2000 Abstracts Table of Contents

Patient Characteristics

00/001 Cellular Activation During Hemofiltration and Prostacyclin Infusion

00/002 Four Years of CRRT in ICU: Outcome Prediction and Prognostic Indexes in Patients with SIRS and/or MODS
G. Splendiani*, D. Zazzaro, P. Dipietrantonio, A. Pisani, L. Delfino*

00/003 Using Risk Stratification Models to Compare Continuous and Intermittent Therapy in Severe ARF
C. Martin, R. Saran, S. Leavey, R. Swartz

00/004 Continuous Renal Replacement Therapy (CRRT) —An Experience from an Indian Hospital
S. Jasuja, A. Mishra

00/005 Intensive Care for Septic Haematological Patients with Acute Renal Failure
N.K. Schoenemann, O. Viborg, M.B. Moeller

00/006 APACHE III may be Better than APACHE II for Predicting Mortality in ICU Patients with Acute Renal Failure
R. Michael Hofmann, R. Mak, B.N. Becker

00/007 Results of Continuous Renal Replacement Therapy in 4 Years-Single Center Experience
F. Rainoldi, C. Gasparini
Emerging Concepts in ARF and CRRT

00/008 The Usefulness of Serum Ferritin Estimations in Continuous Ambulatory Peritoneal Dialysis Patients  
A.E. Grzegorzewska, I. Mariak

00/009 A Retrospective Study Analyzing the Efficacy of Continuous Veno-Venous Hemodialfiltration in the Treatment of Chronic Renal Failure  
C. Barbour, G. Juta, T. Rogovein, S. Karanicolas

00/010 Liver Dialysis in Treatment of Hepatic Failure and Hepatorenal Failure: Summary of Randomized, Prospectively Controlled Clinical Trials  
S.R. Ash1,2,3, T.Kuczek4, D.E.Foster5, D.E.Blake2, C.H. Gingrich2

00/011 Cocaine-Induced Thrombotic Thrombocitopenic Purpura (TTP) Treated Successfully with Plasmapheresis  

00/012 Novel Therapeutic Uses of Continuous Renal Replacement Therapy in Critically Ill Patients  
A. Tolwani, R.C. Campbell, B. Schenk, M. Allon, D.G. Warnock

00/013 Implementation of CRRT in the ICU: A Succesfull Education Program  
L. Damgaard, C.D. Rossau, and N.K. Schonemann

00/014 Continuous Veno-Venous Haemodialysis (CVVHD) for Methanol Intoxication —A Case Report  
A.A. Walele, S.W. Tobe, M. Miletin, A. Manual, and D. Naimark

00/015 Bloodless CRRT II: Recirculation PD with the Fresenius 2008H  
R. Amerling, S. Sikand, R. Inciong-Reyes
00/016 Childhood Diethylene Glycol Poisoning Treated with Alcohol Dehydrogenase Inhibitor Fomepizole and Hemodialysis

00/017 Current Canadian Approaches to Dialysis for Acute Renal Failure in the ICU
A.R. Hyman, and D.C. Mendelssohn

00/018 Hemodynamic Response of Critically Ill Patients on Norepinephrine Once Continuous Venovenous Hemodialysis is Initiated: A Retrospective Case Series
S. Jolly, G. Yatzkan, and A. Quartin

00/019 Improvement of Hepatorenal Syndrome with Extracorporeal Albumin Dialysis Mars: Results of a Prospective, Controlled Clinical Trial

00/020 Continuous Renal Replacement Therapy (CRRT) with Albumin Dialysis Using the Mars-System in Patients with Jaundice Due to Liver Failure

00/021 Continuous Extracorporeal Liver Assist for Fulminant Hepatic Failure Patients
J. Cavitt1, C. Conlin1, P. Maguire1, J.M. Millis1, R. Johnson1, J. Brotherton1, D. Triglia1

00/022 High Cut Off Membrane Haemofiltration in Septic Patients with Multiorgan Failure. A Preliminary Report
S. Morgera1, W. Buder1, C. Lehmann1, S. Ziemer1, M. Haase1, J. Rocktaschel1, W. Beck4, R. Buck4, H. Gohl4, W. J. Kox2, H.-H. Neumayer1
Technique Characteristics

00/023 Initial Results of a Comparison Study between Anticoagulant Citrate Dextrose Solution and Sodium Heparin as the Anticoagulant Utilized During Continuous Veno-Venous Hemofiltration
C. Barbour, T. Rogovein, S. Karanicolas

00/024 Simple, Safe, Single-Lumen System for Long Duration Dialysis
S.R. Ash1,2, D.J. Carr, K.D. Harker, R.B. Truitt, A.C. Korkor

00/025 Effect of a New Treatment System Using Albumin Dialysate for Multiple Organ Failure (MOF)

00/026 Successful Use of an Anticoagulation Regimen Based on a Citrate Replacement Fluid Solution in Continuous Veno-Venous Hemofiltration
M. Dorval1, R. Levesque2, M. Leblanc2, D. Geadah2, F. Madore1

00/027 Continuous Renal Replacement Therapy Using 2% Trisodium Citrate Regional Anticoagulation: A Retrospective Study
A. Tolwani, R.C. Campbell, B. Schenk, M. Allon, D.G. Warnock

00/028 An Interim Evaluation of a Regional Citrate Anticoagulation (RCA) Protocol for Continuous Renal Replacement Therapy
A.A. Walele, D. Naimark, J. Sasal, P. Aujla, M. Beardsall, and S.W. Tobe

00/029 Regional Sodium Citrate Anticoagulation in Continuous Veno-Venous Hemofiltration
Th. Kuenstle, S. Maulhardt, K.F. Rothe

00/030 Antibiotic Dosing in Slow Continuous Dialysis (SCD)
R. Amerling, G. Alexander, L. DeSimone, C. Schlaeper
00/031 Gentamicin and Vancomycin Dosing in a Pediatric Intensive Care Unit Population Receiving Renal Replacement Therapy
P.D. Brophy, K.D. McBryde, T.A. Mottes, and T.E. Bunchman

00/032 Specific Removal of Large Amounts of Endotoxin from Dialyzate by Dialguard™
L. Chicorka, J. Paluh, K. Reszegi, P. Grandics, E. Hegyi

00/033 Characteristics of Intraoperative Continuous Venous Venous Hemofiltration in the Pediatric Intensive Care Unit Population
P.D. Brophy, K.D. McBryde, T.A. Mottes, B.J. Adams, and T.E. Bunchman

00/034 Techniques to Avoid Hypotensive Dialyzer Reactions in the Pediatric Population Requiring Blood Priming for Continuous Veno-Venous Hemofiltration
P.D. Brophy, T.L. Kudelka, T.A. Mottes, and T.E. Bunchman

00/035 Early Experience with the Safety and Effectiveness of the Cobe PRISMA for Pediatric CRRT

00/036 Treatment of Hirudin Overdose with Hemofiltration
K.-G. Fischer, S.M. Weiner, K. Benz, M. Nauck, J. Bohler

00/037 Bacterial Contamination of the Dialysate Circuit in CRRT
N.S. Kanagasundaram, M. Showers, B. Larive, E.P. Paganini

00/038 Surface Treated Catheters with Ion Beam-Based Process for Blood Access in Hemodialysis
R. Bambauer, P. Mestres, R. Schiel, S. Bambauer, P. Sioshansi
Targeted Intervention with CRRT

00/039 Continuous Renal Replacement Therapy Outcomes Study: Quality Assurance in the ICU
P. Hynes-Gay, S. Mehta, S. Lapinsky, M. Leo, A. Sarjoo-Devries

00/040 Nine Equivalents of Nursing Manpower Use Score in Intensive Care Unit in Patients Treated with Continuous Renal Replacement Therapy (GAMBRO PRISMA)
O. Viborg, H. Ibsen, and N.K. Schoenemann

00/041 The Effect of Continuous Renal Replacement Therapy on Rhabdomyolysis Induced Acute Renal Failure

00/042 Continuous Veno-Venous Hemofiltration in the Burn Intensive Care Unit
M.-L. Bilodeau, J.L. Niles, R.G. Tompkins, and J.T. Schulz

00/043 Maintaining a Standardized Continuous Renal Replacement Therapy Program in Multiple Critical Care Units: The CRRT/CVVH Newsletter
K. Laliberte-Murphy, C. Griffith, J. Niles, J. Nardini

00/044 Observational Comparison of Intermittent Hemodialysis and Continuous Venovenous Hemodialysis in Acute Renal Failure in the Intensive Care Unit
A.F. Charest¹, S. Tobe¹, L. Garred², M. Leblanc³, D. Mazer¹, J. Granton¹, A.M. Jones¹, D.C. Mendelssohn⁴

00/045 Conversion from Adapted Systems to the Cobe PRISMA System in Pediatric CRRT: Impact of Bedside Nursing Education and Overtime Costs

00/046 Maintenance of Circuit Patency is Possible After Temporarily Suspending Continuous Veno-Venous Hemodialysis
A.M. Jones, S. MacLeod, M. Smillie, A.F. Charest, and D.C. Mendelssohn
00/047 Treatment of Severe Acute Renal Failure with Continuous Renal Replacement Therapy Versus Intermittent Hemodialysis
J. Daxi, X. Honglang, X. Bin, L. Yun, L. Leishi

00/048 Creative Educational Program as a Way of Enriching Self-Progress
Z. Gavish, G. Myster, E. Zur, S. Lap

00/049 Writing a Policy for the Hemodialysis Unit to Ensure Comprehensive Performance and Minimize Incidents of Conflict Between the Treating Staff and the Patients
E. Zu, Y. Brandiner, S. Lap, G. Meister, K. Ravid, Z. Gavish

00/050 What is the Preferred Nursing Method in the Dialysis Unit
D. Brik, K. Fraizond, Z. Gavish
00/001 Cellular Activation During Hemofiltration and Prostacyclin Infusion

M. Felfernig, A. Michalek-Sauburer*, B. Gustorff, M. Zimpfer*, S. Kozek

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Cellular activation of platelets and leukocytes occurs during extracorporeal circulation and has been incriminated to play a role in the pathophysiology of sepsis and multiple organ failure. Prostacyclin (PGI2) is a potent endogenous inhibitor of platelet and leukocyte activation. The goal of this study was to evaluate the effect of PGI2 on cellular activation during continuous venovenous hemofiltration.

After IRB approval, 16 patients with acute renal failure were studied during the first 48 hours of continuous venovenous hemofiltration using polysulfone filters (AV 400S, Fresenius, Germany) and heparin anticoagulation (6 IU/kg/h). Patients were randomly assigned to receive a continuous infusion of either PGI2 (5 ng/kg/min; n = 8) or saline (n = 8) administered into the extracorporeal circuit. Citrated whole blood was obtained from systemic and extracorporeal circulation. Platelet reactivity in response to thrombin receptor activator peptide was assessed by flow cytometry (FACS Calibur, Becton Dickinson, USA) using fluorescent monoclonal antibodies PAC-1 and CD62P. Leukocyte activation was assessed using CD11b and CD45. Statistics: ANOVA for repeated measures.

Cellular activation increased during 48 hours of continuous venovenous hemofiltration in the control group. PGI2 attenuated platelet activation in the extracorporeal circuit without impairing platelet reactivity in systemic blood. PGI2 had no significant effect on the marker of leukocyte activation studied. These results confirm that cellular activation occurs in vivo during the contact of blood with polysulfone haemofilters. PGI2 attenuated platelet activation but had no protective effect on leukocyte activation during continuous venovenous hemofiltration.

PGI2 at 5 ng/kg/min is not completely effective for inhibition of cellular activation during continuous venovenous hemofiltration.
00/002 Four Years of CRRT in ICU: Outcome Prediction and Prognostic Indexes in Patients with SIRS and/or MODS

G. Splendiani, D. Zazzaro, P. Dipietrantonio, A. Pisani, L. Delfino

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The aim of the present research was to evaluate the outcome of CRRT (Continuous Renal Replacement Therapy) in patients affected by MODS (Multi Organ Dysfunction Syndrome) with SIRS (Systemic Inflammatory Response Syndrome) versus patients without SIRS (NonSIRS). We also evaluated the outcome referred to specific organ failure AND APACHE II and APACHE III prognostic indexes. We studied 98 patients affected by MODS in Intensive Care Unit (ICU) during a period of 47 months from 01/96 to 11/99. All patients presented acute renal failure requiring dialysis, associated with other organ failures. Sixty-eight (69%) with a diagnosis of SIRS (SIRS, MODS C SIRS, MODS C SEPSIS) and thirty (3.1%) of NonSIRS (MODS). We registered the APACHE II and APACHE III scores: the values for the APACHE II and III and SIRS were calculated from data obtained at admission in ICU. We compared the results of the two groups (SIRS and NSIRS). In the NSIRS group the mortality rate was 40% (12/30 pts), in the SIRS group the mortality rate was 69% (47/68 pts). Mean APACHE II: NSIRS recovery 18.7; NSIRS death 28; SIRS recovery 24; SIRS death 25.3. Mean APACHE III: NSIRS recovery 75.4; NSIRS death 84.3; SIRS recovery 73.3; SIRS death 86.7.

The APACHE scores have not been used for decision-making, but mainly for stratifying the organ failures and for studying the value of different organ failures. The prognosis was significantly better in the NSIRS group than in the SIRS group. Among the prognostic indexes the APACHE II was more predictive of outcomes than APACHE III.
00/003 Using Risk Stratification Models to Compare Continuous and Intermittent Therapy in Severe ARF

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Acute renal failure (ARF) requiring renal replacement therapy (RRF) is generally associated with mortality at or above 50%. Continuous renal replacement therapy (CRRT) has theoretical advantages over intermittent hemodialysis (IHD) which include cardiorespiratory stability, metabolic control and fluid balance allowing adequate nutrition. However, retrospective studies fail to demonstrate these advantages, largely the result of co-morbidities and severity of illness inherent in the triage of patients to CRRT (Swartz et al, AJKD, 1999).

In order to further identify key predictors of outcome, published models of risk stratification were applied to the 359 patients at University of Michigan (UM) who required RRT for ARF during 1995 and 1996. Comparative analysis using logistic regression (Statview, SAS Inst Inc, 1998) evaluated the Cleveland Clinic Foundation (CCF) scores (Paganini et al, Clin Nephrol, 1996), the Lohr clinical index (Lohr et al, AJKD, 1988) and the APACHE II scores (Knaus et al, Crit Care Med, 1985) in our patient population.

Table 1 shows that the CCF score predicted mortality among all UM patients, with stratified outcome similar to CCF patients having equivalent risk scores. Initial CRRT was associated with higher mortality than initial IHD at all risk levels among UM cases, and with excess mortality comparing CCF to UM cases at the lower risk levels. It appears that the clinical decision to use CRRT implies an inherently higher mortality risk.

Table 2 shows that the Lohr index (number of dysfunctional organ systems) also predicted mortality in UM patients and confirmed the higher overall mortality for initial CRRT. However, as with the analysis using CCF scores, CRRT patients again had excess mortality at lower risk levels.

Table 3 shows that APACHE II scores assessed at the time of initial RRT treatment in UM patients did not predict mortality at any risk level, confirming the results of Paganini et al. However, UM patients initially receiving CRRT had a significantly higher mortality than IHD patients at all risk levels, suggesting the predictive importance of triage to CRRT over and above that ordinarily included in the APACHE II assessment. (NOTE: The original APACHE II analysis did not focus on patients with ARF, so that the overall mortality listed for “Knaus” in Table 3 is expectedly lower overall.)

In conclusion, risk stratification analysis using published and recognized models confirms the excess mortality associated with the need to triage patients to CRRT. More important, there appears to be an additional, and as yet unspecified, severity of illness that is not identified by the commonly established risk paradigms and which is most noticeable at the lower levels of risk in those models. Therefore, it will be important to address these factors, intrinsic to the RRT triage decision and predictive of mortality, in any future studies evaluating risk, outcome and RRT modality ARF, whether such investigation encompasses a prospective-controlled treatment trial or a prospective observational study.
### Table 1: CCF Risk Model — % Mortality ($p < 0.0001$)

<table>
<thead>
<tr>
<th>Risk Score</th>
<th>CCF</th>
<th>UM-All</th>
<th>UM-IHD</th>
<th>UM-CRRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–4</td>
<td>24%</td>
<td>19%</td>
<td>13%</td>
<td>60%</td>
</tr>
<tr>
<td>5–7</td>
<td>49%</td>
<td>41%</td>
<td>32%</td>
<td>55%</td>
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<td>8–14</td>
<td>75%</td>
<td>70%</td>
<td>58%</td>
<td>79%</td>
</tr>
<tr>
<td>15–20</td>
<td>89%</td>
<td>83%</td>
<td>77%</td>
<td>90%</td>
</tr>
<tr>
<td>All</td>
<td>68%</td>
<td>61%</td>
<td>46%</td>
<td>74%</td>
</tr>
</tbody>
</table>

### Table 2: Lohr Clinical Index — % Mortality ($p < 0.0001$)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Lohr</th>
<th>UM-All</th>
<th>UM-IHD</th>
<th>UM-CRRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–1</td>
<td>48%</td>
<td>40%</td>
<td>36%</td>
<td>54%</td>
</tr>
<tr>
<td>2</td>
<td>70%</td>
<td>64%</td>
<td>52%</td>
<td>93%</td>
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<tr>
<td>3</td>
<td>81%</td>
<td>78%</td>
<td>69%</td>
<td>83%</td>
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<td>4–5</td>
<td>97%</td>
<td>81%</td>
<td>83%</td>
<td>85%</td>
</tr>
<tr>
<td>All</td>
<td>75%</td>
<td>62%</td>
<td>50%</td>
<td>81%</td>
</tr>
</tbody>
</table>

### Table 3: APACHE II Scores — % Mortality (NS, $p = 0.274$)

<table>
<thead>
<tr>
<th>Risk Score</th>
<th>Knaus</th>
<th>UM-All</th>
<th>UM-IHD</th>
<th>UM-CRRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–15</td>
<td>5%</td>
<td>64%</td>
<td>48%</td>
<td>74%</td>
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<td>16–20</td>
<td>16%</td>
<td>48%</td>
<td>40%</td>
<td>62%</td>
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<td>21–25</td>
<td>36%</td>
<td>59%</td>
<td>41%</td>
<td>76%</td>
</tr>
<tr>
<td>26–30</td>
<td>48%</td>
<td>68%</td>
<td>56%</td>
<td>78%</td>
</tr>
<tr>
<td>&gt; 30</td>
<td>77%</td>
<td>67%</td>
<td>46%</td>
<td>86%</td>
</tr>
<tr>
<td>All</td>
<td>17%</td>
<td>59%</td>
<td>45%</td>
<td>74%</td>
</tr>
</tbody>
</table>
00/004 Continuous Renal Replacement Therapy (CRRT) —An Experience from an Indian Hospital

S. Jasuja, A. Mishra
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Continuous renal replacement therapy is well-established modality in management of critically sick patients in ICU settings. Majority of literature available is from developed countries, however any literature of Indian experience is not available till date.

Aims: To share our center experience of continuous renal replacement therapy, in 32 critically sick patients requiring renal support.

Methods: Retrospective analysis of 32 critically sick patients admitted at Apollo hospital New Delhi requiring continuous renal replacement therapy because of hemodynamically unstable state and conventional hemodialysis was not possible.

Patients: Thirty-two patients, 10 (31.25%) were females, 22 (68.25) were male patients. Mean age of our patients was 43.4 years, ranged between 17 and 78 years. Primary cause among these patients for multiorgan failure included postoperative sepsis including by pass surgery and liver transplant patients 12 (37.5%); complicated infective disorders 9 (28.12%); ischaemic cardiac dysfunction 4 (12.5%); fulminant hepatic failure 3 (9.3%); 64 acute pancreatitis 3 (9.3%); electrical burns 1 (3.1%) and 1 (3.1%) of dermatomyositis.

Procedure: Various modalities of CRRT performed on these patients included SCUF (slow continuous ultra filtration) in 4 (12.5%); CAVH/CVVH (slow hemofiltration) in 8 (25%); CAVHD/CVVHD in 16 (50%) and CAVHDF/CVVHDF was performed in 4 (12.5%) patients. Heparin was used as sole anticoagulant in 8 (25%) patients; In twenty two (68.75%) patients heparin was neutralized with protamine; Remaining 4 (12.5%) heparin free procedure with periodic saline ush were performed. Mean APACHE 2 score was 27 (range 17–31), patients who survived had APACHE 2 of 21 mean against mean of 28 in patients who died despite best of efforts.

Results: Nine patients (28.12%) out of 32 could survive, severity of underlying disease disorder was critical factor in patient survival. Technique survival was 100%; Mean duration of single filter satisfactory life was 76 hours (range between 6–112 hours). Mean urea clearance was 19.3 ml per minute, highest urea clearance of 36.76 ml per minute was achieved with CVVHDF procedure. In our study no correlation was observed between dose delivery and patient outcome.
00/005 Intensive Care for Septic Haematological Patients with Acute Renal Failure

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Department of Anesthesiology and Intensive Care, Aarhus Amtssygehus, Aarhus University Hospital, Aarhus, Denmark

Complication with acute renal failure in patients with medical complications of haematological malignancies has mortality rates between 60–90%. In many centers this complication is regarded as fatal, and renal replacement therapy is not routinely offered. It is our impression that there is a general reluctance concerning intensive care unit (ICU) treatment to patients with haematological malignancies. This attitude is probably based on papers published during the last two decades, reporting these high mortality rates. Special focus has been addressed the combination of mechanical ventilation and dialysis. The documented poor outcome of these patients, should be seen in relation to the high cost of treatment in the ICU, if these patients are admitted. During the last couple of years the prognosis of certain haematological disease has improved, and this can make the application of more aggressive ICU-treatment relevant.

In the last couple of years we have applied a more aggressive strategy towards haematological patients with severe sepsis and multiorgan failure. Continuous renal replacement therapy (CRRT) has for the last two years become a routine procedure to this category of patients, if acute renal failure developed.

From January to November 1999, eight haematological patients (4 women and 4 men) with severe sepsis were admitted and treated with CRRT. Retrospective evaluation of these patients is presented. Their mean (±SD) age was 53 ±17 years. Seven out of eight had sepsis related to chemotherapy and five out of eight had extreme neutropenia, six patients had severe thrombocytopenia. The average ICU-stay was 19 ±23 days, and 7:5 ±7 days of CRRT were performed in average. The mean APACHE II score on arrival to the ICU was 36 ± 5.0, range 27–42. Six out of eight patients required mechanical ventilation and all of the patients were on vasopressors/inotropes. The main reasons for treatment with CRRT were azotemia (8/8) and metabolic acidosis (7/8). Urea and creatinine serum concentrations at CRRT initiation were 29.0 ±5.6 mmol/l and 434 ±145 μmol/l. In all cases continuous veno-venous haemodiafiltration (CVVHDF) was applied with the PRISMA system, Multi ow 100 filters, with predilution and Hemafiltrasol 22 or Hemasol B0 (Hospal-Gambro). In seven out of eight patients the dialysis was performed without anticoagulation. Filters were changed routinely every 24 hours. The mortality rate was 50 percent, and all of the survivors had APACHE scores above 33. None of the survivors needed dialysis after discharge from ICU.

In our opinion this justifies aggressive intensive care treatment for selected cases of patients with life threatening complications of haematological malignancy, even with combined respiratory and renal failure. But further investigations are needed to answer the question:

Does CRRT influence the outcome of ICU-treatment to haematological patients?
00/006 APACHE III may be Better than APACHE II for Predicting Mortality in ICU Patients with Acute Renal Failure

R. Michael Hofmann, R. Mak, B.N. Becker

Background: Predicting outcomes in critically ill patients continues to be a topic of interest with significant social and financial implications. APACHE II scoring is one tool that has been used to grade severity of illness to try to predict morbidity and mortality in critically ill patients. Unfortunately, this grading system has proven inaccurate in the setting of acute renal failure (ARF). Currently, there is no accepted standard severity-of-illness scoring tool that incorporates outcomes determinations for patients with ARF, despite the fact that urine output may actually correlate with outcome in ARF. The APACHE III scoring system differs from APACHE II by including urine output and variable weighting of physiologic parameters depending on the presenting illness. APACHE III scoring is more accurate in predicting mortality in non-ARF patients but there is little data examining APACHE III vs. APACHE II scoring in ARF patients.

Methods: Fifteen consecutive patients admitted to the ICU at a single institution were examined. Each patient developed ARF requiring dialysis. APACHE II and APACHE III scores were calculated according to the APACHE scoring system. Scores were calculated on the day prior to initiating dialysis or day of ICU admission (if requiring immediate dialysis) and on days 2, 4, and 6 after starting dialysis. Additional data collection included: age, gender, comorbid illness, diagnosis, length of hospital and ICU stay (LOS-hospital and LOS-ICU), survival to discharge from the ICU and home, dialysis days and dialysis-dependence at the end of hospitalization were all evaluated. Student’s t-test was used to compare average APACHE II and III scores on the days indicated. A Cox proportional hazards model was used to assess the impact of APACHE II and APACHE III on LOS-hospital and LOS-ICU.

Results: 12 men and 3 women were included in the analysis with a mean age of 51.8 years (range 17–74). 5 patients had died, 6 were alive and discharged from the hospital and 4 remained hospitalized at the conclusion of the study period. 5 patients remained dialysis-dependent at the conclusion of the study period. Average APACHE II scores for survivors were: day 0: 23.7; day 2: 17.6; day 4: 13.0; day 6: 11.6. For non-survivors, average APACHE II scores were: day 0: 25.8; day 2: 20.0; day 4: 12.5; day 6: 20.6 (N.S. vs. survivors). Average APACHE III scores for survivors were: day 0: 104.7; day 2: 88.8; day 4: 72.2; day 6: 60.8. Comparatively, average APACHE III scores for non-survivors were: day 0: 119.0; day 2: 120.4; day 4: 47.5; day 6: 106.5 (overall N.S. vs. survivors APACHE III; p D 0:058 day 6 vs. survivor APACHE III day 6). Interestingly, APACHE III scores did not correlate significantly with LOS-hospital, LOS-ICU per the Cox proportional hazards model, or with return of renal function.

Conclusions: Despite the small sample size noted here, APACHE III scoring was associated with a strong trend in differentiating survivors from non-survivors among ICU patients with ARF. Notably, APACHE III scoring was not predictive for other important outcome events in this small study. In focusing on survival, it may be appropriate to utilize APACHE III as a predictive scoring system for ICU patients with ARF in trying to determine mortality as this scoring system is already standardized. However, APACHE III may not be an accurate tool for assessing other surrogate outcome measures in ARF ICU patients.
00/007 Results of Continuous Renal Replacement Therapy in 4 Years-Single Center Experience

F. Rainoldi, C. Gasparini
Renal SRL Buenos Aires, Argentina

Between 1995 and 1999 29 patients were subjected to CRRT, 18 CVVHF, 5 CVVHDF, 6 CVVVHF C HD; 15 M and 14 F, age C. They were evaluated according to the following parameters: APACHE score, respiratory support, vasoactive drugs, number of failing organs, KT/V urea, C urea, hemofiltration duration (hs) and all these parameters were compared by student-T test between two groups: decreased (D) and improved (I) patients

Conclusion: No significant difference was found between two groups evaluated.

<table>
<thead>
<tr>
<th>N'p</th>
<th>EDAD</th>
<th>APACHE</th>
<th>KT/V urea</th>
<th>C urea</th>
<th>CCRT</th>
<th>Failing organs &gt; 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>24</td>
<td>59.9 + 19</td>
<td>22.4 + 3</td>
<td>0.4 + 0.2</td>
<td>20.4 + 6</td>
<td>57 + 56</td>
</tr>
<tr>
<td>I</td>
<td>5</td>
<td>55.0 + 18</td>
<td>19.7 + 5</td>
<td>0.3 + 0.2</td>
<td>14.6 + 2</td>
<td>27 + 11</td>
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</table>
00/008 The Usefulness of Serum Ferritin Estimations in Continuous Ambulatory Peritoneal Dialysis Patients

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Serum ferritin concentration is an indicator of both iron status and acute phase reaction. In continuous ambulatory peritoneal dialysis (CAPD) patients it is also concerned as a predictor of CAPD outcome. The aim of our studies is to show in which aspect of physiopathology serum ferritin level is specially involved and when its estimation has the highest value.

In 50 patients treated with CAPD through 16:9 ± 12:1 months (range 0.7 –45.2 months) serum ferritin level was estimated every 3 months (12 study periods) and related to other serum indicators of iron status (Fe, TIBC, TSAT, transferrin), peripheral blood morphology (RBC, Hb, Hct, WBC, PLT, MCV, MCH, MCHC) and serum CRP level.

Through the entire CAPD course except the last study period median levels of ferritin were over 300ng/ml. Significant correlation (p < 0.05, n = 50) was found between serum ferritin level and transferrin (r = -0.462), RBC (r = -0.441), Hb (r = -0.412), Hct (r = -0.483) and CRP (r = +0.389).

Our studies indicate that in CAPD patients a high serum ferritin level is reliable indicator of both inflammatory status (positive correlation with CRP) and protein malnutrition (negative correlation with transferrin, RBC, Hb and Hct), but it does not confirm adequacy of other serum iron parameters.
00/009 A Retrospective Study Analyzing the Efficacy of Continuous Veno-Venous Hemodialfiltration in the Treatment of Chronic Renal Failure

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Background: During the past 2 years our facility experienced a severe shortage of available Hemodialysis stations. This situation was compounded by an increase in the number of patients who were experiencing failure with their Peritoneal Dialysis treatments. Hemodialysis was available to these patients only if they were able to travel a great distance, and for some patients this was not an option. In September 1997 the decision was made to temporarily provide Continuous Veno-venous Hemodialfiltration (CVVHDF), utilizing the Hospal Gambro PRISMA, to these patients until a Hemodialysis station became available.

Purpose: From September 1997 until May 1999 our facility provided CVVHDF to those patients who required, but were unable to access, chronic intermittent Hemodialysis. This therapy was carried out in the Intensive Care Unit. This study has analyzed the efficacy of this practice.

Method: Patients were admitted twice weekly to the Intensive Care Unit for a 24-hour treatment. A nurse/patient ratio of 1:2 was determined appropriate. CVVHDF was utilized for all patients. Blood flow rates ranged from 125–150 milliliters (ml.) per minute. Dialysate and Replacement fluid rates were 1000 ml. per hour. Hospal Gambro’s HEMOSOL solution was the primary dialysate and replacement fluid. Fluid removal was individualized for each patient. During initial treatments standard blood work, including a full biochemical and coagulation profile, was obtained. Heparin was the primary anticoagulant for these patients, however 17 patients did utilize Anticoagulant Citrate Dextrose Solution (ACD-A) at sometime during their treatments. Vital signs and weight were obtained prior to onset of treatment and were monitored throughout the 24-hour period.

Findings: Fifty-four patients utilized this therapy. A total of 725 treatments (18,980 hours) were completed. The number of treatments ranged from one up to fifty treatments, with a Median of 8.0 (12.58 Standard Deviation). Pre-dialysis electrolytes were within normal limits with only a rise in blood urea nitrogen and creatinine noted. We found that patients treated with CVVHDF did not have the expected rise in Potassium prior to each treatment. A Urea Reduction Ratio (URR) was obtained during initial treatments. The Median URR for the 54 patients was 47.0 (S.D. 5.98).

Of the 54 patients who accessed this therapy, 30 eventually went on to Hemodialysis, 5 patients were placed on Peritoneal Dialysis, 6 patients recovered renal function and 13 patients expired due to multiorgan failure. Of the 30 patients who went on to have Hemodialysis, 6 have expired.

The treatment costs, limited only to the dialysis supplies, were approximately $350.00 daily. A patient interview was carried out with those patients who remain on Hemodialysis. All but one patient was pleased with the care and the therapy, but did feel that the 48 hours spent in hospital each week was too long.

Conclusions: CVVHDF can be utilized as a temporizing measure in order to treat those patients with Chronic Renal Failure who are unable to access Hemodialysis. Patients treated with this therapy continue to have a normal biochemical profile during their treatments with only a rise in Urea and Creatinine noted prior to each treatment. The costs associated with this treatment are higher than those associated with Hemodialysis.
00/010 Liver Dialysis in Treatment of Hepatic Failure and Hepatorenal Failure: Summary of Randomized, Prospectively Controlled Clinical Trials

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The Liver Dialysis Unit (LDU) is a currently marketed artificial liver device that employs hemodiabsorption (dialysis of blood against powdered sorbent) to remove numerous small molecular weight toxins. Five prospective and randomized studies of the LDU in treatment of hepatic failure have been completed, enrolling 47 patients with: hepatic failure due to fulminant hepatic failure (FHF, 23) or acute-on-chronic hepatic failure (A-on-C, 24), stage II–IV encephalopathy (usually stage IV), renal insufficiency (not yet on dialysis), and potential for liver recovery or transplant. Another 28 patients were treated in crossover studies (FHF, 9; A-on-C, 19) without concomitant controls. Treatments with the LDU System were for 6 hours daily, 3–5 days, with similar observation periods for control patients. LDU treatment significantly improved neurologic (70%) and physiologic status (72.2%) of all patients versus control groups (27.1%). LDU treatment significantly improved patient outcome (improvement for transplant or recovery of liver function) for patients with A-on-C (57%) versus control patients (36%), though no improvement in outcome was found for FHF patients. In 32 patients with hepatorenal failure on entry to the study, LDU treatment resulted in long-term survival or improvement to transplant in 41%, versus 0% for control patients. Treatment with the LDU, a simple, sorbent-based blood treatment system, improves clinical status and outcome of hepatic failure and hepatorenal failure patients, especially for the frequently encountered patients with A-on-C hepatic failure.
00/011 Cocaine-Induced Thrombotic Thrombocitopenic Purpura (TTP) Treated Successfully with Plasmapheresis

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Purpose of the study: Presentation of one infrequent case of secondary TTP and its resolution with plasmapheresis.

Material and methods: We used filters Plasma o OP-05 W (L) Medical Asahi Co Ltd., Tokyo, Japan, and Pump of blood type Mini Pump, Renal Inc. System, Minneapolis, USA. with exchange of 1 Plasma Volume (PV) (3.5 lt.) by session with fresh-frozen plasma during seven consecutive sessions.

Summary: A 36 year-old woman with antecedents of alcoholism, consumption of cocaine and anti-HCV-positive (RIBA-2), was admitted for deterioration of the sensorium, acute hepatic dysfunction and purpura in legs. She presents gynecologic bleeding. Microangiopathic hemolytic anemia and thrombocitopenia was found in blood smear. Laboratory: BUN: 40 mg/dL. Creatinine: 0.42 mg/dL. LDH: 3.075 U/L. HIV: negative. HCV-RNA was negative by RT-PCR. HCG Beta Sub-unit < 5 IU/L.

Evolution: Rapid deterioration of the sensorium, adding aphasia and moderate left hemiparesia. Normal brain CT scan. In suspicion of TTP, empiric treatment begins with IV methyl-prednisolone 1gr. and fresh-frozen plasma. Plasmapheresis was added 24 hours later with replacement of 1 PV, being carried out 7 serial sessions (see table).

Conclusion: Cocaine-induced TTP is an infrequent entity. Our case has been solved satisfactorily with the precocious use of plasmapheresis, like in other secondary TTP cases.
00/012 Novel Therapeutic Uses of Continuous Renal Replacement Therapy in Critically Ill Patients

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We have found that CRRT can be used to address unique clinical problems. We currently utilize 8 PRISMA CRRT devices, and have standardized regional citrate anticoagulation using 2% Trisodium Citrate (70 mM citrate, 210 mM Sodium) as the prefilt er replacement solution (delivered at 250–330 ml/hr) with systemic Calcium infusion to maintain target post-filter and systemic ionized Calcium levels of 0.4 and 1.1 mM, respectively. The Standardized CRRT Dialysate, delivered at 1000 ml/hr contains Normal Saline, 3 mM KCl and 1.5 mM MgSO4. This approach avoids hypernatremia and citrate toxicity, and reduces delays in pharmacy preparation of the standard solutions (see accompanying abstract).

Severe Metabolic Alkalosis: citrate erroneously given to a patient as prefilt er replacement fluid at 1000 ml/hr resulted in severe metabolic alkalosis (pH 7.5=HCO3 45) within 16 hrs. Conversely, a patient erroneously dialyzed with Standardized CRRT Dialysate without receiving Trisodium Citrate replacement solution developed metabolic acidosis with serum bicarbonate falling to 10 mM and pH to 7.09 within 7 hrs. This approach (citrate-free replacement fluid with Standardized CRRT Dialysate) can therefore be used to treat metabolic alkalosis in anephric patients.

Lactic Acidosis: bicarbonate administration is of limited utility in treating lactic acidosis because of the volumes required and the effects of hypertonic sodium bicarbonate. Acidification of the administered bicarbonate generates CO2 which can cause intracellular acidosis. We have treated severe lactic acidosis in an HIV C patient receiving didanosine with a replacement solution containing 3 ampules of sodium bicarbonate in 1 L D5W administered at 1000 ml/hr, while dialyzing against the Standardized CRRT Dialysate. The initial pH/pCO2 =HCO3 lactate were 7.13/12/6/24. The systemic pH and bicarbonate deficit were corrected in 1 hour and the lactate level was decreased after 7 hours from 24 to 10.7 mM/L. CRRT was discontinued; systemic pH remained above 7.36, lactate stabilized at 14 with no further need for bicarbonate administration. The patient’s hemodynamic status improved with correction of the severe metabolic acidosis.

Hypercalcemia: use of 2% Trisodium Citrate replacement solution at 300 ml/hr with the Standardized CRRT Dialysate rapidly corrected hypercalcemia due to excess CaCO3 in a peritoneal dialysis patient. Systemic Calcium infusion was withheld until the initially elevated ionized Calcium returned to an acceptable range. In conclusion, standard CRRT with variations on the use of Trisodium Citrate regional anticoagulation and a Standardized CRRT Dialysate which is free of any buffer can be used to treat several unique acid-base and electrolyte disorders in critically ill patients.
00/013 Implementation of CRRT in the ICU: A Successful Education Program
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Introduction: During the past 6–8 years CRRT has become a common used treatment in many Danish ICUs. CRRT is performed at 15 out of a total of 36 Danish ICUs. Previously the treatment of critically ill patients who developed acute renal failure was limited to haemodialysis only taking place at ICUs at some university hospitals.

CRRT provides the advantage of the patients being kept in the same unit and nursed by the same staff at the ICU and by doctors from their specialized units respectively as well as the intensive care consultants. The year before we started CRRT at our unit, 25 patients where transferred to other hospitals to receive dialysis, most of these patients in a critical condition with multiorgan failure. This does not even illustrate the actual number of patients in our ICU who needed dialysis in that period of time. The dangers of transporting a critically ill patient from one hospital to another are avoided when CRRT is offered. It makes adequate treatment faster accessible since one does consider referring the patient to another hospital but can start CRRT the moment it seems appropriate. Finally it is of great value to the staff to follow the patient through the entire treatment.

CRRT was a new treatment to be performed by ICU-doctors as well as ICU-nurses and it demands a high degree of teamwork between the two groups. Both parts did have a specialized intensive care education but no experience with dialysis. The nurses according to the doctor’s prescriptions mainly do the practical work. Our purpose is to describe how we successfully dealt with these problems in our ICU and present a flowsheet to illustrate the education process.

Aarhus Amtssygehus is a part of the University Hospital, Aarhus with 290 bed, 8 of these are in the ICU. The hospital has colorectal surgery, orthopedics surgery including trauma, two general medical wards with subspeciality in endocrinology and cardiology respectively and a hematological department. There is no nephrology department but we received advice from the nephrology department at another Hospital.

Method: We started implementing CRRT in our department by allocating an ICU-nurse and a consultant doctor to make plans for education of staff as well as a protocol containing detailed treatment standards. During the entire process we were in close cooperation with Gambro who delivered the Prisma. A time schedule was made and a starting date was set, 10 nurses were selected to be educated as superusers. Their education was started two months before starting up CRRT at our ICU. Seminars were held, containing one-hour lecture by a nephrologist, two hours by the doctor in charge of the CRRT, two hours by a nurse-educated representative of Gambro and finally one hour by a nurse already working at a department giving CRRT. The superusers also spend one day at an ICU performing CRRT and had the machine available in our department in order to become familiar with it.

CRRT was started up as planned and it was arranged that there was always one superuser in each shift and one more at call from home during a period of 6 months. They were also to educate their colleagues’ bedside, this was supplemented by two hours of theoretical education from the doctor in charge of CRRT. During the entire period there have been regular meetings between the superusers and doctors in charge in order to make adjustments of the protocol.

CRRT was started up as planned and it was arranged that there was always one superuser in each shift and one more at call from home during a period of 6 months. They were also to educate their colleagues’ bedside, this was supplemented by two hours of theoretical education from the doctor in charge of CRRT. During the entire period there have been regular meetings between the superusers and doctors in charge in order to make adjustments of the protocol.

Results: We have accomplished to establish a very dynamic team and currently implement new knowledge such as: Anticoagulation free CRRT. High replacement fluid flow (4 l/h). Recirculation with heparin. All modes of CRRT are being used. It is possible to perform and initiate CRRT at all shifts, and 20 minutes after the decision is taken the treatments can be started (e.g. pulmonary edema). The fluid balance is well understood and calculated by the nurses.
The education programs as well as the time schedule were observed. Implementing CRRT at ICU was an uncomplicated process. One year after the start all 44 nurses were educated in performing CRRT independently following doctors’ prescriptions. In the first year from September 1998 to September 1999 we treated 99 patients with CRRT totaling 458 ICU days, 65% survived to be discharged to stationary ward.

Conclusion: It is important in advance to realize that the nurses are performing the practical tasks around CRRT and accordingly set up a proper protocol and provide sufficient education. It is also of great importance to realize that the protocol is a dynamic tool, which will often be changed in cooperation between doctors and nurses according to clinical experience and new knowledge. Designing the protocol and implementing it will be an individual process to each ICU because of differences in patient categories and other local conditions but the program outlined here provides a good basic structure.
00/014 Continuous Veno-Venous Haemodialysis (CVVHD) for Methanol Intoxication — A Case Report
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Methanol is a small molecular weight substance with a small volume of distribution and is metabolized to toxic compounds causing metabolic acidosis and life-threatening complications. Treatment includes ethanol infusion and haemodialysis (HD), often for many hours until the drug is completely removed.

A case of the use of sequential CVVHD after initial treatment with conventional HD for methanol intoxication is reported. To assess the effectiveness of CVVHD by this method a retrospective study of the elimination of methanol by conventional HD was undertaken for comparison.

A 48 year old male deeply comatose with wide anion gap metabolic acidosis with a wide osmolar gap was found to have a methanol blood level of 109 mmol/l. HD with an Althin 2000 using an F80 dialyzer, blood flow (Qb) 350 ml/min and dialysate flow (Qd) 500 ml/min was initiated. Ethanol infusion was continued to maintain blood levels above 20 mmol/l throughout dialysis. After 8 hours of dialysis methanol levels had dropped to 14 mmol/l and each successive methanol level showed a smaller absolute drop. A decision was undertaken to switch the patient to CVVHD when the blood methanol level was below 15 mmol/l. The CVVHD prescription was Qb 150 ml/min, bicarbonate dialysate flow 2500 ml/hr. The patient passed urine at 120 ml/hr and replacement fluid was given appropriately. The methanol level then decreased from 15.2 mmol/l to 8.4 mmol/l over the next 15 hours on CVVHD. Overall, the osmolar gap decreased on dialysis therapy, correcting for the blood alcohol level. The methanol clearance on CVVHD was 38 ml/min and renal clearance of methanol was 7.5 ml/min, accounting for 83% and 17% of total methanol clearance contributions respectively.

The haemodialysis records of six patients, median age 57 years (range 40–65 years) treated for methanol toxicity were available for review. The patients were treated by conventional haemodialysis, using large surface area dialyzers for a median duration 11 hours (range 9–21 hours). The blood methanol levels are shown for the duration of each conventional HD treatment together with the reported case of methanol elimination by sequential HD and CVVHD for comparison.

Methanol removal after sequential HD and CVVHD was not as effective as the removal of methanol by conventional HD alone in our experience. In our patient the CVVHD technique described was unable to effectively remove methanol from the circulation in a timely manner.
The Elimination of Methanol by sequential HD and CVVHD compared to Conventional HD.
00/015 Bloodless CRRT II: Recirculation PD with the Fresenius 2008H

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Traditional acute PD is of limited usefulness in severely ill patients with acute renal failure (ARF) mainly because of inadequate solute clearance. Maintaining a high transmembrane concentration gradient can maximize transperitoneal solute transfer. Using a constant intraperitoneal volume, continuous recirculation of dialysate, and extracorporeal solute removal, can achieve this with little or no downtime from in and out flow.

We previously reported results of an in vitro study using a Gambro CVVHD device for the extracorporeal system with dialysate ow rates (DFR), and extracorporeal clearances, of 16–32 ml/min. Predicted maximal peritoneal mass transfer coefficients are in the 50–80 ml/min range. Thus, higher extracorporeal clearances will be required to optimize total clearance.

We performed an in vitro study of extracorporeal solute clearance using a 2 liter bag of spent peritoneal dialysate as the “patient,” a dual lumen silicone catheter, and the Fresenius 2008H operating in CRRT mode. Heparin was added to the PD solution to prevent clotting. Fresenius F-40 hemofilter was used. External dialysate was made online with purified tap water and bicarbonate/acid concentrate. The PD recirculation rate was 300 ml/min; the dialysate flow rate was 100 ml/min. Dialysate potassium concentration was 4 mEq/l. Ultrafiltration was used only to obtain samples and was minimal. Electrolytes, BUN, creatinine, were measured in the PD before and after 120 minutes of dialysis. Simultaneous PD and ultrafiltrate samples were taken to assess solute extraction ratios. Results are as follows:

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<th>Time (min)</th>
<th>UN (mg%)</th>
<th>Creat (mg%)</th>
<th>Gluc (mg%)</th>
<th>K (mEq/l)</th>
<th>CO₂ (mEq/l)</th>
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</thead>
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</tr>
<tr>
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<td>3</td>
<td>0.2</td>
<td>259</td>
<td>3.6</td>
<td>25</td>
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The urea extraction ratio was 0.6, giving an approximate urea clearance of 60 ml/min. The urea reduction ratio (URR) after 2 hours was 0.93. The very high urea removal rate is explained by the improved efficiency of dialyzing uid rather than blood. The Fresenius 2008H in CRRT mode will produce extracorporeal solute clearance high enough to allow transperitoneal solute transfer to become the rate-limiting process in total solute clearance in vivo.
00/016 Childhood Diethylene Glycol Poisoning Treated with Alcohol Dehydrogenase Inhibitor Fomepizole and Hemodialysis


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Unlike the more commonly seen ethylene glycol ingestion, little is understood about diethylene glycol (DEG) metabolism or kinetics in humans. This has made the clinical presentation, biochemical correlates, and treatment options confusing. Patients presenting less than 12 hours after DEG ingestion may not demonstrate a metabolic acidosis, while those presenting later may demonstrate florid metabolic acidosis. Kinetic data lends support to these observations.

A 10 kg, 17-month-old female ingested what appeared to be brake fluid noted to contain DEG, tetraethylene glycol ether and pentaethylene glycol ether. After receiving activated charcoal and fomepizole 15 mg/kg (an alcohol dehydrogenase inhibitor) intravenously as a one-time dose, the patient was referred to our center for acute hemodialysis (HD). The patient, who had only a barking cough, arrived at our center 6 hours post-ingestion. Laboratory values showed no evidence of metabolic acidosis or osmolar gap. A urine toxicology screen was negative. After placement of an 8 French Quinton hemodialysis catheter the patient underwent 3 hours of acute HD. A CA-50 dialyzer was utilized with pediatric lines. A standard physiologic dialysis bath composed of 140 mEq/L NaCl, 40 mEq/L NaHCO₃, 3.5 mg/dl Ca, 4.6 mg/dl PO₄, 3.5 mEq KCl, and 1.0 mEq/L MgCl₂ was utilized. The patient’s dialysis flow rate was 500 ml/hr and the blood flow rate was 75 cc/min. Prior to beginning and after finishing hemodialysis DEG levels were obtained and sent for subsequent analysis by gas tomography.

There was 1.7 mg/dl (1.6 mmol/L) of DEG in our patient’s serum prior to HD. No DEG was noted after the initial hemodialysis or in subsequent specimens. The patient was subsequently discharged after the hemodialysis line was removed and has no apparent sequelae.

This is the first time to our knowledge that pre- and post dialysis DEG levels were measured. These levels support DEG clearance with hemodialysis.
00/017 Current Canadian Approaches to Dialysis for Acute Renal Failure in the ICU

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Although major technical advances in renal replacement have occurred, the mortality rate of acute renal failure in the ICU remains high (> 50%). At present, there is no general consensus on the appropriate dialytic technique to treat acute renal failure. Therefore we surveyed, by mail questionnaire all adult academic and community CORR registered Canadian nephrology centres that offer treatment for acute renal failure.

The overall response rate was 58% (52/91), the majority of respondents were from Ontario (46%) and Quebec (29%). Comparing current dialysis methods with those of five years ago, the largest increase was in continuous renal replacement therapies (CRRT) (23% vs. 7%). Both intermittent hemodialysis (IHD) and peritoneal dialysis decreased in utilization. The choice of CRRT method has also shifted towards pumped, veno-venous access with CVVHDF (38%) and CVVHD (24%), as compared with 5 years ago when the most common forms utilized were arterio-venous with CAVHD (24%) and CAVH (22%).

Despite data from chronic dialysis suggesting reduced mortality and morbidity with increasing dialytic dosing (and preliminary data in ARF), there is no formal method of dialysis monitoring for CRRT or IHD in over 75% of centres. The treatment length for IHD is most commonly 3 1/2 to 4 1/2 hours by protocol. At present, polyacrylonitrile (PAN) remains the most common membrane used for CRRT (84%), in contrast to IHD where polysulfone is most common (76%). Although newer methods of anticoagulation have been recently introduced, systemic heparinization still remains the treatment of choice in most dialysis centers employing CRRT.

Overall, the nephrologist and not the intensivist maintains primary responsibility for dialysis prescription and termination decisions. This is not necessarily the case in the management of fluid balance and vascular access. This is best exemplified in CRRT, where 38% of the responsibility for fluid balance is shared, as compared to IHD where the responsibility is shared in only 14% of cases. The procedure of vascular access is dominated by the intensivist for CRRT (38%) as compared with IHD where the nephrologist places most of the vascular access. Whereas the dialysis nurse still maintains primary responsibility for administering IHD, this role is shared more evenly for PD and CRRT.

In conclusion, despite the lack of any definitive evidence of superior outcomes, the utilization of CRRT is increasing in the treatment of acute renal failure in Canada. Given the Canadian experience with successful, collaborative multicentre clinical research projects, it would appear that there may be opportunities to explore whether the observed shifts in modality selection are justified. Furthermore, given the paucity of prospective data on the treatment of acute renal failure, the formation of a larger database will be essential in quantifying the standard for dialysis adequacy.
00/018 Hemodynamic Response of Critically Ill Patients on Norepinephrine Once Continuous Venovenous Hemodialysis is Initiated: A Retrospective Case Series

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Purpose: In the intensive care setting, physicians have observed that acute renal failure patients who are receiving inotropes such as norepinephrine tend to become hypotensive once continuous venovenous hemodialysis (CVVHD) is initiated. This observation is independent of the amount of fluid removed from the patient during CVVHD. Acute hypotension during dialysis has a negative impact on survival and on the renal healing process.1

The investigators wished to retrospectively examine if systemic arterial blood pressure is reduced or if a blood pressure equivalent (an increase in norepinephrine dosing to maintain a desired blood pressure) occurs when CVVHD is started in a critically ill patient receiving norepinephrine. Such a reduction in blood pressure may be a result of serum norepinephrine being removed by dialysis.

Methods: The patient census for the medical and surgical intensive care units at the University of Miami Jackson Memorial Hospital from August to September 1999 was examined retrospectively. From this census, a retrospective review of charts was performed of the patients receiving norepinephrine who were subsequently started on CVVHD. For a period of 24 hours before and after the initiation of CVVHD, patients’ levels of mean arterial blood pressure (MAP), central venous pressure (CVP), and doses of inotropes were recorded and graphed. The effect of initiating CVVHD in patients receiving norepinephrine was determined using this data.

Results: In this census, seven patients were identified who started CVVHD while receiving norepinephrine. Six of the 7 patients (86%) had a reduction in the MAP (range 2–22 mmHg, mean 9.8 mmHg) within 2 hours of initiating CVVHD. All of these patients had a positive fluid balance during the 24 hours before and after CVVHD was initiated. In two of the seven patients, the norepinephrine dose was reduced (by 6 and 10 micrograms) at the same time there was a fall in the MAP. In one patient, the CVP fell (17 mmHg) during the fall in MAP but the patient was still in positive fluid balance. In another patient, dosages of norepinephrine and dopamine were increased (3 and 6 micrograms respectively) during the reduction in MAP. In these patients’ charts, there was no evidence of changes in their medical condition or medications that would account for their drop in MAP when CVVHD was initiated.

Conclusion: This retrospective case series shows that there may be a significant reduction in blood pressure when CVVHD is initiated in patients who are receiving norepinephrine. This hypotension may due to norepinephrine that is cleared by CVVHD. The authors suggest that a formal pharmacokinetic analysis should be done to determine the clearance of norepinephrine by CVVHD. Although there are no published data on the pharmacokinetics and specifically the clearance of norepinephrine during CVVHD, vasoactive substances like norepinephrine are small molecules and are easily cleared diffusively, thereby possibly exacerbating hemodialysis-associated hypotension.2 Identifying the clearance of norepinephrine by dialysis in this clinical setting is important since clinicians can determine if such hypotension is secondary to the removal of norepinephrine by CVVHD or because of other clinical factors. By understanding the dynamics of norepinephrine removal during CVVHD, hypotension secondary to norepinephrine clearance might be avoided, thereby decreasing patient mortality and morbidity.

References
00/019 Improvement of Hepatorenal Syndrome with Extracorporeal Albumin Dialysis Mars: Results of a Prospective, Controlled Clinical Trial


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In hepatorenal syndrome (HRS) renal insufficiency is often progressive and the prognosis is extremely poor under standard medical therapy. The Molecular Adsorbent Recirculating System (MARS) is a modified dialysis method employing an albumin containing dialysate, that is recirculated and on-line perfused through charcoal and anion exchanger columns. MARS enables the selective removal of albumin-bound substances. In former studies a significant improvement of clinical and blood chemical parameters in acute on chronic hepatic failure complicated by multiorgan failure could be observed. The latter include increased survival, decrease in hepatic encephalopathy grade and Child points, increase of mean arterial pressure and reversal of renal failure. A prospective controlled trial was performed to determine the effect of MARS treatment on 30 day-survival in type I HRS patients at high risk (bilirubin ≥ 15 mg/dl) compared to standard treatment including hemodiafiltration (HDF). Thirteen cirrhotic patients with type I HRS were included from 1997 to 1999. All were Child C with 12.4 ± 1.0 Child points, UNOS 2A; total bilirubin was 25.7 ± 14.0 mg/dl, serum creatinine 4.0 ± 1.4 mg/dl, serum sodium 127 ± 8 mmol/l, urine sodium 17.9 ± 7.8 mmol/l, urine volume 53 ± 74 ml/day. Eight patients were treated with the MARS method in addition to hemodiafiltration and standard medical therapy; five patients were in the control group (hemodiafiltration and standard medical treatment alone). None of these patients was liver transplanted or received a transjugular intra-hepatic portosystemic shunt (TIPS) or vasopressin analogs during the observation period. In the MARS group 5.2 ± 3.6 treatments (range 1–10) were done for 6–8 hours/day per patient. A significant decrease of bilirubin and creatinine (p < 0.01) and an increase in serum sodium and prothrombin activity (p < 0.01) was observed in the MARS group. However, no significant changes occurred in the control group. Mortality was 100% in the control group at day 7, and 62.5% in the MARS group at day 7, and 75% at day 30, respectively (p < 0.01). We conclude, that the removal of albumin bound substances with the MARS method can contribute to the treatment of multiorgan failure on the basis of a hepatic failure including subsequent renal failure as in type I HRS.
00/020 Continuous Renal Replacement Therapy (CRRT) with Albumin Dialysis Using the Mars-System in Patients with Jaundice Due to Liver Failure


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Severe intrahepatic cholestasis and high serum levels of bile acids may be followed by acute renal failure (ARF) due to tubular cell damage. A new extracorporeal blood purification method has been developed based on dialysis against a dialysate solution containing ligandin like protein as a Molecular Adsorbent that is on line regenerated by removing albumin bound toxins using a Recycling System (MARS) that contains charcoal and anion exchange adsorption and hemofiltration. Thus, the system combines CRRT with additional support of excretory liver function.

The aim of the present work was to investigate the influence of this blood treatment on blood clearance from bile acids and on clinical outcome of 16 patients suffering from acute on chronic hepatic failure associated with jaundice and renal failure.

The initial bile acid concentration (105 μmol/l ± 45 μmol/l) could be decreased to nearly 50% (49 μmol/l ± 26 μmol/l) within a 6 hour treatment. Calculated from the reduction of serum levels of bile acids the total distribution volume for bile acids was estimated to be ten times of total plasma volume. Clinically, this reduction was accompanied with improvement of kidney function (16 out of 16) and a survival rate of 56% (9 out of 16).

We conclude, that additional support of excretory liver function with the MARS-treatment may be a therapeutic tool for CRRT in renal failure secondary to liver failure.
00/021 Continuous Extracorporeal Liver Assist for Fulminant Hepatic Failure Patients

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Patients with Fulminant Hepatic Failure (FHF) have a narrow margin of opportunity to obtain an acceptable organ for orthotopic liver transplantation (OLT) due to rapid deterioration of their native liver and the critical shortage of donor organs. The Extracorporeal Liver Assist Device (ELAD®) system has been developed to provide metabolic support until an acceptable organ becomes available.

Plasma ultrafiltrate is generated via a blood circuit similar to CVVH at 200 mL/min and pumped into a recirculation circuit at 20 mL/min. The recirculation circuit includes up to 4 hollow fiber cartridges, each housing 100 grams of human immortalized hepatocytes (C3A cell line, patent # 5290684) in the extracapillary space, with an oxygenator and glucose infusion system to maintain the C3A cells. Cartridge function is continuously monitored for pH and glucose and oxygen consumption. The ultrafiltrate is pumped through the circuit at 500 mL/min/cartridge and the treated fluid returns to the patient at 20 mL/min. Treatment continues for a maximum of 10 days or until the patient either receives OLT or meets discontinuation criteria.

In the ongoing Phase I/II clinical trial, three patients have been treated with the ELAD® system and bridged to OLT. No adverse events, mechanical failure, or complement activation in the patient (C3a, C5a), was observed during patient treatment. Metabolic activity of the ELAD® cartridges was monitored for 14 days after each treatment and showed stability in the clearance of galactose and ammonia and production of albumin and transferrin.

The use of ELAD® therapy was not associated with any adverse events. The ELAD® system demonstrated metabolic activity beyond the period of ELAD® therapy.
00/022 High Cut Off Membrane Haemofiltration in Septic Patients with Multiorgan Failure. A Preliminary Report

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Septic multiorgan failure requiring renal replacement therapy is a challenging problem in intensive care medicine. For continuous venovenous haemofiltration (CVVH) biocompatible low cut-off membrane (30 KD) are commonly used. We investigated the impact of a newly developed high cut off membrane (P1-SH, Gambro) on protein clearances, cardiovascular haemodynamics and Interleukin-6 clearance. Twenty patients were included to the study, 14 patients were treated with the high cut-off, 6 patients with the low cut-off membrane (PF 11, Gambro). High cut-off haemofiltration was per-formed for a maximum of 5 days, thereafter therapy was switched to the low cut-off membrane if necessary. Cardiovascular monitor-ing consisted in measuring cardiac output, vascular resistance and free body water. In the high cut-off group mean protein loss at 30 min was 2145 ± 963 mg/l. Protein loss declined rapidly to values between 0.5 to 1 g/l and remained stable thereafter. CVVH led to a cardiovascular stabilization in both groups. We found a significant elimination of circulating IL-6 during high cut-off haemofiltration. Sieving coefficient was 1.16 ± 0.9 at 30min and 0.73 ± 0.3 at 12 hours compared to 0.02 ± 0.06 at 30 min for the control group (p < 0.001).

High cut-off haemofiltration was well tolerated and no severe site effects were observed. Preliminary evaluation indicates a clear superiority of the high cut off membrane in the elimination of circulating cytokines.
00/023 Initial Results of a Comparison Study between Anticoagulant Citrate Dextrose Solution and Sodium Heparin as the Anticoagulant Utilized During Continuous Veno-Venous Hemodialfiltration

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Background: Anticoagulant Citrate Dextrose Solution (ACD-A) has been used for over two years at our facility when patients were not able to receive Sodium Heparin during Continuous Veno-Venous Hemodialfiltration (CVVHDF) utilizing Hospal-Gambro’s PRISMA. We found ACD-A to be an excellent and effective alternative to Heparin. The question was posed however, could ACD-A be the first choice for anticoagulation during CVVHDF.

Purpose: In order to evaluate the efficacy of the two anticoagulants we have initiated a randomized non-blinded prospective study. Fifty patients will eventually be included in this study.

Method: Each patient agreeing to participate in the study is fully informed and consent is obtained. In order to be included in the study, patients must be able to receive either Heparin or ACD-A. Information regarding anticoagulant utilized, filter life, vital signs, biochemical profile and cost associated with each therapy is obtained. Patients who are randomized into the Heparin group will utilize Hospal-Gambro’s Hemosol solution as the replacement and dialysis uid. Patients who are randomized into the ACD-A anticoagulant will utilize a Calcium free dialysis solution, which Baxter has manufactured for our use during this study.

Findings: To date 6 patients have been entered into the study. Three patients were randomized to receive Sodium Heparin and three have received ACD-A. All six patients maintained normal vital signs and biochemical profiles. The following information has been obtained.

No Citrate Reactions were noted in the three patients who received ACD-A. No bleeding complications were noted in the three patients who received Sodium Heparin.

Conclusions: The preliminary information appears to favor conventional heparin anticoagulation, however, the low number of patients recruited to this point does not allow us to draw any definitive conclusion.
00/024 Simple, Safe, Single-Lumen System for Long Duration Dialysis

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Many of the benefits of continuous renal replacement therapy are obtained by long duration dialysis of 8 hours (LDD). In the ICU or home setting, what is needed to provide this therapy is a hemodialysis system which is so simple, safe, and automated that it can operate by itself, unattended, while the patient sleeps or is under care. Standard roller-pump, water/concentrate proportioning and controlled filtration machines do not meet this requirement. The HemoCleanse-HHD, a new hemodialysis system has been approved for market in treatment of acute or chronic renal failure. The HHD System has pressure-controlled blood pumping, direct blood flow measurement, and completely automated priming and fluid management (including fluid boluses and final rinse). Safety features include detection of: blood tubing leaks or disconnects, in flow bubbles, and empty or nearly empty replacement fluid containers. The system was first utilized for acute hemodialysis and home hemodialysis with a Redy column for regenerating dialysate. We are modifying the system to utilize a 100-liter tank for batch bicarbonate dialysate production from dry powder. All other blood-side and dialysate-side components are disposable after each treatment. A clinical trial is now planned to utilize the machine on an 8-hour treatment schedule, every other day, in treatment of patients in the home setting and in a nursing home setting. The study will focus on the degree to which the machine performs all functions of the dialysis procedure without any human interaction (except for setup and breakdown). If the trial is successful, the system may allow a night-time dialysis program in which a dialysis technician (or partner) checks the health of the patient, sets up the machine, and presses a button to initiate dialysis, all within a one-hour period. The resulting dialysis treatment would not only be highly chemically effective, but economically practical. The same system and advantages could be implemented in the ICU for 8–12 hour treatments each night, with either a Redy column for regeneration or the 100-liter dialysate tank.
Effect of a New Treatment System Using Albumin Dialysate for Multiple Organ Failure (MOF)


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Although various kinds of blood purification technique have been applied to the treatment of MOF, toxins with strong binding affinity to albumin (albumin binding toxins: ABT) could not be efficiently removed by continuous hemodialysis (CHD) with conventional dialysate (CD). Considering the ability of albumin to bind many molecules, we investigated the effects of CHD with albumin containing dialysate (AD) on removing ABT, and evaluated the clinical efficacy of CHD with AD combined with adsorbent column for detoxicating albumin (continuous albumin purification system: CAPS) on MOF.

In vitro CHD with AD demonstrated over than 30% increase in removing ABT comparing to CHD with CD. CAPS brought about a significant decrease in serum bilirubin levels in patients with MOF accompanying with hyperbilirubinemia using adsorbent for bilirubin in CAPS.

These results suggest that CHD with AD can remove ABT more efficiently than conventional CHD, and CAPS may become one of the new therapeutic tools for MOF.
Successful Use of an Anticoagulation Regimen Based on a Citrate Replacement Fluid Solution in Continuous Veno-Venous Hemodiafiltration

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Regional citrate anticoagulation is becoming a standard in continuous veno-venous hemodiafiltration (CVVHDF) since it avoids systemic anticoagulation and appears as effective as heparin-based regimens. Unfortunately, the currently proposed protocols may be complicated and troublesome. They are usually based on a diffusive technique with a concentrated 4% citrate solution and a custom-made hypotonic (Na 110) dialysate solution. An additional central venous access is also required for the infusion of the neutralizing calcium solution.

We present our experience with a more convenient regimen based on convection and using an isotonic citrated calcium and magnesium-free pre-dilution replacement fluid solution (Na 145 mmol/L, citrate 20 mmol/L) and a post-filter infusion of the neutralizing calcium and magnesium solution in the venous return at the end of the circuit. The initial blood flow rate is initially set at 125 cc/h and the hemofiltration uid rate at 1250 cc/h and thereafter adjusted according to blood activated coagulation time (ACT) (180–220 sec). If higher solute clearances are desired, a diffusive component with a dialysate solution (consisting of normal saline) can be added. These are the results of the 8 first patients treated with such a modality:

Electrolytes and acid-based balances were both well-maintained using this technique, the average time-life of filter was 60 h and no particular complications were observed. We therefore believe this novel citrate anticoagulation regimen to be efficacious, safe and indeed convenient.
00/027 Continuous Renal Replacement Therapy Using 2% Trisodium Citrate Regional Anticoagulation: A Retrospective Study

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Systemic anticoagulation with heparin in continuous renal replacement therapy (CRRT) is associated with a significant risk of bleeding. Citrate anticoagulation has been shown to be an effective alternative. However, the use of 4% trisodium citrate has been associated with metabolic complications requiring adjustments in dialysate solutions. We have designed a novel protocol for citrate anticoagulation for CRRT to address these problems.

We currently utilize 8 PRISMA CRRT devices, and have standardized regional citrate anticoagulation using 2% trisodium citrate (70 mM citrate, 220 mM sodium) as the predialyzer replacement solution, delivered initially at 250 cc/hr and adjusted to maintain a postdialyzer ionized calcium (iCa) of 0.4 mM. An infusion of 1.96% calcium gluconate is delivered initially at 60 cc/hr and adjusted to maintain a systemic iCa of 1.1 mM. Our standardized CRRT dialysate solution, consisting of 0.9% saline, 3 mM KCl/L and 1.5 mM MgSO4/L, is delivered at 1000 cc/hr. This protocol has been in effect since July 1999 at our institution.

We evaluated retrospectively the outcomes and complications associated with this CRRT protocol at our institution between July and October 1999. We included patients from adult medical, surgical and cardiac intensive care units. Patients surviving less than 48 hrs were excluded from analysis. A total of 29 patients were included with clinical characteristics as follows: 14 males and 15 females, 6 diabetics, mean age of 54 years SD ± 16, mean albumin of 2.0 SD ± 0.8, and mean APACHE II score of 23 upon initiation of CRRT. Twenty-three patients had acute renal failure and 6 had preexisting end stage renal disease.

CRRT failure was defined as a dialyzer life of less than 48 hrs due to clotting. Bleeding complications were defined as a need for transfusion of at least 4 units of packed red blood cells within 48 hrs of initiation of CRRT and documentation of a bleed. We assessed citrate toxicity by monitoring changes in the serum pH, sodium, bicarbonate, and iCa. We measured postdialyzer iCa levels to assess adequacy of anticoagulation. Mortality was defined as death at any point during the hospitalization.

Fourteen out of 29 patients did not clot their dialyzers at the end of 48 hrs. Of the remaining 15 patients, 9 clotted their dialyzers and 6 were disconnected from CRRT for reasons not related to clotting, bleeding, or citrate toxicity. After excluding from the analysis patients who were disconnected, 9 of the 23 remaining patients (39%) clotted their dialyzers within 48 hrs. Three out of the 9 who clotted (33%) had a min. post dialyzer iCa > 0.5 whereas only 2 of the remaining 14 patients who did not clot their dialyzers (14%) had a min. postdialyzer iCa > 0.5. There were no significant bleeding events. There were no significant episodes of trisodium citrate toxicity. The maximum serum sodium was 150 meq/L, maximum serum bicarbonate 33 meq/L and the maximum pH 7.53. Twenty-one patients (72% of the total) died during their hospitalization for reasons unrelated to CRRT.

In conclusion, a CRRT protocol using 2% regional trisodium citrate anticoagulation is safe and not associated with significant bleeding complications or citrate toxicity, metabolic alkalosis or hypernatremia. The use of isotonic trisodium citrate replacement solution and the simplified standard buffer-free dialysate has decreased costs and minimized delays in the preparation of specialized CRRT solutions.
00/028 An Interim Evaluation of a Regional Citrate Anticoagulation (RCA) Protocol for Continuous Renal Replacement Therapy

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Background: Problems encountered with RCA have been reported, including systemic hypocalcaemia, hypernatraemia and citric acidosis. Metabolic alkalosis is a particular problem if bicarbonate or lactate dialysis solutions are used in addition to RCA. We present an interim evaluation of our early experience of RCA for CRRT with bicarbonate dialysate using Anticoagulant Citrate Dextrose Solution USP (ACD) Formula A, Baxter Fenwall ??. An evaluation of (i) the efficacy of the RCA Protocol on dialysis filter life, (ii) filter clotting at the target ionized calcium range and (iii) adverse events relating to the RCA Protocol were undertaken.

Methods: All CRRT use the Prisma set in CVVHDF mode with an M100 AN69 filter. Calcium free bicarbonate dialysate (Normo-carb®) is prescribed at 20 ml/kg/hour. Extracorporeal anticoagulation is achieved by an infusion of the ACD Formula A Solution on a sliding scale based on post filter ionized calcium levels, target range 0.25–0.35 mmol/L. Systemic ionized calcium is replenished by re-infusion systemically. Metabolic alkalosis (HCO₃ > 28 mmol/L) is corrected by haemofiltration with normal saline replacement modeled to match the calculated interval gain in bicarbonate. A bicarbonate haemofiltration rate and normal saline replacement sliding scale was designed.

Results: There were 15 patients, 11 male and 4 female, age 64 ± 13 years treated with CVVHDF according to the Regional Citrate Anticoagulation (RCA) Protocol during the pilot study period March and October 1999. Acute renal failure was the indication for dialysis in all patients; 6 post-surgical, 2 burns and the remaining medical patients. Six patients died as a result of their illness in the ICU and all but one patient remained dialysis free after transfer from the ICU. There was a total of 2310 patient-hours of CVVHDF treatment during which a total of 46 dialysis filters were utilized. The duration of CVVHDF was 154 ± 130 hours per patient. The dialysis filter life was 50 ± 34 hours. Of the 46 dialysis filters utilized, 11% (n = 5) spontaneously clotted on the RCA Protocol, 32% (n = 15) performed > 70 hours mandating filter change, 28% (n = 13) lasted less than 70 hours due to termination of dialysis, and 28% (n = 13) lasted less than 70 hours due to interruption of dialysis for diagnostic procedures or surgery.

The post-filter ionized calcium was measured every 6 hours (measurement periods) with a target of 0.25–0.35 mmol/L. During 337 measurement periods without clotting the ionized calcium was 0.32 ± 0.10 mmol/L and 0.40 ± 0.15 mmol/L during 5 measurement periods for the filters that clotted.

A low systemic ionized calcium level (< 0.75 mmol/L) at some point was observed in 6 patients with the mean ionized calcium level 0.93 mmol/L. For the patients with normal systemic ionized calcium the mean was 1.0 mmol/L. A high serum bicarbonate level (> 28 mmol/L) was observed in 9 patients (mean bicarbonate level 30.2 ± 1.6 mmol/L) and in the remaining six patients the mean serum bicarbonate was 20.5 mmol/L.

Conclusion: RCA demonstrates a prolonged dialysis filter-life during CRRT. One-third of filters functioned in excess of 70 hours and the mean filter-life was 50 ± 34 hours. Spontaneous clotting did occur with citrate anticoagulation in 11% of filters. Utilizing a readily available citrate product and calcium-free bicarbonate dialysate, a protocol based regional citrate anticoagulation may be made more convenient.
00/029 Regional Sodium Citrate Anticoagulation in Continuous Veno-Venous Hemofiltration

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Introduction: Continuous veno-venous hemofiltration (CVVH) has become standard in acute renal failure in critically ill patients. Usually the extracorporal circuit is prevented from clotting by systemic heparin infusion. Complications of systemic heparin anticoagulation include bleeding, coagulation disorders and associated-associated thrombocytopenia. Alternative methods to heparin anticoagulation are systemic or regional infusion of low molecular weight heparin, prostacycline, nafomostat mesilate, lepirudine, danaparoide or sodium citrate.

Citrate forms a chelate complex with serum calcium. Infusion of sodium citrate in the extracorporal circuit results in regional coagulation inhibition due to decalcification. Citrate anticoagulation will be counteracted by serum calcium once extracorporal blood has own back to the patient and thus systemic coagulation will be maintained.

We retrospectively evaluated all patients receiving CVVH because of acute renal failure due to septic shock or severe multiple trauma from July 1998 to September 1999.

Method: CVVH was performed using Hospal Prisma (postdilution mode). We used a bicarbonate buffered calcium free substitution fluid, in which bicarbonate has to be added immediately before use. Sodium citrate 4% was infused prefiler in the extracorporal circuit. (Fig. 1). Infusion rate was adjusted according post-filter activated clotting time (ACT). Target ACT range was 180 to 220 seconds. Acid-base-status and serum levels of ionized calcium were monitored.

Results: 32 patients were treated 8200 hours of CVVH using 103 filters. Mean filter lifetime was 79.9 (SD 25.4) hours, which is at least more than twice of the life time if systemic heparin infusions for anticoagulation are used. To prevent systemic anticoagulation calcium was infused to maintain serum calcium levels above 0.84 mmol/l. Mean calcium substitution rate was 9.2 (SD 5.0) mmol/h. We didn’t see any bleeding neither in patients after craniotomy due to severe intracerebral bleeding nor during surgical interventions. To avoid alkalosis we reduced the bicarbonate admixture, when pH rose above 7.45. Nevertheless 18 patients received hydrochloric acid at an arterial pH above 7.5.
Conclusion: Regional anticoagulation of extracorporeal circuit during CVVH with sodium citrate 4% is a safe and effective alternative in patients in which heparin has to be avoided.
00/030 Antibiotic Dosing in Slow Continuous Dialysis (SCD)

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SCD is emerging as a modality for treatment of acute renal failure (ARF). Little information is available on antibiotic dosing during this therapy. We retrospectively studied random, peak and trough blood levels of tobramycin and vancomycin in two patients who received extended courses of SCD with the Fresenius 2008H.

Two women, aged 46 and 33, developed anuric ARF due to complications following the Ross procedure and fulminant meningococcemia, respectively. Approximate dry weights were 75 and 66 kg, respectively. Both received courses of vancomycin and one also received tobramycin. Both received SCD for several weeks (treatment times 544 and 330 hours). With dialysate flow rates of 100 ml/min and blood flow rates of 160–200 ml/min, urea clearances are in the 60–90 ml/min range. Antibiotic dosing was prescribed empirically using peak, random and trough levels in conjunction with the Infectious Disease consultant. These levels were analyzed and compared to levels of BUN and creatinine.

Results: Vancomycin clearance mirrored creatinine clearance, while the clearance of tobramycin was similar to the urea clearance. Once-daily doses of 0.5–1.0 gm of vancomycin maintained therapeutic blood levels in these patients. Once-daily doses of 60–80 mg of tobramycin yielded trough levels that were subtherapeutic.

Conclusion: Daily dosing of aminoglycosides and vancomycin is indicated in SCD.
00/031 Gentamicin and Vancomycin Dosing in a Pediatric Intensive Care Unit Population Receiving Renal Replacement Therapy

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Treatment of septic children in the ICU with standard antibiotics such as gentamicin and vancomycin has become a standard of care. Based on the severity of illness, these children also often require concurrent treatment with renal replacement therapies in the form of continuous venous venous hemofiltration (CVVH).

The dosing requirements, kinetics and clearance of vancomycin and gentamicin in children undergoing CVVH are not clear. The potential for toxicity as well as concomitant renal damage in these patients should not be underestimated. Here we report data on 8 children treated in our pediatric intensive care unit over the past 2 years. These patients received gentamicin, vancomycin, or both during their ICU admission. The following table demonstrates their dosing requirements along with concomitant levels and general characteristics.

Based on this data it is clear that as a general rule 2 mg/kg of gentamicin and 10 mg/kg of vancomycin given every 18 or 24 hours respectively appear to be the dosing frequency of choice for children undergoing CVVH in the intensive care unit. It should be remembered that these medications are not without side effects and therefore close scrutiny of random levels as well as dosing adaptations based on those levels are of the utmost importance in the treatment of these children. Vancomycin is highly protein bound while gentamicin is not and therefore has greater clearance on CVVH. Thus, while standard dosing regimens are appropriate for individuals with normal renal function, care must be afforded the implementation of these medications in patients with renal dysfunction and especially those receiving renal replacement therapy.
00/032 Specific Removal of Large Amounts of Endotoxin from Dialyzate by DialguardTM

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It has been recognized that regular exposure to even low amounts of endotoxin (ET) may lead to harmful consequences in dialyzed patients. The quality of water used to prepare dialysate is very important. Besides the water there may be other sources of ET in the dialysis system. The aim of our study was to demonstrate the possibility of efficient removal of large amounts of ET from dialysate by DialGuardTM; an affinity based endotoxin-removing device.

In order to challenge the device the dialysate was spiked with high amounts of ET. As source for natural ET, Pseudomonas maltophilia culture-supernatant was used. The bacteria were grown for 4–6 days. After the cultures were terminated the supernatants were collected, filtered, treated with antibiotics, tested for sterility, and finally characterized for ET content. The experiments were carried out by placing the affinity based ET removing column-device into a hemodialysis circuit prior to the dialyzer. The circuit was governed by Fresenius 2008 E hemodialysis unit. Before each experiment routine “heat clean” and “rinse” cycles were performed including a stabilization period of 15 minutes with unspiked dialysate. Samples were taken pre- and post-DialGuardTM for base ET level determination. The bicarbonate portion of the dialysate was spiked with natural Pseudomonas ET. The final dialysate contained 35 EU/ml ET. Two 9-hour experiments and a 20-hour experiment were run continuously with 500 ml/min flow rate. Samples were taken at T = 0, and every 30 minutes thereafter. Endotoxin measurements were performed by standard LAL assay.

The device immediately decreased the ET in the dialysate to an average of 0.022 EU/ml. The same low levels were maintained through the entire time of the experiments.

The results demonstrate continuous and specific ET removal from dialysate by affinity binding. With the use of such a device patients can be continuously provided with high quality dialysate. The use of ultrapure dialysate may decrease endothelial damage and cardiovascular complications possibly contributed by ET-induced cytokine reactions.
00/033 Characteristics of Intraoperative Continuous Venous Venous Hemofiltration in the Pediatric Intensive Care Unit Population

P.D. Brophy, K.D. McBryde, T.A. Mottes, B.J. Adams, and T.E. Bunchman

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During an intensive unit care stay many children suffer from volume abnormalities as well as electrolytes and/or metabolic derangements. Renal replacement therapy in the form of continuous venous hemofiltration (CVVH) has offered a venue for treatment of these critically ill children. We present data on 5 patients ranging in age from 2–18 years, whereby intraoperative renal replacement therapy was necessitated based on various underlying surgical conditions. These conditions included; severe full thickness burns (N = 1), splenectomy (N = 1), amputation (N = 1) and liver transplantation (N = 2). During our experience over the past several years with intraoperative CVVH it has become apparent that certain characteristics are necessary for the appropriate and successful treatment of these children. The following table provides a list of patients their ages, duration of intraoperative CVVH and fluid replacement along with blood flow rates, dialysate rates, type of filter utilized, and the blood lines.

Results indicate that successful intraoperative renal replacement therapy in the form of CVVH is a viable option for treatment of critically ill children. In conclusion, CVVH offers a prompt, effective, and safe modality for therapeutic intervention intraoperatively. From our experience several important issues should be anticipated prior to initiating intraoperative therapy. Most notably being the potential difference in electrolyte replacement requirements in the form of absence of potassium chloride or potassium phosphate in the CVVH, as well as an increased requirement for calcium chloride based on the high volume of citrate containing products normally administered intraoperatively. Therefore the utilization of a custom-made dialysate solution is paramount. Finally, a highly trained staff and good cooperation between the surgical team and the intensivist, anesthesiologist and nephrologist are of utmost importance in instituting and maintaining this therapy.

<table>
<thead>
<tr>
<th>Patients</th>
<th>Hemofiltration System</th>
<th>Blood Flow Rate</th>
<th>Dialysate Rate</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.2 Kg 141 mos</td>
<td>HF400 w/Pediatric lines</td>
<td>200 ml/min</td>
<td>1500 ml/hr</td>
<td>OK+ Dialysate</td>
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<tr>
<td>13.7 Kg 17 mos</td>
<td>HF400 w/Pediatric lines</td>
<td>45 ml/min</td>
<td>500 ml/hr</td>
<td>OK+ Dialysate CaC3 70 mg/hr</td>
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<tr>
<td>52.4 Kg 180 mos</td>
<td>M60 w/Adult lines</td>
<td>150 ml/min</td>
<td>2000 ml/hr</td>
<td>OK+ Dialysate CaC3 300 mg/hr</td>
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<tr>
<td>43.7 Kg 215 mos</td>
<td>MF 60 w/Prisma</td>
<td>180 ml/min</td>
<td>2900 ml/hr</td>
<td>OK+ Dialysate CaC3 1000 mg/hr</td>
</tr>
</tbody>
</table>
00/034 Techniques to Avoid Hypotensive Dialyzer Reactions in the Pediatric Population Requiring Blood Priming for Continuous Veno-Venous Hemofiltration

P.D. Brophy, T.L. Kudelka, T.A. Mottes, and T.E. Bunchman

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The safety and efficiency in children treated with renal replacement therapy in the form of continuous veno-venous dialyhemofiltration (CVVHD) has significantly improved over the past several years. With the advent of improved and available technologies in the form of hemofiltration devices, internal fluid balance measurements have become far more accurate. Children treated with CVVHD are extremely sensitive to blood volume changes. This is based on the fact that neonates and children less than 10 kg have blood volumes of approximately 75–80 cc/kg. Many available pediatric and neonatal lines at times reach high proportions of the patient’s blood volume in the circuit making it necessary to prime these circuits with blood.

We report 3 patients, who required blood priming for CVVHD. Each of these patients developed a significant hypotensive episode with onset with the initiation of CVVHD, which resolved immediately, once CVVHD was discontinued. The most notable characteristics of these patients was the utilization of the multifo 60 (an AN-69) dialyzer membrane. Of note no similar episodes were encountered when patients were saline primed. On further investigation and discussion with the designers of the AN-69 membrane it become apparent that the dialyzer itself was exquisitely pH sensitive. Via their own studies it appeared that the lower the pH concentration of the blood the greater the activation of bradykinin, a known hypotensive-inducing agent, by the dialyzer. On review of blood available from our blood bank the following parameters became apparent. The pH of standard blood available from our blood bank was anywhere from 6.1 to 6.4. Additionally, the blood obtained from our blood bank had a significant hyperkalemia, hyponatremia, and hypocalcemia. No reactions were noted when patients were primed with normal saline, which has a pH of around 5.9. It appeared that the presence of endogenous blood substances such a bradykinin induced the hypotensive episodes.

Our approach at this time was two-fold. The first approach required the addition of two two-way stopcocks on the venous return line to the patient. The CVVHD circuit was saline primed. As the machine was being setup to deliver therapy to the patient the proximal stopcock was opened on the venous side thereby allowing the saline to run into a collecting bag. At the same time the distal stopcock on the venous side was opened to allow packed to be administered directly to the patient and the arterial side was allowed to draw normally. In effect this allowed the patient to buffer the received blood bank blood prior to the membrane seeing the blood bank blood. With this technique, to our knowledge, no subsequent hemo-hypotensive episodes have occurred in at least 4 patients. A subsequent approach, which we have developed, necessitates the prior buffering of blood bank blood with the following parameters based on 1 unit of PRCs. This mixture appears to be effective however, we have not had the opportunity to deliver it in the prime circuit to this point. We suggest; 1) checking the pH, hematocrit and electrolytes of the PRCs, 2) discard 50 ml from the PRCs (leaving approximately 300 ml) and add 50 ml THAM plus 250 mg CaCl plus 5–7 units of 1/100 heparin, 3) Mix equal parts of the PRCs mixture with a solution of 850 ml sterile water plus 150 ml (3 amps) NaHCO3, 4) recheck the pH, hematocrit and electrolytes of the mixed priming solution. This accomplishes the following goals. First it brings the PRCs pH to 7.3 –7.6. Secondly, the Na remains between 110–145 and will be corrected along with the high K by the patient’s own blood. Thirdly, the hematocrit is brought down to around 33 % and the ionized Ca is between 0.95 and 1.30. These measures should decrease membrane reactions.
These two options we feel will allow the increased safe and effective utilization of the AN-69 membranes in CVVHD circuits. In addition, these observations indicate the requirement for careful and close attention to detail when delivering renal replacement therapy to any children but especially those under 10 kg.
00/035 Early Experience with the Safety and Effectiveness of the Cobe PRISMA for Pediatric CRRT


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Introduction of the PRISMA CRRT machine by Cobe has resulted in significant simplification of the management of patients with acute renal failure by combining many of the various pumps required for this therapy. Although use of this machine for CRRT in adults has become widely accepted as a major improvement in CRRT therapy, the fixed large circuit volume and filter size have remained an impediment to its use for pediatric patients, as this has necessitated blood priming of the circuit for use in smaller children. We report here our early experience with the use of the PRISMA for 13 CRRT treatments in 12 pediatric patients. Patients ranged in age from 1–269 mo (180 ± 22 mo; x ± SEM), while the weight range was 5.2 –129 kg (58 ± 10 kg). The most frequent indications for treatment included fluid overload (69%), electrolyte imbalances (62%), and acute renal failure (23%), while the most common underlying diagnosis was bone marrow transplantation (38%). Blood pressures at the onset of therapy were < 5% ile for age in 85% of patients, and all 12 patients were on vasopressors at the time therapy was begun. All patients were treated with CVVHD and the duration of treatment ranged from 1–20 d (8.8 ± 2 d). Blood priming of the circuit was required in 1/12 (8%) patients, where the extracorporeal circuit volume exceeded 10% of the patient’s calculated blood volume. Circuit anticoagulation with heparin was used in 38% of treatments and filter lifespan ranged from 0.43 –1.0 filters/patient/d (0.73 ± 0.06 filters/patient/d) using a total of 70 filters. Complications related to CRRT therapy occurred in 2 (15%) treatments and included bleeding around the access and hemofilter rupture in one patient and an apparent acute membrane reaction in a 5.2 kg infant who had required blood priming of the circuit. Patient survival to hospital discharge was 58% (7/12 patients). Based on these early findings we conclude that use of the Code PRISMA CRRT machine in pediatric patients is both effective and safe, with a similar filter lifespan, complication rate, and patient survival rate to that for CRRT using other systems in both adults and children. With an anticipated modification of the circuit to lower the circuit volume and reduce the need for blood priming of the circuit in small children (< 13 kg), we anticipate the use of this machine in pediatric patients will expand significantly in the future.
00/36 Treatment of Hirudin Overdose with Hemofiltration

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Recombinant hirudin (r-hirudin) is the recommended anticoagulant for patients with heparin-induced thrombocytopenia type II (HIT) in Europe. However, in renal failure its use may be dangerous because of the long half life, inducing therapeutic anticoagulation after a single bolus for up to one week. We report the use of hemofiltration as a rescue measure in a chronic renal failure patient with HIT who suffered from life-threatening bleeding after a surgical procedure due to r-hirudin hangover after a previous hemodialysis session one day earlier.

A 55 year old patient with end-stage renal disease after bilateral nephrectomy because of renal cell carcinoma developed HIT one year earlier and was successfully dialyzed with r-hirudin anticoagulation since then. As an isolated lung metastasis was detected, she was scheduled for pulmonary lobectomy. On the day before surgery, routine hemodialysis was performed in her dialysis center using a low flux polysulfone dialyzer (Fresenius F8). She received her usual dose of r-hirudin (5 mg) for anticoagulation during hemodialysis, which normally elevated activated partial thromboplastin time (aPTT) to approximately 60 sec. On the evening after hemodialysis and prior to surgery aPTT was 78 sec. Inadvertently, the patient underwent pulmonary lobectomy the next morning without further anticoagulation studies. Hours after the uneventful surgical procedure the patient developed a large intrathoracic hemorrhage, associated with a drop in hemoglobin from 9.7 to 6.6 g/dL. At this time aPTT was 66 sec. Since r-hirudin is known to exhibit no significant protein-binding and has a low volume of distribution, the nephrology consultant started hemofiltration using a high flux polysulfone (Fresenius F60) hemodialyzer at a rate of 2.5 L/h in order to remove r-hirudin. r-hirudin levels and aPTT decreased over the next 6 hours and bleeding subsided. The patient was later discharged home and continues on chronic HD with regular use of r-hirudin.

In a previous in vitro study we evaluated 8 different types of hemodialyzers regarding their sieving coefficient for r-hirudin (MW 7 kD). In essence, 4 high flux dialyzers showed a high sieving coefficient from whole blood (polysulfone: 0.95 ± 0.07, poly-acryl-ether-sulf-one: 0.77 ± 0.02, poly-methyl-methacrylate: 0.74 ± 0.03; poly-a-mide: 0.55 ± 0.02). Low flux dialyzers did not allow significant filtration of r-hirudin (cuprophan: 0.06 ± 0.02, polysulfone: 0.03 ± 0.03, hemophan: 0.02 ± 0.02, poly-methyl-methacrylate: 0.01 ± 0.01). The r-hirudin clearance by hemofiltration measured in the patient was well within the proposed clearance range estimated from the respective in vitro study on the high flux polysulfone hemodialyzer.

We conclude that high flux dialyzers allow r-hirudin removal by hemofiltration. A filtration rate of 50 mL/kg body weight per hour resulted in a r-hirudin half life of 3 h, which was sufficient in our case to almost normalize aPTT and stop bleeding. Among the hemodialyzers tested the polysulfone high flux membrane appears best to eliminate r-hirudin. Hemofiltration may be used as detoxification method in case of excessive r-hirudin levels.
00/37 Bacterial Contamination of the Dialysate Circuit in CRRT

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Background: Bacterial contamination of dialysate fluid is well recognised and has led to the establishment of clear standards of water and dialysate purity in chronic intermittent haemodialysis. The bacterial integrity of CRRT has yet to be defined but the prolonged lifespan of the therapy may pose additional hazards.

Aim: To define levels of bacterial contamination in both source bicarbonate dialysate (study 1) and dialysate circuitry (study 2) in CVVHD.

Methods: CVVHD utilised a BM11 blood pump (Baxter Health-care, IL) with 2 pairs of Accupro N7510 infusion pumps (McGaw, CA) providing pre- and post-dialyzer flow of a custom-made, bicarbonate-based dialysate. Dialysate was manufactured in batches and sealed in sterile infusion bags. Dialysate circuitry was changed, according to unit protocol, every 48 hours. Study 1: a random, 1 in 4 sample (n = 41) was set aside from consecutively manufactured dialysate bags (n = 150) before use. After breaking the seal using sterile technique, fluid was collected from each bag at 1 of 4 timepoints as determined by a rolling schedule: at time of manufacture (t), t + 24h, t + 48h or t + 72h. Samples were sent for gram stain, aerobic / anaerobic culture and colony count. Study 2: dialysate –drawn from the circuit using sterile technique and processed as study 1–was sampled during ongoing CVVHD at the following sites; point 1 (p1), proximal to dialysate “in” pumps; p2, pre-dialyzer; p3, post-dialyzer; p4, distal to dialysate “out” pumps. All points were sampled at the start of therapy, with p1 then sampled after every dialysate bag change and p2-4 sampled daily. Therapy start was defined as first institution of CVVHD or re-institution with an entirely new system. Contamination was classified as follows: significant if ≥ 1000 colony forming units (cfu)/ml; isolated (IC) if confined to a single point and timepoint, disseminated (DC) if the same organism involved > 1 point at the same time (widespread) and/or persisted over time (sustained).

Results: Study 1: 6 separate dialysate batches were manufactured on 5 different days. Only 1/41 was culture positive (sampled at t + 48h from a 12 bag batch, 1000–5000 cfu/ml staphylococcus sp, 5000–10000 cfu/ml diphtheroids). Study 2: 18 studies were performed in 17 patients (1 re-studied after 36.5 h with a new system), lasting (19.5 h ± 72.0 [23.4–271:2]). Initial dialysate used were: F4 (n = 14) (Fresenius, MA), PAN 03 (n = 3) (Asahi Medical, Tokyo). There were 15 IC in 9 studies (10/15 at p1, 11/15 with single organisms, 11/15 involved gram positive cocci (gpc) including the only significant IC). 7 DC (6 sustained) occurred in 6 studies, all involving significant growths of at least 1 organism. 4/7 involved only 1 organism. The spectrum of significant growth was as follows: Enterobacter cloacae (n = 2), gnb (4), gram negative coccobacilli (1), gpc (1). Time to the first DC was 50.4 h ± 60.4 [0.1–163.3]. DC duration was 45.75 ± 40.1 [5.0–95.2]. Points affected were p1 (in 4/7), p2 (6/7), p3 (5/7), p4 (5/7), p2 and/or p3 were significantly affected at some stage in all sustained DC. Of the sustained DC, 3 were not cleared by 1–2 dialysate line changes. 1 cleared spontaneously and 2 had no dialysate circuit changes before the end of therapy. There were no significant differences between DC and non-DC studies in terms of therapy duration (DC (n = 6); 104.1 h ± 54.9 [34.25–177.6]; non-DC (12); 127.2 ± 80.3 [23.4–271.2]; p = 0.61 (Wilcoxon rank sums test), rate of interruptions (DC: 1 per 17.7 h ± 7.3 [9.8–26.2]; non-DC; 16.6 ± 4.8 [9.7–23.3]; p = 0.66), rate of interruptions > 2 h (DC: 1 per 68.4 h ± 37.8 [34.25–122.5]; non-DC; 90.4 ± 72.8 [16.25–205.2]; p = 0.82) or time between dialysate line changes (DC: 41.2 ± 13.9 [13.1–73.0]; non-DC: 36.6 ± 14.8 [2.8–70.25]; p = 0.60).

Discussion: Significant and sustained bacterial contamination is common during CVVHD. Rather than being introduced from source dialysate, we speculate that bacteria, introduced through conneciology, subsequently thrive within the
bicarbonate-rich milieu of the dialysate circuitry. Persistent DC, despite dialysate circuit changes, may have arisen as a result of recontamination from other system components when these were not changed (e.g. dialyzer or existing, unsealed dialysate bag) or from incomplete replacement of the multi-component dialysate circuit itself. No factor appeared to reliably predict DC.

Conclusion: Regular monitoring of source and spent dialysate is needed to detect bacterial contamination in CRRT. More importantly, we suggest that all system components are changed at least every 48 hours during therapy to curtail any ongoing bacterial growth.
00/38 Surface Treated Catheters with Ion Beam-Based Process for Blood Access in Hemodialysis

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Using blood-contacting catheters, infections, thrombosis and stenosis are the most frequent complications. They are caused by surface properties of the basic material. Ion beam-based process such as ion beam assisted deposition (silver-based coatings) affect only the outer micron of the treated material surface. These processes were employed also in the production of large-bore catheters used for extracorporeal detoxification as vascular access. In a prospective study in 122 patients, 156 large-bore catheters (LBC) were inserted into the internal jugular (IJV) and subclavian veins (SV) and investigated after removal for bacterial colonization and with a scanning electron microscope (SEM). In 22 patients 32 surface-treated catheters (Spi-Argent, average in situ time $x = 15.5$ days/cath.) as acute catheters and in 33 patients 46 LBC as long term catheters (Spi-Argent, average in situ time $x = 173$ days/cath.) were used. 35 untreated acute catheters used in 28 patients (average in situ time $x = 16.5$ days/cath.) and 43 long-term catheters in 39 patients (average in situ time $x = 123$ days/cath.) served as control. Bacterial colonization of the catheter tip was observed in 7.7% in Spi-Argent (pos. blood culture 9%) in contrast to 22.4% in untreated catheters (pos. blood culture 25.6%).

There was no significantly difference between the acute and long term catheters in the same group. SEM investigations showed a low thrombogenicity and thrombus formation in the Spi-Argent Catheters in contrast to the untreated catheters with deposits of fibrin proteins and blood cells after in situ time of only some days. The second layer covered the entire surface after 3 days in situ time and increased to a thickness of 3–60 mm in all untreated catheters. Ion beam-based technologies are able to improve biocompatibility of synthetic materials without affecting tensile strength, bulk modulus or flexibility and to create thrombus and infection resistant coatings. Spi-Argent treatment processes for catheters can be used in blood-contracting applications.
Continuous Renal Replacement Therapy Outcomes Study: Quality Assurance in the ICU

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Background: Continuous renal replacement therapies offer significant advantages over conventional intermittent hemodialysis, including greater hemodynamic stability and the ongoing ability to optimize fluid balance in critically ill patients. Our unit is a 13 bed medical-surgical ICU that previously relied on intermittent hemodialysis for renal replacement support, until CRRT was recently introduced.

Purpose: We prospectively evaluated the efficiency of our approach to education and implementation of Prisma Continuous Renal Replacement Therapies in an academic university-affiliated ICU staffed by nurses without previous dialysis experience.

Methods: Resources were identified among attending physicians and nurses; one physician and two nurses were sent to The Fourth International Conference on Continuous Renal Replacement Therapy. All full-time and part-time nurses were assigned to one of three core groups. In collaboration with the Hospal-Gambro Representative, education was provided at three-month intervals to facilitate early exposure to patients receiving continuous dialysis following classroom training. Principles of adult learning (self-directed learning package, small group discussion) were used to reinforce theoretical concepts while 6–8 hour hands-on workshops provided practical experience. A quality assurance study conducted in our ICU gathered data on the patients who were ordered CRRT during the implementation phase. Outcomes were defined as the number of patients managed with CRRT, the mean duration of circuit use, complications, and the number of patients we were unable to manage on CRRT who required intermittent hemodialysis.

Results: After 10 months, more than 90% of full-time and part-time nurses were educated to set up the Prisma Continuous Fluid Management System in CVVHDF. During this time, 25 consecutive patients received CRRT, 19 for > 24 hours and, of those, the mean duration of circuit use exceeded 24 hours in 84% (16 patients). The maximum duration of therapy was 24.8 days. There were no significant adverse patient incidents. Anticoagulation of the extracorporeal circuit presented the greatest challenge. The primary choice was Heparin, but was associated with thrombocytopenia or bleeding in a number of cases. CRRT was continued in all patients, either by using alternate anticoagulation (eg Danaparoid, Citrate) or no anticoagulation.

Conclusions: A planned educational approach for implementation of CRRT using the Prisma system appears to have been an effective means of introducing this highly technical skill into a critical care unit without previous dialysis experience. The therapy has been well received by the multidisciplinary team and has become an established component of patient management. The cost-effectiveness of CRRT as compared to intermittent dialysis remains to be established.
00/40 Nine Equivalents of Nursing Manpower Use Score in Intensive Care Unit in Patients Treated with Continuous Renal Replacement Therapy (GAMBRO PRISMA)

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The purpose of this paper is with Nine Equivalent of Nursing Manpower Score (NEMS) to describe the need for nursing manpower to patients treated with Continuous Veno-Venous Haemodiafiltration (CVVHDF) in an Intensive Care Unit (ICU).

Allocation of nursing manpower to patients in ICU is controversial, at least partly because of its economic consequences, and our ICU is no exception. Several scoring systems have been applied to intensive care trying to assess the need for nurses, and the latest in a row of Therapeutic Intervention Scoring System (TISS), the “TISS 9”, Nine Equivalent of Nursing Manpower Score (NEMS) has in recent publications shown a good correlation with TISS 28 and is found suitable to measure nursing workload at the ICU level. In our opinion NEMS has the advantage of being practically applicable in daily nursing routine in intensive care in opposition to both TISS 76 and TISS 28.

We present the NEMS of the first 37 adult patients treated with CRRT (GAMBRO PRISMA) in a general 8–bed ICU in a University Hospital, since implementation of this procedure September 98. Indication for CRRT was severe azotaemia or severe hypervolemia in patients either with unstable haemodynamic or in acute conditions of hypervolemia (We don’t have a Nephrology service in our hospital). NEMS is registered in every nursing shift and the score is summarized on a 24 hourly basis, if the patient has been in the ICU for at least 6 hours since the last 24 hours registration.

Thirty seven adult patients in whom CRRT was performed during their ICU stay with a total of 388 (24-hourly) registrations had NEMS of 34.56 ± 9.12 (mean ±SD) compared to a general NEMS of 24.74 ± 10.18 in the whole ICU population 2379 registrations (p < 0.001).

During days with CRRT the NEMS rises to 39.56 ± 7.63 (dialysis adds 6 point in the NEMS), and censoring for dialysis gives NEMS 33.56 ± 7.63. In days without dialysis the NEMS of the 37 patients was 29.79 ± 7.85. (All scores significantly higher than the general score).

In our ICU patients treated with CVVHDF had a significant higher NEMS than the total ICU population probably calling for more nursing manpower to these patients. Higher NEMS was not restricted to days of dialysis but was seen throughout their stay in the ICU.

This observation is in accordance with the fact that CRRT primarily was introduced in ICU to patients intolerant to intermittent haemodialysis because of cardiovascular instability.
00/41 The Effect of Continuous Renal Replacement Therapy on Rhabdomyolysis Induced Acute Renal Failure


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The management of acute myoglobinuric renal failure, the major complication of rhabdomyolysis, is considered a crucial factor in determining the prognosis of such patients. Although immediate intensive care may prevent serious injury or death, the clinical efficacy of renal replacement therapy including continuous dialysis has never been investigated in this hazardous syndrome. 29 patients with acute renal failure due to rhabdomyolysis (age 51 ± 17, 20 male and 9 female, MOD score 8 ± 2) were analyzed retrospectively. Etiology of rhabdomyolysis were severe dehydration (n = 21), crush syndrome (n = 3), and malignant syndrome (n = 5). All the patients received intensive care management and continuous venovenous hemodialysis from onset of acute renal failure. Eighteen patients (62%) recovered from acute renal failure and 11 patients (38%) were dead within 7 days after the initiation of continuous venovenous hemodialysis. Comparing 2 groups classified according to final outcome, life survival was independent of age, sex, and peak of serum creatine kinase, but dependent on initial MOD score as previous reports have shown. The mortality of present study was better than that of previous reports in which patients were treated with infusion-diuretics therapy or conventional hemodialysis. Our results suggest that continuous renal replacement therapy is an effective extracorporeal therapeutic technique to rescue acute myoglobinuric renal failure.
Continuous Veno-Venous Hemofiltration (CVVH) has been employed as one method of renal replacement therapy for critically ill patients at the Massachusetts General Hospital since 1992. It has been and continues to be used extensively in the cardiac, general surgical and medical patient populations. Experience in the thermally injured patient and the patient with desquamating skin disorders is more limited. This abstract reports our experience with the first 16 patients treated with this therapy.

Charts for all patients who underwent CVVH in the years 1993–1999 were reviewed for 50 clinical characteristics in the five days preceding and the five days after institution of CVVH.

The mean age of patients was 48 ± 5 years (range 16–80). There were eight burn patients, four patients with toxic epidermal necrolysis, two patients with necrotizing fasciitis and two with purpura fulminans. (Two patients were admitted with a pre-existing diagnosis of chronic renal failure.) All patients were either oliguric or anuric. Mean creatinine 3.2 (range 1.0 –5.1), BUN 75 (range 12–201). All but one patient had a positive fluid balance during the 24 hours prior to the initiation of therapy (Average Total Body Balance: +5517 (range -400-34,052). All patients were intubated (mean FiO2 0.76, mean pCO2 55 torr, mean pO2 116 torr, mean arterial pH 7.25). 12 of 16 patients met criteria for septic shock and were on multiple parenteral antibiotics. The primary, immediate indication for initiating therapy was uid removal in nine (9), acidosis in two (2) and uremia in five (5).

Despite being oligoanuric, hypercatabolic (sepsis and burns) and receiving aggressive total parenteral nutrition the mean creatinine and BUN decreased by day four of CVVH to 2.2 and 50 mg/dl respectively. Filling pressures were targeted to optimize hemodynamics. Goal filling pressures were achieved despite administration of medications, TPN and blood products without limitation. In two patients, CVVH was initiated in an attempt to ameliorate their metabolic acidosis during concurrent efforts aimed at treating overwhelming sepsis. Both received a bicarbonate based replacement solution and supplemental bicarbonate. However, both patients expired within 36 hours. No patient developed hyperkalemia.

Three of these patients went on to complete renal recovery. To date two have left the hospital; the third continues to require excision and grafting. Unfortunately, the remaining patients expired.

CVVH is a resource intensive therapy that can serve as a bridge to recovery for critically ill patients with reversible renal injury. Despite excellent control of renal parameters, mortality remains high, indicating that ARF in the burn patient is indeed a poor prognostic indicator. To actually evaluate individual variables in terms of their effect on survival would require a large data collection and multivariate analysis. The size of our data set precludes this type of analysis. Improved definition of prognostic markers in this subset of critically ill patients is imperative in order to better allocate this resource intensive therapy.
00/43 Maintaining a Standardized Continuous Renal Replacement Therapy Program in Multiple Critical Care Units: The CRRT/CVVH Newsletter

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Purpose: The Massachusetts General Hospital (MGH) Continuous Renal Replacement Therapy (CRRT) Program includes nine critical care units and over three hundred nurses trained in hemofiltration therapy. We utilize a critical care model of nursing support. Patient complexity and time limitations pose an ongoing challenge to the critical care nurses ability to obtain information relevant to their practice and share their expertise and experience with other CRRT nurses. Communication initially was by meeting minutes and facts sheets, which were not always considered a priority by the staff and often discounted. Our purpose was to improve the dissemination of CRRT practice changes, equipment updates, educational opportunities and troubleshooting ideas across the units at MGH.

Methods: We developed a plan to publish a newsletter written in a format that would catch the nurses’ attention, be available at the bedside and be informative, inclusive and personal. The newsletter was divided into columns which included the following categories: a CRRT feature story, educational updates and class schedules, equipment updates, policy and procedure changes, troubleshooting ideas and a ‘test your skills’ section to provoke interaction and dialogue. The newsletters were initially placed in each nurses’ mailbox and in strategic locations throughout the intensive care units. Evaluations were given to staff members of the highest volume unit, the medical intensive care unit, following the distribution of the second edition.

Summary of Results: Of 22 nurses who received the survey, 17 completed the form. Thirty-five percent of the respondents did not know where or how the CRRT updates had been distributed for the preceding 3 years and 88% reported that they had only occasionally or never read them, 12% reported always reading them. In contrast, 100% had seen the newsletter and 94% had read some or all of both issues. Respondents identified the most useful sections to be the policy and procedure update, 23%; troubleshooting sections, 23%; ‘test your skills’ section, 6%; or some combination of these, 47%. 100% of the respondents felt that the newsletter was an enjoyable and useful tool for acquiring information.

Conclusion: In summary, it was clearly identified that the nurses either didn’t know where to find the facts sheets or found them uninteresting, and therefore didn’t utilize them. The newsletter, because of its multifeature approach was utilized and enjoyed by all the surveyed nurses and therefore successful in communication of CRRT issues. The practice and procedure and troubleshooting sections were listed as the most useful and helpful sections. The authors conclude that this newsletter was an effective means of disseminating CRRT information. In response to the readers’ interest, we developed a future plan to expand the newsletter to include case study presentations and literature review.
00/44 Observational Comparison of Intermittent Hemodialysis and Continuous Venovenous Hemodialysis in Acute Renal Failure in the Intensive Care Unit

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Acute renal failure (ARF) in critically ill patients portends a bad prognosis. Recent data in ARF associates better outcomes with higher dialysis dose, but also shows generally low delivered dose in these patients.

To evaluate our baseline performance in terms of dialysis dose and to better characterize our patient population, we collected data on all incident ARF patients requiring either intermittent hemodialysis (IHD) or continuous venovenous hemodialysis (CVVHD) over a 4 month period.

During that interval, 39 patients required dialysis (14 IHD and 25 CVVHD). Mean age was 65.7 ± 2.1 years, 65.8% were male and 45.9% had a pre-existing renal disease (average serum creatinine (SCr) 1.3 ± 0.1 mg/dL). At ICU admission 74.4% were ventilated, 61.5% required inotropic support, 51.3% were oliguric and 38.5% were septic (according to accp/sccm consensus criteria). APACHE II score was 20.1 ± 1.2. On average, patients were on renal replacement therapy (RRT) for 7.4 days. Death rate was 66.7% and most survivors recovered renal function (75%) (last SCr was 1.7 ± 0.2 mg/dL). There was a trend for younger patients to survive (58.9 vs 66.3 years; p = 0.10) and males were more likely than females to survive (44.0% vs 7.7%; p = 0.03). Survivors were more likely to have a longer hospital length of stay (LOS) (44.3 vs 21.2 days; p = 0.006), and also tended to have longer LOS in ICU (30.6 vs 17.3; p = 0.08). Comparing patients by initial method of RRT, there were no differences except for a higher proportion requiring inotropic support with CVVHD (76.0% in CVVHD vs 35.7% in IHD; p = 0.02). The arterial lactate level before initiating RRT was higher in CVVHD patients (2.0 ± 0.6 mmol/L vs 0.6 ± 0.3 mmol/L; p = 0.04) and SCr was lower in CVVHD patients at initiation of RRT (3.4 ± 0.3 mg/dL vs 4.9 ± 0.6 mg/dL; p = 0.01). Severity scores were not statistically different between modality. RRT modality was not different in survivors vs non-survivors. Patients recovering renal function were less likely to be oliguric (trend: 33.3% vs 62.5%; p = 0.10). They had a lower APACHE II score at RRT initiation as compared with patients not recovering (16.6 ± 1.4 vs 20.5 ± 1.0; p = 0.03). There was no difference in proportion of patients recovering renal function when comparing by initial RRT modality. Urea reduction ratio (URR) was only available for 39 of the 115 IHD treatments and was 49.8 ± 3.1 and equilibrated URR was 39.4 ± 2.4 on average. The average prescribed and delivered Kt/V on IHD were 0.99 ± 0.04 and 0.89 ± 0.06, respectively. The IHD survivors had a trend toward higher delivered dose (PRU 57.2 ± 5.2 vs 41.2 ± 5.3; p = 0.10). The average clearance on CRRT was 22.1 L/D including dialysate and ultrafiltration with the equilibrated urea being around 23 mmol/L after 3–4 days. Total clearance and total ultrafiltration in CVVHD patients were not different among survivors or non-survivors.

Like others, we observed a very high mortality rate in these patients. Patients without renal recovery appeared to be sicker and as expected had higher mortality. Both prescribed and delivered dose were very low in IHD. We are now studying whether targeting and achieving a higher dialysis dose in these very sick patients is feasible with IHD or CRRT. Whether this might reduce mortality remains the key issue.
00/45 Conversion from Adapted Systems to the Cobe PRISMA System in Pediatric CRRT: Impact of Bedside Nursing Education and Overtime Costs


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The pediatric program at the C.S. Mott Children’s Hospital of University of Michigan has had over 150 patients on hemofiltration over the last 9 years. We recently have acquired the use of the PRISMA system (Cobe, Gambro, Hospital, Lakewood, CO) for use in pediatric hemofiltration. This is used in children for indications that range from acute renal failure, inborn error of metabolism, to support for metabolic disease. In our program, the pediatric dialysis nursing staff is responsible for Pediatric Intensive Care Unit (PICU) nursing education, PRISMA set up and initiation of the CRRT, but the bedside PICU staff maintains it. It has been our perception that the comfort level in the use of the system as well as our overtime hours has been positively impacted by the PRISMA system.

PICU Nursing Education: Our program compared the PICU and Pediatric dialysis nursing learning curve of our adapted system to the PRISMA system. The PICU nursing staff and the Pediatric Dialysis nursing staff completed a two part survey focusing on the nursing comfort level from the end of the orientation through a six months time period of both systems. The second part of the survey evaluated the ease of use of both systems. In respect to the ease of use we evaluated three areas, machine setup, alarm systems, and UF pump systems. The survey used a scale of 1 to 5, 1 Very uncomfortable/difficult and 5 very comfortable/easy.

Upon analyzing the data we found the nursing comfort level at the end of orientation, two months and six months on the adapted system to be 3.1, 3.4, and 5 respectively, compared to the PRISMA system of 4.2, 4.6, 5 respectively. When evaluating the both systems in respect to ease of use, we found the PRISMA system scored higher in all three areas, machine setup, alarms systems, UF pump systems, with 5, 5, 4.6 respectively compared to that of the adapted systems of 4.4, 2.4, 1.6 respectively.

Dialysis Staff Overtime: We next looked at the amount of over-time hours necessary to support the PRISMA system by the dialysis program. Analysis of the first 13 patients on the PRISMA system was evaluated. We compared these to 13 patients who have been on a historically adapted system (matched for age, indication, weight, and heparin use, use of pressors as well as time on hemofiltration). In this group 1 (PRISMA) vs group 2 (adapted) we then looked at the amount of dialysis staff overtime hours that were needed to restart the PRISMA system due to malfunction or clotting after hours. Our program has pediatric dialysis staff Monday-Saturday, 7:00 –5:00 pm, therefore overtime hours were considered anytime between 5:00 pm-7:00 am Monday-Saturday as well as the 24 hour period on Sunday. Per protocol all circuits are changed at 72 hours but systems were changed on Saturday in order to avoid a routine change on Sunday.

When we looked at Sunday’s hours, 9.4 hours of pediatric dialysis nursing overtime was needed to restart the PRISMA system as compared to 16.2 hours on the adapted machinery. When one looks at the Monday-Saturday time 30.8 hours of pediatric dialysis nursing overtime were expended on resetting up the PRISMA system vs. 71.6 overtime hours of the pediatric dialysis nursing staff spent on the adapted system. These data confirms our perception that the user friendliness of the PRISMA system is not only better accepted by the PICU staff, but there is a financial advantage in a program such as ours, where an external group of nursing staff come in to reset up the system. From a cost-effective point of view we have cut our overtime costs for the use of pediatric CRRT by 50%.
In conclusion the use of the PRISMA system does not only give improved care of the child on CRRT but care can be done in a more cost-effective manner.
Maintenance of Circuit Patency is Possible After Temporarily Suspending Continuous Veno-Venous Hemodialysis

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Extracorporeal circuits for continuous veno-venous hemodialysis (CVVHD) are expensive. The cost of providing CVVHD can be more than anticipated, especially if patients require frequent interruption of this treatment to attend diagnostic tests or surgical procedures.

The purpose of this prospective study is to determine whether implementation of a “temporary disconnect procedure” will reduce the number of circuits used for patients requiring temporary suspension of CVVHD. A secondary aim is to evaluate the advantages, from a cost perspective, of reusing the same circuit. Preliminary data is presented.

Methods: At our facility, CVVHD is a collaborative effort between intensive care and nephrology services. Hemodialysis nurses initiate CVVHD with the Prisma CFM System, and communicate daily with intensive care unit (ICU) nurses to determine whether changes in the plan of care have arisen. Nurses in the ICU monitor the extracorporeal pressures hourly and contact the renal unit as needed. According to our protocol, circuits are changed every 72 hours. During an 11-month period, a prospective series of patients requiring continuous renal replacement were reviewed. A temporary disconnect procedure for the Prisma was modified and taught to a core group of hemodialysis staff. The three major steps of the procedure are blood return, repriming the blood circuit, and continuous recirculation of heparinized saline (3000 units of heparin per litre of saline) at blood flow rates of 100 to 150 ml/min. During the recirculation phase, dialysate and anticoagulation flow rates were turned to zero; heparinized saline was removed across the filter at a rate of 10 ml/hr.

Results: Twenty-one patients (16 men, 5 women) with acute renal failure or end stage renal disease received CVVHD during the period of study. Of these, 6 patients required temporary interruption of renal replacement therapy. The reasons were due to lung biopsy (1), CT scan (1), laparoscopy (1), cholecystectomy tube insertion (1), vascular surgery (1), and isolation precautions (1) due to infection with methicillin resistant staphylococcus aureus (MRSA). All patients requiring interruption of CVVHD were retransfused with their blood prior to being disconnected from the circuit.

For the first three patients, circuits were in use for more than 48 hours prior to disconnection. The temporary disconnect procedure had not yet been developed. Therefore, these used circuits were discarded; CVVHD resumed with the use of a new set-up.

After the introduction of the temporary disconnect procedure, interruption of CVVHD was required for the other 3 patients within the first 24 hours of a new circuit being used. Treatment suspension time ranged from 50 minutes to 5.5 hours. Two of these patients required invasive procedures. Treatment was permanently withdrawn for one patient upon return to ICU; the other had a cardiac arrest two hours after it was reinstituted. For the third patient, the anticoagulation infusion rate remained unchanged; pressures routinely monitored on the circuit remained within acceptable ranges until it was due to be changed again according to protocol.

Our preliminary opinion is that maintaining circuit patency is possible for patients requiring temporary suspension of Prisma based CVVHD. A collaborative approach is a pre-requisite to being fiscally responsible while ensuring that standards of care are not compromised for critically ill patients in the ICU.
00/47 Treatment of Severe Acute Renal Failure with Continuous Renal Replacement Therapy Versus Intermittent Hemodialysis

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Objective: To investigate the efficacy and prognosis of continuous renal replacement therapy (CRRT) versus intermittent hemodialysis (IHD) in severe acute renal failure (ARF) patients.

Methodology: One hundred and ninety-three severe ARF patients who received renal support between Dec 1978 and Dec 1998 were involved in this study. Of them, 101 (52.3%) were treated with CRRT (CRRT group) and 92 (47.7%) with IHD (IHD group). Simple set-up and Prisma machine were used in CRRT.

Results: Sixty (59.4%) patients in CRRT group survived the acute phase of the illness and 41 (40.6%) patients died, while 59 (64.1%) in IHD group survived and 33 (35.9%) patients died, no significant difference in survival was found between the two groups. As to patients with MODS, 24 out of 26 patients (37.5%) with MODS in CRRT group survived, while in IHD, 8 out of 44 (27.3%) survived, which was much higher in CRRT group. Patients in CRRT group were more severely ill as manifested by a lower mean arterial pressure, higher APACHE II score, more dysfunctioned organs and more frequent requirement of mechanical ventilation and vasopressor support as compared with patients in IHD groups. And CRRT was associated with improved hemodynamic stability, better control of fluid balance and biochemistry, increased nutritional intake and a shorter duration of acute renal failure (P < 0.05).

Conclusion: Our data suggest that CRRT is the first choice in the treatment of severe ARF patients, for it can offer several distinct advantages compared with IHD which may translate into improved survival, particularly in the more severely ill patients.
00/48 Creative Educational Program as a Way of Enriching Self-Progress

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Rationale: Entering into the third millennium, there have been expected changes in nursing database education resources and increasing competition for customers and their demands for up-to-date information. This has obligated the nursing profession, as a main resource of knowledge, to enrich and promote the staff creatively, in order to direct them towards individual and group education.

Aims: 1. To improve and deepen clinical skills, as a tool for better quality treatment; 2. To raise staff awareness for self-education; 3. To identify learning needs of the nursing staff; 4. To estimate acquired knowledge internalization, in a creative and non-threatening manner; 5. To supply tools and direction towards self-education; 6. To encourage team education for crossbreeding of knowledge and mutual enrichment; 7. To raise self-assurance in daily nursing work; 8. to promote staff consolidation.

Process: 1. Establishment of a working group for planning of educational programs; 2. Distribution of questionnaires to identify staff educational needs and logistic preferences; 3. Analysis and processing of questionnaires; 4. Writing annual educational programs; 5. Fulfillment of eight monthly staff workshops; 6. Preparing creative knowledge tests; 7. Answering knowledge tests either individually or as a group; 8. Presenting feedback by the guidance team.

Results: 1. Unique staff educational requirements were identified; 2. Awareness of self-education was raised; 3. Tools and resources for self-education were provided; 4. An interesting educational process was achieved, individually and in groups, which contributed to mutual fertilization and reduced anxiety; 5. Self-confidence of the team in daily clinical work was improved.

Conclusions: 1. A built-in educational program expands knowledge and raises confidence in daily work; 2. Involving the staff in the educational program and logistic decision-making contributes to a sense of obligation, self-responsibility and collaboration; 3. Examining the staff’s needs exposes different and interesting subjects; 4. Creative homework encourages clinical work and provides stimulation; 5. Providing the guidance team with the authority to provide feedback, contributes to a sense of independence and reduces anxiety among the staff; 6. Joint identification of the staff’s educational needs, broadens the feeling of belonging and of consolidation.
Writing a Policy for the Hemodialysis Unit to Ensure Comprehensive Performance and Minimize Incidents of Conflict Between the Treating Staff and the Patients

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Rationale: Certain factors have pointed out the need for writing a policy for the Hemodialysis Unit as a means of improving the quality of treatment and service: 1) changes in the health system in the legal, professional and social aspects, 2) confrontations and misunderstandings between patients and staff concerning professional and personal subjects.

Aims: Comprehensive, consistent and predictable performance; appropriate pleasant and safe treatment conditions according to the “Statute of Patient Rights”; increase the satisfaction of the patients and their families; construct tools in order to deal with irregular situations; improve cooperation and communication between staff and patients; preserve medical equipment and avoid waste; receive backing from the department and hospital administration; reduce conflicting situations between patients and staff.

Process: set-up a work group composed of 5 staff members and 3 patients; set-up a country-wide inquiry to check existing policies in dialysis units; arrange 8 work meetings for writing of the policy; receive feedback from the multi-disciplinary staff; re-write the policy; present the written policy to the hospital’s legal adviser to get legal validity; obtain approval from the department and hospital administration; present the policy to the entire staff; translate the policy into Arabic and Russian; transmit the policy to the patients by an appointed nurse; receive feedback from the patients and document; analyze the conclusions.

Results: Existence of uniformity in the performance of the multi-disciplinary team; full backing given by the department and hospital administration; a rise in patients’ satisfaction; improvement in the dialysis room’s atmosphere: decorum, order, cleanliness and safeguarding of individual privacy; quality treatment, quick and available.

Conclusions: the development of a uniform and clear policy raises both the quality of treatment and satisfaction of the staff and patients; clear work rules are an essential condition for doing professional and humane work, which assures patients’ rights; receiving feedback from the patients is indispensable in achieving cooperation; the patients’ participation in the writing of the policy increases the feeling of belonging and of taking responsibility; involving the lawyer and management gives the staff a feeling of security and backing, enabling them to act according to policy; it is necessary to assess the need for continually correcting the policy at fixed time periods.
00/50 What is the Preferred Nursing Method in the Dialysis Unit

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Rationale: In nursing, we distinguish between two major work methods: the method of Primary Nursing, which emphasizes the advantage of a single nurse who has autonomy both professionally and on the organizational level; as opposed to the functional method, in which planning and managing of treatment is carried out by a group of nurses and therefore the question of responsibility is not quite clear. A change in our work method raised the need to examine whether working according to the Primary Nursing method indeed provides the patient with a holistic approach, increases the nurse’s professional responsibility and pays more attention to interactions and mutual trust between nurse and patient.

Aims: to examine the patients’ satisfaction as a result of the change in the work method; to identify deficiencies in the current treatment; to pinpoint important subjects which require interference; to improve communication between nurse and patient; to improve nursing skills; to persist in guidance of patients; to increase motivation and awareness of the nursing staff of the patients’ needs; to emphasize the nurse’s role as mediator between the multi-disciplinary team and the patients; to increase satisfaction of patients in the dialysis unit.

Process: review of the literature and collection of information regarding work methods in nursing; integration of the concept of analysis, research question and research hypothesis; compiling questionnaires; filling out questionnaires individually with each patient; processing of data for research results; drawing conclusions and recommendations for the future.

Results: Changing the work method to Primary Nursing appointment, improved patient satisfaction. The following was observed: 1) Recognizable improvements in the communication between nurse and patient, and in the readiness of the nurse to help the patient; 2) Moderate improvement in nurses’ guidance of patients; 3) The method of Primary Nursing did not improve cooperation between nurses and the multi-disciplinary team.

Conclusions: the patient’s satisfaction is influenced by the work method; technical treatment and skills are not major factors that determine satisfaction of the patients; communication and cooperation between the Primary Nurse and the multi-disciplinary team should be improved; it is important to promote the subject of patient guidance; the nursing staff should be provided with communication skills to enable them to improve satisfaction of patients and quality of treatment.