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99/001: NITROGEN BALANCE IS NOT A REQUIREMENT FOR SURVIVAL IN ADULTS RECEIVING CONTINUOUS RENAL REPLACEMENT THERAPY AFTER TRAUMATIC INJURY

Catherine J. Klein, Lisa G. Gettings, H. Neal Reynolds
R. Adams Cowley Shock Trauma Center, Baltimore, MD, USA

Purpose: Patients receiving continuous renal replacement therapy (CRRT) do not require the protein restrictions imposed on patients supported with traditional hemodialysis. Typically, patients receiving CRRT at our facility are provided with protein of $\geq 2.0 \text{ g/kg}$ The purpose of this study was to investigate the relationship between protein intake and patient outcome in patients on CRRT.

Methods: Protein intake, nitrogen loss, and nitrogen balance studies from patients with traumatic injuries, who were treated with CRRT from 1988 through 1994 and in 1997, were retrieved from an in-house database. Patients were excluded if CRRT was discontinued within 2 days of initiation. Data were used only from days when patients received 19 or more hours of CRRT and urine output was less than 500 mL/d. One hour samples of CRRT effluent, collected every 6 hours, were analysed for nitrogen in order to calculate the amount of urea nitrogen filtered each day. Other nitrogen losses were estimated to be 4 g/d. Nitrogen intake was determined using product labels for tube feeding formulas or physician orders for parenteral formulas, and records of the volume of formula administered. Body weights were adjusted in calculations for those subjects who were 125% or more of ideal body weight. Results were compared for survivors and nonsurvivors.

Results: Of 79 subjects, 42 received arteriovenous hemofiltration with or without dialysis, 23 had venovenous hemofiltration with or without dialysis, and 14 had a succession of both types of CRRT. Days studied averaged 12 per subject. Comparisons between survivors and nonsurvivors are presented in the Table. The risk of death ratio for patients achieving a neutral or positive nitrogen balance (greater than $-1.0 \text{ g/d}$) compared with a negative nitrogen balance was 1.06; $p = 0.65$. Women were 1.9 times as likely as men to achieve a neutral or positive nitrogen balance ($p < 0.04$). There was a 59% chance of achieving mean neutral or positive nitrogen balance when protein feeding averaged $\geq 2.0 \text{ g/kg}$. Age was not correlated with nitrogen balance.

Conclusion: This retrospective look at a large sample of trauma patients with CRRT suggests that neutral or positive nitrogen balance during CRRT is not a requirement for survival.
<table>
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<th>Survivors (n = 20)</th>
<th>Non-survivors (n = 59)</th>
<th>P value</th>
</tr>
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<tr>
<td>Age</td>
<td>33 ± 11</td>
<td>49 ± 19</td>
<td>0.001</td>
</tr>
<tr>
<td>Protein intake (g/d)</td>
<td>159 ± 40</td>
<td>148 ± 37</td>
<td>0.26</td>
</tr>
<tr>
<td>Filtered urea nitrogen loss (g/d)</td>
<td>26 ± 8</td>
<td>24 ± 10</td>
<td>0.31</td>
</tr>
<tr>
<td>Nitrogen balance (g/d)</td>
<td>-4.6 ± 7.4</td>
<td>-4.0 ± 9.7</td>
<td>0.82</td>
</tr>
<tr>
<td>Subjects who achieved a mean daily nitrogen balance greater than -1.0 g</td>
<td>7 of 20</td>
<td>24 of 59</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>(35%)</td>
<td>(41%)</td>
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</table>
99/002: USE OF CVVHDF WITH CITRATE ANTICOAGULATION FOR CARBAMYL PHOSPHATE SYNTHASE DEFICIENCY IN A 2.5 KG INFANT

P. Vanderford; Kapiolani Medical Center for Women and Children and University of Hawaii School of Medicine, Honolulu, HI, USA

This abstract describes our experience using CVVHDF for carbamyl phosphate synthase deficiency in an infant weighing 2.5 kg. She was born at term and did well initially. At 36 hours of life, she was noted to have temperature instability, mild respiratory distress, and was not feeding well. A sepsis work-up and ABG were done, revealing a metabolic acidosis. Further work-up revealed an ammonia level of 1,599 mmol/l. She was referred to the NICU, where peritoneal dialysis was started, as well as ucepan, carnitine, vitamins B12, niacin, thiamin, riboflavin, and pyridoxine. Organic and amino acid screens were sent, and the results were consistent with carbamyl phosphate synthase deficiency. Despite the above therapies, her ammonia continued to rise, to a maximal level of 2,082 mmol/l. She was then transferred to the PICU for CVVHDF.

On arrival to the PICU the patient was being mechanically ventilated, and had UAC (3.5 Fr), and UVC (5 Fr double lumen) lines in place. A 5.3 Fr femoral line (single lumen) was placed for CVVHDF. The arterial line did not provide adequate flow, and therefore a second 5.3 Fr femoral line was placed. Despite running the blood pump at the minimum blood flow rate (30 ml/min), the access was still limiting blood flow. After several hours, the therapy was discontinued due to persistent access problems. By this time her ammonia had dropped to 705 mmol/l, and her clinical status had improved. With the medical therapy her ammonia dropped to 76 mmol/l in the next 24 hours. In the subsequent 36 hours, however, she developed signs of sepsis, and required the use of inotropic infusions, including epinephrine. Her ammonia level was rising (153 mmol/l) and she was becoming very edematous. CVVHDF was again started, this time using an IJ 6 Fr single lumen catheter for “arterial” access, and returning to one of the femoral lines. This worked well using blood flow rates of 30 ml/min. Citrate was used for anticoagulation of the circuit; calcium chloride was infused into the patient at the venous access port. Initial citrate and calcium infusion rates were calculated based on a protocol provided by Dr. R. Mehta (UCSD), and were adjusted to maintain circuit ionized calcium levels in the range of 0.25–0.3 mmol/l, and physiologic systemic ionized calcium levels. Dialysate ran at 500 ml/hour. The therapy was successful in reducing her ammonia levels, and also seemed to be beneficial hemodynamically. She was successfully weaned off of the inotropic infusions, and her fluid balance was negative. The CVVHDF circuit was discontinued after four days, with an ammonia level of 39 mmol/l.

She has done well subsequently. Her medications were changed to buphenyl, and L-citrulline, in addition to the carnitine and the vitamins. Feedings were gradually introduced, and she is currently receiving a cyclinex-based formula providing 1.3 grams of protein per kg. Her ammonia levels average ~50 mmol/l. She was weaned off the ventilator, and is taking full nipple feedings. Unfortunately, she does have some abnormal neurologic findings (tone), and her MRI revealed mild cerebral atrophy and basal ganglia injury. She is making progress, however, and was discharged to home in the care of her family.
Conclusions: CVVHDF using citrate anticoagulation can be safely and effectively performed in small infants with hyperammonemia due to carbamyl phosphate synthase deficiency. Access size often remains limiting in terms of flow. In this case, the patient’s sepsis syndrome also improved while on this therapy.
99/003: IMPROVED OUTCOME PREDICTION FOR PATIENTS WITH MULTIPLE ORGAN FAILURE (MOF) UNDERGOING CONTINUOUS HEMODIAFILTRATION (CHDF)

S. Takahira, H. Okada, H. Takane, N. Ikeda, S. Sugahara, H. Nakamoto, H. Suzuki; Department of Nephrology, Saitama Medical College, Irumagun, Saitama, Japan

**Purpose:** The objective of this study is to determine the most suitable time for assessment of the outcomes of patients with MOF undergoing CHDF using common prognostic methods, i.e., Multiple Organ Dysfunction (MOD) score, Liano score, and APACHE III score.

**Methods:** The MOF patients treated with CHDF for more than 7 days in intensive care unit (ICU) of our department were divided into 2 groups. Group 1 consisted of 17 patients (64.5 ± 2.7 y/o) who died in the ICU, and Group 2 consisted of 9 patients (62.7 ± 6.6 y/o) who survived to discharge from the ICU. The prognostic scores of patients were calculated individually based on data on Day 1 and Day 3 in the ICU, and the mean value of each score was compared between those groups by un-paired student’s t test with p < 0.05 as statistical significance.

**Results:**

<table>
<thead>
<tr>
<th></th>
<th>MOD score</th>
<th>MOD score</th>
<th>Liano score</th>
<th>Liano score</th>
<th>APACHE III score</th>
<th>APACHE III score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>8.41 ± 0.52</td>
<td>9.65 ± 0.66</td>
<td>0.488</td>
<td>0.616</td>
<td>81.0 ± 5.48</td>
<td>101.8 ± 4.26</td>
</tr>
<tr>
<td>Day 3</td>
<td>± 0.04</td>
<td>± 0.05</td>
<td>± 0.06</td>
<td>± 0.07</td>
<td>7.15</td>
<td></td>
</tr>
<tr>
<td>Group 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td></td>
<td></td>
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</table>

**Conclusion:** There was no remarkable difference in each score between those groups on Day 1, but each score was significantly higher in Group 1 than in Group 2 on Day 3. It is suggested that outcome prediction on Day 3 using MOD score, Liano score or APACHE III score could improve their predictive power and discriminate the ICU patients with MOF who had worse prognosis.
99/004: COMMUNITY HOSPITAL NETWORK EXPERIENCE WITH RENAL REPLACEMENT THERAPY: REVIEW OF 407 CASES
C. Old, R. Baker, C. Briner, S. Short, G. Stegall

A single group of nephrologists at three non-academic, community hospitals treated 140 critically ill patients having acute renal failure (ARF) with continuous veno-venous hemodialysis (CVVHD), using the PRISMA system, and 297 patients with ARF with Intermittent Hemodialysis (IHD), from January 1997 through October 1998.

Purpose of Study: to evaluate patient characteristics leading to CVVHD, to identify possible predictors of successful CVVHD by comparing comorbid factors of these patients, to compare mortality rates with patients who received acute hemodialysis for acute renal failure during the same time frame.

Methods Used: concurrent data collection on all patients receiving CVVHD to document anticoagulant used, length of CVVHD; and patient outcome. Retrospective medical record review was done to collect information on admitting diagnosis, reason for renal failure, and other comorbidities. Hemodialysis data was obtained from the physicians’ records. An ICU nurse in each facility collected the data for her hospital. An Outcome Manager collated and assisted with aggregating data and data analysis.

Results: 110 CVVHD patients’ records were reviewed; thirty records at hospital one, 47 at hospital two, and 33 at the third hospital. IHD was done in 297 patients with ARF during the time frame of 22 months. CVVHD or IHD was used to treat patients with ischemic or nephrotoxic acute renal failure, glomerulonephritis, reno-vascular disease, and sepsis syndromes.

The demographic data on the CVVHD patients were comparable across all facilities; the aggregate data is as follows:

<table>
<thead>
<tr>
<th>CVVHD</th>
<th>N =</th>
<th>Average Age</th>
<th>Age Range</th>
</tr>
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<tbody>
<tr>
<td>Male</td>
<td>58</td>
<td>63.2</td>
<td>41-77</td>
</tr>
<tr>
<td>Female</td>
<td>52</td>
<td>63.6</td>
<td>35-82</td>
</tr>
<tr>
<td>TOTAL</td>
<td>110</td>
<td>63.4</td>
<td>35-82</td>
</tr>
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<table>
<thead>
<tr>
<th>Dialysis (N)</th>
<th>Average days</th>
<th>Renal Recovery</th>
<th>Death</th>
</tr>
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<tr>
<td>CVVHD (110)</td>
<td>6.5</td>
<td>13 (12%)</td>
<td>75 (68%)</td>
</tr>
<tr>
<td>IHD (297)</td>
<td>77 (26%)</td>
<td>184 (62%)</td>
<td></td>
</tr>
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</table>

Conclusions: CVVHD is a successful modality for treatment of ARF of multiple etiologies in the community hospital ICU. When comorbidities are considered, we believe that CVVHD is a better mode of therapy than IHD. That comparison is currently being made. Control of metabolic disturbances, increased
capacity for total parenteral nutrition, dialysis adequacy, and patient outcome all favor CVVHD. Criteria for use of CVVHD to optimize outcomes in the ICU setting will be proposed.
99/005: THE IMPORTANCE OF PRONE POSITION VENTILATION IN ARDS FOR THE IMPROVEMENT OF OXYGENATION-INDEX

J.-C. Lewejohann, H.-J. Dupree, J. Gleiß, S. Lewejohann, E. Muhl, H.-P. Bruch

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Introduction: In acute respiratory distress syndrome (ARDS) change from supine (SP) to prone position can improve gas exchange by recruiting alveoli situated in dorsal dependent regions and by alteration of ventilation/perfusion ratio. The aim of this study was to investigate the effect of prone position (PP) after application of high fractional inspired oxygen (hFiO₂), inverse ratio ventilation (IRV), positive end expiratory pressure (PEEP) as well as kinetic therapy (KT) and hemofiltration (HF) did not lead to a breakthrough in treatment of severe ARDS.

Methods: We studied 22 consecutive patients with severe ARDS (mean age 64 ± 11.16 [SE] years) in a clinical follow-up design. All patients received hFiO₂, IRV and PEEP before starting prone position, while 15 obtained HF (Prisma, Hospal) and 3 KT (Rotorest). Prone position was commenced 82 h median time (range 6 to 417 h) after onset of severe ARDS at a mean PaO₂/FiO₂ ratio of 98.02 ± 6.11 [SEM] mmHg. We compared individual oxygenation index (PaO₂/FiO₂) before and after start of prone position with linear regression analysis [Excel regression-procedure; SPSS T-test].

Results: In the stage of supine position neither treatment with hFiO₂, IRV, PEEP nor HF and KT led to an improvement of oxygenation index. After starting prone position ventilation 20 of 22 patients showed a significant increase of the oxygenation index (responder. Y[SP] = [-46.11 ± 3.41] * X + [194.03 ± 3.78]; Y[PP] = [25.00 ± 3.05] * X + [170.36 ± 2.68]; [mean ± SEM]; p < 0.05), while 2 patients showed no improvement of oxygenation index (slope of regression SP/PP: 42.96/-22.70 and -11.63/-19.33). Renal failure of these two non-responders was not treated by HF. Improvement of oxygenation index was independent of duration in supine before the begin prone position (range 6 to 417 h). In one patient PP was started actually after 417 h of treatment at our Intensive Care Unit.

Conclusion: Starting prone position seems to mark a U-turn for oxygenation for the majority of patients with severe ARDS, while application of high fractional inspired oxygen, inverse ratio ventilation, positive end expiratory pressure as well as kinetic therapy and hemofiltration do not necessarily improve oxygenation. The timing of this non invasive technique primarily depends on the decision to turn the patient from supine to prone. We recommend prone position in ARDS as soon as possible to reduce lung injury and complications resulting of mechanical ventilation.
99/006: TWO-YEAR EXPERIENCE IN THE MANAGEMENT OF ACUTE RENAL FAILURE POST-CARDIOTHORACIC SURGERY WITH CONTINUOUS RENAL REPLACEMENT THERAPY (CRRT): THE ST. PETER’S HOSPITAL CRRT PROGRAM

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A new CRRT program was established in October 1996 at St. Peter’s Hospital (SPH), a 446-bed tertiary care hospital with an active cardiothoracic (CTS) service, affiliated with the Albany Medical College. The CTS program at SPH performed 917 surgeries in 1997 and 617 so far in 1998. Survival rate was 98.1% in 1997 and 97.6% in 1998. In the experience of the CTS group, preoperative renal failure was associated with a mortality of 11%, the highest of tracked co-morbid conditions. In the SPH CTS program, postoperative acute renal failure (ARF), defined by New York State (NYS) criteria (increase in creatinine ⊕ 2.5 mg/dl for >7 days or dialysis) occurred in 9/917 patients (0.98%) in 1997; 6 received CRRT. In 1998, 7/617 patients developed ARF (1.1%); 5 received CRRT. ARF patients had a mortality of 44% (3/7) in 1997 and 45% (4/9) in 1998.

By comparison, most recent NYS data shows a 1995 incidence of post-CTS ARF of 2.31% (445/19,283); mortality was 10.79%. Of these patients 0.73% (140/19,283) needed dialysis and their mortality was 11.43%. 1996 incidence of post-CTS ARF was 2.51% (503/20,078); mortality was 8.75%. Of those, 196 needed dialysis and their mortality was 11.22%.

Between October 1996 and September 1998, eleven patients (age 69.7 (11SD), 82% male) who developed post-CTS ARF were treated by CRRT. CRRT procedures are described elsewhere. Patient characteristics and outcomes:

Severity of disease assessed retrospectively at the time of initiation of CRRT using the ATN-ISI score (Liano et al, Blood Purification 1997; 15: 346–53) demonstrated a significant difference between survivors [0.653 (0.147SD)] and non-survivors [0.983 (0.101SD)], p < 0.01, but the overlap in scores precluded their use to predict outcome. Overall, 55% of the patients left the ICU alive, and 45% were discharged home, 2/5 remained on chronic dialysis.

Conclusions: Our results compare favorably with the 63.7% 30-day post-CTS mortality reported by Chertow et al (Circulation 1997; 95: 878–84). We believe the apparently higher mortality of our population, when compared to NYS as a whole, is explained by: 1. The small number of cases, making individual cases weigh heavily in the overall outcome, 2. Possible differences in case-mix and, 3. The complexity of surgeries, co-morbidities and complications, as shown by the elevated ATN-ISI scores. Prospective studies are needed to compare outcomes with other databases and assess the impact of CRRT.
99/007: ANTICOAGULATION MEASURE FOR WANT OF CRRT REALIZATIONS AT THE PATIENTS WITH DISTURBANCE OF HEMOSTASIS SYSTEM

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For want of CRRT realizations the application of anticoagulants (AC) is obligatory. Use AC at the patients with the initially disturbance of hemostasis has the features.

**Materials and Methods:** 62 patients with disturb thrombocyteic hemostasis and/or concentration of the plasma coagulation factors. The causes of thrombocytopenia were - aplasia of hemopoiesis, stipulated by hematological disease (11), inhibition of thrombocytopoiesis after a rate of multichemotherapy (21), acute IDC (32). Three patients had hereditary deficiency of the blood coagulation factors. Acute deficiency of the plasma coagulation factors was stipulated by the consumption coagulopathy (46), hepatic insufficiency (3), massive blood loss (2).

Synthetic membranes (PAN, PS) were used. Vascular access - perfusion catheter (31), arteriovenous shunt (21) and fistula (10). Standard heparin and fraxiparin were used as the AC. Platelet concentrate was applied to the patients with a platelet count of less than 20 '10 9 /l or more than 50 '10 9 /l but with reduction of aggregation and hemorrhagic syndrome. By the patients with inherent coagulopathy entered the insufficient coagulation factors. The fresh frozen plasma in a dose of less than 40 ml/kg or concentrates of the factors (I, VIII, IX) was applied in a hypocoagulation stage of IDC. Constant heparin infusion at a dose of 500–1000 ME/h was carried out in a hypercoagulation stage of IDC. The monitoring of hemostasis included the following parameters: clinical features of hemorrhagic syndrome, clotting time, APTT, PI, TT fibrinogen, platelet count and their function. The control of parameters reflecting heparin activity was conducted every 4 hours. With the help of scanning electron microscope superficial architectonics of platelets supervised for want of use standard heparin and fraxiparin.

**Results:** The long-life of the filter accounted 42.7 h (8–72). The lethality has made 92%, including hemorrhagy of the vital organs - 9% (brain - 2, adrenal - 2, pulmonary bleeding - 1). In 2 cases the hemorrhagy availability of brain was diagnosed prior to the CRRT beginning. By 3 patients CRRT procedure was continued for the whole time of the operation of surgical stop of bleeding.

**Conclusions:** the risk of AC using at the patients with coagulopathy is reduced due to coagulation monitoring and specific transfusion therapy. CRRT, providing removal of liquid excess and proteinolysis products, promotes hemostasis normalization.
99/008: EFFECTS OF VARIABLE GLUCOSE-BASED LACTATE VS. PYRUVATE PERITONEAL DIALYSIS SOLUTIONS ON THE GENE EXPRESSION ON GLUT1, RAGE AND SIGNAL TRANSDUCT IN PERIPHERAL BLOOD NEUTROPHILS

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**Objective:** Commercial glucose-containing lactate peritoneal dialysates have negative effects on peritoneal mesothelial cells, peritoneal macrophage and peripheral blood phagocytes (monocytes and neutrophils). The purpose of our study mainly focused on the effects of high glucose-containing lactate vs. pyruvate peritoneal dialysates on the expression of Glut 1, receptor for advanced glycation end product (RAGE) and transforming growth factor β 1 (TGΦβ 1 ), also the role of tyrosine phosphorylation in transmembrane signal transduction.

**Methods:** RT/PCR was employed to investigate the gene expression of Glut 1, RAGE and TGΦβ 1 . Study of signal transduction was performed using PKC inhibitor and tyrosine phospherase inhibitor.

**Results:** 4.25% Glucose/lactate could up-regulate Glut 1 mRNA in peripheral blood neutrophils, which could be inhibit by PKC inhibitor Herbimycin A, while vana-date enhanced the expression of Glut 1 mRNA, indicating activity of PKC played an important role in reducing cell damage. Similarly, TGΦβ 1 and RAGE genes also were up regulated by high tonic lactate dialysate, which suggested that they took part in the mechanism of toxicity of high tonic glucose. Nevertheless variable glucose pyruvate dialysates had little effects on the expression of Glut 1, RAGE, and TGΦβ 1 , demonstrated that pyruvate could neutralized the effects of high glucose concentration.

**Conclusion:** Pyruvate dialysate is promising in vitro, it has little effect on the expression of Glut 1, RAGE and TGΦβ 1 which provides a new area in peritoneal dialysis treatment.
99/009: FLOW REDUCTIONS ASSOCIATED WITH CVVH: A COMPARISON OF FREQUENCY, SEVERITY AND DURATION BETWEEN THREE ACCESS CATHETER SITES

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**Purpose of Study:** The mechanical pumping of blood in the extracorporeal circuit required for CVVH is dependent upon the correct relationship between the vascular access catheter and the machine blood pump. Actual blood flow may not always be as set on the pump (flow reduction). This discrepancy may be related to the site of the access. The nature and severity of this phenomenon was studied with the use of an ultrasonic flow doppler: Neomedix systems HT109 Transonic device. Actual flow was monitored at three access catheter sites in order to determine which site may be the best for CRRT blood flow.

**Methods:** The study was approved by the hospital ethics committee and patient consent was obtained. The HT109 flow doppler was placed around the blood line before the hemofilter. Instantaneous blood flow rate data was recorded to a connecting bedside laptop computer, facilitated by Windaq software program. The monitoring was continuous and uninterrupted in each circuit until it failed or clotted. A total of 525 hours of monitoring was completed. The subsequent data files were then re-viewed to assess the: frequency, duration and severity of flow reductions.

**Results:**

**Conclusions:** Flow reductions are frequent, of significant magnitude and can be prolonged. Data from this study indicates that the site least affected by flow reduction is the femoral site. This may have implications for achieving greater filter life and better functioning of CRRT systems.
99/010: COMPARATIVE PERFORMANCE OF 4 DIFFERENT ANTICOAGULATION STRATEGIES IN CONTINUOUS VENO-VENOUS HEMODIAFILTRATION

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In this retrospective study, we compared the performance of four different anticoagulation modalities that are currently used in continuous veno-venous hemodiafiltration (CVVHDF) in their ability to maintain a functional extracorporeal circuit. We observed 134 events defined as an interruption of treatment or a change of anticoagulation strategy during the course of CVVHDF in 32 patients (8 women, 24 men) that needed CVVHDF in our institution from September 1997 to October 1998. The patients’ mean APACHE II score was 24 ± 3.5 (standard deviation). 47% (15/32) of patients were in a surgical intensive care unit. All were treated using the Hospal-Gambro PRISMA system for 4.25 ± 4.5 days on average. The usual prescription of CVVHDF included a blood flow rate of 150 cc/min, a dialysate flow rate of 1000 cc/hr, a replacement flow rate of 850 ± 200 cc/hr and a net ultrafiltration rate of 50 cc/hr. The overall mortality was 66% (21/32).

Full dose heparine (FdH) (i.e. a bolus dose of 2000 units at the initiation of CVVHDF and an adjusted heparine infusion of no less than 500 units/hr at the start) was used in 62 (46%) of these events, low dose heparine (LdH) (any heparine prescription less than in FdH) in 32 (24%), no anticoagulant (NA) in 24 (18%) and citrate (CIT) in 16 (12%). The overall average duration of a circuit was 21 ± 21 hours and the average length of time to restart the CVVHDF was 2 ± 2 hours. The average number of events per patients was 4 ± 3. There were 3 significant bleeding (one tracheal, 2 gastro-intestinal) in the FdH, none in the other groups. The mean duration of a circuit was 11.2 ± 10.6 hours using NA, 15.6 ± 16.3 hours using LdH, 25.0 ± 23.4 hours using FdH and 30.2 ± 20.5 using CIT (ANOVA, p = 0.003). A significant difference was seen between the CIT and NA group (p = 0.015) and FdH and NA group (p = 0.019). There were no statistical differences among the other groups. The difference between the anticoagulation groups remained significant after adjusting for a number of covariates (hematocrit level, platelet count, partial thromboplastin time (PTT) and prothrombin time (INR)) using multivariate analysis (p = 0.009). The multivariate model did not show that these covariates were related to the duration of circuits.

We conclude that CIT appears an as efficacious modality of anticoagulation as FdH for CVVHDF and that both offer a longer duration of circuit than NA. CIT may be a safer strategy since it does not induce systemic anticoagulation. Prospective trials are needed to firmly determine the more appropriate anticoagulation modality to use in the different settings of CVVHDF.
99/011: DIALYZER CLOTTING IN CONTINUOUS VENO-VENOUS HEMODIALYSIS USING A NOVEL METHODOLOGY: FIBER BUNDLE VOLUME

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Continuous Veno-Venous Hemodialysis (CVVHD) in the Intensive Care Unit Setting is frequently associated with system clotting, leading to “down-time” and decreased dialysis dose delivery. Dialyzer Fiber Bundle Volume (FBV) On-Line measurement is a novel application of Transonic Hemodynamic Monitor technology. It can be determined using specific software and a 10 cc normal saline injection into the arterial limb of the dialysis circuit. Serial objective FBV observations during CVVHD sessions could potentially reveal a progressive decline of available dialyzer surface area.

We prospectively evaluated nine patients, having 15 CVVHD sessions (one Fresenius F 4 dialyzer lifetime per session). We measured FBV at the start of each session and then every four hours on-line until clotting of the system occurred. A total of 55 paired measurements of FBV (average of two back to back measurements) were obtained. In 32 of those measurements we also determined sequential dialyzer urea extraction ratios (UER). Subgroups were evaluated regarding heparinization, access type and recirculation (measured with the Transonic Monitor).

Overall dialyzer start-to-end FBV declined by 16 +/- 13% (0–42%) and subgroup analysis revealed the least FBV drop-off in the heparinized (dose 750 +/- 480 u/hr) group (0.3 +/- 7.9% versus 5.1 +/- 8.6% overall per 4 hour interval, P < 0.05). FBV was significantly lower at the end than at the start (P < 0.05) overall and for all subgroups. UER (pumpflow - mean 211 ml/min) did not change significantly between measurements (start-to-end change of -3.9 +/- 27.5%); however the change in FBV% from start-to-end was significant (P < 0.05).

We conclude that (a) repetitive fiber bundle volume measurements can quantitate filter anatomy on-line, (b) FBV declines significantly during CVVHD treatment and (c) the declining FBV is not necessarily associated with a decrease in urea clearance.
99/012: POST-FILTER IONIZED CALCIUM AS A METHOD FOR MONITORING REGIONAL CITRATE ANTICOAGULATION IN CONTINUOUS VENO-VENOUS HEMODIAFILTRATION

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Purpose: The requirement for prolonged continuous anticoagulation appears to be the major drawback in the use of continuous veno-venous hemodiafiltration (CVVHDF). Citrate is an anticoagulant through its ability to chelate calcium, and recently, regional citrate anticoagulation has been proposed as an alternative to systemic heparin anticoagulation in patients who are at high risk of bleeding and require CVVHDF therapy. We conducted a cohort study of the survival time of 25 hemodialysis filters in 9 critically ill patients who required CVVHD therapy and were anticoagulated with regional citrate. A predetermined algorithm of regional citrate administration was utilized in order to achieve a post-filter ionized calcium level of 0.25 to 0.35 mmol/L.

Methods: CVVHDF was undertaken using the PRISMA CFM system with a Fresenius F-100 (F-60 in one patient) polysulfone dialysis membrane at a blood flow rate of 100–125 ml/min. An isosmotic solution of 3.9% (weight/volume) trisodium citrate was utilized for regional anticoagulation and initiated at a rate of 190 ml/hr. This citrate solution was dissipated in the circuit by diffusion into the citrate, calcium, and bicarbonate-free dialysate as well as being neutralized by a 0.74% (w/v) calcium chloride solution initiated at a rate of 60 ml/hr in the central venous catheter re-entering the patient. Subsequent adjustments in the rate of the trisodium citrate infusion was based on the levels of circuit (post-dialysis membrane) serum ionized calcium drawn every 4–8 hours and aiming for a level of 0.25 to 0.35 mmol/L.

Results: A total of 9 patients requiring regional citrate anticoagulation were studied; 2 with chronic renal failure, and 7 with acute renal failure (3 suffered from septic acute tubular necrosis (ATN), and one with each of surgical ATN, medical ATN, Wegener’s Granulomatosis, and hepatorenal syndrome). A total of 25 dialysis filters were used in these 9 patients, and the primary endpoint was that of filter survival time. Non-censored observations were defined as either circuit clotting or persistently high filter pressures (generally >200 mmHg) indicating poor circuit efficiency. Twenty-five other predetermined reasons for terminating CVVHDF were counted as censored observations. Ten of the 25 filters in five patients failed (i.e. clotted or were terminated because of high filter pressures) and the remaining 15 membranes (60%) were considered as censored observations. The overall median survival time using the Kaplan-Meier estimator was 3.38 days (Kaplan-Meier survivor function = 0.51, 95% confidence interval 0.22 to 0.74). We hypothesized that individual patients would have a specific ‘propensity’ to clot the dialysis membrane, and this was confirmed by our demonstrating an intra-patient correlation of 0.2578 in those 5 patients where the filters failed. The citrate anticoagulation algorithm maintained post-filter ionized calcium at a levels of 0.25 to 0.35 mmol/L in the majority of the assays performed on a q4–8 hourly basis.

Definite bleeding occurred in four patients anticoagulated with regional citrate for an incidence rate of 0.08 per person-day on citrate anticoagulation for CVVHDF (95% confidence interval, 0.02 to 0.21 per
person-day). Similarly, the incidence rate of occult bleeding was 0.04 per person-day on regional citrate anticoagulation (95% confidence interval, 0.005 to 0.15 per person-day). No systemic cardiac complications attributable to citrate intoxication were observed.

**Conclusion:** The use of post-dialysis filter ionized calcium to achieve a level of 0.25 to 0.35 mmol/L is an effective and inexpensive method for monitoring regional citrate anticoagulation in CVVHDF.
99/013: RAPID PRODUCTION OF BICARBONATE-BASED DIALYSATE FOR CONTINUOUS VENOVENOUS HEMODIAFILTRATION (CVVH-D)

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Currently in the United States, bicarbonate-based dialysate is not easily available for use in CVVH-D. Many units instead use lactate- or acetate-based solutions such as peritoneal dialysis solution. Studies have suggested using lactate or acetate as buffers in critically ill patients can acutely worsen metabolic acidosis. Additionally, the high dextrose content of peritoneal dialysis solution can lead to hyperglycemia. Standard hemodialysis (HD) uses bicarbonate-based dialysate with a physiologic concentration of glucose that is made by mixing water with concentrates of acid and bicarbonate. The Dialysis Unit at Strong Memorial Hospital has developed a technique using a standard volumetric, single pass HD unit, standard HD tubing and standard hemofilters to easily and rapidly make bicarbonate-based dialysate for CVVH-D.

The technique is summarized in the figure. The dialysis outflow line of the HD machine is attached to blood tubing using a quick-connect adapter. A Y-connection allows dialysate to run through the blood side of two parallel hemofilters. The dialysate runs through the filters and a second Y-connection connects the outflow to a regulator valve, which allows control of the membrane pressure. The pressure is monitored continuously to prevent the development of high pressures that could lead to membrane rupture. Standard blood tubing is connected to the upper dialysate ports of both hemofilters to collect filtered dialysate. A Y-connection brings both lines to a common connector with a standard dialysis drip chamber that allows measurement of pressure in the lines using the machine’s arterial pressure monitor. The tubing is then run through the blood pump and the filtered dialysate collected in standard CVVH collection bags.

Using this set-up, it is possible to make 300–500 ml filtered dialysate/min without approaching the maximal transmembrane pressures of the hemofilters. The sodium, bicarbonate, and potassium concentrations can be varied within the range of the HD machine. Laboratory analysis of filtered dialysate with sodium concentrations ranging from 138–145 mEq/l, bicarbonate concentrations ranging from 30–35 mEq/l and potassium concentrations ranging from 2–4 mEq/l have shown the electrolyte composition to be within 2% of desired concentration. Calcium, magnesium, and glucose were also found to be within 2% of expected values. Cultures of the filtered dialysate taken over a time span of one month were all negative. After three months of storage, no visible precipitate was seen, although the presence of microprecipitate has not been excluded. This set-up can be manually sterilized for re-use and the adaptability to automated sterilization is currently being investigated.

We present a new technique for producing bicarbonate-based dialysate for CVVH-D using a standard HD machine. This technique differs from those previously published by using parallel filters and the HD blood pump to allow high-volume production of up to 500 ml/min. The set-up is reusable, making it economical as well as efficient.
**99/014: SINGLE BAG BICARBONATE SOLUTIONS IN CRRT – IS THAT SAFE?**

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Metabolic control is one of the major aims of CRRT. Although bicarbonate (HCO₃) is the major extracellular buffer and is now considered the optimal solution for intermittent hemodialysis, lactate or acetate are still the most frequently used buffers in commercially available solutions for CRRT. Technical problems such as calcium/bicarbonate precipitation and endotoxemia have prevented the widespread use of HCO₃ solutions, and the use of customized solutions, as reported by a few groups, appears as an alternative approach.

The aim of this preliminary study was to evaluate the stability of HCO₃ buffered solutions containing calcium (Ca) and magnesium (Mg) as frequently used by different CRRT groups.

**Methods:** 3 liter PVC dialysis solution bags were manipulated in sterile conditions (classified 1:10,000 room, laminar flow hood, sterile distilled water and electrolytes) as in parenteral nutrition preparation. Final electrolyte concentration was designed to achieve maximal needs to normalize patient serum values as: Glucose = 150 mg/dl, Na = 150 mEq/l, K = 4 mEq/l, HCO₃ = 40 mEq/l, Mg = 2.0. Solutions were analyzed up to 96 h after preparation in progressively increasing (0 to 5 mEq/l) Ca concentrations. Precipitation was evaluated by 2 different observers, ranging from (no precipitation) to +++ (maximal precipitation) using visual and light microscopic observation in different physical conditions: 1) 4 °C temperature + centrifugation (CT); 2) 4 °C + rewarming(RW) at 37°C for 60 min. + CT and 3) 4 °C + RW + agitation + CT.

**Results:** precipitation as detected by visual inspection was observed starting at 36 h, according to [Ca]. Microscopic analysis ( ) however, showed that all Ca containing solutions precipitate within the first 24 h following mixture in the different conditions studied.

**Conclusions:** Safety in the use of customized CRRT bicarbonate solutions containing Mg and Ca cannot be estimated by visual inspection only. The simultaneous use of these electrolytes in a single bag leads to precipitation of salts, even when low calcium concentrations are used, as evidenced by microscopic analysis only.
99/015: EXTENDED DAILY DIALYSIS: AN ALTERNATIVE TO CONTINUOUS VENOVENOUS HEMOFILTRATION IN THE INTENSIVE CARE UNIT

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Continuous venovenous hemofiltration (CVVH) has gained wide acceptance for treating renal failure in critically ill patients because it can improve solute clearance and remove large amounts of fluid without compromising cardiovascular stability. However, significant barriers to the successful implementation of CVVH persist.

We report preliminary experience with extended daily dialysis (EDD), an alternative treatment that solves many of these problems and we compare EDD with CVVH. Major differences between EDD and standard thrice-weekly hemodialysis included lower blood and dialysate flows, prolonged duration, and the daily schedule. Lower blood flow rates allowed the minute-to-minute supervision of the dialyzer to be left in the hands of the intensive care unit (ICU) nurse, thereby freeing up the dialysis nurse to monitor more than one patient. In this study the dialyzer membrane was polymethylmethacrylate (Toray model 2.0) and dialysate was generated by a bicarbonate proportioning system (Fresenius model 2008 H). Blood and dialysate flows were 200 and 300 ml/min, respectively. Dialysate potassium (K), calcium, and bicarbonate (HCO₃) concentrations were 4, 1.5–2.5, and 30–35 mEq/L respectively. EDD was prescribed for 8 hours, 6 days a week. For patients with contraindications to use of heparin, the dialyzer was flushed hourly with normal saline. Patients were monitored by the dialysis nurse every 30–60 minutes and more frequently as needed. CVVH was performed with an integrated monitor (Cobe Prisma).

Five patients (ages 29 to 72) received 29 EDD treatments. Causes of renal failure were sepsis (n = 3), cardiogenic shock with contrast nephropathy, and ESRD. Two patients (ages 19 and 31) received 11 days of CVVH. Causes of renal failure were hemorrhagic shock and sepsis. APACHE scores were comparable for EDD (16 (2) and CVVH (20 (6), p = 0.13), but CVVH had a longer hospital stay (34 (32 vs. 96 (2 days, respectively, p = 0.042) and ICU stay (23 (17 vs. 62 (8 days, respectively, p = 0.024).

Solute clearance was comparable as judged by serum levels of K, blood urea nitrogen (BUN), creatinine (Cr), and phosphorus (P) at baseline and after 3–4 days of EDD or CVVH. Both modalities were able to maintain normal serum sodium and HCO₃ levels. Though not statistically significant, EDD tended to normalize K and HCO₃, and reduce BUN, Cr, and P faster.

Hemodynamic stability was maintained during EDD [pre-mean arterial pressure (MAP) 82 (13, mid-MAP 81 (13, end-MAP 83 (12 mm Hg, p = 0.5)] and CVVH (79 (29, 77 (25, 78 (26, p = 0.6). MAP did not differ between the two modalities. The occurrence of low blood pressure (0.1 (0.4 vs. 0.2 (0.4 episodes per patient-day, respectively, p = 0.5) and the use of vasopressors (30% vs. 64% of treatments, respectively, p = 0.11) were comparable. Hemodynamic stability was comparable despite a shorter treatment duration for EDD (7 (2 hours vs. 13 (9 for CVVH, p = 0.001) yet similar net UF (2.2 (1.4 vs. 2.6 (2.1 L, respectively, p = 0.45). CVVH required more replacement fluid than EDD (18.4 (14.5 versus 0.5 (0.2 L, respectively), as
expected. Despite a lower or no heparin requirement per patient-day in EDD (6,200 (3,400 vs. 16,000 (12,600 units for CVVH, p < 0.001), episodes of dialyzer clotting were lower (1.0 (1.1 vs. 2.0 (1.4, respectively, p = 0.02). Technique acceptance by the ICU nurses was much higher for EDD than for CVVH.

Our preliminary data demonstrate that EDD is comparable to CVVH with respect to efficient solute clearance, hemodynamic stability, and amount of UF. However, EDD may be superior to CVVH because of less or no heparin requirement; less clotting; more precise volume and temperature control; reduced pharmacy expense and manpower for mixing replacement fluids; less coordination between pharmacy, ICU nursing, and dialysis staff; shorter treatment duration resulting in less interruption of dialysis for other procedures; improved nephrology staff control over the technique; no nighttime troubleshooting of the dialysis circuit; better nursing acceptance, and reduced cost. The potential benefit of filtration versus dialysis for critically ill patients is a question that will require larger studies of patient outcomes.
99/016: DAILY 12-HOUR SUSTAINED LOW-EFFICIENCY HEMODIALYSIS (SLED) FOR THE TREATMENT OF CRITICALLY ILL PATIENTS WITH ACUTE RENAL FAILURE (ARF): INITIAL EXPERIENCE

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Continuous renal replacement therapies (CRRT) are the modality of choice for renal replacement in hemodynamically unstable intensive care unit (ICU) patients with ARF. As an alternative therapy, we performed daily 12-hour SLED using a Fresenius 2008 H machine to treat critically ill and hemodynamically unstable patients with ARF. The 2008 H machine was programmed to deliver a dialysate flow rate of 100 ml/min. The blood flow rate was 200–250 ml/min and F8 polysulfone dialyzers were used. Dialysate was prepared on-line using RO treated tap water. The dialysate bicarbonate concentration was maintained at 35 mEq/L and the potassium concentration was 3–4 mEq/L. The rate of ultrafiltration was set to achieve adequate fluid balance. This therapy required no substitution fluid. The anticoagulation regimen consisted of heparin infused at the rate of 250 U/hr. Femoral vein was cannulated for vascular access in 3 patients, and 3 patients had internal jugular venous access.

The ICU nursing staff were trained using an instructional video (developed by us) and 2 hours of inservice. They were trained to monitor the treatment, set the rate of ultrafiltration, watch for alarms and clotting, as well as perform saline flushes. They were also taught to perform emergency take off procedures. The renal dialysis nurses performed the setting up of the dialysis procedure and routine take-off. A 12-hour SLED session was considered as a single treatment. A total of 13 treatments in 6 critically ill ICU patients (5 male and 1 female) have been performed thus far. Their average age was 59.3 years (range 32–79). All patients failed conventional hemodialysis because of hemodynamic instability. The mean APACHE II score at the time of initiation of therapy was 32 (range 21–55), and the mean number of failing organs was 3.6 (range 3–4). ATN was the etiology for ARF in all patients. 4 patients had sepsis and 2 had cardiogenic shock. 2 patients were on parenteral nutrition and all 6 patients required mechanical ventilation. All patients required inotropic drugs to maintain mean arterial pressure (MAP), prior to starting SLED.

The daily 12-hour SLED treatments were well tolerated. The blood pressure readings were as follows:

The mean ultrafiltration achieved during the 12-hour session was 3.78 liters (range 0.99–7.02). Serum Na+, K+, Cl–, Ca++ and HCO3– remained in the normal range throughout the treatment. Serum BUN, creatinine and phosphate levels decreased significantly during the treatment (see accompanying Shaver abstract). Clotting of the dialyzer was the most frequent complication noted (3/13 treatments). Consequently, SLED was terminated early thrice- after 7.5, 8 and 10 hrs. Furthermore, 2 treatments were terminated early because of significant hypotension. No vascular access related complications were noticed. 4 patients survived and are in the ICU, none of them have recovered renal function and all of them
have switched to conventional hemodialysis. 2 patients died in the ICU from sepsis. None of the deaths occurred during the SLED treatments. The nursing acceptance of this procedure was high compared to CRRT because the procedure was less labor intensive (see accompanying Hall abstract).

In summary, daily 12-hour SLED is an effective and viable alternative to CRRT in critically ill ICU patients with ARF. The complications associated with SLED were no more frequent or serious than those seen with CRRT.
Background: Anticoagulant Citrate Dextrose Solution (ACD-A) has been utilized during Continuous Venovenous Hemodiafiltration (CVVHDF) on Hospal-Gambro’s PRISMA for the last 2 years at our facility for patients in which Heparin is contraindicated. It was determined that preparation of Dialysate solutions by Nursing staff or Pharmacist would be labour intensive and not cost effective. Hospal-Gambro’s commercially available HEMOSOL solution which contains 1.75 millimoles of Calcium per litre was selected as our Dialysate solution. The Replacement solution consisted of Normal Saline alternating with Half-Normal Saline. Calcium Chloride was infused to maintain normal Ionized Calcium levels during dialysis.

Purpose: To determine the efficacy of our practice, a retrospective study of 45 patients who had received this therapy was completed. Information regarding the indications for ACD-A use, filter life, biochemical profile, infusion rate for ACD-A, complications of ACD-A use, Activated Clotting Times (ACT’s), and Blood, Dialysate, Replacement flow rates was obtained. Nursing workload during ACD-A usage was also evaluated.

Findings: Patients selected to receive ACD-A Anticoagulation during CVVHDF were primarily at risk for bleeding. Post-operative patients accounted for 29% of the patients studied. Three patients (7%) had diagnosed Heparin Induced Thrombocytopenia. The 45 patients in the study utilized 231 filters during their treatments. The treatment hours were 6267 (261.1 days). The mean filter life of the 36 clotted filters (16% of all filters) was 22 hours (Standard Deviation [S.D.] 27.2). Of the remaining filters, 55% were electively discontinued, 23% lost due to vascular access problems, and 6% from equipment or systems failures. The mean filter life of the non-clotted filters was 21 hours (S.D. 26.3). All patients maintained a normal biochemical profile during treatment. Alkalosis occurred transiently in 12 of the 45 patients studied. The average infusion rate for ACD-A was 322 milliliters (ml) per hour. The ACT’s were maintained at 180 to 280 seconds. The blood flow rate utilized on 95% of the patients was 125 ml per minute. Flow rates for the Replacement and Dialysate solutions ranged from 500 ml. to 1000 ml. per hour. Nine patients developed an ACD-A reaction which included hypotension (mean arterial pressure less than 55 mm hg or a decrease in systolic blood pressure greater than 40 mm hg), rigors, a ‘feeling of doom’ and diaphoresis. Two patients required discontinuation of dialysis. The remainder recovered within five to fifteen minutes with minimal intervention. ACD-A re-actions occurred immediately after starting a treatment, but not necessarily with the first treatment. The Intensive Care Nurses who set-up, maintain, troubleshoot and discontinue the
CVVHDF systems as part of their patient assignment have found that ACD-A administration has not significantly increased Nursing workload.

**Conclusions:** ACD-A Anticoagulation can effectively be used in conjunction with commercially available Dialysate solutions that contain Calcium. In some patients where ACD-A reactions occurred immediately after starting a treatment, initial ionic Calcium levels may have been below normal range. It is now our practice to obtain Ionic Calcium levels prior to starting therapy. The use of ACD-A was found to have minimal impact on Nursing workload.
99/018: A CAP FOR TREATMENT AND PROTECTION AGAINST INFECTION, WHICH IS ATTACHED TO THE EXIT-SITE OF A CATHETER

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**Purpose:** There is a limit to the treatment of infection caused by a side catheter used for emergent blood catheter dialysis and the treatment of a side effect of the CAPD. In many such cases the catheter have to be removed. The purpose of this study is to develop a method of treatment and protection against the infection which occurs at the exit-site of the catheter.

**Subjects and Methodology:** the subjects were 8 cases in which infection occurred at the exit-site or the cuff of a catheter during the application of CAPD. A groove, cut in the shape of “U”, was made on a cap of a vessel of balanced saline solution. The cut was made long enough to reach the center of the cap. The inside of the cap around the catheter was filled with small pieces of cotton or gauze which contained 10% povidone-iodine or 0.05% chlorhexidine gluconate. Then the cap was attached firmly to the skin around the exit-site of the catheter. It was kept attached to the skin for thirty minutes. This treatment was made 1 $B!A (B 5 times a day. In some cases, this treatment was carried out every day.

**Result:** In five out of the eight cases, this treatment was remarkably effective. Two cases among the five were treated with this method for eight month. No infection occurred and no side effects were produced. In the two cases with a single-cuff, although this treatment was effective against the infection through the exit-site of the catheter, peritonitis was sometimes found. In the cases with a double-cuff, this treatment was effective, but two or three months later, the patients relapsed, and their catheters were replaced.

**Discussion:** The amount of the antiseptic solution used in this method should be over 200 times as much as that used in the ordinary method; the sterilized area of the subcutaneous catheter should be more than 10 times bigger, and the length of time for sterilization was ten times as long. According to “the diffusion theory”, “the antiseptic solution” replaces “the infectious leachate” and works a strong sterilizer. The authors designed a cap which as the functions of (1) sterilizing the exit-site of a catheter, (2) drying up and protecting the exit-site, (3) fixing and holding the catheter, (4) being used with belts or inside pockets of an undergarment instead of plasters. It is also useful for treatment and protection against infection caused by the insertion by blood catheter for emergent dialysis.
99/019: COST EFFECTIVENESS OF BICARBONATE BASED DIALYSATE FOR CONTINUOUS VENOVENOUS HEMODIALYSIS (CVVHD)

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A Fresenius 2008 H machine modified to maintain a dialysate flow rate of 100 ml/min has been used to treat patients with ARF. Bicarbonate dialysate (BD) is prepared online using concentrate and RO-treated tap water.

Patients with acute renal failure (ARF) dialyzed with acetate or lactate based dialysate often exhibit changes in myocardial contractility and vascular tone, which can cause hypotension. BD is better tolerated and improves hemodynamic stability. Commercially available BD solutions for CVVHD in the US are expensive.

20 patients with ARF, 10 male, 10 female (age: 63 ± 15 years) were treated with the modified 2008 H using F8 or F40 dialyzers and BD. The average time on dialysis was 2 days and 8 hours, BD cost worth $36 per patient. This is comparable to the calculated costs in table 1. There were no incidents of acute hypotension associated with the treatments. Total CO₂ increased from pre = 19.75 ± 5.01 meg/L to post = 24.3 ± 4.73 meg/L.

In addition to providing superior hemodynamic stability, use of the 2008 H with online bicarbonate dialysate production is associated with significant cost savings.
99/020: THE ROLE OF THE CLINICAL EQUIPMENT SPECIALISTS IN SUPPORTING CONTINUOUS RENAL REPLACEMENT THERAPY IN CARDIAC PATIENTS

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**Purpose:** Continuous Renal Replacement Therapy (CRRT) has been established as a treatment option for both acute and chronic renal failure in cardiac intensive care patients. However, this treatment is complex, labor intensive, and requires expertise throughout the therapy. Additionally, when CRRT use is sporadic, nursing CRRT skills may be comprised. At the University of Alberta Hospital, a group of multidisciplinary specialists has been utilized to facilitate the initiation, troubleshooting, and education of CRRT.

**Methods:** Within the Cardiac Sciences Program is a small team of Clinical Equipment Specialists (CES’S) who front-line selected new therapies for managing critically ill patients. This group has initiated all CRRT therapy, worked cooperatively with nursing staff in the maintenance of treatment, helped to develop operational policies, and supported the education and training of staff.

**Results:** Since February 1996, 91 patients have been treated with the Hospal “Prisma” TM CRRT system within Cardiac Sciences. The total number of filters used was 347 with total patient hours on 9780, and the average treatment length per patient being 4.47 days. The CES team has been involved with ongoing education for nursing and medical staff. Over thirty formal classroom inservices have been presented.

**Conclusions:** CRRT has been shown to be a safe and effective mode of therapy for renal failure in cardiac patients. The role of the Clinical Equipment Specialists has effectively aided the introduction, evolution, and education surrounding this complex treatment modality.
99/021: INITIATION OF A CONTINUOUS VENOVENOUS HEMOFILTRATION PROGRAM AT A CHILDREN’S HOSPITAL BY THE EXTRACORPOREAL LIFE SUPPORT TEAM

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**Purpose:** To describe the initiation of a continuous venovenous hemofiltration (CVVH) program utilizing unique resources within a pediatric intensive care unit (PICU) at a children’s hospital.

**Introduction:** At Egleston Children’s Hospital in Atlanta, the methods of providing renal replacement therapy prior to initiation of the CVVH program included: hemodialysis, peritoneal dialysis and continuous arteriovenous hemofiltration (CAVH). Certain patients may not be optimally managed by any of these techniques.

The use of CVVH fell under investigation as a potential service. The initiation of the program fell to the Extracorporeal Life Support (ECMO) Advanced Practice Team due to the following reasons: time constraints of the PICU and Hemodialysis nursing staff; the necessity of a blood pump; and the requirement for anticoagulation management. The ECMO Team already assumed a 24-hour/7-day call schedule for ECMO priming, so the additional responsibility of CVVH was minimal.

**Discussion:** The ECMO Advanced Practice Team consists of registered nurses and registered respiratory therapists. The certification program includes didactic and experiential classes in the provision of life support utilizing artificial organs and a roller pump. Additionally, training includes the use of heparin to maintain an anticoagulated state, fluid management skills, and priming of tubings and components. After determining that a defined population would benefit from the availability of pump driven CVVH, the first phase of training and education began for the ECMO team.

The team was already competent at priming circuitry, so the majority of the training focused on the specifics of the Baxter BM11 pump. The second phase of training included the nursing staff. The PICU educators identified a core group of nurses who would complete an advanced competency packet on the care of the patient on CVVH. The nurses would be responsible for the hour-to-hour management of the pump, circuit and fluids; while the ECMO Team would be available for questions, troubleshooting and circuit primes as required.

**Conclusion:** The initiation and maintenance of a CVVH program may be too cumbersome for ICU nursing and dialysis unit staff to support. In our case, the ECMO team was willing and able to assume the responsibility for the priming and initiation of the procedure; as well as the on call expertise required for any infrequently used service.
99/022: TREATMENT OF END-STAGE RENAL DISEASES
HEMODIALYSIS BY DIALYSATE LOW FLOW

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Contemporary hemodialysis therapy, based on blood high flux and dialysate solution, permits fulfill purification of organism of uremic patients quickly and with high clearance. However not all the patients are able to adequately withstand such powerful aggression and as a rule the patients start reacting by manifesting a breach of hemodynamics and development disequilibrium syndrome.

An alternative for patients with unstable hemodynamic and cerebrovascular insufficiency, particularly in geriatric practice might serve hemodialysis with dialysate solution low flow (LFHD) - 250 ml/min, with usual perfusion.

31 patients with ESRD had been examined by us, their age being from 18 to 71 (average age 41.1 \pm 2.7, among them 6 female and 25 male). These patients received 215 LHD and 167 standard hemodialysis (SHD). Both groups could be considered completely randomised. Acetate HD had been conducted by “KN-401” HD machines produced in East Germany with the use of standard plate dialyzer with active surface area 1 sq. m. Blood perfusion with LFHD made up 264 \pm 7.0 ml/min, and with SHD 217.4 \pm 8.0 ml/min.

Considering low flow dialysate solution, ultrafiltration level was increased and pressure difference of the SHD went down to -8.9 \pm 1.5 mm Hg.

Continuity HD was 300 \pm 12 min and 274 \pm 18 min with SHD correspondingly. The level of urea, creatinine, concentration of plasma potassium and osmolality had been studied. Clearance of procedure on urea, creatinine, middle molecular mass oligopeptide, phosphate, acid-base condition and influence exerted on blood cells had been determined. Quantitative indices of central hemodynamics (CHD) according to computer rheovasography had been determined. Frequency of headache occurrence, nausea, vomiting hypotension and hypertension had been clinically tested. Laboratory research had been conducted by poly analyzers “Backmann Synchron”, “System 9000”, “ABL-3”.

The following results had been received: with LFHD frequency of headache occurrence was 20.4%, nausea 13.3%, vomiting 15.2% hypotension 16.8% lower, as for hypertension it was to 2.5% higher than with SHD, although removed ultrafiltration volume was 1.88 \pm 0.01 and 1.76 \pm 0.42 L. correspondingly (p < 0.05). Urea clearance made up 142.27 \pm 4.1 mmol/min, creatinine clearance 111.4/mcmol/min, OMMM - 50.4 \pm 2.1 and clearance phosphate 90.3 \pm 4.7 mmol/min, that significantly exceeded standard dialyzers characteristic SHD. Ratio of white blood cells before dialyzer and after it didn’t change. Similarly behaved red blood cells, middle volume of RBC, practically didn’t change as well as Hb concentration in them. Platelets reliably increased that could be explained by the changes in the volume of liquid although no surplus adhesion of platelets on membrane could be observed. Acid-base condition, oxygen blood saturation before dialyzer and after it reliably didn’t change, but for BE, which, taking in to consideration acetate buffer, increased from -5.2 \pm 0.7 mmol/l until -10.3 \pm 1.1 mmol/l; peroxide hemolysis of RBC reliably decreased from 0.426 u. until 0.398 u.

From the whole spectrum of CHD indices cardiac output and total vascular resistance (TVR) had been chosen as most informatively. CHD measurement showed following results: patients receiving LFHD had
been conventionally divided in two groups according to hemodynamics type - first - cardiac output higher than standard rate and second below than standard. Patients with unstable hemodynamic were of hypodynamic type. Measurements have been conducted before beginning HD, 1 hour after HD beginning, immediately after HD and 1 hour after the end HD. Patients with hypodynamic type had initial cardiac output of 53.8 ± 2.9 ml, by the end HD increased to 62.4 ± 2.9 ml (p < 0.05). Total vascular resistance progressively lowered from 2434.2 ± 2.9 din/cm/s -5 to 1887.6 ± 7.1 din/cm/s -5 , practically coming to normal.

Patients with hyperdynamic type of hemodynamic had unreliable changes. The patients subjectively felt the mild conditions of the procedure and noted that they feel better during LFHD.

In summary, LFHD is effective enough on clearance characteristics, had no negative effect on the blood cells, had practically no effect on CHD and is well tolerated by patients. Its usage is justified for hemodynamically unstable patients and in order to introduce in HD-program.
99/023: ACUTE HAEMODYNAMIC EFFECTS OF CVVH IN A NEONATAL ANIMAL MODEL

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CVVH is a support modality of critically ill infants in multiorgan failure. Hypotension can occur during initiation of CVVH in these children. The cause remains speculative. 10 healthy neonatal piglets (mean weight 4.24 kg) were studied under anesthesia. Hemodynamic monitoring included arterial pressure, CVP, and PAP. A 6.5 Fr. 10 cm double lumen dialysis catheter (Gamcath: Hospal-Gambro) was positioned in the right atrium.

CVVH was performed using the PRISMA machine with an M60 filter (SA 0.5 m 2 ) and extracorporeal circuit (total volume 90 mls). (Hospal-Gambro) The circuit was primed with a previously collected pig blood mixture (Hct. 0.35). Base-line hemodynamics were performed. CVVH was initiated, aiming for a blood flow of 50 mls/minute by one minute (zero replacement fluid/even fluid balance). Hemodynamic measurements were recorded continuously. Sequential blood sampling included arterial and mixed venous blood gases and electrolytes. At the conclusion, static and dynamic circuit compliance was measured (off the animal).

Significant hypotension occurred in all animals within 5 minutes of initiation of CVVH, which reflects our own clinical experience. Mean iCa++ dropped from 1.3 to 0.94 mmol/L (p < 0.001), while K+ changes were not significant. Circuit compliance was insignificant (0.05 mls/cm). The cause of this hypotension remains speculative but an acute fall in ionized calcium in a critically ill child could be contributory. Caution is warranted when commencing CVVH in inotrope dependent critically ill infants.
99/024: DAILY 12-HOUR SUSTAINED LOW-EFFICIENCY HEMODIALYSIS (SLED): RATIONALE FOR INTERVENTION AND FUTURE PROSPECTS


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Over the last decade, continuous renal replacement therapies (CRRT) have been the modality of choice for renal replacement in hemodynamically unstable intensive care unit (ICU) patients with acute renal failure (ARF). Disadvantages of CRRT’s include procedural cost, initial investment in new equipment, and increased workload for already busy intensive care nurses. Furthermore, there is a moderate amount of protein lost with these therapies. As well out-of-unit diagnostic or therapeutic procedures require discontinuation of the treatment, and subsequent reinitiation with new extracorporeal circuitry, leading to extra expense and workload, and reduced renal replacement dose.

We hypothesized that the ideal therapy for unstable ARF patients should have the following characteristics:

1. Adequate solute control and renal replacement dose
2. Adequate ultrafiltration
3. Limited daily protein losses
4. Hemodynamic stability
5. Daily intermittent scheduling allowing time for procedures and tests
6. High acceptance by nursing personnel

Keeping the above 6 points in mind we decided to perform 12-hour SLED in critically ill and hemodynamically unstable ICU patients using the Fresenius 2008 H dialysis machine. The accompanying abstracts (Chatoth; Shaver; and Hall) describe the technique, solute removal, protein losses and nursing perspective of this therapy. Our experience shows that daily 12-hour SLED provides adequate dialysis dose, and maintains stable acid-base and electrolyte balance. Problems encountered have only been those ubiquitous to renal replacement therapy in ICUs, such as extracorporeal circuit clotting and on rare occasions hemodynamic instability. Nursing acceptance and technical competence with SLED was high.

Daily 12-hour SLED is now supplanting CRRT in many situations in our institution. Although the technique was initially performed during the day, the majority of treatments are now overnight thus allowing unrestricted access to the patient during the day for other purposes. While established in critical care, the use of SLED may be extended in modified form to nephrology ward patients requiring renal replacement therapy, in particular those who, while not critically ill, are hemodynamically brittle.

After our initial experience with the 12-hour SLED therapy, the question arose over the optimal duration of treatment. We chose 12-hour SLED initially for nursing convenience. Two-hourly collections of dialysate have demonstrated that approximately 20% of the total urea and 16% of phosphate removal occur in the last 4 hours of a 12-hour session. Consequently, we feel that shortening the treatment duration may impact solute control as well as ultrafiltration goals.
Protein losses were undetected by our analysis, but a more sensitive assay is needed. Further studies are being conducted to assess the cost effectiveness of daily 12-hour SLED versus CRRT’s.

In summary, SLED is a convenient, effective, and flexible renal replacement therapy, and is being used for daily nocturnal 12-hour treatments in the intensive care setting. Plans are underway in establishing a modified SLED treatment protocol in the nephrology ward setting.
99/025: SEQUENTIAL PLASMAPHERESIS AND RENAL REPLACEMENT THERAPY IN PEDIATRICS

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Plasmapheresis (PP) is often utilized in children with pulmonary renal syndromes (PRS) or hemolytic uremic syndrome (HUS). PP utilizes citrate as its anticoagulant. The blood flow rate of PP, thus the time of a PP treatment, is dependent upon the rate of citrate infusion. Citrate administration is based upon total blood volume of the child and has side effects of inducing hypocalcemia. Therefore if one could eliminate citrate infusion of PP one could not only decrease the time of each PP therapy but also negate the side effects of hypocalcemia.

Over the last 18 mos 3 children (16.3 ± 2.3 kg) required PP as well as renal replacement therapy (RRT). A 12 kg child had HUS with neurologic involvement and underwent hemofiltration (HF) with PP. A 21 kg child who had PRS and was on ECMO with simultaneous HF required PP, while another child (19 kg) with PRS required hemodialysis (HD) and PP. Local standard of care uses heparin adjusted to a target ACT during all RRT and ECMO if anticoagulation is needed. PP was performed utilizing a COBE Spectra 2997 plasmapheresis machine. Due to limited access and desire to avoid citrate, simultaneous serial PP and RRT was performed. Initial experience using a 3 way stopcock at the “arterial” access as a PP draw side and a 3 way stop cock on the “venous” side as a PP return failed due to collapse of the PP re infusion line. This occurred due to compliance of the return blood line. Subsequently, 2 separate 3-way stop cocks in serial were added on the “arterial” side to create a proximal PP pull line and a immediate PP return infusion line. This allows blood to come from the “arterial” access of the child and some of the blood would go to the PP machine while the rest would go the normal pathway of RRT. The return PP line drains into the arterial line of the RRT and follows the normal pathway of RRT. Using this procedure no citrate needs to be infused and any blood products administered for PP (e.g. Fresh frozen plasma [FFP]) would be dialyzed prior to return to the child.

Seventeen treatments in these 3 children were carried out without citrate infusion decreasing the normal time of PP from 67 ± 7.3 mins to 39±4.3 mins for the same amount of therapy without complications. Analysis of ACT and ionized calcium (ICa) during these therapies reveal no change in ACT nor change in heparin rate but a drop in ICa occurred due to the infusion of (citrate containing) FFP during the time of simultaneous PP and RRT on HF and on ECMO but not during HD. An infusion of calcium adjustment of an already present calcium infusion that is normally used in our HF or ECMO with HF normalized the ICa. Normalization of ICa occurred with 1 hour of ending of PP and HF or ECMO with HF. The calcium bath of HD prevented any ICa changes during PP and HD.

We conclude that in situation of limited access or need to avoid citrate anticoagulation simultaneous PP and RRT can be carried out without complications. Extra calcium may need to be infused if FFP is infused during PP due to the citrate that is contained in the FFP.
99/026: HEMOFILTER HEMATOCRIT CHANGES (AND CLOTTING POTENTIAL) IN PEDIATRIC HEMOFILTRATION: PRE-FILTER CVVH VS POST-FILTER CVVH VS CVVHD

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Previous work by the program has demonstrated that a CRRT prescription of fixed blood flow rates (4 mls/kg/min), fixed dialysate rate (CVVHD) or prefiltered filter replacement fluid (CVVH), using a Renal Systems HF-400 results in a similar urea clearance at 30 mls/min/1.73 m2.

Often it has been suggested that predilution CVVH may have less clotting then other routes of hemofiltration (HF) due to the dilution effect of the infusate. Clotting in HF should be related to a variety of factors including blood flow rates and anticoagulation. Prescriptions that increase the hemofilter hematocrit (Hct) such as blood transfusions or aggressive net ultrafiltration, should in theory increase the distal Hct in the hemofilter thus setting up a point of hyperviscosity which may impact upon clotting.

We prospectively evaluated the impact of CVVH (using both pre filter or post filter) or CVVHD upon Hct changes within the hemofilter. Ten children on HF were evaluated. We maintained the CRRT prescription as noted above and varied the infusate as a prefilter CVVH, then post filter CVVH then finally changed to CVVHD with no infusate but with the dialysate identical to the rate of the pre or post infusate of CVVH. During these times of analysis the net ultrafiltration was fixed, the total IV and/or enteral infusion of fluids was fixed, the BFR was fixed, the infusate rate or dialysate rate was fixed and the HF-400 was used. No infusate is used with CVVHD other then IV fluids (which were identical for CVVH).

We measured immediate pre and post hemofilter Hcts and present the data as the percent increase in Hct over the hemofilter. Pre filter CVVH (19.3 ± 4.2%) and post filter CVVH (18.1 ± 2.9%) show a similar percent increase in Hct over time while CVVHD demonstrated a lower and statistically significantly difference rise in Hct (4 ± 1.7%; p < 0.05). Whereas this data does not prove that CVVHD would have less clotting it does demonstrate that CVVHD, with equal urea clearance, has less step up in Hct and may prolong the life of the HF system. Randomization of CVVH vs. CVVHD will help address the question of impact of clotting over time.
99/027: PROSPECTIVE, CROSS-OVER COMPARISON OF BICARBONATE VS. LACTATE-BASED DIALYSATE FOR PEDIATRIC CVVHD

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The optimal approach to acid base control in pediatric hemofiltration (HF) has been debated. The use of commercially available lactate based solutions allows costs to be controlled but may in theory cause more acidosis in children. Commercially based bicarbonate solutions are not available at present in the United States although they are under evaluation and available in Europe and Canada. Commercially available lactate based solutions include peritoneal dialysis (PD) solution which contains 40 mEq/L of lactate or the Baxter Corporation premixed hemofiltration solution which contains 30 mEq/L of lactate.

Since 1991 we have used a pharmacy made bicarbonate solution for either CVVH or CVVHD. Due to concerns of the high costs of the bicarbonate based solution we instituted a prospective study of our locally made bicarbonate solution comparing it to a lactate based solution. We used a 3 liter bag of Ringers Lactate (LR) and added to it 100 mg/dl of glucose, 1 mEq/L of magnesium and 10 mEq/L of NaHCO₃, resulting in solutions that were identical except for a bicarbonate concentration of 40 mEq/L of NaHCO₃ in the bicarbonate based solution, vs. 28 mEq/L of lactate and 10 mEq/L of NaHCO₃ in the LR based solution. All children requiring CVVHD were eligible for entry except children with a baseline lactate > 2 mmol/L (mEq/L) or hepatic dysfunction (defined as transaminases > 3 ‘above baseline).

Patients were randomized to either the HCO₃ based or the adapted LR based solution at the onset of HF then after 24 hrs crossed over to the opposite solution. At the end of the second 24 hr period the study ended and local standard of care resumed. Analysis of costs, blood pressure and pressor use, ventilator management, pH, pCO₂, serum CO₂ and lactate levels were measured at base line and every 6 hrs during each 24 hrs of the study. Since April of 1998, 20 children were evaluated for entry into the study; 10 were excluded due to medical criteria and 5 were excluded due to family request (1) or they were not approached (4). Therefore, 5 children to date have undergone evaluation and these data are presented.

Costs were less with the adapted LR solutions due to decreased pharmacy time.

From hemodynamic and ventilatory standpoints, no difference was seen between the 2 arms. Arterial pH and serum HCO₃ were similar. Arterial PCO₂, although not significant, tended to be higher during the HCO₃ solution arm due to the higher amount of HCO₃ administered. Serum lactate levels at baseline and throughout the 24 hr arm of the HCO₃ were steady at 2.06 ± 0.5 mmol/L at baseline and 2.08 ± .5 mmol/L at 24 hrs. In contrast, serum lactate levels in the adapted LR arm rose from 2.1 ± 0.7 mmol/L at baseline to 3.3 ± 1 mmol/L at 24 hrs. Despite the trend, these results were NS due to the small number of children evaluated.

Although preliminary, these data suggest that a lactate based solution in children results in higher serum lactate levels than a HCO₃ based solution. Larger numbers of patients are being studied to learn
whether this trend may become significant. In addition, the higher lactate levels in the current commercially available solutions (PD or HF) could result in even higher serum lactate levels, and might result in clinical compromise due to lactic acidosis.
99/028: THE INFLUENCE OF CONTINUOUS VENO-VENOUS HEMODIAFILTRATION (CVVHDF) AND CONTINUOUS VENO-VENOUS HEMOFILTRATION (CVVH) ON THE PHARMACOKINETICS OF FLUCONAZOLE

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Since frequent analysis of serum fluconazole levels is costly and over- and under-dosage will be dangerous for the patients with deep-seated fungal infection, data of drug elimination during CVVHDF and CVVH are important.

Patients and Method: In six patient of a surgical ICU concentration of fluconazole in serum and in dialysate/ultrafiltrate were determined before drug administration and 1, 2, 4, 8, 12, 16, 20 and 24 hours postdosing (400, 600 or 800 mg of fluconazole) during CVVDH (first day) and CVVH (second day). Blood flow was 90 ml/min, dialysate flow 1000 ml/h. The area under curve (AUC) of fluconazole serum levels, total clearance, extracorporal clearance and sieving coefficient were calculated.

Results: AUC was significantly lower during CVVHD (data in table 1) over all patients and in the interindividual comparison (p < 0.05). Minimum levels below 6 mcg/ml were seen only with CVVHDF.

Conclusion: CVVHDF requires higher dosage of fluconazole in comparison to CVVH. Since the minimal inhibition concentration for most species of candida is 6 mcg/ml, 400 mg/d of fluconazole may be insufficient in patients undergoing CVVHDF.
99/029: QT INTERVALS AS PREDICTORS OF IONIZED CALCIUM LEVELS IN CONTINUOUS RENAL REPLACEMENT THERAPY PERFORMED WITH CITRATE ANTICOAGULATION

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The use of citrate as anticoagulant for CRRT allows for anticoagulation of the dialytic system without anticoagulation of the patient. To ensure this, calcium levels within the patient must be constantly maintained in normal range to counteract the effect of any citrate returning from the dialyzer. As we have reported previously, total calcium levels are inaccurate measures of physiologically available calcium. Ionized calcium measurements are more accurate, but nonspecific ionic interactions are known to occur such that this value may be an overestimate of available calcium. For these reasons, we have sought a physiologic marker of adequate calcium availability which could be performed at the bedside. To this end, we and others have looked at QTc as such a marker with disappointing results. However, several investigators have found better correlations when measuring the QT interval from Q to onset of T (QoT) or Q to apex of T (QaT) rather than the traditional Q to end of T (QeT).

Thirty-six patients receiving CRRT with citrate anticoagulation were evaluated sequentially. A rhythm strip was generated every 4–6 hours at the time of each ionized calcium determination. All specimens were obtained from an indwelling arterial line separate from the dialytic system. QoT, QaT and QeT intervals were measured by a single observer and QTc for each was calculated by Bazett’s formula. Correlation was then assessed in each patient as well as a subset of 6 patients with >25 data points (range 26–71). QoTc and QaTc did correlate better with measured ionized calcium levels than QeTc but did not reach significance. When patient data was assessed individually, excellent correlation was seen between ionized calcium levels and all QT variants in some subjects but was much more variable in most. Because no single interval correlated reliably with ionized calcium levels, we used a logistic regression model which identified 6 variables at, 150 significance levels. These included the preceding ionized calcium level, QeTc, QeTc lag1, QeTc lag2, QaTc, and QoTc lag2. We then generated a formula to predict ionized calcium levels. When compared to biochemical measurements, the predicted ionized calcium was within 95% confidence limits in 56 of 71 (79%) observations (subject # 30). However, the wide confidence bands of this technique limit its’ clinical usefulness.

In conclusion, QoTc and QaTc intervals are better correlated with ionized calcium levels than QeTc but it is clear that no ECG measurement adequately substitutes for biochemical measurement. Predictions of calcium levels derived from the ECG may be useful between actual measurements, especially in patients with fairly stable levels, and may allow less frequent blood sampling.
99/030: DAILY 12-HOUR SUSTAINED LOW-EFFICIENCY HEMODIALYSIS (SLED): A NURSING PERSPECTIVE

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We introduced daily 12-hour SLED as an alternative mode of renal replacement therapy (RRT) for critically ill, hemodynamically unstable, intensive care unit patients with acute renal failure (ARF). Initial questioning of the intensive care unit (ICU) nursing staff prior to initiation of SLED revealed fear and concern over handling the Fresenius 2008 H machine. An inservice was conducted for all ICU nursing staff prior to initiation of this therapy. The inservice consisted of a brief instructional video and a 2-hour "hands-on" training session. We hypothesized that this form of therapy would be more nurse friendly as compared to our already established form of continuous renal replacement therapy (CRRT), which was continuous veno-venous hemofiltration (CVVH) with 2 liters/hour of ultrafiltration rate using Hospal BM-22.

Subsequently, a questionnaire was submitted to the nurses who had prior experience with CRRT’s and had performed 12-hour SLED in the last 2 months. All 8 nurses who had performed SLED were polled. Six of eight nurses (75%) felt that the single inservice had been adequate for them to initiate this form of RRT. All nurses found the therapy less difficult to manage, 5 of 8 found it less intense and 6 of 8 found it less time consuming, and that it added less to their 12-hour workload when compared to CVVH.

All nurses polled stated that 12-hour SLED was the same as or easier than CVVH in terms of the ability to grasp the concepts and 7 out of 8 felt the Fresenius 2008 H was easier to understand and handle as compared to other CRRT devices. The majority also felt that trouble shooting, management of alarms, and emergency take-off was at least equal to if not easier than CVVH.

Six out of eight nurses felt that patients had better (4/8) or equivalent (2/8) hemodynamic stability when compared to their experience with CVVH. Very few alarms required management during a 12-hour treatment and consisted primarily of venous pressure alarms and conductivity alarms. All nurses polled preferred 12-hour SLED over CVVH for therapy in their patient with ARF.

In summary SLED was preferred over CVVH as RRT in critically ill ICU patients with ARF.
**99/031: ADEQUACY, SOLUTE AND ACID-BASE CONTROL WITH DAILY SUSTAINED LOW-EFFICIENCY HEMODIALYSIS (SLED) FOR ACUTE RENAL FAILURE (ARF)**

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Solute changes were closely monitored during 5 SLED treatments (see accompanying Chatoth abstract) in 5 critically ill ARF patients. 4 patients were male, one female. Ages ranged from 32 to 79 years and weights from 46.3 to 115.3 kg. SLED treatments were standardized on a Fresenius 2008 H, using an F-8 polysulfone dialyzer, with dialysate flow of 100 ml/min. For the 5 treatments, blood pump flow averaged 210 ml/min (range 200–250), and mean duration was 11.6 hours (range 10–12). Dialysate contained [Na+] of 136 mEq/L, [Ca2+] of 2.5 mEq/L, [HCO3–] of 35 mEq/L. Dialysate [K+] was 4 mEq/l for 2 treatments, and 3 mEq/l for the rest. 2/5 patients required post-SLED K+ supplementation, 20 and 40 mEq respectively.

Average protein intake per patient was 0.72 g/kg/24 hours (range 0–1.6).

Electrolytes, creatinine, blood urea nitrogen (BUN), Ca2+, inorganic phosphorus (Pi), and CO2 were measured in the serum at 2 hourly intervals. Serum albumin concentrations were measured pre- and post-SLED. One-tailed t-tests were used to compare pre-and post-SLED serum solute concentrations.

Total dialysate collection, using sterile 15-liter peritoneal dialysis cycler effluent bags, was used with a kinetically derived V to directly quantify dialysis dose (L. Garred, ARRT 2 (4); 305–318), and also evaluate dialysance of Pi and total protein.

(i) BUN was assumed to have equilibrated at 1 hr post SLED. Mean BUN removed per treatment was 19.4 g (range 9.5–35.1). Residual renal function was assumed to be zero, with mean 24-hour urine volume 70 ml (range 0–350). Mean single-pool and equilibrated Kt/V were both 1.64 (range 1.14–2.55), and mean solute removal index (SRI) 0.79 (range 0.61–1.0).

(ii) Mean Pi removed per treatment was 798.1 mg (range 349.1–1317.6). K Pi (the total Pi removed/AUC for intradialytic serum [Pi]) was 33.2 ml/min (range 16.3–49.3).

(iii) Protein was not detectable in dialysate to a lower limit of 6 mg/dl.

In summary, daily SLED provided a dose of dialysis comparable to other intermittent dialytic therapies in ARF. Despite a low K Pi, total Pi removed was at least equivalent to the amount usually removed per conventional hemodialysis treatment, and it is likely that daily SLED will necessitate Pi supplementation. Patients had no threatening changes in Na+, K+, CO2, Ca2+, or Pi although 2 patients needed a small K+ supplement post-SLED. Protein losses were minimal and did not affect serum levels of albumin. Daily SLED provides excellent metabolic control and a high dialysis dose. It may be superior to conventional hemodialysis, and comparable to continuous therapies, in the provision of renal replacement in critically ill patients.
99/032: CONTINUOUS RENAL REPLACEMENT THERAPY (CRRT) OUTSIDE THE MEDICAL CENTER: THE ST. PETER’S HOSPITAL CRRT PROGRAM AT 2 YEARS OF AGE

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A new CRRT program was established in October 1996 at St. Peter’s Hospital (SPH), a 466-bed tertiary-care hospital with active cardiothoracic (CTS) and vascular surgery services, affiliated with Albany Medical College. Initially, CRRT was restricted to CTS patients, but subsequently it was expanded to all critically ill patients.

Continuous veno-veno procedures were utilized, either Hemofiltration (CVVHF) or Diafiltration (CVVHDF), with post-pump pre-filter fluid replacement and Dianeal 1.5% (Baxter Corp) as the dialysis fluid. Heparin was the anticoagulant, goal PTT 1.5–2.0 times normal. Filters were Renaflo HF 700 (Minntech Co) until 3/98, when Fresenius polysulfone F8 filters were substituted because of persistent thrombocytopenia. This change resolved this problem. Since July 1998 we have used Asahi 06 polyacrylonitrile filters (Hemotronic Inc). Average filter duration was 21.56 (4.65SD) hours (minimal 6.7, maximal 47 hs.). The fluid/blood urea nitrogen ratio was measured daily and filters were discarded if the ratio > 0.8. We used sliding scales for heparinization, ultrafiltration, and blood sugar management. Hemoaccess was a double lumen catheter percutaneously inserted in the femoral vein in 21 patients, in the internal jugular in 2 and in the subclavian vein in 3. Severity of disease was assessed retrospectively, considering status at initiation of dialysis, with the ATN-ISI score described by Liano [Blood Purification 1997; 15: 346–53]. Significance of results was evaluated by non-paired Student’s t-test, linear regression and Chi-squared where appropriate.

Between October 1996 and September 1998, 26 patients [age 66 (14SD), 65% male] received CRRT. Ten patients were treated exclusively for volume excess (~4 Kg above baseline), one because of severe azotemia (BUN > 80 mg/dl, Creatinine > 6.5 mg/dl), seven exclusively for electrolyte and acid-base disorders and fifteen for combined azotemia and volume excess. Of the 26 patients treated, 8 survived (31%) and 18 died (69%). Of the 8 survivors, 6 recovered normal renal function and 2 remained on chronic hemodialysis. Analysis of survival over time showed a mortality of 8% at 24, 31% at 48 and 42% at 72 hours. A similar curve was found patients who recovered function, with rapid recovery of function by 72 hours and leveling-off thereafter. Severity scores were significantly higher for non-survivors [mean score 0.954 (0.106SD)] than survivors [0.662 (0.148SD)], p < 0.001. Analysis of the causes of death showed that multiple organ failure (MOF) represented 65% of the causes of death; 47% of those patients were septic. MOF plus cancer comprised an additional 12%. Six percent of the patients died of liver failure and 30% were withdrawn from treatment, 6% of those with sepsis. We observed an apparent association between death and sepsis: septic patient survival was 24%, while non-septic patients showed a 66% survival. The association was not statistically significant ([2 = 1.44, p < 0.3], likely due to the small size of the sample.
Initial results of the application of this state-of-the-art modality for the treatment of ARF in a large, university-affiliated community hospital are excellent. Patients showed a remarkable survival, considering the severity of their disease, the complexity of their surgeries, the prevalence of sepsis and the elevated ATN-ISI scores. Notwithstanding the significant difference in scores between survivors and non-survivors, the large overlap precludes the use of the scores to predict outcome. The growth of the CRRT program was possible by a close interaction between Nephrologists, critical care nurses, and all other involved subspecialists; such interaction and clear definition of responsibilities avoided conflict and ensured appropriate patient management. As a result, SPH has become the regional center of reference for this technique.
99/033: PROSPECTIVE IN VIVO AND IN VITRO ANALYSES OF DIALYSATE AND ULTRAFILTRATE PUMP ACCURACY AND PRESSURE CHANGES DURING CRRT

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Inaccuracy in dialysate and ultrafiltrate pumps used for CRRT can result in clinically significant fluid balance errors, particularly in small children and infants. Pump error within the industry standards of 5–10% of the set rate have resulted in life-threatening volume depletion in several pediatric patients within 4–6 hours.

We have previously reported preliminary in vivo data showing net underinfusion of dialysate and excess removal of ultrafiltrate during CVVHD. We hypothesize that these unanticipated fluid losses seen during CVVHD are clinically significant, and result from variable pressure loads on the pumps. To test this we significantly extended our in vivo pump accuracy studies, and devised an in vitro system to analyze the effects of blood flow rate, dialysate/ultrafiltrate flow rate, and net ultrafiltration rate on pump pressure loads. We analyzed pump accuracy in vivo using 3 currently available volumetric pumps (Medex Trilogy, Alaris Gemini, Baxter Colleague). Data for each pump were collected at a blood flow rate of 4 ml/kg/min in individual patients during sequential hourly fluid measurements using an infant scale accurate to within ±0.5 ml. Pump error was calculated as: [measured rate – set rate]. Analysis of 1049 total pump-hours at various flow rates in 4 pediatric patients revealed that dialysate (inflow) pump error ranged from +0.5 to -6.8% (+4.7 to -34 ml/hr), but did not increase with increasing flow rates. Ultrafiltrate (outflow) pump error ranged from +7.4 to -1.5% (+16 to -14 ml/hr), and also did not increase with increasing flow rates. Cumulative (dialysate + ultrafiltrate) pump error ranged from +0.9 to −7.9% (+9 to -48 ml/hr). In vitro studies performed on the Trilogy pump using pre- and post-dialysate and ultrafiltrate pump pressure monitors accurate to within ±2mmHg (Abbott; Sorenson TRANSPAC IV) revealed: 1) A direct correlation between increasing blood flow rate (100 (250 ml/min) and both dialysate post-pump (80% increase) and ultrafiltrate pre-pump (52% increase) pressures, 2) A direct correlation between total dialysate/ultrafiltrate flow rate (0 (1000 ml/hr) and ultrafiltrate post-pump pressure (0 (15 mm Hg), and 3) An inverse correlation between net ultrafiltration flow rate (ultrafiltrate - dialysate; 0 (300 ml/hr) and ultrafiltrate pre-pump pressure (38% decrease).

We conclude that: 1) Use of currently available IV pumps for CRRT results in unanticipated fluid losses, and that these losses may exceed 1000 ml/24 hr, and 2) Manipulation of blood flow rate, dialysate/ultrafiltrate flow rate, and net ultrafiltration rate within clinically relevant ranges results in significant alterations in pump pressure loads. Correlation of the impact of these pressure changes on pump performance is currently underway. Analogous in vivo data on pump performance for the Baxter BM 25 and Cobe Prisma are not yet available.
**99/034: CONTINUOUS HEMODIAFILTRATION WITH BICARBONATE- AND LACTATE-BUFFERED REPLACEMENT FLUIDS IN SEPTIC SHOCK**

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**Introduction:** Acid-base imbalances are an important aspect while using continuous renal replacement techniques in critically ill patients. The quality of replacement fluid needs to be considered regarding to the acid-base requirements especially in septic patients. Commonly used replacement fluids contain lactate as buffer. Whereas lactate has to enter the Cori- or Citrate-Cycle to become effective as a buffer, bicarbonate can act immediately. The metabolism of lactate in addition is depending on the impaired liver function of patients with septic shock and represents an oxygen consuming process.

**Methods:** We investigated the metabolic effects of lactate- and bicarbonate-buffered hemofiltration substitution fluids in a clinical follow-up design in 13 patients (mean age 67 ± 9 years [± SD]) with acute renal failure during septic shock. All patients received continuous veno-venous hemodiafiltration (CVVHDF, Prisma Hospal). Seven patients have been treated with bicarbonate- (Schiwa Combi-Paχ, Schiwa) and 6 patients with conventional lactate-buffered replacement fluid (Biosol, Hospal). We evaluated individual course of pH, HCO₃⁻, BE and lactate levels within the first 5 days after start of CVVHDF by linear regression analysis (Excel regression-procedure). The slopes of the regression equations for bicarbonate- and lactate-buffered hemodiafiltration were compared by T-test (SPSS).

**Results:** The use of bicarbonate replacement fluids for CVVHDF leads to a significant improvement of acid-base balance in the course of acute renal failure in septic shock. Linear regression equations for bicarbonate- and lactate CVVHDF are shown in the following table (mean ± SEM):

**Discussion:** Lactate buffered CVVHDF leads to the removal of large amounts of endogenous bicarbonate per day (600–1,000 mmol). Its impact on the acid-base balance in septic shock is considerable. The approach with bicarbonate replacement fluid for the treatment of acute renal failure in septic shock seems to be advantageous to normalize an impaired acid-base balance.
99/035: INTENSIVE CARE NURSING COMPARISON OF THE GAMBRO PRISMA AND BAXTER BM-11/INFUSION PUMP CONTINUOUS VENO-VENOUS HEMODIALYSIS (CVVHD) SYSTEMS FOR ACUTE RENAL FAILURE SUPPORT

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Continuous Renal Replacement Therapy (CRRT) is a labor-intensive form of support for ICU pts with ARF. Dialysis system designs may influence nursing perception of CRRT. In an effort to compare systems, CVVHD using bicarbonate-based dialysate was performed in the same patient, by the same staff and staffing ratio using either a Baxter BM-11 Blood Pump with dialysate infusion-pump delivery or a Gambro Prisma delivery system. The nurses were asked to compare and contrast the two systems for frequency of intervention and ease of care. They were also asked to critique both systems without following any pre-defined evaluation tool or methodology.

There was uniform agreement that system intervention and overall ease of care were markedly improved with the Prisma System. The required hourly fluid reset with the infusion-pump delivery apparatus was avoided while the intake/output calculations were automatically generated and much more precise using the Prisma. The required complicated connectology using the infusion-pump method was found to be quite cumbersome. Dialysate bag weight and disposal related more to the dialysate preparation techniques and packaging, however spent dialysate disposal was much easier with the infusion-pump system. Accuracy of dialysate and ultra-filtrate volume rates were greater with the Prisma, while blood flow ranges were greater with the BM-11. There was no difference noted in clotting between the two blood-side systems.

Overall, the ICU nursing staff preferred the Prisma system to the BM-11 with infusion-pump dialysate delivery. The perception of CRRT was greatly improved when the system which allowed reduced nursing intervention was employed.
Acute Renal Failure (ARF) support utilizing Continuous Veno-Venous Hemodialysis (CVVHD) is vulnerable to system clotting and decreased dialysis delivery. Several patient and system specific factors have been invoked as causes for clotting.

We prospectively evaluated fourteen Intensive Care Unit (ICU) patients who received CVVHD for ARF with respect to dialysis catheter site, heparin use, recirculation and blood flows (measured with the Transonic Hemodynamic Monitor, Transonic Systems, Ithaca, NY, USA). Thirty individual sessions (using Baxter BM-11 dialysis pumps and Fresenius F 4 dialyzers) were observed in those fourteen patients. We obtained the measurements at start of the session and proceeded with every four hourly evaluations until system clotting occurred (one hundred and three data sets). There were seven femoral catheters, ten subclavian catheters and one internal jugular catheter (several patients had two different types of catheters).

In five out of thirty sessions the blood lines had to be reversed. The mean number of measurements overall was 3.4 +/- 1.7 (1–7) per session. Recirculation was 18 +/- 10% (0–36) in the reversed line group, and 4 +/- 7% (0–30) in the regular group (P < 0.0001). The pumpflow was set at 188 +/- 19 (120–205) ml/min, however measurements with the Transonic Monitor revealed a blood flow of 216 +/- 21 (160–260) ml/min (P < 0.0001) and subgroup analysis showed this not to be different for any of the catheter types (P = 0.98). Heparin dosage was 470 +/- 631 (0–2000) units/hour and not significantly different for any of the studied subgroups. Recirculation was higher in the femoral catheter (9 +/- 10%) versus subclavian catheter (5 +/- 9%), but this did not reach statistical significance (P = 0.13). Time on dialysis was not significantly different with respect to catheter type, the need for line reversal or recirculation.

We conclude that (a) extracorporeal circuit blood flow usually exceeds the set pumpflow and (b) the need for line reversal, access recirculation at the observed levels and catheter type do not necessarily imply enhanced clotting propensity.
99/037: EFFICACY OF CONTINUOUS HEMODIAFILTRATION IN THE TREATMENT OF ACUTE RESPIRATORY DISTRESS SYNDROME

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Introduction: It is generally accepted that increased capillary and alveolar permeability caused by variety of humoral mediators and resultant pulmonary interstitial edema play major role in the pathogenesis of ARDS. We have claimed that continuous hemodiafiltration (CHDF) can remove various humoral mediators from blood stream and that CHDF can remove pulmonary interstitial edema through the removal of water in blood and concomitant water refilling from extravascular space. Therefore, the present study was undertaken to investigate whether CHDF would be effective in the treatment of ARDS.

Methods: Thirty ARDS patients were entered to the study. They were treated with CHDF regardless of their renal function addition to the conventional treatment. CHDF was performed using a polymethyl methacrylate (PMMA) membrane hemofilter under the anticoagulation with nafamostat mesilate. Change in respiratory index (RI) with 3 days of CHDF was studied. Also studied were the changes in blood levels of tumor necrosis factor (TNF), interleukin-6 (IL-6), interleukin-8 (IL-8) and granulocyte elastase (GE) blood level with 3 days of CHDF. Oxygen delivery, oxygen consumption and oxygen extraction ratio were also measured. Twenty-six patients with ARDS who were treated with intermittent hemodialysis addition to the conventional treatment served as controls and the 28 days survival was compared between the two groups.

Results: RI was significantly improved with 3 days of CHDF. The blood levels of TNF, IL-6, IL-8 and GE decreased significantly with 3 days of CHDF. Furthermore, there were significant and positive correlation between the degree of the decrease in the blood level of TNF and IL-6, and the degree of the improvement in RI. There was no change in oxygen delivery with CHDF. However, oxygen consumption and oxygen extraction ratio were significantly increased with CHDF. The 28 days survival was 63.3% in CHDF group and 34.6% in intermittent hemodialysis group, respectively (p < 0.05).

Conclusion: Those results indicate that CHDF improves pulmonary oxygenation and tissue oxygen metabolism and improves the survival of ARDS patients. Those results suggest that ARDS can play an important role in the treatment of ARDS.
99/038: THE EFFICACY OF CONTINUOUS VENO-VENOUS HEMODIAFILTRATION IN THE MANAGEMENT OF THE POST CARDIOPULMONARY BYPASS PATIENT

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Purpose: Renal failure has ~100% mortality if untreated in this often hemodynamically unstable population in which conventional dialysis therapies are impractical. We sought to assess the role of continuous veno-venous hemodiafiltration (CVVHDF) in the management of renal failure in these patients.

Methods: 32 consecutive patients with renal failure underwent management with CVVHDF between Jan. 1/97 and Feb. 28/98 and data collected prospectively. Indications for use of CVVHDF were volume overload, uremia, hyperkalemia, and acidosis, alone or in combination.

Results: 17 patients underwent urgent cardiac surgery. 11 patients had preoperative renal dysfunction (creatinine > 130). One of these patients was on preoperative chronic hemodialysis. CVVHDF was initiated 2 days (median) post-operatively (range 0–27 days) for an average duration of 113 +/- 87 hours (mean +/- SD) per patient. 218 +/- 106 ml/hr of fluid were removed per patient. The average changes from pre to post-CVVHDF were (using paired t-test): weight loss = 3.3 +/- 5.9 kg (p = 0.001), creatinine reduction = 76 +/- 13 mmol/L (p = 0.003), K+ change = -0.6 +/- 1.3 mmol/L (p = 0.018), and H+ change = +5 +/- 11 mmol/L (p = 0.019). The MAP dropped (pre-CVVHDF MAP = 76 +/- 12 mm Hg, post-CVVHDF MAP = 68 +/- 16 mmHg) (P = 0.011, paired t-test) but this was not clinically significant. Of the patients that were on epinephrine, amrinone, and/or dopamine, there was no statistically significant change in the dose of epinephrine and/or amrinone pre to post CVVHDF. There was a drop (p = 0.043) in the amount of dopamine needed pre to post-CVVHDF. There was a decrease (p = 0.011) in the number of patients on intra-aortic balloon pump pre to post-CVVHDF. There was no mortality attributed to the CVVHDF procedure. Fourteen patients survived to discharge. Three survivors needed intermittent hemodialysis after CVVHDF. Three patients died >25 days post-CVVHDF. No patient died of isolated renal failure; all deaths were from multisystem organ failure.

Conclusions: CVVHDF is a safe, and relatively effective renal replacement therapy in critically ill post-CPB renal failure patients.
99/039: COMPARISON OF CLEARANCES OF CYTOKINES WITH CONTINUOUS HEMODIAFILTRATION USING THREE TYPES OF HEMOFILTER/HEMODIALYSER MADE OF DIFFERENT MEMBRANE

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Purpose: To compare the clearances of cytokines with continuous hemodiafiltration (CHDF) therapy using three types of hemofilter/hemodialyser made of different membrane.

Methods: Hemofilter or hemodialyser made of three different types of membranes, polymethyl methacrylate (PMMA) membrane, ethylene vinyl alcohol copolymer (EVAL) membrane and polyacrylonitrile (PAN) membrane, were applied in this study. Blood levels of cytokines (IL-6, IL-8, TNF) were measured before and after 72 hours CHDF therapy using three different types of hemofilter/hemodialyser. The clearances of cytokines with CHDF therapy were measured in three groups treated with different hemofilter/hemodialyser. And the changes in blood level of cytokines following 72 hours CHDF were investigated.

Results: With CHDF therapy using a PMMA membrane hemofilter, the clearance of the cytokines showed significant and positive correlation with pre-CHDF blood level of each cytokine (p < 0.05). These results indicate that the mechanism of the removal of cytokines with CHDF might not only due to convection and diffusion but also due to adsorption of cytokines to the hemofilter membrane. The blood level of all three cytokines were significantly reduced with 72 hours CHDF therapy using a PMMA membrane hemofilter when pre-CHDF blood levels of these cytokines were high (p < 0.05). However the blood level of these cytokines did not decrease when pre-CHDF blood levels of these cytokines were low. There were neither significant correlations between pre-CHDF blood levels of cytokines and the clearances of cytokines nor significant reductions in blood levels of cytokines with CHDF therapy using an EVAL or PAN membrane hemofilter/hemodialyser. These results suggest that CHDF can remove those cytokines only when a PMMA hemofilter was used and when pre-CHDF blood levels of cytokines are high.

Conclusions: A PMMA membrane hemofilter should be chosen for CHDF therapy if the purpose of CHDF includes removal of cytokines.
99/040: CONTINUOUS HEMODIAFILTRATION IN THE TREATMENT OF SEVERE ACUTE PANCREATITIS COMPLICATING ORGAN FAILURES

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Objective: Severe acute pancreatitis (SAP) is a very hazardous condition and remains to be a challenge in critical care. It has been claimed that various humoral mediators play important roles in the pathogenesis of multiple organ failure (MOF) in SAP. Therefore, we have applied continuous hemodiafiltration (CHDF) in the treatment of the patient with SAP aiming at the removal of causative humoral mediators. Thus, the present study was conducted to determine the efficacy of CHDF in the treatment of SAP complicating organ failures.

Methods: Twenty-three patients with SAP treated in our ICU were entered to this study. The patients were treated with CHDF using a PMMA (polymethyl methacrylate) hemofilter and nafamostat mesilate as anticoagulant addition to the conventional treatment. The standard blood flow, filtration rate and dialysate flow was 60 mL/min, 300 mL/hr, 500 mL/hr, respectively. To investigate the efficacy of CHDF on SAP patients complicating organ failures, their clinical courses including assessment of illness severity were investigated.

Results: Illness severity on admission was severe (APACHE II score: 17.4 ± 6.3, Ranson’s score: 4.6 ± 1.7, respectively.). Fifteen patients had complicated organ failures before the admission to the ICU and 9 out of those 15 patients (60%) developed MOF. On other 8 patients, CHDF was started before the onset of organ failures and only one out of the 8 patients developed MOF. The overall complication rate of MOF was 43%. Renal failure and respiratory failure were the most common organ failures (61%, respectively). 8.4 ± 8.3 days of CHDF treatment was necessary to improve respiratory index <3) in the SAP patients complicating respiratory failure. 8.2 ± 8.3 days of CHDF was necessary to increase urine output >3000 mL/day) and all patients except 2 non-survivors recovered renal function. In the 4 patients without organ failures, mean duration of CHDF was 8.3 ± 6.7 days. The overall survival rate was 91% (21/23).

Conclusion: The results of the present study indicate that CHDF is an effective tool in the treatment of the patients with SAP because the overall survival rate was very high in spite of the serious severity of these patients. We suggest that earlier application of CHDF on SAP patients could decrease the complication rate of MOF in SAP and that it could improve the survival rate of SAP patients.
From 1995 to 1998, 12 burned patients (9 men and 3 women) with acute renal failure (ARF) were treated by veno-venous continuous renal replacement therapy (CRRT) at the Burn Unit of Hotel-Dieu de Montreal. Their mean ± SD age was 51 ± 12 years, mean APACHE II score, 19.7 ± 3.6, and the mean burned surface covered 48.6 ± 15.8% of total body surface area. Burns were from thermic origin in all cases. All patients were mechanically ventilated and presented evidence of sepsis.

The mean delay before occurrence of ARF was 15 ± 6 days and ARF was related to sepsis (12/12), hypotension (11/12), nephrotoxic antimicrobials (9/12), vasopressors (5/12), and/or rhabdomyolysis (3/12). Six patients were non-oliguric. The main reasons for CRRT initiation were: azotemia (12/12), fluid overload (6/12), hyperkalemia (2/12), and/or acidosis (1/12).

A total of 15 CRRT modalities were applied (12 continuous veno-venous hemodiafiltration CVVHDF, 2 continuous veno-venous hemofiltration CVVH, and 1 continuous veno-venous hemodialysis CVVHD) for a mean duration of 14 ± 13 days (median 6) using the Prisma system, Multiflow-60 filters (0.6 m² AN69) in pre-dilution, and Hemosol LG-2 solutions (Hospal-Gambro, St-Leonard, Canada). For CRRT, 9 patients were receiving heparin (500 to 2000 U/h) and 3 were not anticoagulated; mean time-life of the filters was 28 ± 8 h. Mean values for blood, dialysate, and reinjection flow rates were respectively 136 ± 19 ml/min, 1134 ± 250 ml/h, and 635 ± 327 ml/h.

Admission weight was 78.8 ± 12.7 kg with a mean weight gain before CRRT initiation of 10.0 ± 5.8 kg and a mean weight loss during CRRT of 8.9 ± 5.5 kg. Urea and creatinine serum concentrations were 6.0 ± 1.8 mmol/L and 106 ± 36 mmol/L upon admission to the Burn Unit and reached values of 35.1 ± 8.4 mmol/L and 292 ± 72 mmol/L at CRRT initiation, respectively. Nine patients were receiving enteral plus parenteral nutrition, and 3, parenteral nutrition only; the total caloric intake was 31.5 ± 7.0 kcal/kg/day and protein intake, 1.8 ± 0.4 g/kg/day. The normalized protein catabolic rate (nPCR) was evaluated at 2.26 ± 0.86 g/kg/day (range 1.08 to 4.25) during CRRT.

The mortality rate was 50%. The 6 survivors all recovered normal renal function with 4 of them requiring intermittent hemodialysis for short periods (from 2 days to 1 month); serum creatinine at hospital discharge was 82 ± 12 mmol/L. In all 12 patients, no complication due to CRRT was identified.

In summary: 1) ARF in our burned patients was usually delayed by more than 10 days after admission to the Burn Unit and was frequently multifactorial; 2) these ARF patients were septic and usually hemodynamically unstable; 3) most of them were in fluid overload and highly catabolic; 4) veno-venous CRRT was very well tolerated in these patients and devoided of complications. In conclusion, veno-venous CRRT is particularly well suited for this selected population allowing smooth fluid removal and aggressive nutritional support.
99/042: COMBINATION EFFERENT THERAPY ACUTE LIVER FAILURE CAUSED ACUTE VIRAL HEPATITIS B

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The problem of treatment acute liver failure (ALF) especially actual for severe acute viral hepatitis B (AVHB). Complication forms of AVHB with ALF accompany severe damage system of haemostasis, injury of gastrointestinal tract, development respiratory distress-syndrome of adults and disturb other systems. This may be consider as multiple organs failure syndrome (MOFS), and complication forms AVHB as universal model of endotoxicosis.

The aim of this research is receive optimal combination of efferent methods of detoxification permit the most effective and quickly maintenance detoxification and synthetic functions defeat liver support.

From these clearance characteristics of methods of detoxification we come to conclusion that the combination of haemofiltration (HF) and plasmapheresis (PA) permit extraction whole the pool from low-molecular to high-molecular endotoxins.

This combination was applied to 33 patients with ALF. All the patients had MOFS symptoms. HF was done through haemofilters "Multiflow-60", "Crystal", "Amicon", "HF-80" and other by the post-dilution method with one-moment extraction 50% and more tissue fluid, which replace standard substitute "HF-21-23" by "Fresenius". All the possible variants of HF were applied from continuous arterial-venous HF to intermittent veno-venous HF. PA was done through "PF-0.5" machine or plasmafilters, or discrete method with extraction one or more liters of blood plasma with adequate make up free-freezing human plasma. The level of bilirubin, serum enzymes immunoglobulins A, M, G-class, subpopulation of lymphocytes and circulating immunity complex (CIC) were studied.

These methods were able to decreased of bilirubin level from $491 \pm 24.2$ mcmol/l to $280 \pm 14.1$ mcmol/l, AlaT from $1998 \pm 149$ IU/l to $1317 \pm 149$ IU/l, AsaT from $124 \pm 8.8$ IU/l to $68 \pm 2.2$ IU/l, Gamma-glutamatranspeptidasa from $70.3 \pm 2.3$ IU/l to $47 \pm 1.8$ IU/l and ALP from $341.5 \pm 3.9$ IU/l to $94.7 \pm 1.5$ IU/l levels correspondingly for one cycle. CIC-levels 3% were decreased from $117$ to $96$ U/l, 4% from $194$ to $167$ U/l. Immunoglobulin levels became normal. Numbers of supressors increased on 20%. These methods were able to realiz efferent therapy with injury of gastrointestinal tract complication of bleeding. Time of treatment these severe patients in the Intensive Care Department was 13.6 days.

From 33 patients were critically ill two died, mortality is 6%.

Thus the use of combination efferent therapy including HF and PA is able to do treatment ALF by AVHB more effectively.
99/043: COMPARATIVE STUDY OF OUTCOME FROM ACUTE RENAL FAILURE REQUIRING RENAL SUPPORTIVE THERAPY: PATIENTS UNDERGOING LIVER TRANSPLANTATION VERSUS ALL OTHER CAUSES IN INTENSIVE CARE

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**Purpose of Study:** Acute renal failure (ARF) is associated with an increased morbidity and mortality in patients receiving intensive care. Patients in liver failure awaiting liver transplantation are at risk of developing this complication but the prognosis is believed to improve after transplantation. We compared the outcome of patients in acute renal failure receiving continuous renal replacement therapy (CRRT), on the general intensive care unit (GITU) to that in patients in the Liver intensive care unit (LITU), following liver transplantation, in a tertiary referral centre.

**Methods Used:** A retrospective study of patient databases from the GITU and LITU from April 1996 to March 1998.

**Results:** During the study period 63 and 46 patients received CRRT for ARF on the GITU and LITU and the mortality rate for these two groups were 36% (23/63) and 39% (18/46) respectively (Table 1). The length of stay on the intensive care unit was 8.1 days on GITU and 13.5 days on LITU. Following liver transplant (Table 2), fulminant hepatic failure patients had the highest pre-transplant serum creatinine (mean 255 mmol/l) and a mortality rate of 40% (4/10), chronic liver failure patients with a mean pre-transplant serum creatinine of 191 had a mortality of 46% (14/30), while those undergoing a transplant for a second time had a mean pre-transplant serum creatinine of 231 and all (6) survived.

**Conclusions:** The outcome of ARF in patients undergoing liver transplant appears to be similar to that seen in a general population receiving intensive care. Patients with fulminant liver failure despite worse renal chemistry have a better outcome than those with chronic liver failure following liver transplantation. This may be attributed to the poor physiological reserve in those with a long-standing disease than in those suffering from an acute event.
99/044: SUCCESSFUL METABOLIC CONTROL WITH THE USE OF CUSTOMIZED SOLUTIONS IN CRRT


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The aim of this study was to evaluate whether metabolic acidosis of critically ill patients with acute renal failure (ARF) could be effectively controlled using customized bicarbonate solutions for CRRT.

**Patients and Methods:** patients requiring dialysis for ARF and hemodynamic instability in an adult ICU from July to November 1998 were included in the study. CVVHD was performed in all cases using a case-oriented dialysis bicarbonate solution, prescribed daily according to early morning blood exams. The procedures were performed using a FAD 100, controlled ultrafiltration device (BBraun) and PAN membranes. Blood flow rate was set at 100 mL/min. Dialysate solutions were prepared on a 2-bag system (A + B): bag A containing the estimated bicarbonate needed for acidosis correction (48–80 mEq/l), Na (135–145 mEq/l), K (1.5–4 mEq/l), and acetate (4 mEq/l); bag B containing Ca (3–6 mEq/l), Mg (2–4 mEq/l), Na (135–140 mEq/l) and K (1.5–4 mEq/l). Chloride levels were prescribed, accordingly in both bags. Bags A and B were simultaneously infused in a Y connection, with dialysate flow rate set at 1.000 ml/h. Desired final concentrations were obtained at filter level. Early morning arterial blood gas analysis, serum electrolytes and lactate measurement were performed and repeated according to patients needs. APACHE II on day 0, mortality on day 30 from the discharge from hospital and renal function recovery based on SCr were analyzed.

**Results:** 18 patients, 13 males and 5 females were included. Mean age was 62.5 ± 17.3 (28 to 87). ARF was associated to sepsis (n = 15); liver transplantation (n = 2) and one case of fulminant hepatic failure. Patients received full nutritional support during CRRT. Mean time for CRRT was 12.6 days (1 to 40). Mean APACHE II on day 0 was 17 (14 to 22).

**Follow-Up:** 10 patients died within the first 48 h of CRRT, 6 within 24 h. Correction of metabolic acidosis was not achieved in this latter group (mean HCO₃ = 14.4 ± 1.4 mEq/l). Three patients were alive 30 days after discharge from the hospital with normal SCr (0.9, 1.3 and 1.5 mg/dl).

**Conclusions:** Customized bicarbonate solutions can be successfully used for metabolic acidosis control in ARF in spite of severe hemodynamic insult. Unsuccessful metabolic control, associated to death within the first 24 h of CRRT, calls attention for the relevance of timing on indication and initiation of the procedure. Renal function recovery, as observed in a few cases, may be achieved.
99/045: CONTINUOUS VENO-VENOUS HEMOFILTRATION IN ACUTE CARDIAC DECOMPENSATION

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**Introduction:** The use of continuous veno-venous hemofiltration (CVVH) has become a routine procedure in the therapy of acute renal failure. Case reports of CVVH during cardiopulmonary resuscitation in hypothermia have been published. We report the use of CVVH for fluid removal in two patients with acute cardiac and renal failure following massive volume overload.

**Patient 1:** A 60-year-old patient following abdominal surgery due to peritonitis was admitted on ICU with cardiac failure. Following massive intraoperative fluid intake (4000 ml cristalloids, 1600 ml colloides, 2 RBC, 2 FFP; diuresis 200 ml) the patient presented a cardiac depression due to volume overload and sepsis. Therapy with high-dose catecholamines was not successful in stabilizing blood pressure and reversing diuretic-resistant acute renal failure. After visualizing a massive dilated heart with only slight contractions by ultrasound, acute CVVH was performed for fluid removal. Cardiocirculatory stability and spontaneous diuresis were reestablished after removal of 1500 ml volume and application of 80 mg furosemid two hours after onset of therapy.

**Patient 2:** A 80 year old patient following abdominal surgery due to colorectal cancer was admitted on ICU after intubation presenting cardiogenic shock, pulmonary edema and acute renal failure following massive intraoperative and post-operative fluid intake (7500 ml cristalloids, 1500 ml colloides, 2 RBC). Pulmonary artery catheter confirmed low cardiac output and high CVP. Cardiopulmonary resuscitation was necessary due to catecholamin resistant low cardiac output and cardiac arrest. 2500 ml volume was removed by hemofiltration during CPR. Following a short period of stabilisation with spontaneous diuresis the patient died five hours after onset of therapy.

Both patients received continuous veno-venous hemodiafiltration (CVVHDF, Prisma Hospal).

**Conclusions:** Hemofiltration is an effective strategy for fluid removal in patients with acute cardiac and renal failure due to volume overload. Continuous veno-venous hemofiltration in patients with cardiac instability is recommended to be performed with invasive hemodynamic monitoring.
99/046: SURVIVAL IN PATIENTS WITH SEVERE LACTIC ACID ACIDOSIS IS PROLONGED BY CVVHD WITH CITRATE ANTICOAGULATION

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Metabolic acidosis from lactic acid is associated with a high mortality rate in critically ill patients when serum lactate levels exceed 4 mmol/L. Survival has not been improved by administration of NaHCO₃ or dichloracetate or intermittent hemodialysis-sis. Indeed, NaHCO₃ infusion has been associated with higher mortality, presumably because of stimulation of phosphofructokinase (PFK) and increased lactate production. Previous observations have suggested that citrate is associated with beneficial effects in 3 patients on CAVH. We have developed a protocol for CVVHD at our institution which employs trisodium citrate as a regional anticoagulant (46.7% solution).

**Purpose:** To determine if citrate prolongs survival in critically ill patients with metabolic acidosis from lactic acid.

**Methods:** Trisodium citrate (46.7% solution) was administered at 15 ml/hr prefilter and CaCl₂, 10 mEq/dl at 40 ml/hr via a central line.

**Results:** We report prolonged survival in 5 critically ill patients with severe lactic acid acidosis and MODS using CVVHD and continuous citrate infusion. Citrate administration was associated with an increase in arterial pH (7.23 ± 0.25 to 7.39 ± 0.07), and HCO₃⁻ (16.1 ± 5.3 to 21.3 ± 3.7), and a decrease in lactate (10.1 ± 3.6 to 5.6 ± 3.1 mmol/L). The need for NaHCO₃ infusion was decreased, thus avoiding the potential detrimental effects of bicarbonate therapy. Median survival was 17.5 days.

**Summary:** These findings indicate that CVVHD using citrate anti-coagulation represents a reasonable and practical method to stabilize critically ill patients with lactic acid acidosis, even when lactate production remains high. Prolonged survival allows redirection of efforts to treatment of the underlying disorder.

**Conclusion:** We propose that citrate, by enhancing the inhibitory effect of ATP on PFK, could offer potential advantages beyond the expected alkalinization associated with citrate metabolism. Future studies will need to address prospectively the possible favorable impact of citrate/CVVHD on outcomes in severe and prolonged lactic acid acidosis in the critically ill patient.
CONTINUOUS VENO-VENOUS HEMODIAFILTRATION (CVVHDF) IN ETHYLENE GLYCOL INTOXICATION

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Introduction: Intoxication with ethylene glycol (EG) represents one of the most serious and dramatic poisonings encountered in clinical medicine. EG, commonly used as an antifreeze solution, is rapidly metabolized to toxic products including glycoaldehyde, glycolate and oxalate. Severe metabolic acidosis is common and the result of accumulation of toxic metabolites and lactate. Treatment involves administration of ethyl alcohol to compete for alcohol dehydrogenase, elimination of these products with hemodialysis, and correction of the metabolic acidosis. Prolonged therapy with conventional hemodialysis is often necessary to achieve these goals, and is often inconvenient. There are only a few reports of the application of continuous renal replacement therapies in EG intoxication. We report a patient in which conventional hemodialysis was followed successfully by CVVHDF.

Case Report: A 35-year-old man was admitted to Hermann Hospital, unresponsive, with a severe anion gap metabolic acidosis (pH = 6.8, HCO₃⁻ = 5, Na⁺ = 149, K⁺ = 5.5, Cl⁻ = 111 mEq/L, BUN = 13, S. Cr = 0.6 mg/dl). The measured osmolality was 405 and the osmolar gap was 89 mOsm/kg. The patient was intubated, but hemodynamically stable. Treatment was initiated with intravenous bicarbonate; an infusion of 10% ethyl alcohol solution to maintain a blood alcohol level of 100–150 mg/dl; and acute intermittent hemodialysis. At the end of 4 hours of hemodialysis the osmolar gap had declined from 89 to 27. While the acidemia improved, the anion gap remained high (21 mEq/L). Because the patient was now anuric despite positive fluid balance, and because of the necessity to eliminate EG products, CVVHDF was initiated. For this purpose we employed a Q of 150 ml/min, and a collected outflow dialysate rate of 2000 ml/hr. Trisodium citrate (46.7% at a rate of 15 ml/min) was used for regional anticoagulation. CaCl₂ (10%) was administered through a central line. The citrate also provided additional alkali to correct the acidosis. We achieved a significant clearance of ethylene glycol, (mean clearance of 17 ml/min ± 5.77). In parallel, a decrease in the osmolar gap and correction of acidosis was observed. CVVHDF was discontinued 30 hours after initiation. The data are displayed in detail below:

The patient continued to improve objectively but required 3 additional hemodialysis treatments over the next week before recovery from acute renal failure.

Conclusion: In the setting of ethylene glycol intoxication, after rapid elimination of metabolites by conventional hemodialysis, and in the setting of oliguric acute renal failure, continuous renal replacement therapy offers a reasonable alternative to intermittent conventional hemodialysis. The role of citrate in the correction of the accompanying metabolic acidosis requires further investigation.
99/048: FILTER LIFE IN CVVH THERAPY: A CASE STUDY

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Intro: The following is a case report of one patient receiving a prolonged complicated course of CVVH characterized by unplanned and frequent filter changes. A hypercoagulable state possibly induced by intravenous administration of lipids is discussed.

Case: A 41-year-old male with acute respiratory failure secondary to ARDS and varicella pneumonia was admitted to the ICU in April of 1998 in our community hospital. His course was characterized by profound hypoxemia unresponsive to high FiO2 and PEEP. Complications included: acute renal failure, hemodynamic instability, disseminated intravascular coagulation, and multiple infections. To maintain adequate oxygenation and patient comfort, multiple sedatives were used including a prolonged course with Diprivan. After a trial of enteral nutrition the patient received parental nutrition which included the administration of 10% intralipids. CVVH therapy was started 2 days after admission. Percent ultrafiltration was maintained at under 11%.

Methods: A retrospective chart review was done to tabulate the number of filter changes per day and the number of hours per filter. Also reviewed were the use of medications including anticoagulation (heparin infusion), anticoagulation parameters, use of intralipids and blood levels of amylase and lipase and the visual presence of lipemia in the serum. A clotted filter and tubing was sent to pathology for analysis. A Medline search using keywords: ‘hyperlipidemia’, ‘filter life’ and ‘continuous renal replacement’ was done via the Internet grateful med. and pub med for 1985–present.

Results:

Numerous articles including issues of anticoagulation and continuous renal re-placement were found, however none specific to hyperlipidemia states. Textbook review was not yet done.

The final pathology diagnosis of a clotted filter and tubing was 1) microscopy: 2+ fat. 2) Blood clots. 3) Oil red o stain reveals presence of irregularly shaped ORO positive material mixed with the blood clot, both within the clots and outside of it. These particles were identified on H&E and thought to be not of lipid nature. However, ORO definitely stains them positive

Conclusion: Filter life is a daily issue in the management of patients receiving CVVH. Common reasons for clotting include inadequate anticoagulation and hyper-viscosity states. This case suggests that the use of concurrent medications and nutrition may also be a factor. The association of hyperlipidemia and filter clotting has apparently not been previously reported and deserves further clinical investigation.
**99/049: OUTCOME IN POST-TRAUMATIC ACUTE RENAL FAILURE WHEN CONTINUOUS RENAL REPLACEMENT THERAPY IS APPLIED EARLY VS. LATE**

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**Purpose:** To determine whether the timing of initiation of Continuous Renal Re-placement Therapy (CRRT) affects outcome in patients with post-traumatic Acute Renal Failure (ARF).

**Methods:** The medical records of 100 adult trauma patients at a level I trauma center who were treated with CRRT for ARF from 1989 to 1997 were reviewed. Patients were characterized as either “early” or “late” starters based upon whether the Blood Urea Nitrogen (BUN) was less than or greater than 60 mg/dL, at time of CRRT initiation. Chi-square testing was used to test frequencies between groups, and Student’s t test was used to compare means. Statistical significance was set at 0.05.

**Results:** The mean BUN of the “early” and “late” starters were 42.6 mg/dL, and 94.5 mg/dL respectively (p < 0.0001). Dialytic intensity of the two groups was al-most identical, maintaining BUN between 62 and 72 mg/dL (Figure 1). CRRT was initiated earlier in the hospital course of “early starters” compared to “late starters” (hospital day 10.5 vs. 19.4, p < 0.0001). Creatinine clearance prior to CRRT did not differ statistically between the two groups. No significant difference was found between “early” and “late” starters with respect to Injury Severity Score (ISS), admission Glasgow Coma Scale score (GCS), presence of shock at admission, age, gender distribution or trauma type. Admission lab values including BUN, serum creatinine, lactate, and bilirubin, as well as fluid and blood requirements in the first 24 hours were statistically the same for the two groups, suggesting a similar risk of developing renal failure. Survival rate was significantly increased among “early starters” compared to “late starters” (39.0% vs. 20.0%, respectively, p = 0.041). Relative risk of death in “late” vs. “early” starters = 1.31 (0.99 < RR < 1.72). Renal function recovery in survivors, number of CRRT days, and length of stay of the “early” and “late” starters were not statistically different.

**Conclusion:** This retrospective review suggests that an earlier initiation of CRRT, based on pre-CRRT BUN, may improve the rate of survival of trauma patients who develop ARF, when the intensity of dialysis is essentially identical.

Figure 1. A comparison of early vs. late starters with respect to mean BUN over time a.
99/050: COMPARISON OF “PREDICTIVE” FORMULAS VS INDIRECT CALORIMETRY IN ASSESSING NUTRITION SUPPORT NEEDS IN PATIENTS WITH ACUTE RENAL FAILURE RECEIVING CONTINUOUS RENAL REPLACEMENT THERAPY

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Difficulties in determining nutritional requirements for critically ill patients (pts) are paramount despite the myriad of formulas published to accomplish this task. Confounding variables in Acute Renal Failure (ARF) patients make accuracy question-able when even subtle changes in management can lead to an in morbidity. In-direct calorimetry, considered the gold standard to determine energy needs, is not available in most institutions because of its high dollar cost, therefore, reliance on “predictive” equations is essential. The accuracy of the predictive formula used with respect to outcomes is one of ongoing debate. The purpose of this study of 41 patients was: a) to compare energy needs using the most common “predictive” equations (group 1, n = 21) vs. energy needs derived from a metabolic cart (MC) (group 2, n = 20) and, b) assess changes in N2 balance with increasing protein intake to determine “optimal” protein needs.

Methods: Ten dietitians, physicians and pharmacist were poled to determine the most “common” method utilized in predicting energy and protein needs in ARF patients receiving Continuous Veno-Venous Hemofiltration with/without dialysis (CVVH/CVVHD) in a teaching and community hospital. Two methods were determined to be predominant, the Harris-Benedict equations (HBE) and the “generalized” factor (GF) of 30 kcal/kg. Protein estimates were based on clinician assessment and laboratory data. All patients were receiving ventilator support. Metabolic cart reading were completed in a non-fasting state using 24 hr averages. No activity factor was included in either group because of the level of paralysis and sedation required. Ideal body weight (IBW) was used to determine energy needs utilizing the Hamwi formula. All pts received Total Parenteral Nutrition (TPN) as their predominant nutrition intervention. Sixty-six percent of the patients received simultaneous “trickle” enteral feeds at 5–10 cc/hr. Enteral feeding were considered in calorie calculations. Nutrition support was initiated at “goal” rate with 66% of the patients; the remaining 44% achieved goal by day 2.

Results: Results show a negative correlation between “predictive” vs. MC readings for energy expenditure (p < 0.05, r = 0.42); No significant difference was seen in Apache II scores between the groups. Gross mortality was similar in Group 1 (83%) to Group 2 (80%). Nutrition calculations in the “predictive” formulas were evaluated based on weight and laboratory data. However, calorie calculations for energy needs were rarely changed, despite changes in the patient’s clinical condition. Staff responded to changes in energy needs based on MC readings 100% of the time. The HBE overestimated energy needs on average by 27%. Ninety-three percent of the pts required ≈ 2.0 g/kg of protein for positive nitrogen balance. Protein changes were made in response to laboratory data (prealbumin levels and nitrogen balance) 100% of the time in both group 1 and group 2. Metabolic cart reading determined caloric requirements of 25–28 kCal/kg. in 93% of the patients except when a “septic incident” occurred. Readings on FIO2 > 60% were not considered per manufacturer recommendations; changes in calculations for air
leaks resulting from chest tubes or trachs were recognized as a possible negative bias. APACHE II scores, length of stay, CVVH/CVVHD days, and intensive care unit days did not correlate with nutrition outcomes. Nitrogen balance did not correlate with outcomes.

**Conclusion:** 1) Clinicians were more likely to make changes in nutrition support based on available technical data vs. an equation; 2) Optimal protein intake for positive N 2 balance was 1.8–2.2 g/kg, with a total calorie: nitrogen ratio of 80–100:1; 3) This data supports previous studies exhibiting positive nitrogen balance with hypocaloric feedings and high protein intakes; 4) Although adequate nutrition has been shown to blunt catabolic responses, decrease infections and reduce length of stay, confounding variables in this population make assessment of clinical outcomes based on nutritional variables difficult to interpret.
**99/051: CLINICAL ANALYSIS OF 283 CASES OF ACUTE RENAL FAILURE**

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**Purpose:** Acute renal failure (ARF) is one of the commonly encountered acute diseases that are usually seen in the departments of internal medicine, surgery, gynecology, obstetrics, pediatrics, infectious disease, traumatology and etc. ARF is one among the few organ failures that can be completely cured. If it can be detected and diagnosed at the early stage, treated timely with adequate dialysis, renal function of the patient can be completely restored, but delay of diagnosis or absence of dialysis therapy can lead to death of the patient. With the above perspective, we made observation of etiology, clinical symptoms and therapy of 283 renal failure patients who were treated in our hospital during 1987 to 1997, this article is to summarize treatment and prognosis of these patients.

**Method:** 283 ARF patients were selected as the objects of the study, There were 117 men and 116 women, the oldest is 26 years old, the youngest is 4 years old. Etiology: pre-renal: 49 cases (17.39%) including 3 cases of postpartum hemorrhage; renal parenchyma: 221 cases (78.19%) including 78 cases of septicemia and infectious shock; 66 cases of toxic mushroom poisoning, 52 cases of epidemic hemorrhaged fever, 41 cases of fish bile poisoning, 23 cases of acute drug poisoning and tonic poisoning, 8 cases of various kinds of glomerulonephritis, the rest 15 cases are other; post renal: 10 cases (3.5%); unknown reason: 3 patients (1.1%). Clinical manifestation: oliguria type: 275 cases, non-oliguria type: 8 cases.

**Results:** Laboratory test: BUN $30.20 \pm 14.14$ (mmol/L), Cr $1295.83 \pm 519.17$ mmol/L. Complications: various kinds of infection: 42 cases, acute cardiac insufficiency: 16 cases, digestive tract hemorrhage: 12 cases, uremic cerebropathy: 8 cases. All the patients were treated with measures like diuretics, regulation of water, electrolyte, acid-base balance, anti-infection, and etc. 84 patients were given 2 to 6 times of hemodialysis, 12 patients were given peritoneal dialysis. Prognosis: 86 patients were died, (all of them were died at the period of oliguria with complication of multi-organ failure), 4 patients left the hospital during the study, the rest were cured.

**Discussion:** among the 283 ARF cases, renal parenchyma are predominant in terms of etiology (78.1%), except for commonly encountered septicemia, shock and epidemic hemorrhaged fever, mushroom poisoning and fish bile poisoning are also the main cause (107 cases, accounting for 37.89% of the total), however, the etiology has no correlation with that in the common knowledge of science popularity, therefore, publicity and health education on knowledge of science popularity.

**Conclusion:** analysis of the relations between therapy and prognosis shows: the mortality of hemodialysis and peritoneal dialysis groups is 16.4%, the mortality of non-dialysis group is 25.8%, the differences between them is of great significance ($P > 0.05$), therefore, administrative coordination should be strengthened so as to achieve blood purification therapy of ARF patients in general hospitals.
99/052: EXTENDED DAILY DIALYSIS: AN ALTERNATIVE TO INTERMITTENT HEMODIALYSIS AND CONTINUOUS VENO- VENOUS HEMOFILTRATION FOR THE INTENSIVE CARE PATIENT IN RENAL FAILURE

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Purpose
Implement an Extended Daily Dialysis (EDD) program to provide a simplified delivery of renal replacement therapy for the intensive care patient with a comparison to IHD and CVVH.

Methods
1. EDD on a Fresenius 2008 H dialysis delivery system 8 hours, 6 times per week. IHD on Fresenius 2008 H system 3–4 hours, 3–6 times per week. CVVH with Cobe Prisma up to 24 hours daily.
2. Patient fluid removal (UF) time: EDD 8 hours; IHD 3–4 hours; CVVH 0–100 ml/hr net for up to 24 hr.
3. Flow rates: EDD Qb 150–200 ml/min, Qd ≤ 300 ml/min; IHD Qb 300–400 ml/min, Qd 500–800 ml/min; CVVH Qb 150–180 ml/min, Replacement Fluid Rate 1000–2000 ml/hr.
4. Collaborative delivery of Extended Daily Dialysis with ICU and Dialysis Nurses

5. Five patients (age 54 ± 19 years, range 29–72) received 29 EDD sessions. Two patients (19 & 31 years) received 11 CVVH sessions. Six patients (age 58 ± 16 years, range 34–73) received 19 IHD sessions.

6. APACHE scores were completed on all patients.

7. The frequency and type of nursing interventions for machine and patient problems were recorded on 20 EDD and 20 IHD sessions.

Results
1. Clearance of solutes was increased compared to IHD and similar to CVVH.
2. Enhanced fluid removal with comparable hemodynamic stability EDD vs. CVVH, improved stability vs. IHD
3. EDD simplifies documentation compared to CVVH and is similar to IHD.
4. Minimal ICU nurse time interventions delivering EDD compared to CVVH.
5. EDD requires similar or less Dialysis nursing hours compared to IHD.
6. EDD readily accepted by ICU staff compared to CVVH. EDD has shorter learning curve for ICU staff.
7. Equipment, supply and labor costs were less when comparing EDD to CVVH. Daily IHD and EDD were comparable in terms of cost.
8. EDD, IHD and CVVH were comparable in terms of patient safety. No incidents were reported.

Conclusion
When comparing EDD to IHD and CVVH, EDD seems to combine advantages of the other therapies. EDD provides an enhanced or comparable product in terms of clearances and patient stability while simplifying the delivery of renal replacement therapy using fewer resources without sacrificing patient safety.
Continuous Veno-Venous Hemofiltration (CVVH) was introduced at the Massachusetts General Hospital (MGH) in 1992. At that time program implementation was based on the philosophy that the nurse at the bedside manages the patient and as such should be responsible for the management of the CVVH system. Further, it was decided that in order to promote ownership of the therapy the Critical Care Staff Nurse should manage all technical aspects of the system as well.

The program has evolved from a unit-based therapy done on a limited basis with an informal educational effort to a centralized program. Part of the evolution was due to an increased volume of patients (2 cases in 1992; >100 in 1998) and an increased number of units performing the therapy (2 in 1992; 9 in 1998).

As the program began to develop the question of limiting the number of units performing the therapy to assure continued competence of the nurses was addressed. The decision not to do this was based on the fact that the requirement for CVVH stems from a complication rather than a primary diagnosis. Patients should remain in the units where nurses have the expertise to manage the primary problem. This philosophical position demands an organized, programmatic effort.

Not all the Critical Care Units assumed implementation of the therapy and thus participation in the program at the same time. One of the general surgical ICU’s was the first unit to begin, followed by the Cardiac Surgical ICU and Medical ICU. The specialty units (Burn, Pediatric, Neonatal) also implemented early because of the inability to transfer their patients to another unit. Other units wished to assess their potential volume prior to implementation and chose to transfer patients requiring the therapy during the early years of the program.

Based on projected volume (supported by the numbers of patients actually requiring transfer for therapy) those remaining units have chosen to join the program. There is a commitment by the Nursing Leadership for 1:1 staffing of these patients (which is the institutional standard for patients on CVVH). Additionally, a Nursing Resource (usually a Clinical Nurse Specialist) must be identified who will be responsible for introductory and continuing education (both theoretical and technical), participating as a member of the Central Resource Group and assuring clinical implementation and management of these complex patients.

The CVVH Program at MGH has four (4) main components (Professional, Technical, Educational and Quality Improvement) for which the Central Resource Group is responsible: identifying programmatic and educational standards, assessing and modifying the technical aspects of the system, writing and revising the Policies, Procedures, Standing Orders and methods of Documentation.
The standard for Education is as follows: Each nurse attends an 8 hour work-shop to learn concepts and participate in technical practice. This is followed by a precepted experience with a patient where competencies are demonstrated. There is also a written evaluation of knowledge. Each unit has a resource manual for self-learning experiences. Monthly review sessions are offered to experienced staff nurses who wish to “fine-tune” their skills. There is also expert back-up available to staff 24 hours a day via an on-call system.

Quality Improvement involves, first documentation of calls received by the on-call team with subsequent review if calls indicate a systems issue (equipment problems are immediately addressed). Additionally, staff nurses are asked to document their Clinical Contact time with the system. The goal is two-fold: first to identify the essential components and time involved in demonstrating competence and secondly to identify common educational issues. Though somewhat subjective the data indicates that in a relatively high volume unit (defined as a CVVH patient > once per week) staff are competent to initiate, maintain and discontinue the system after an 8 hour preceptorship. With frequent, subsequent experiences, the staff nurse gains competence with troubleshooting. By contrast, in a low volume unit (defined as a CVVH patient < once per month), staff may gain competence with initiating, maintaining and discontinuing the system with each patient experience. However, in these low volume areas there is considerable “re-orienting” with each experience; troubleshooting requires the presence of an expert resource.
99/054: CYTOKINE REMOVAL BY HEMOFILTRATION

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Cytokines possess proinflammatory properties. At appropriate concentrations they activate cells involved in the inflammatory process. Too high a concentration of mediators may be dangerous or even lethal.

Useful removal of mediators out of the plasma is dependent on two factors:
1. The elimination must be so effective that biologically significant amounts are removed.
2. The removal of mediators must have a beneficial effect on the course of the disease.

Effective elimination is strongly dependent on answers to the following questions:
1. Is the appearance of mediators in plasma of pathological significance?
2. What is the molecular weight of the mediators?
3. Are the mediators bound to other proteins, for example soluble receptors?
4. What is the distribution volume of the mediators?
5. What is the biological half-life of the mediators?
6. Will new mediators form and if so how long will it take?

From the standpoint of molecular weight most of the cytokines should have a sieving coefficient of 1. Theoretically, a large amount of cytokines should be removed, and this is confirmed by measurements in the hemofiltrate. But measurement in plasma shows no or only a slight initial reduction of cytokines. The reason for this discrepancy and its clinical significance will be discussed.