara Samoni, Silvia De Rosa, Alessandra Brocca, Grazia Maria Virzì, Federico Nalesso, Alessandra Brendolan, Claudio Ronco

Department of Nephrology and Dialysis, International Renal Research Institute, (IRRV) San Bortolo Hospital, Vicenza, Italy

Introduction: Neutrophil gelatinase-associated lipocalin (NGAL) is a biomarkers which may effectively predict the renal functional recovery during acute kidney injury (AKI). Its molecule exists in three different molecular forms; as a 25-kDa monomer, as a 45-kDa homodimer and as a 135-kDa heterodimer. Continuous veno-venous hemodialysis with high cut-off membranes (HCO-CVVHD) is a blood purification therapy used in critically ill septic patients with AKI which allowsthe transmembrane removal of high molecular weight molecules (up to 50–60 kDa, as inflammatory mediators) across its large membrane pores size. This characteristic may increase the clearance of NGAL. The aim of this study is to evaluate the transmembrane removal of NGAL during HCO-CVVHD.

Methods and Results: Three liters of plasma, enriched with 1 mg of NGAL solute (containing all the molecular forms; median initial concentration of 326.5 ng/ml) have been treated (N = 3) with HCO-CVVHD for 30 minutes (blood flow 100 ml/min, dialysate flow 2,450 ml/h–35 ml/kg/h for a 70 kg patient- and net-ultrafiltration rate of 0 ml/h). Samples for NGAL analysis have

Table 1. Parameters of Urea and NGAL extracorporeal removal (N = 3) (for Abstract 43)

	Formulas	Median [I–III interquartile]
Effluent rate (ml/min)		40.83
Urea mass balance error (%)	$(M_{art} - M_{ven} - M_{eff})/M_{art}$	1.58 [0.54–2.62]
Urea Saturation Coefficient	$2 \cdot [Urea]_{eff}/([Urea]_{art} + [Urea]_{ven})$	1.02 [1.01–1.04]
NGAL Saturation Coefficient	$2 \cdot [NGAL]_{eff}/([NGAL]_{art} + [NGAL]_{ven})$	0.19 [0.19–0.19]
Clearance of Urea (ml/min)	$Qb \cdot (([Urea]_{art} - [Urea]_{ven})/[Urea]_{art})$	41.65 [41.03–42.26]
Clearance of NGAL (ml/min)	$Qb \cdot (([NGAL]_{art} - [NGAL]_{ven})/[NGAL]_{art})$	10.15 [8.02–12.28]
NGAL adsorption (μg)	$M_{art} - M_{ven} - M_{eff}$	437.29 [422.63–451.94]

Abr: M_{art}, M_{ven} and M_{eff}, the solute mass in the initial, final and effluent bag; $[Solute]_{eff}$, $[Solute]_{art}$ and $[Solute]_{ven}$, the Urea or NGAL concentration in the arterial, venous and effluent line; Qb = the blood flow.

Table 1. Parameters of Urea and proBNP extracorporeal removal (N = 3) (for Abstract 44)

	Formulas	Median [I–III interquartile]
Effluent rate (ml/min)		40.83
Urea mass balance error (%)	$(M_{art} - M_{ven} - M_{eff})/M_{art}$	1.58 [0.54–2.62]
Urea Saturation Coefficient	$2 \cdot [Urea]_{eff}/([Urea]_{art} + [Urea]_{ven})$	102 [101–104]
proBNP Saturation Coefficient	$2 \cdot [proBNP]_{eff}/([proBNP]_{art} + [proBNP]_{ven})$	13.08 [12.89–13.27]
Clearance of Urea (ml/min)	$Qb \cdot (([Urea]_{art} - [Urea]_{ven})/[Urea]_{art})$	41.65 [41.03–42.26]
Clearance of proBNP (ml/min)	$Qb \cdot (([proBNP]_{art} - [proBNP]_{ven})/[proBNP]_{art})$	8.76 [7.69–9.84]
proBNP adsorption (ng)	$M_{art} - M_{ven} - M_{eff}$	80.17 [76.06–84.29]

Abr: M_{art}, M_{ven} and M_{eff}, the solute mass in the initial, final and effluent bag; $[Solute]_{eff}$, $[Solute]_{art}$ and $[Solute]_{ven}$, the Urea or proBNP concentration in the arterial, venous and effluent line; Qb = the blood flow.

been obtained from pre-filter/post-filter/effluent lines at 15 min, and from the effluent, initial and final bags. At the same time concentrations of urea have been obtained to evaluate the accuracy of sampling and clearance/mass balance calculations. Clearances, saturation coefficients and mass balances are reported in the table, as well as the formulas used to calculate them.

Conclusion: The transmembrana dialytic clearance of NGAL is not clinically relevantduring HCO-CVVHDand it should be not considered when the kinetic of plasma NGAL levels is used as an indicator in clinical practice.

44

In-vitro Evaluation of proBNP Extracorporeal Removal during Hemodialysis with High Cut-Off Membrane

Gianluca Villa, Mauro Neri, Marco Sartori, Sara Samoni, Silvia De Rosa, Anna Lorenzin, Massimo De Cal, Alessandra Brocca, Valentina Corradi, Monica Zanella, Federico Nalesso, Alessandra Brendolan, Claudio Ronco

Department of Nephrology and Dialysis, International Renal Research Institute, (IRRV) San Bortolo Hospital, Vicenza, Italy

Introduction: pro-Brain natriuretic peptide (proBNP) is a peptide used as biochemical marker ofheart failure. Myocardial dysfunction frequently occurs during sepsis and proBNP have been proposed to evaluate the severity and prognosis of critically ill septic patients. Continuous veno-venous hemodialysis with high cut-off membranes (HCO-CVVHD) is a blood purification therapy used in critically ill septic patients with AKI to remove the high molecular weight molecules, as inflammatory mediators. During

HCO-CVVHD, the extracorporeal clearance may reduce the effectiveness of several biomarkers, as proBNP. The aim of this study is to evaluate the transmembrane removal of proBNP during HCO-CVVHD.

Methods and Results: Three liters of plasma (initial median concentration of proBNP was 143 pg/ml) have been treated *in vitro* (N = 3) with HCO-CVVHD for 30 minutes (blood flow 100 ml/min, dialysate flow 2,450 ml/h–35 ml/kg/h for a 70 kg patient- and net-ultrafiltration rate of 0 ml/h). Samples for proBNP analysis have been obtained from pre-filter/post-filter/effluent lines after 15 min, and from the effluent, initial and final bags. At the same time concentrations of urea have been obtained to evaluate the accuracy of sampling and clearance/mass balance calculations. Clearances, saturation coefficients and mass balances are reported in the table, as well as the formulas used to calculate them.

Conclusion: The transmembrane dialytic clearance of proBNP may be not clinically relevant during HCO-CVVHD and it may be nottaken into consideration when the kinetic of plasma proBNP levels is used in clinical practice.

45

The Rationale for Routine Colour Doppler Sonographic Vascular Mapping in Pre-Operative Planning of Hemodialysis Access. Maximizing Construction Rates and Patency of Native Arteriovenous Fistulae. A Retrospective Study

I. Giannikouris[1,2], F. Nalesso[2], S. Samoni[2,3], I. Petrucci[3], A. Brendolan[2], M. Meola[3], G. Triantafylis[1], C. Ronco[2]

[1]Ilion Medical Nursery, Medifil AE, Athens, Greece; [2]International Renal Research Institute (IRRIV), Department of Nephrology, Dialysis and Transplanation, San Bortolo Hospital, Vicenza, Italy; [3]Institute of Life Sciences, S. Anna School of Advanced Studies, Pisa, Italy

Introduction: Successful native arteriovenous fistula (AVF) formation has a significant impact on hemodialysis (HD) patients. A complicated and failing native AVF is associated with increased morbidity and mortality rates. Traditionally, the selection of vascular access and the eligibility for native AVF construction was mainly determined by findings of clinical examination. Colour Doppler ultrasonographic (CDUS) vascular mapping is a non-invasive, effective and safe method that permits the identification of vessels that are suitable for AVF construction. According to the Kidney Disease Outcomes Quality Initiative it is recommended that routine pre-operative vascular mapping is to be performed in all HD patients who are candidates for vascular access formation. However, it is acknowledged that Level I evidence to support preoperative mapping is lacking.

Objective: The purpose of the present study was to compare the outcomes of vascular access procedures performed in terms of access selection and long-term patency using physical examination alone to CDUS vascular mapping and physical examination, for the assessment of patients requiring HD access.

Methods: Comparative analysis of data obtained by retrospective review of records of 68 patients, 46 (68%) males and 22 (32%) females, aged 71 ± 13 years, which underwent procedures for vascular access formation, between January 2012 to January 2014, were performed. Eventually, 51 patients received native AVF (75%) while 17 (25%) arteriovenous grafts. Patients were assigned into two groups according to whether they underwent physical examination alone (group A) and vascular mapping using CDUS in addition to physical examination (group B), during their preoperative assessment. The impact of the different preoperative approaches in vascular access eventually constructed and surgical outcomes in terms of patency rates, assessed at 12 months, were compared in the two groups.

Results: Group A included 34 patients, 24 (71%) males and 10 (29%) females aged 69 ± 9 years, while 34 patients, 22 (65%) males and 12 (35%) females, aged 65 ± 12 years, were assigned into group B. The rate of successfully constructed native AVF appeared to be significantly increased from 68% (n = 23) in group A to 82% (n = 28) when preoperative CDUS was performed (group B patients), $p < 0.01$. Moreover, when established native AVF patency rates were compared, group B patients demonstrated a 88% patency rate at 12 months, which was significantly higher than the corresponding rate of patients in group A (71%), $p < 0.01$.

Conclusion: Preoperative CDUS vascular mapping prior to HD access placement seems to facilitate definite selection of potential sites, maximizing the number of native AVF and ensuring high patency rates. However, intensive and detailed research is required to elucidate the role and evaluate the value of CDUS.

46

Analysis of 121 Vascular Accesses for Hemodialysis: Correlation of Body Surface Area to Brachial Artery Volume Flow Estimates by Colour Doppler Ultrasonography. A Dual Center Experience

I. Giannikouris[1,2], F. Nalesso[2], S. Samoni[2,3], I. Petrucci[3], María Fernanda Golzarri[4], Luis Ignacio Bonilla-Reséndiz[2], A. Brendolan[2], M. Meola[3], C. Ronco[2]

[1]Ilion Medical Nursery, Medifil AE, Athens, Greece; [2]International Renal Research Institute (IRRIV), Department of Nephrology, Dialysis and Transplantation, San Bortolo Hospital, Vicenza, Italy; [3]Institute of Life Sciences, S. Anna School of Advanced Studies, Pisa, Italy; [4]National Institute of Cancerology, Secretaría de Salud, México City, México

Background: An important quality initiative and an essential parameter in the achievement of high hemodialysis (HD) efficiency is the vascular access (VA). The negative influence of a failing HD access on patient morbidity and mortality is well validated. The challenges of dialysis access maturation, long term patency and efficacy prompted the use of various methods, one being colour Doppler ultrasound (CDUS). The later allows not only evaluation of VA maturation but also the recognition of complications, by brachial artery diameter measurements permitting estimations of access volume flow (VF). According to data from the

literature, a dependency between patient-related factors such as sex, age, body size, co morbidity and AVF efficiency has been described.

Objective: The aim of the present study was to evaluate the potential correlation between body surface area (BSA) and brachial artery diameter and VF estimations by CDUS of VA in HD patients.

Methods: Patients from the Department of Nephrology, Dialysis and Transplantation, San Bortolo Hospital, Vicenza, Italy and the Hemodialysis Unit of Medifil-Ilion Medical Nursery, Athens, Greece were recruited. In total, 121 patients, 83 males and 38 females, aged 64.8 ± 15.4 years, on maintenance HD were studied. Among them, 95 (79%) patients were treated by arteriovenous fistulae (AVF) and 26 (21%) patients had arteriovenous grafts (AVG). CDUS was utilized to image brachial artery anatomy and to measure vessel diameter so that estimates of VF were obtained, while BSA was calculated from Dubois formula.

Results: Mean brachial artery diameter was 6.1 ± 1.4 mm and VF 1.34 ± 0.6 l/min, while average BSA was found to be 1.9 ± 0.5 m^2. Non-significant changes in artery diameter and VF among patients with well-functioning AVF (6.1 ± 1.4 mm and 1.38 ± 0.6 l/min, respectively) and AVG (6.24 ± 1.4 mm and 1.45 ± 0.55 l/min, respectively) were observed ($p > 0.05$). A high degree of correlation between brachial artery diameter and VF measurements was demonstrated ($R^2 = 0.85$), while a weak positive though non-significant correlation was observed between BSA and brachial artery diameter ($R^2 = 0.0102$) and between BSA and VF ($R^2 = 0.014$) in all patients. Weak correlations with response to BSA, diameter and VF were also demonstrated in the AVF and AVG patient subgroup, respectively.

Conclusion: Body surface area of HD patients does not seem to be a major determinant of brachial artery diameter, the cornerstone of access flow and efficacy. The challenge of dialysis VA prediction of performance and patency requires more intensive and detailed research.

47

Early Nephrology Consultation and Length of Stay in the Intensive Care Unit

Jose J. Zaragoza[1,2], *Laura Muralla-Sil*[1], *Hector Toledo*[1], *Ulises Ceron-Diaz*[1,2], *Ricardo Martinez-Zubieta*[1,2]

[1]Intensive Care Unit, Hospital Español de Mexico, Av. Ejercito Nacional 613 Zip code 11520, Mexico City, Mexico; [2]ARUAL medicina de reanimacion, Society, Av. Ejercito Nacional 613-9 Zip code 11520, Mexico City, Mexico

Introduction: Acute kidney injury is a very common pathology in the Intensive Care Unit (ICU) [1, 2]. However, the cooperative management between nephrology and the critical care physician is sometimes not accomplished as it should be, and nephrology consultation is delayed until advance stages of acute kidney injury [3]. We studied the relationship of early nephrology attention and the length of stay in the intensive care.

Methods: We included patients from a prospectively obtained database since September 1, 2009 until February 28, 2015. The definition of early consultation was based on maximum renal Sequen-

Table 1. Patients characteristics (for Abstract 47)

Variable	No Nefro (n = 474)	Nefro (n = 34)	Total (n = 508)	P value univariate analysis	P value multivariate analysis
Demographics					
Age	74 (58–83)	71 (58–85)	73 (58–83)	0.09*	0.26
Female gender	180 (37%)	18 (52%)	198 (38%)	0.08*	0.011
Maximum SOFAs	7 (4–10)	7 (4–10)	7 (4–10)	0.75	
Maximum RSOFA	1 (1–2)	2 (1–2)	1 (1–2)	0.06*	0.65
Full code (No DNR)	453 (95%)	31 (91%)	484 (95%)	0.21	
Mortality % Saps3	34 (14–60)	40 (20–72)	34 (15–60)	0.17*	0.242
Surgical	87 (18%)	1 (3%)	88 (17%)	0.01*	0.34
Cardiac surgery	28 (6%)	4 (12%)	29 (5.7%)	0.71	
MV	328 (69%)	24 (70%)	378 (70%)	0.86	
NIMV	103 (22%)	12 (35%)	115 (22%)	0.08*	0.75
Outcomes					
Hospital mortality	155 (32%)	13 (38%)	168 (33%)	0.57	
Hospital stay	12 (7–21)	14 (7–35)	12.6 (7–21)	0.20	0.06 (Nefro)
ICU mortality	92 (19%)	9 (26%)	101 (20%)	0.37	
ICU stay	3 (1.8–6.5)	4.1 (1.5–8.6)	3 (1.6–6.6)	0.28	

* Included in the multivariate linear regression analysis.

SOFAs = Sequential organ failure assessment score; RSOFA = renal sequential organ failure assessment score; DNR = do not resuscitate order; MV = mechanical ventilation; NIMV = non-invasive mechanical ventilation; ICU = intensive care unit.

tial Organ Failure Assessment (SOFA) sub score during the ICU stay of 1 or 2. Univariate analysis examining for differences among those evaluated by a nephrologist and those who were not was performed. A subsequent multivariate linear regression analysis was done including variables with an alpha value of p less than 0.2 and those physiologically meaningful variables.

Results: In total 1899 patients were admitted into the ICU in the mentioned period. We excluded 64 who were transferred to another hospital and 32 readmissions to the ICU in the same hospitalization. Of the remaining, 508 patients reached a renal SOFA sub score of 1 or 2. 34 were evaluated by a nephrologist, and 474 were not. Those patients evaluated had more often a surgical diagnosis rather than a medical one. After the multivariate linear regression analysis, evaluation by a nephrologist was not associated with reduced hospital length of stay (table 1).

Conclusion: Evaluation by a nephrologist in those patients with a maximum renal SOFA sub score in the ICU of 1 or 2 was not related with shorter hospital length of stay after adjustment in a multivariate linear regression analysis.

References

1 Prowle JR, Bellomo R: Continuous renal replacement therapy: recent advances and future research. Nat Rev Nephrol 2010;6:521–529, DOI: 10.1038/nrneph.2010.100.

2 Bouchard J, Soroko SB, Chertow GM, et al: Fluid accumulation, survival and recovery of kidney function in critically ill patients with acute kidney injury. Kidney Int 2009;76:422–427, DOI: 10.1038/ki.2009.159.

3 Perez-Valdivieso JR, Bes-Rastrollo M, Monedero P, de Irala J, Lavilla FJ: Prognosis and serum creatinine levels in acute renal failure at the time of nephrology consultation: an observational cohort study. BMC Nephrol 2007;8:14, DOI: 10.1186/1471-2369-8-14.

48

Total Parenteral Nutrition and Renal Replacement Therapy in the Intensive Care Unit: A Retrospective Analysis

Laura Muralla-Sil[1], *Héctor Toledo*[1], *José J. Zaragoza*[1,2], *Ulises Ceron-Diaz*[1,2], *Ricardo Martinez-Zubieta*[1,2]

[1]Intensive Care Unit, Hospital Español de Mexico. Av. Ejercito Nacional 613 Zip code 11520, Mexico City, Mexico, [2]ARUAL medicina de reanimacion, Society, Av. Ejercito Nacional 613-9 Zip code 11520, Mexico City, Mexico

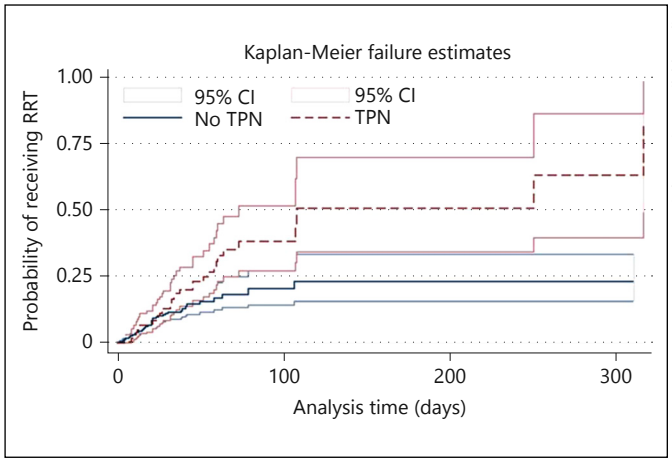
Introduction: Acute kidney injury (AKI) is a common condition in critically ill adults with mortality rates as high as 80% with numerous contributing causes [1, 2]. A poor nutritional state and a caloric deficit are associated with increased morbidity and mortality. Both accumulation of a caloric deficit and poor outcomes in the Intensive Care Unit (ICU) patients have led to the hypothesis that feeding could ameliorate kidney injury and improve survival of ICU patients [3]. However, nutrition, especially total parenteral nutrition (TPN), has also been associated with prolonged ICU and

Table 1. Patients characteristics (for Abstract 48)

Variable	No RRT (n = 1,594)	RRT (n = 123)	Total (n = 1,717)	P value univariate analysis	P value multivariate analysis
Demographics					
Age	65 (47–78)	69 (55–76)	65 (48–78)	0.17	
Female gender	813 (51%)	77 (62%)	890 (51%)	0.01*	0.47
Maximum SOFAs	4 (2–8)	10 (7–13)	5 (2–8)	<0.001*	0.007
Maximum RSOFA	0 (0–1)	4 (4–4)	0 (0–2)	<0.001*	–
Full code (No DNR)	1,537 (96%)	150 (95%)	1,655 (96%)	0.75	
Mortality % Saps3	19 (6–42)	38 (17–64)	20 (6–44)	<0.001*	0.03
Surgical	305 (19%)	13 (10%)	318 (18%)	0.01*	0.67
Cardiac surgery	91 (6%)	3 (2.4%)	94 (5.4%)	0.12	
MV	928 (58%)	90 (73%)	1018 (59%)	0.001*	0.26
NIMV	307 (19%)	29 (23%)	336 (20%)	0.24	
TPN	164 (10%)	39 (31%)	203 (12%)	<0.001*	0.002
Outcomes					
Hospital stay	11.7 (6.6–20)	14.4 (7.6–30)	11.9 (6.6–21)	0.01	
ICU mortality	215 (13%)	41 (33%)	256 (15%)	<0.001	
ICU stay	2.4 (1.32–5)	4.7 (2.2–9)	2.5 (1.3–5)	<0.001	

* Included in the multivariate logistic regression analysis.

SOFAs = Sequential organ failure assessment score; RSOFA = renal sequential organ failure assessment score; DNR = do not resuscitate order; MV = mechanical ventilation; NIMV = non-invasive mechanical ventilation; TPN = Total parenteral nutrition; ICU = intensive care unit.



Color version available online

Fig. 1. (for Abstract 48).

hospital length of stay, increased incidence of new infections, extended need for mechanical ventilation. We studied the relationship between TPN and receiving Renal Replacement Therapy in the ICU.

Methods: We retrospectively analyzed a prospectively obtained database of patients admitted to the ICU from September 2009 to February 2015. We sought to test for differences in demographics and rates of renal replacement therapy between those who received Renal Replacement Therapy and those who didn't. A logistic regression analysis was used to adjust for variables with a p value in alpha level less than 0.1. Primary outcome was analyze the possibility that TPN was statistically related to receiving RRT.

Results: In total 1899 patients were admitted into the ICU in the mentioned period. We excluded 64 who were transferred to another facility and 118 who were readmitted in the same hospitalization. Of the remaining 1717 patients 123 received RRT during the ICU stay. Patients receiving RRT were more ill as demonstrated by a higher Sequential Organ Failure Assessment (SOFA) score, higher predicted mortality and higher rates of receiving mechanical ventilation. After adjustment by a logistic regression analysis TPN continued to be related with being treated with RRT.

Conclusion: In this retrospective analysis TPN was related with RRT in the ICU after adjustment by a multivariate logistic regression analysis.

References

1 Qianyi P, Lina Z, Yuhang A, Lemeng Z: Epidemiology of acute kidney injury in intensive care septic patients. Chin Med J (Engl) 2014;127:1820–1826, DOI: 10.3760/cma.j.issn.0366-6999.20140387.
2 Bellomo R, Ronco C, Kellum JA, Mehta RL, Palevsky P: Acute renal failure – definition, outcome measures, animal models, fluid therapy and information technology needs: the Second International Consensus Conference of the Acute Dialysis Quality Initiative (ADQI) Group. In: Critical Care (London, England) 2004;8:R204–R212, DOI: 10.1186/cc2872.
3 Gunst J, Vanhorebeek I, Casaer MP, et al: Impact of early parenteral nutrition on metabolism and kidney injury. J Am Soc Nephrol 2013;24:995–1005, DOI: 10.1681/ASN.2012070732.