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95/001: CONTINUOUS RENAL REPLACEMENT THERAPY (CRRT), THE ALFRED WAY
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Of 4926 patients admitted to a university attached tertiary referral ICU, 10.1% developed renal failure. One third received renal replacement therapy and 94% of these had 3 Organ System Failures (OSF). We describe our method of performing CRRT which is simple, efficient and associated with a good outcome.

1. Access was via cannulation of ipsilateral femoral artery and vein with single lumen haemofiltration catheters (VasCath - Ontario, Canada) allowing relocation of both catheters to a “clean” groin every 2 weeks. Only if groin access was not possible, did we use a double lumen haemofiltration catheter (VasCath -Ontario, Canada).

2. Heparin was infused at exit from femoral artery at low dose (300–500 U/hr), as we have demonstrated that the degree of heparinization does not influence survival of filters under normal circumstances. Only when filter clotting was a major problem, was the extracorporeal circuit fully anticoagulated. Protamine (1 mg: 100 U heparin) was then infused distally into the venous return and the degree of anticoagulation was measured post filter, where APTT is lowest and clotting risk highest.

3. Blood was pumped through the extracorporeal circuit using a Gambro blood pump (BMM 10 - 1 Blood Monitor - Gambro, Sweden) with a flow rate set between 175–250 mls/sec.

4. Filters were size 12 (surface area 1.3 m 2) Filtral (Hospal, France) with an AN 69 membrane. Very catabolic patients were treated with a size 16 (surface area 1.7 m 2) filter.

5. Haemofiltration solution (Gambro Formula I - NSW, Australia) was infused into the dialysate port of the haemofilter and pumped countercurrently to the blood at a flow rate of 2 L/hour having previously been warmed via an Astotherm IFT 200 (Stihler Electronic, Germany) blood warmer. 2 channels of a Gemini PC 4 (Imed, USA) pump were used for this purpose. We have found no need to vary the dialysate solution from the Cambro fluid for either hypercalcaemia or acidosis.

6. Dialysate & ultrafiltrate were pumped out of the ultrafiltrate port of the haemofilter using the other 2 channels of the Imed PC 4 at about 2 L/hour. Inflow and outflow pump rates were adjusted about the 2 L/hr level in order to achieve the desired fluid balance. The ultrafiltrate bags (5 L - Gambro- NSW, Australia) were weighed at the end of each 5 hour cycle to confirm accurate fluid balance.

7. The infusion rate of TPN in parenterally-fed patients was adjusted to compensate for amino acid ~30%) and glucose losses in the ultrafiltrate. We found no problem with infusion of intralipid in regard to filter survival.

8. Thrombocytopenia was one of the most common complications of CRRT. When this occurred, heparin was withheld from the system (and from all other lines if HITS was confirmed). We found thrombocytopenia to have a protective effect on filter life whilst platelet transfusions could precipitate filter clotting.

In conclusion, this is a simple, relatively automatic method of CRRT which was easily handled by the ICU nurse at the bedside without the need for additional staff or expensive equipment. It provided effective dialysis in critically
ill patients (APACHE 2: 27 ±8) despite protein intakes >2 gm/kg. This technique has advantages over those described by others in:

1. Ipsilateral groin cannulation with continued use of arterial blood provided excellent access and flow.
2. Very proximal infusion of low dose (not anticoagulating) heparin resulted in good filter life without bleeding complications.
3. Use of high volume haemofiltration fluid as dialysate resulted in very effective dialysis.
4. Use of peristaltic pumps to pump in and pump out dialysate resulted in non-labour intensive but tightly regulated fluid management.
5. Adjustment of nutrition to compensate for amino acid and glucose losses in the ultrafiltrate.

Overall survival in these 174 patients was 41% with 37% for 3 OSF and 19% for 7 OSF. These results are better than previously reported by Knaus (37% vs 20%, p <0.01).
95/002: ANTICOAGULATION DURING CONTINUOUS VENOVENOUS HEMOFILTRATION: HEPARIN AND PROSTAGLANDIN E1 VS. HEPARIN AND PROSTACYCLIN

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Continuous venovenous hemofiltration (CVVH) is an effective technique for the treatment of acute renal failure. Anticoagulation during CVVH with heparin and prostacyclin is well established. Prostaglandin E1 (PGE1) is a platelet-inhibiting prostanoid that has a better hemodynamic profile and costs less than prostacyclin. The aim of this study was to compare the combined anticoagulation regimes heparin and PGE1 to heparin and prostacyclin.

After Ethics Committee approval and informed consent were obtained, 21 patients (10 f, 11 m; aged 68 ±13 yrs) with postoperative acute renal failure were studied before and for 48 hours during hemofiltration. Anticoagulation was accomplished using heparin 6.0 ±0.3 IU/kg/hr plus PGE1 5 ng/kg/min (group 1, n = 7), heparin 6.0 ±0.3 IU/kg/hr plus PGE1 20 ng/kg/min (group 2, n = 7) or heparin 5.9 ±0.3 IU/kg/hr plus prostacyclin 5 ng/kg/min (group 3, n = 7) administered into the extracorporeal line before hemofiltration. Blood samples were obtained from the systemic and extracorporeal circulation. Hemodynamic variables, hemofilter performance, plasma coagulation profile, and platelet counts were obtained. Platelet function was determined in vitro by means of thrombostat (T4000 TMDG, Germany). Statistical significance was analyzed by using the Wilcoxon test (within groups) and Mann-Whitney test (between groups). A p <.05 was considered statistically significant.

Mean hemofiltration duration was 25.3 ±0.7 hr in group 1, 35.4 ±0.2 hr in group 2 (p<.05 compared to group 1) and 31.2 ±0.8 hr in group 3 (p <.05 compared to group 1). Hemodynamic variables, coagulation profile, and platelet counts were stable and not different between groups. In the extracorporeal circulation platelet function was inhibited significantly in all groups. In systemic blood no changes in platelet function were documented. No major bleeding complications were observed in any patient. During the study period blood urea nitrogen and creatinine concentrations decreased significantly in all groups.

Anticoagulation with heparin and PGE1 proved successful and is comparable to standard anticoagulation regimens using heparin and prostacyclin. Higher doses of PGE1 provided longer hemofiltration duration without increasing side effects. Anticoagulation using equipotent doses of PGE1 costs 1/3 less than using prostacyclin.
In Australia continuous venovenous hemodiafiltration (CVVHD) has been proposed as the optimal therapy for acute renal failure in critically ill patients. The introduction of this continuous pump driven dialysis has created a demand for critical care nurses in Australia to competently and efficiently manage CVVHD circuits. In our Intensive Care Unit at Flinders Medical Centre, it is the critical care nurses’ responsibility to manage and recognize potential complications of CVVHD. Despite the popularity of CVVHD, there are no uniform guidelines for circuit management and monitoring.

**Purpose of the Study:** To evaluate methods monitoring circuit function which included circuit pressures, creatinine clearance (CrCl) and urea ratio (UR), and subsequently develop a protocol for bedside nurses to use in the management of CVVHD.

**Methods:** Circuit pressures (pre-filter, post-filter) and the pressure gradient (P-grad) (mean pre-filter pressure minus mean post-filter pressure) were recorded continuously. CrCl and UR were measured three times daily and circuit flow was routinely set at 200 mls per minute. Forty-one hemofilters in six patients with a mean (SD) duration of 30 (28) hours were studied.

**Results:** The patterns of circuit cessation identified were:
1. Hemofilter clotting (63%): P-grad increased from 56 (13) at circuit commencement to 149 (61) mmHg prior to cessation. This was associated with a fall in CrCl (19.0 to 14.7 mls/min; p <0.01) and UR (0.96 to 0.79; p <0.01).
2. Venous bubble trap clotting (7.5%): sustained rise in post-filter pressure without a rise in P-grad.
3. Vascath return obstructions (2.5%): characterized by transient rises in pre or post filter pressures without a rise in P-grad or change in CrCl or UR.
4. Elective Discontinuation (15%): Elective discontinuation due to the patients going to the operating room or to radiology.
5. Unknown (12%): no causes were found for cessation. All circuits diagnosed as failing because of hemofilter or venous bubble trap clotting had visible clot present. However, visible clot was not specific and frequently present before circuit pressures demonstrated increasing resistance. The resistance across the filter measured by P-grad often rose rapidly in the hours prior to cessation of a clotting filter.
The 99% confidence intervals for the rise in P-grad in clotted and unclotted filters were widely separated. The lower limit of 99% confidence interval for P-grad for clotted filters was 59 mmHg and the upper limit for unclotted filters was 25 mmHg.

**Conclusion:** A rise in P-grad above 25 mmHg from baseline P-grad will accurately differentiate a clotted from unclotted filter with an accompanying decrease in function as measured by CrCl and UR. Routine measurement of P-grad is a useful bedside monitor of filter function because it: allows for removal of an inefficient filter, enables a planned approach to nursing care, allows return of circuit blood to the patient, is cheaper than CrCl and UR, and easy to use.

<table>
<thead>
<tr>
<th></th>
<th>Urea Ratio Fall</th>
<th>CrCl Fall</th>
<th>P-grad Rise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clotted Mean (SD)</td>
<td>0.19 (0.14)</td>
<td>4.3 (2.8)</td>
<td>89 (59)</td>
</tr>
<tr>
<td>Unclogged (SD)</td>
<td>0.08 (0.12)</td>
<td>0.4 (1.8)</td>
<td>4 (24)</td>
</tr>
<tr>
<td>P-value (2-sample t-test)</td>
<td>&lt;0.05</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
95/004: PLASMA-FREE HEMOGLOBIN LEVELS DURING CONTINUOUS VENOVOUS HEMODIAFILTRATION

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In Australia continuous venovenous hemodiafiltration (CVVHD) has become standard renal replacement therapy for critically ill patients with acute renal failure. Maximizing circuit life and maintaining patient safety are important management objectives. Extracorporeal circuits, such as extra corporeal membrane oxygenators can cause intravascular hemolysis, resulting in an increase in plasma-free hemoglobin concentrations [PFHb]). High circuit pressures and the presence of blood clots have been associated with hemolysis resulting in replacement of these circuits. In CVVHD however, hemolysis has not been reported as a primary factor in considering such a circuit change. Often during CVVHD high circuit pressures are encountered as the circuit clots. We were concerned these high circuit pressures may be associated with significant intravascular hemolysis and any resulting rise in [PFHb] may further prolong renal dysfunction.

**Purpose of the Study:** The purpose of this study was to determine if circuit life, maximum circuit pressures and clotted filters directly effected [PFHb] during CVVHD.

**Methods:** Pre- and post-filter pressures were measured continuously in 26 hemofilters with a mean (SD) duration of 31 (38) hours. Calculation of the pressure gradient (P-grad) across the filter (mean pre filter pressure minus mean post filter pressure) was used to distinguish clotted and unclotted filters. One hundred and five plasma samples in 8 patients were collected in duplicate on commencement and thereafter daily for PFHb analysis. They were also collected when a rise in P-grad of 26 mmHg occurred, when post-filter pressures exceeded 250 mm Hg and on cessation of each circuit. Estimation of PFHb was by a rate spectrophotometric method. The normal range of PFHb using this method is less than 50 milligrams per litre.

**Results:**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Predicted rise in mean [PFHb] mg/L</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time up to 50 hours</td>
<td>-38</td>
<td>NS*</td>
</tr>
<tr>
<td>Time up to 100 hours</td>
<td>56</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Clotted filters: P-grad &gt; 26 mm Hg</td>
<td>31</td>
<td>NS</td>
</tr>
<tr>
<td>Peak circuit pressure: per mm Hg</td>
<td>1</td>
<td>NS</td>
</tr>
<tr>
<td>Hematocrit: per volume %</td>
<td>-0.20</td>
<td>NS</td>
</tr>
</tbody>
</table>

*Regression analysis; *NS not significant

**Conclusion:** There was a statistically significant rise in [PFHb] with duration of circuit life. This significant relationship could only be demonstrated when prolonged circuits, up to 100 hours were included in the analysis. Duration of circuit life up to 50 hours had no significant effect on [PFHb]. The rise in [PFHb] with circuits lasting
more than 50 hours was small and clinically insignificant. However, we can recommend the safe continuation of a CVVHD circuit up to fifty hours without a concern for hemolysis despite high circuit pressures. The results of this study have allowed the bedside nurse to confidently continue with a CVVHD circuit up to fifty hours without a concern for hemolysis. Maximum circuit life implies maximum patient safety, thus optimizing the outcome for the patient and increasing the cost effectiveness of CVVHD.
95/005: MODIFIED PROTOCOL FOR REGIONAL CITRATE ANTICOAGULATION IN HIGH EFFICIENCY CONTINUOUS VENO-VENOUS HEMODIALYSIS (CVVHD)

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Regional citrate anticoagulation (RCA) has been used as an alternative to heparin in various types of continuous hemodialysis. RCA is advantageous in patients with contraindications to systemic heparinization and may have an overall lower bleeding complication rate. We proposed that a modification of the dialysate described by Mehta et. al. would facilitate high efficiency continuous hemodialysis.

We designed a dialysate that would allow higher flow rates for increased clearance during veno-venous continuous hemodialysis. Fifteen liters of reverse osmosis water is passed through an F-8 filter and collected in a sterile bag. Under sterile conditions 130 meq/L of NaCl, 1.5 meq/L MgCl, and 0 to 4.0 meq/L KCl was added to the dialysate. The dialysate flow and ultrafiltration rate are regulated by pre and post-filter pumps. A 4% solution of trisodium citrate is infused pre-filter and started at a rate of 150 cc/hr. The ACT is measured post filter, and citrate infusion is regulated to achieve an ACT between 150–200 sec. A 3.33% CaCl 2 solution is infused via central line at a rate of 10 mL/hr and regulated to achieve a normal ionized calcium. Labs were drawn each hour for four hours, then every 6 hours.

The modified citrate protocol was offered to five patients. All patients had contraindications to systemic anticoagulation, were on CVVHD, and had frequent clotting of the circuit (more than three filters a day). All five patients had liver failure, one had active gastrointestinal bleeding. The average laboratory values before beginning citrate were: Na+ 133 mmol/dl (121–140), K+ 4.5 mmol/dl (5.0–4.0), HCO3 22 mmol/dl (18.5–26), Ca++ 1.27 mmol/dl (1.20–1.48), Mg++ 2.3 mg/dl (1.9–2.8), pH 7.37 (7.29–7.46), BUN 54 mg/dl (37–66), Creatinine 3.6 mg/dl (2.3–4.1), Glucose 192 mg/dl (172–333), Bilirubin 9.6 mg/dl (3.7–19.1), ACT 142 (120–180). The average laboratory values after citrate were: Na+ 136 mmol/dl (131–139), K+ 4.2 mmol/dl (3.9–4.6), HCO3 -24 mmol/dl (18–27), Ca++ 1.2 mmol/dl (1.05–1.34), Mg++ 2.5 mg/dl (2.3–2.6), pH 7.38 (7.35–7.44), BUN 46 mg/dl (31–66), Creatinine 3.2 mg/dl (2.2–4.1), Glucose 242 mg/dl (161–484), Bilirubin 12.1 mg/dl (4.5–28), ACT 173 (155–224). One patient required administration of HCl for mild metabolic alkalosis (0.2 N HCl at 25 cc/hr) over a 24 hour period. The average clearance was 35 ml/min. The average dialysis inflow rate was 1700 ml/hr. and the average outflow rate was 1900 mL/hr. The average ultrafiltration was 200 mL/hr. The Qb was set at 200 ml/min, and all patients were treated with F5 filters. All filters were patent for 48 hours.

Our modified citrate protocol allows the nephrologist to make large quantities of dialysate using standard dialysis reverse osmosis water. Higher continuous dialysis flow rates increase efficiency without the use of pre-filter dilution techniques. The only systemic metabolic abnormality with our modified protocol was an alkalosis, which is an easily treated complication in any dialysis involving citrate anticoagulation. Further studies are required to determine the cost effectiveness of regional citrate anticoagulation in continuous veno-venous hemodialysis.
**95/006: CONTINUOUS RENAL REPLACEMENT THERAPY WITH REGIONAL CITRATE ANTICOAGULATION IN CRITICALLY ILL CHILDREN**

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**Introduction:** Continuous renal replacement therapy (CRRT) has been shown to be effective in the treatment of acute renal failure in children. However, the need for systemic heparinization has limited the application of CRRT to some patients. Recently a system of regional anticoagulation has been described which avoids heparin by using of citrate as an anticoagulant; this technique has been successfully applied to adults. The purpose of this study was to determine if CRRT with regional citrate anticoagulation can be used in children with acute renal failure.

**Patients:** The average age was 7.6 years (range 1 to 16 years). Underlying diagnoses were postoperative Fontan procedure, postoperative lung transplant, acute monocytic leukemia and meningococcemia.

**Methods:** A dual lumen venous catheter was used for vascular access. Blood was pumped using a BSM-22 Hospal machine with a venous pressure monitor. Blood flow was 100 mL/minute/M². Pediatric tubing was used in patients weighing less than 30 Kg. A polyacrylonitril AN69S hemofilter was employed. Four percent trisodium citrate was infused into the arterial line in order to anticoagulate the extra-corporeal circuit. The citrate infusion rate was adjusted to keep the activated clotting time between 180 and 220 seconds. An infusion of calcium chloride (0.74% in normal saline) was given to maintain the ionized calcium in the normal range. A special dialysate was used as previously described (Kidney International 38: 976–981, 1990). Dialysate flow was 10–14 ml/minute/M².

**Results:** CRRT with regional citrate anticoagulation was performed in four children with acute renal failure for a total of 78 days. Average CRRT urea clearance was 21.4 ml/minute/M². Average ultrafiltration rate was 8.9 ml/minute/M². During CRRT the average serum chemistries were: creatinine 1.3 mg/dl, BUN 49.9 mg/dl, sodium 141 meq/L, potassium 4.0 meq/L, magnesium 1.87 meq/L and glucose 192 mg/dl. Average PH was 7.37 and base excess -0.3 meq/L. Average ionized calcium was 1.18 mmol/L. The average dialyzer sieving coefficient was well maintained at 0.96. The duration of CRRT ranged from 9–34 days. Transient metabolic alkalosis was observed in two patients and was corrected by adjusting the flow rates of citrate and dialysate. Three of the four patients survived the acute episode.

**Conclusion:** CRRT with regional citrate anticoagulation is an efficient and safe procedure for treating critically ill children with acute renal failure without the risks of systemic heparin administration.
CRRT
The First International
Continuous Renal Replacement Therapies
Conference
San Diego, California

95/007: HIGH DIALYSATE INFLOW RATE CONTINUOUS ARTERIOVENOUS HEMODIAFILTRATION
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Objective: The patients who are kept on continuous arteriovenous hemodiafiltration (CAVHD) for 24–72 hours will suffer from great pain and the procedure per se can induce the release of cytokines (TNF-α and IL-1 etc). For the purpose of overcoming these disadvantages, we designed a high dialysate inflow rate CAVHD (high Qd CAVHD) with still keeping the feature of bedside use.

Design: Experimental protocol (in vitro study): High Qd CAVHD was performed using polysulfone hollow fiber filters (YT-40 ps, Ning-Bo, CHINA) and the plasma was collected from MSOF patients, who were treated by plasma exchange. The plasma flow rate was fixed at 100 ml/min and the dialysate inflow rate varied from 15 to 250 ml/min. Clinical study 45 patients with ARF, suffering from multiple system organ failure (mean number of system organ failure 3.3 ±0.3, range 2–6) receiving high Qd CAVHD. Blood flow rate and dialysate inflow rate were both 100 ml/min.

Main Results: Clearance of any substance was designed as uv/p (where u and v are dialysate concentration and volume, respectively and p was the mean plasma concentration over the clearance period). In vitro study: when Qd was 15 ml/min, the clearance of urea, creatinine and uric acid was 14.7 ±1.5, 15.0 ±1.4 and 14.9 ±1.7 ml/min respectively. When Qd increased to 100 ml/min, these parameters increased to 45.6 ±1.3, 45.7 ±1.4 and 53.0 ±1.6 ml/min. Of Qd exceeds 150 ml/min, the clearance decreased conversely. These findings suggest that the optimal plasma flow rate and dialysate inflow rate were both 100 ml/min. The efficiency of high Qd CAVHD for six hours was the same with 24 hs of conventional CAVHD. In vivo study: Serum urea and creatinine levels rapidly declined six hours after Qd CAVHD. (urea 45.4 ±2.4 to 30.3 ±1.4 mmol/L, P <0.01 and creatinine 592 ±28 to 350 ±23 mmol/L P <0.01) C BUN and Ccr was 41.1 ±2.8 ml/min and 47.5 ±3.2 ml/min, respectively. Controlled steady-state levels kept below 30 mmol/L with full protein alimentation. Significant electrolyte derangements could be easily corrected and maintained within normal limits. High Qd CAVHD also allowed rapid removal of excess body water (up to 1 liter/h).

Conclusions: These studies suggest that high Qd short duration (6 hours/day) CAVHD replacements a significant advance in the management of critically ill patients with ARF and may contribute to improve survival.
95/008: NAFAMOSTAT MESILATE IS THE FIRST CHOICE ANTICOAGULANT FOR CONTINUOUS RENAL REPLACEMENT THERAPY

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Continuous renal replacement therapy (CRRT) has become an essential therapeutic modality in critical care. However, the bleeding complications caused with continuous administration of either heparin or low molecular weight heparin (LMWH) as anticoagulants have been the most serious and inevitable complications long-term CRRT. The incidences of bleeding complications caused with heparin and LMWH during CRRT were 67% and 29%, respectively. On the other hand, Nafamostat Mediate (NM), a synthetic protease inhibitor, has potent inhibitory activity in coagulation-fibrinolysis system and was reported to be a safe anticoagulant for hemodialysis patients with high bleeding tendency. This study was undertaken to investigate the efficacy of NM as anticoagulant for CRRT and also to establish the optimal dose of the drug to perform continuous hemofiltration (CHF) and continuous hemodiafiltration (CHDF) for critically ill patients.

Between November 1987 and June 1995, the number of patients treated with CRRT using NM as anticoagulant was 199, including 31 treated with CHF and 168 treated with CHDF. Activated coagulation time (ACT) was applied as a monitoring of anticoagulation, and we tried to keep ACT of arterial blood to be 150 seconds during CHF and CHDF, considering uncoagulability during extracorporeal circulation, the avoidance of bleeding complications and the life time of a hemofilter. The incidence of bleeding complications and the administration rate of NM to maintain ACT 150 seconds during CHF and CHDF were studied. The correlation between ACT and blood concentration of NM was also studied.

The bleeding complications due to prolonged administration of NM occurred in 22 (11%) cases, including 1 (3%) case treated with CHF and 21 (12.5%) cases treated with CHDF. There was a significant difference in bleeding incidences between the CRRT cases with NM and those with heparin (p <0.01), and between the CRRT cases with NM and those with LMWH (p <0.05). However, hazardous complications compelling to cease from CRRT occurred only in 7 (3.5%) cases. The infusion rates of NM to maintain ACT around 150 seconds during CHF and CHDF were 0.1 mg/kg/hr and 0.3 mg/kg/hr, respectively. There is a significant correlation between ACT and blood concentration of NM.

Considering low bleeding incidence and easy adjustability of ACT, we conclude that NM is the first choice anticoagulant for CRRT.
95/009: COMPETENCY BASE CONTINUOUS RENAL REPLACEMENT THERAPY EDUCATION

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The University of Louisville’s Acute Dialysis Unit (ADU) established an education program for the Intensive Care Unit (ICU) nurses. This program focuses on Continuous Venovenous Hemofiltration and Continuous Venovenous Hemodiafiltration (CVVH/D). The purpose of this program is to enhance the knowledge base and confidence level of the ICU nurses in caring for the patient receiving CVVH/D.

Our competency-based program was developed to assure a standard level of proficiency in delivering care to the patient requiring CVVH/D. Our objectives, respectively, are: 1) demonstrates understanding of nephrology terms related to CVVH/D, 2) demonstrates understanding of components of the CVVH/D system, and 3) demonstrates skill in the mechanics of the CVVH/D pump.

The ICU nurse attends an initial inservice detailing the above objectives. An ICU nurse also is given an opportunity to practice hands-on skills with the Hospal BSM 22 system. Each nurse is given a review of the system at the bedside when caring for a patient receiving CVVH/D. The ADU nurse will complete a competency checklist when the ICU nurse has met the above objectives.

With reinforced learning, the ICU nurse becomes comfortable with the Hospal BSM 22 and the CVVH/D flowsheet. This helps to ensure accurate flow sheet and Hospal pump readings. It also allows for shorter nurse reaction times when there is a change in the status of the patient receiving CVVH/D on the Hospal system. The Hospal BSM 22 is set up and primed by the ADU nurses. These nurses are available to the ICU nurses twenty-four hours a day. The pump, replacement fluids, and intake and output flow sheet is then maintained by the ICU nurse. Caring for a patient receiving CVVH/D requires critical care knowledge and skills as well as a knowledge base in the mechanics and principles of CVVH/D.

Our competency-based education program has greatly enhanced the confidence the ICU nurses have in caring for the critical patient on CVVH/D. They have also shown a broader knowledge base of the principles and mechanics of CVVH/D and the Hospal BSM 22.
95/010: OVERCOMING BARRIERS TO IMPLEMENTATION OF A CONTINUOUS VENOVENOUS HEMODIALYSIS PROGRAM

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University of Toronto, Toronto, Canada

Overcoming resistance to change in a large institution is often a challenge when implementing a complex new program such as continuous venovenous hemodialysis (CVVHD). The Toronto Hospital (TTH) is a large tertiary care academic teaching hospital. It was formed by the merger of the former Toronto General (TG) and Toronto Western (TW) Hospitals; the nephrology programs merged in 1990. Although a well developed CVVHD program was underway at TW, the merger moved all inpatient beds and most acute renal failure patients to the TG site. Initial efforts to bring CVVHD to the TG site were met with resistance. The ICU nursing managers wanted evidence of clinical benefit before accepting a change from the recently established continuous arteriovenous hemodialysis (CAVHD) program. There were also concerns about the complexity and safety of the blood pump and dialysis equipment (Hospal BSM 22 and large homemade dialysate delivery system). Another concern from hemodialysis (HD) and ICU perspectives was about the substantial costs and other difficulties associated with training and maintaining skills in a potential group of more than 200 ICU nurses in 5 physically distinct ICU’s. Simultaneously, a large budget deficit was discovered at TTH and all new and expanded programs were suspended. Efforts to implement CVVHD were abandoned.

In 1993, a commercial manufacturer approached TTH with a prototype continuous renal replacement therapy (CRRT) machine that it wished to pilot test (Prisma - Hospal-Gambro). This was successfully accomplished in the spring of 1994 with the cooperation of the HD and ICU nurses, who were secure in the 24 hour on-site backup initially provided by the company. At that time 6 HD and 10 ICU nurses were trained. During this pilot test an expert academic nephrologist visited TTH and helped generate interest and enthusiasm within the division of nephrology. Finally, retroactive funding from the Ontario Ministry of Health, meant to cover budgetary deficits for dialysis treatments already performed because of local expansion pressures, made possible the purchase of 3 Prisma machines.

Because of the successful pilot test, and impressed with the user friendly equipment and clinical benefits of CVVHD compared to CAVHD, the various hospital personnel were now ready to accept a change to CVVHD. Policies and procedures were developed. Between January and March 1995, a program of nursing education and certification was developed and completed. All HD nurses (N = 50) received a 3 hour workshop incorporating theory and practice, then were required to demonstrate proficiency with the CVVHD system and pass a written test. A similar experience was provided for approximately 90 ICU nurses from 2 ICU’s, with a 6 hour workshop. The costs of training the HD nurses was paid for out of the HD budget, while it was agreed that the costs of training ICU nurses would be split between HD and the individual ICU’s. The first CVVHD patient was established on March 14, 1995. As of July 14, 1995, CVVHD treatments had been performed on 16 patients. The clinical results are reported separately at this meeting. HD nurses set up the circuit, perform daily assessments, and are available for problems during working hours Monday to Saturday. ICU nurses monitor the treatment, manage dialysate and effluent bag changes, and respond to alarms. Acceptance has been very positive. Some problems remain. These include: 1) a subset of nurses who still are uncomfortable with CVVHD. 2) technical staff who feel their understanding of the
Prisma machine is suboptimal, and 3) occasional conflict between critical care physicians and nephrologists over dialysis orders.

Barriers to implementation of CVVHD exist. Once identified, measures to confront and overcome them can be designed and carried out. At TTH, an actual demonstration of the pumped Prisma CRRT system in action, highlighting safety and ease of use, combined with theory was effective in convincing hospital personnel to embrace this technology.
95/011: COAGULATION PARAMETERS AND LONGEVITY OF CIRCUITS IN CONTINUOUS VENO-VENOUS HEMODIAFILTRATION

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Department of Critical Care Medicine, Flinders Medical Centre, South Australia

Systemic anticoagulation with heparin is the most common method of maintaining the extracorporeal circuits in continuous renal replacement techniques. The appropriate balance between prolonging circuit life thereby achieving cost-effective dialysis and the risk of hemorrhage remains the greatest challenge in CVVHD in critically ill patients. Thrombocytopenia, impaired platelet function due to renal failure and drugs and coagulation factor deficiency due to impaired synthesis or intravascular consumption are all common in critically ill patients and further anticoagulation can readily cause life-threatening hemorrhage. For this reason heparin free CVVHD is being increasingly reported in these coagulopathic patients. Despite the widespread application of CVVHD there are no guidelines for the degree of anticoagulation required or the coagulopathy consistent with adequate heparin free circuit life.

Thromboelastography (TEG) provides a bedside analysis of global coagulation and fibrinolysis. This mechanical measure of the rate of formation, magnitude and lysis of blood clot elasticity has been utilized in the setting of coagulopathies associated with major surgery. TEG generated indices reflect factor activity, heparinization and importantly platelet number and function. Therefore the TEG is likely to quantify the coagulation status of critically ill patients better than conventional parameters.

**Purpose of the Study:** To evaluate the correlation between TEG (reaction time (r), coagulation time (K), clot formation rate (a), maximum amplitude (MA)) and conventional coagulation parameters (APTT, INR and platelet count) and circuit life.

**Methods:** TEG’s were performed at the commencement and thereafter daily for each circuit. APTT, INR and platelet count were measured at commencement and thereafter three times daily. Other factors thought to affect filter life: hematocrit, heparin dose and blood product transfusion were recorded. Circuit clotting was defined as a rise in the pressure gradient across the hemofilter of >25 mmHg. The circuit was a Gambro System AK10 type BMM10-1 blood monitor with a hollow fibre hemofilter (AN 69). Circuit flow, was 200 ml/min and patients without active bleeding, or any contraindication to heparin were anticoagulated with heparin aiming for an APTT of 40–80 sec (control 25–29 sec).

**Results:**
**Conclusion:** There was a significant correlation between the starting APTT and the TEG parameters $r$ and $K$ only. There was a poor correlation between platelet count and TEG parameters. This would suggest that impaired platelet function is an important feature in these patients. The TEG parameter $K$, which is said to reflect intrinsic pathway and platelet function, was the only coagulation parameter to be correlated with circuit duration. The TEG may be a useful method of predicting circuit life, particularly to identify which patients need heparinization.

### Correlation between starting TEG and conventional parameters

<table>
<thead>
<tr>
<th></th>
<th>APTT</th>
<th>INR</th>
<th>Platelets</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r$</td>
<td>0.410*</td>
<td>0.147</td>
<td>0.302</td>
</tr>
<tr>
<td>$p$</td>
<td>0.005</td>
<td>$&gt;0.05$</td>
<td>0.046</td>
</tr>
<tr>
<td>$K$</td>
<td>0.340</td>
<td>0.097</td>
<td>0.254</td>
</tr>
<tr>
<td>$p$</td>
<td>0.032</td>
<td>$&gt;0.05$</td>
<td>$&gt;0.05$</td>
</tr>
<tr>
<td>$MA$</td>
<td>0.112</td>
<td>$-0.107$</td>
<td>0.023</td>
</tr>
<tr>
<td>$p$</td>
<td>$&gt;0.05$</td>
<td>$&gt;0.05$</td>
<td>$&gt;0.05$</td>
</tr>
</tbody>
</table>

*Pearson coefficient

### Correlation between coagulation parameter and duration of clotted circuits

<table>
<thead>
<tr>
<th></th>
<th>$K$</th>
<th>$\alpha$</th>
<th>MA</th>
<th>APTT</th>
<th>INR</th>
<th>Platelets</th>
<th>Hematocrit</th>
<th>Heparin dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r$</td>
<td>0.358*</td>
<td>0.756</td>
<td>$-0.290$</td>
<td>$-0.064$</td>
<td>$-0.121$</td>
<td>0.077</td>
<td>0.041</td>
<td>0.094</td>
</tr>
<tr>
<td>$p$</td>
<td>0.056</td>
<td>$&lt;0.0001$</td>
<td>$&gt;0.05$</td>
<td>$&gt;0.05$</td>
<td>$&gt;0.05$</td>
<td>$&gt;0.05$</td>
<td>$&gt;0.05$</td>
<td>$&gt;0.05$</td>
</tr>
</tbody>
</table>
95/012: CITRATE ANTICOAGULATION IN CONTINUOUS RENAL REPLACEMENT THERAPY

Madeleine V. Pahl, Haejung Lee, Maria Pascual, Gianna Scannell, Gail Tominaga, Ken Waxman

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Systemic heparinization is the preferred form of anticoagulation in continuous renal replacement therapies (CRRT). However, systemic heparinization may be contraindicated in patients with bleeding complications due to multiple trauma. Recently, regional citrate anticoagulation has been used in CAVHD. We report our experience using saline, heparin or regional citrate anticoagulation on 18 patients treated with CRRT at the Univ of Calif, Irvine from July 1993–June 1995. Thirteen patients (mean age 45.4 yrs) were admitted with multiple traumatic injuries, two with sepsis, one with myocardial infarction and one with hepatic failure. The mortality rate was 83% (15/18). Four patients were treated with CAVHD, 10 with CVVHD and 4 with both modalities. All patients were treated with polysulfone filters and access to the circulation was achieved through standard catheters. Heparin therapy was avoided in those patients with multiple trauma, recent surgical intervention or in whom bleeding was an ongoing problem. Anticoagulation was provided with pre-filter heparin or 4% trisodium citrate infusion. In the citrate treated patients a calcium chloride infusion was instituted to maintain a normal ionized serum calcium. 0.9% saline was used as replacement fluid and a calcium free, base free dialysate with a 117 meq/L sodium concentration was used. Standard replacement fluid was the source of saline flushes in those patients receiving no anticoagulation and Dianeal 1.5% was the dialysate used in the saline and heparin treated patients.

<table>
<thead>
<tr>
<th></th>
<th>Saline</th>
<th>Heparin</th>
<th>Citrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Pts</td>
<td>12</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Treatment days</td>
<td>6.9 ± 6.3</td>
<td>4.8 ± 2.9</td>
<td>8.14 ± 7.0</td>
</tr>
<tr>
<td>No. of filters</td>
<td>6.33 ± 5.2</td>
<td>5.67 ± 3.0</td>
<td>3.57 ± 2.9</td>
</tr>
<tr>
<td>Filter duration (hrs)</td>
<td>20.1 ± 17.6</td>
<td>15.6 ± 13.2</td>
<td>55.4 ± 40.5</td>
</tr>
<tr>
<td>Sieving coefficient</td>
<td>0.56 ± 0.16</td>
<td>0.57 ± 0.18</td>
<td>0.63 ± 0.13</td>
</tr>
</tbody>
</table>

Four patients treated with citrate developed alkalemia (pH 7.45) and as a result one had citrate discontinued and was anticoagulated with heparin. Ionized calcium was maintained at a mean of 1.14 ± 0.13 mmoles/L. No other complications were noted in the citrate treated patients. No patient had heparin therapy discontinued due to bleeding. In summary, CRRT can be done successfully with different modalities of anticoagulation. Citrate is a safe and efficient mode of anticoagulation for CRRT associated with improved filter life and sieving coefficients.
95/013: IV PUMP CONTROLLED ULTRAFILTRATE IN CVVH: DIGITAL VALUES VERSUS MEASURED VOLUME AND RELATIONSHIP TO ULTRAFILTRATE PRESSURE

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Introduction: The use of an IV pump to control/measure the ultrafiltrate (UF) in CVVH has the advantages of being a closed system and of allowing prospective management of fluid balance.

Objective: To assess the accuracy of the IMED PC2 Gemini pump with a 2 litre/hr UF generation by comparing the measured hourly volume (actual) to the pump digital readout. To ascertain whether such accuracy was related to pressure in the ultrafiltrate line.

Hypothesis: we hypothesized that pump accuracy may not be within operatively acceptable limits and that such accuracy correlates with UF pressure.

Methods: CVVH with Filtral 8 (Hospal-Gambro) haemofilter, using predilution, at blood pump speed 200 mls/min.

Hourly measures of the UF volume were compared to the digital readout and ultrafiltrate pressure measured in mmHg via a transducer leveled to the filter UF port. IV pump accuracy was validated in vitro by a BIOTEK-IDA2 infusion device analyser.

Subjects: 7 filters over 142 hours of continuous monitoring.

Results:

<table>
<thead>
<tr>
<th>Filter no.</th>
<th>Filter Life (hrs)</th>
<th>hrs UF press. +ve.</th>
<th>Mean discrepancy (mls/hr)</th>
<th>24 hr discrepancy (mls)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11</td>
<td>3</td>
<td>+52</td>
<td>+1248</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>1</td>
<td>+110</td>
<td>+2640</td>
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<tr>
<td>3</td>
<td>51</td>
<td>1</td>
<td>+81</td>
<td>+1944</td>
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<tr>
<td>4</td>
<td>19</td>
<td>3</td>
<td>+63</td>
<td>+1512</td>
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<td>5</td>
<td>6</td>
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<td>6</td>
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<td>4</td>
<td>+81</td>
<td>+1944</td>
</tr>
<tr>
<td>7</td>
<td>14</td>
<td>0</td>
<td>+57</td>
<td>+1368</td>
</tr>
</tbody>
</table>

Mean. 21 hrs 3.5 hrs +73 mls +1765 mls

No significant correlation between UF pressure and measured discrepancy.
Conclusion: Measured volume is frequently greater than digital value during CVVH with UF pump control. This discrepancy has no correlation with the UF pressure) and results in a greater than anticipated fluid removal. This must be considered in managing the patient fluid balance over a 24 hour period.
THE EFFECT OF FILTER CONFIGURATION ON EXTRACORPOREAL CIRCUIT LIFE DURING CONTINUOUS VENO-VENOUS HEMOFILTRATION

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Introduction: Haemofilters with a flat plate configuration have been associated with better creatinine clearance when compared to hollow fibre filters in continuous hemodiafiltration systems without ultrafiltrate control. It is unknown, however, whether the decreased resistance to blood flow offered by a flat plate configuration also results in improved extracorporeal circuit life.

Objective: To study the effect of filter configuration on extracorporeal circuit life during continuous veno-venous hemofiltration (CVVH) with ultrafiltrate control.


Results: Seventeen circuits were randomized to flat-plate filters and twenty-one to hollow fibre filters. Mean circuit life was 14 h and 45 minutes for flat-plate filters and 17 h and 7 minutes for hollow-fibre filters (p <0.109). There were no significant differences between the two groups in INR, APTT, platelet count and hemoglobin, confirming their comparability. No significant correlation was found between circuit life and clotting parameters but the platelet count inversely correlated with circuit life (p <0.018). Circuit failure was due to reasons other than filter clotting in 18 out of 38 cases. Venous air chamber clotting was particularly important with circuit failure being due to it in 9 cases (23%).

Conclusions: Flat plate filters do not provide a circuit survival advantage during CVVH with ultrafiltrate control. So-called filter failure is often due to clotting of other components of the circuit. Further research should be directed at minimizing such problems.
95/015: THE EFFECT OF HEPARIN ADMINISTRATION SITE ON EXTRACORPOREAL CIRCUIT LIFE DURING CONTINUOUS VENO-VENOUS HEMOFILTRATION

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**Introduction:** An operatively acceptable extracorporeal circuit life is important to the successful application of continuous veno-venous hemofiltration. So far, attention has focused on filter clotting as the sole factor responsible for circuit failure. However, venous chamber clotting is also common and can lead to circuit failure in >20% of cases.

**Objectives:** To test the hypothesis that administration of heparin directly into the venous chamber might significantly reduce this problem and prolong circuit life.

**Methods:** Setting: Intensive care unit of a tertiary hospital. Subjects: Fifty-four filters in fourteen critically ill patients. Intervention: Controlled, cross-over randomization of filters to a standardized, heparin-based, anticoagulation protocol, delivered either 100% pre-filter (single site delivery) or 50% pre-filter and 50% directly into the venous chamber (double site delivery). Regular measurement of INR, APTT, platelet count and hemoglobin. Measurement of filter life and assessment of the cause for circuit failure.

**Results:** Twenty-eight filters were randomized to single site delivery and 26 to double site delivery. The two groups were comparable for INR, APTT, platelet count and haemoglobin values (NS). Circuits receiving single site anticoagulation had a mean life of 17 h and 1 minute vs. 17 h and 57 minutes for double site anticoagulation (NS). No correlation between filter life could be demonstrated for INR, APTT, and hemoglobin. The platelet count inversely correlated with circuit life (p <0.012). Venous chamber clotting caused circuit loss in 10 cases (18.5%) and occurred with equal frequency in both groups.

**Conclusions:** Anticoagulant delivery directly into the venous chamber has no impact on circuit life and chamber clotting during CVVH. Avoidance of venous chamber clotting remains an important management goal during CVVH and other strategies aimed at its prevention require scientific assessment.
95/016: TEMPORARY HEMODIALYSIS CATHETER RECIRCULATION STUDIES, A COMPARISON OF DESIGN AND SITE SELECTION

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Amount of therapy delivered has recently been recognized as an important factor in the treatment of acute renal failure. One variable which may have an impact on delivery of therapy is catheter recirculation. The amount of recirculation may vary with catheter design, catheter, composition, site selection and blood flow (Qb). As part of our quality assurance program we measured the amount of recirculation using Medcomp Silicone (S), and Vascath Polyurethane (PU) in the subclavian location and Medcomp Silicone (S), Vascath Polyurethane (PU), Arrow (Arr), and Quinton (Q) catheters at the femoral sites. Recirculation using the stop flow technique was measured in all catheters placed in the acute dialysis unit at Indiana University. The measurements were taken on the first dialysis run within the first 30 minutes of dialysis. When serial recirculations were measured at different blood flows, 15 minutes at the slower blood pump speed elapsed prior to repeat recirculation studies.

Site, catheter make, catheter length, ease of placement, patient sex and recirculation studies were prospectively recorded. Catheter selection was as follows:

<table>
<thead>
<tr>
<th>Site</th>
<th>Qb (S)</th>
<th>(PU)</th>
<th>(Arr)</th>
<th>(Q)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC</td>
<td>300</td>
<td>12</td>
<td>6</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Fem</td>
<td>200</td>
<td>7</td>
<td>3</td>
<td>5</td>
<td>19</td>
</tr>
<tr>
<td>Fem</td>
<td>250</td>
<td>11</td>
<td>2</td>
<td>5</td>
<td>22</td>
</tr>
<tr>
<td>Fem</td>
<td>300</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>6</td>
</tr>
</tbody>
</table>

SC- 20 studies in 20 catheters, Fem- 47 studies in 26 catheters.

Recirculation was significantly higher at all Qb at the femoral site vs the subclavian site at Qb = 300:

<table>
<thead>
<tr>
<th>Site</th>
<th>Qb</th>
<th>Recirc</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fem</td>
<td>200</td>
<td>12.8 +/- 13.2</td>
<td>0-32</td>
</tr>
<tr>
<td>Fem</td>
<td>250</td>
<td>24.5 +/- 18.0</td>
<td>1-57</td>
</tr>
<tr>
<td>Fem</td>
<td>300</td>
<td>24.7 +/- 19.0</td>
<td>2-44</td>
</tr>
<tr>
<td>SC</td>
<td>300</td>
<td>4.2 +/- 3.5</td>
<td>0-11</td>
</tr>
</tbody>
</table>
There was no difference in recirculation values at the SC position with varying catheter size, composition (S vs PU), or location (l vs r). With paired data on the same catheter at the femoral position, in all instances, recirculation at Qb 200 < Qb 250, and Qb 250 < 300. There was no significant difference in recirculation values for catheter size or location at the femoral position. While there was no significant difference between catheters of varying composition and design, at Qb = 200 S and Q had lower recirculation values than A and PU (8.4 ± 12 and 8.8 ± 7 vs. 17.8 ± 16 and 20.3 ± 17). In conclusion, the subclavian insertion site has less recirculation than the femoral site for dialytic therapy. At Qb = 200, there may be differences in recirculation rate by catheter design or composition. These differences should be considered when selecting a catheter and catheter insertion site for acute renal replacement therapies and intoxications.
95/017: ASSESSING NURSING COMPETENCY IN CONTINUOUS VENO-VENOUS HEMODIALYSIS

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Continuous veno-venous hemodialysis (CVVHD) is a highly technical therapy, requiring a baseline understanding of principles and psychomotor skills of both nephrology and critical care nurses. A competency-based assessment program was developed to assure a standard level of proficiency in delivering care to the patient requiring CVVHD. After delineating the role expectations of the nephrology and critical care nurses, competency-based performance criterion were written for each group. The criteria include the cognitive, psychomotor, and affective domains of performance.

The program consists of an exam to determine understanding of theories and principles, and a competency-based skills checklist for assessing technical and clinical skills. The exam and skills checklist can be used after initial training to certify staff in CVVHD, or as a pretest for nurses experienced with the therapy to assess additional learning needs. The competency-based program has helped to define the specific expectations and actions required of the nephrology and critical care nurse, resulting in fewer reported quality assurance variances and more consistent patient outcomes. The use of a competency-based assessment program is beneficial in determining adequate nursing performance and assuring a safe level of patient care.
95/018: A MODEL FOR IMPLEMENTING A CONTINUOUS RENAL REPLACEMENT THERAPY (CRRT) PROGRAM

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Continuous renal replacement therapy (CRRT) requires the coordination and cooperation of professionals from many disciplines. The authors have had the experience of implementing CRRT programs in three institutions, and have identified factors which are essential to a successful implementation. These factors have been integrated into a process composed of four steps: Initial Preparation, Disseminating Information, Initiation, and Evaluation/Follow-Up. The use of this model has had a positive effect in achieving program goals and coordinating multidisciplinary efforts when implementing a CRRT program. This in turn has promoted achievement of positive patient outcomes for patients on CRRT.
95/019: PHARMACOKINETICS OF GANCICLOVIR DURING CONTINUOUS VENOVENOUS HEMODIALFILTRATION (CVVHDF)

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Ganciclovir (DHPG) is frequently used in solid organ transplant patients for prophylaxis and treatment of CMV disease. A significant number of transplant patients post-operatively develop acute renal failure requiring dialytic therapy including CRRT. We evaluated the influence of CVVHDF on DHPG pharmacokinetics. Serum samples were obtained for DHPG concentration determination (RIA method) on two transplant patients (one lung/one liver) requiring both CVVHDF and DHPG therapy (1.25–2.5 mg/kg/d). Both patients had creatinine clearances less than 5 ml/min and underwent CVVHDF using HOSPAL AN69S filters, at a blood flow of 100 m/min, and with a mean ultrafiltration rate (UFR) of 10 ml/min. Serum samples were obtained just prior to and one hr after a one hr infusion on multiple occasions in each patient. Additionally, pre-filter (PRE), post-filter (POST) and ultrafiltrate (UF) samples were obtained at multiple dialysis flow (Qd) rates. DHPG saturation of dialysate/ultrafiltrate (Sa) was calculated as: [UF*2/(PRE + POST)]; and CVVHDF clearance (CL) as: Sa*(Qd + UFR). Total body clearances were estimated using a non-linear fitting program (TDMS). DHPG Sa and CVVHDF CLs were as shown.

<table>
<thead>
<tr>
<th>QD L/hr</th>
<th>n</th>
<th>UFR (ml/min)</th>
<th>Sa</th>
<th>CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>11</td>
<td>0.78</td>
<td>8.5</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>8.6</td>
<td>0.82</td>
<td>20.9</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>12.5</td>
<td>0.56</td>
<td>25.5</td>
</tr>
</tbody>
</table>

With Qds of 1–2 l/hr, CVVHDF accounted for more than half of each patient’s estimated total DHPG CL. In contrast to ultrafiltration alone (Qd = 0), dialysis removes a larger amount of DHPG through added diffusion. DHPG is readily cleared by CVVHDF and resulted in a doubling of the dose requirement for these two patients.
Flucytosine is commonly used in the treatment of serious fungal infections. The drug is a small molecule (MW = 129 daltons) with very limited binding to plasma proteins (<10%). These are characteristics that render the drug highly susceptible to efficient elimination by continuous renal replacement therapy. The removal of flucytosine was measured in a patient who received the drug for systemic candida infection while undergoing continuous renal replacement therapy for acute renal failure.

Five simultaneous arterial, venous and ultrafiltrate sample pairs were collected for flucytosine concentration determination. A bioassay using Saccharomyces cerevisiae was conducted in triplicate. Polysulfone and polyacrylonitrile membranes were used at different periods during the renal replacement therapy.

Ultrafiltrate/arterial drug concentration ratios (U/A) and sieving coefficients (SC) obtained with the polysulfone membrane [U/A = 0.81 ±0.16, SC = 0.81 ±0.14] were higher than those obtained with the polyacrylonitrile membrane [U/A = 0.54 ±0.06, SC = 0.53 ±0.04]. U/A ratios correlate well with SCs for both membranes [r = 0.992 and 0.991, respectively]. Between 2.54–22.56 mg of flucytosine were removed from the patient per hour when the serum drug concentrations were 21.1–126.5 mg/L. The amount of hemofiltration flucytosine removal were proportional to the ultrafiltration flow rate and the serum drug concentration. It was also different between the two hemofilter types. The mean ±SD hemofiltration flucytosine clearance for the polysulfone membrane was 77.0 ±15.6% of the ultrafiltrate flow rate while the percentage for the polyacrylonitrile membrane was 51.0 ±5.7.

Continuous renal replacement therapy can therefore remove an appreciable quantity of flucytosine especially when the ultrafiltrate flow rate is high. More than 50% of the administered dose may be removed from renal failure patients by continuous renal replacement therapy. Dosage supplementation may therefore be needed in these patients. Serum drug concentration determination is necessary to devise an optimal dosage regimen for patients receiving flucytosine while undergoing continuous renal replacement therapy.
95/021: HEMODIAFILTRATION IN PENTOBARBITAL POISONING
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Department of Intensive Care Medicine, Hotel-Dieu Hospital, Nantes, France

We report the use of continuous venovenous hemodiafiltration (CVVHD) in a case of massive ingestion of pentobarbital (20 g). A 33-yr-old man was found comatose (Glasgow score 3), with areactive midriasis, and cardiorespiratory arrest rapidly reversed after Dolethal overdose. The hemodynamic condition remained unstable with hypotension and oliguric. CVVHD was performed using a Hospal machine (BSM 22, Meysieu, France). The blood flow was 100 ml/min during the 17 st hours then increased to 150 ml/min. A 0.43 m 2 polyacrylonitrile flat plate filter (AN 69, Hospal, Meysieu, France) was used. The dialysate (Hemosol, Meysieu, France) flow was delivered at 1 l/hr. Blood samples and ultrafiltrate were simultaneous collected for pentobarbital concentration measurements (arterial (Ca), venous (Cv), and ultrafiltrate CUF)) every four hours. Clearance (Cl) and Sieving coefficient (S) were calculated.

Median clearance of P was 7.6 ml/min with a median S of 0.6. The total drug extraction with CVVHD was 2.7 g (15% of the total drug ingestion). CVVHD contributed to the elimination of the absorbed poison. The amount of epurated drug is higher than with intermittent dialysis techniques and hemoperfusion (8 to 13%) in spite of a lower clearance. We suggest therefore that CVVHD therapy can be used in severe pentobarbital poisoning with poor hemodynamic status. The performance of this treatment could be improved with even higher ultrafiltrate volume than the one used in our report.

<table>
<thead>
<tr>
<th>hour</th>
<th>0</th>
<th>4</th>
<th>8</th>
<th>13</th>
<th>17</th>
<th>21</th>
<th>2</th>
<th>6</th>
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<tr>
<td>Ca mg/l</td>
<td>176</td>
<td>196</td>
<td>160</td>
<td>144</td>
<td>131</td>
<td>138</td>
<td>140</td>
<td>135</td>
<td>85</td>
<td>114</td>
<td>71</td>
</tr>
<tr>
<td>Cv mg/l</td>
<td>168</td>
<td>187</td>
<td>155</td>
<td>139</td>
<td>123</td>
<td>118</td>
<td>127</td>
<td>134</td>
<td>62</td>
<td>84</td>
<td>65</td>
</tr>
<tr>
<td>C UF mg/l</td>
<td>79</td>
<td>130</td>
<td>79</td>
<td>72</td>
<td>81</td>
<td>73</td>
<td>67</td>
<td>76</td>
<td>61</td>
<td>62</td>
<td>48</td>
</tr>
<tr>
<td>S</td>
<td>0.46</td>
<td>0.68</td>
<td>0.5</td>
<td>0.5</td>
<td>0.64</td>
<td>0.57</td>
<td>0.5</td>
<td>0.56</td>
<td>0.83</td>
<td>0.63</td>
<td>0.7</td>
</tr>
<tr>
<td>Cl ml/min</td>
<td>7</td>
<td>5.95</td>
<td>4.27</td>
<td>5.25</td>
<td>11.2</td>
<td>11.51</td>
<td>5.75</td>
<td>7.41</td>
<td>10.9</td>
<td>7.49</td>
<td>7</td>
</tr>
</tbody>
</table>
95/022: PRELIMINARY STUDY ON MYOGLOBIN CLEARANCE WITH HIGH ULTRAFLTRATION RATE CONTINUOUS VENOVENOUS HEMOFILTRATION

Yves Thibeault, Martine Leblanc, Jean Cardinal
Hopital Maisonneuve-Rosemont, Universite de Montreal, Montreal, Canada

Myoglobin has a high molecular weight of 17 000 daltons and is poorly cleared by dialysis (diffusion). However, elimination of myoglobin might be enhanced by an epuration modality based on convection for solute clearances. Therefore, the purpose of our study was to evaluate the efficiency of high ultrafiltration rate continuous venovenous hemofiltration (CVVH) for myoglobin removal in a patient presenting anuric acute renal failure secondary to rhabdomyolysis (peak creatine phosphokinase level: 313 500 IU/L). The hemofilter was a 0.9 m² polyacrylonitrile (PAN) membrane Multiflow-100 (Hospal-Gambro) and the blood flow rate was maintained at 150 mL/min by an AK-10 pump (Hospal-Gambro). The ultrafiltration bag was placed 60 cm below the hemofilter and was free of pump control or suction device.

The plasma myoglobin concentration was 92 000 mg/L at CVVH initiation, and dropped to 28 600 mg/L after 18 hours of the continuous modality. The dialysate to plasma (D/P) ratio for myoglobin was 0.61 during the first six hours of therapy and the clearance of myoglobin was 22 mL/min with a mean ultrafiltration rate of 2153 ±148 mL/h. From 7 to 18 hours, the mean ultrafiltration rate was stable at 2074 ±85 mL/h, but the D/P ratio for myoglobin dropped to 0.40 yielding a myoglobin clearance of 14 mL/min. Contrary to myoglobin, the D/P ratio for urea, creatinine, and phosphorus remained stable at 1.0 during the 18 hours of CVVH. A total of 700 mg of myoglobin was removed by CVVH during the entire treatment.

In conclusion, considerable amounts of myoglobin can be removed by an extracorporeal modality allowing important convective fluxes and middle molecule clearances, such as high ultrafiltration rate CVVH using a PAN hemofilter. If myoglobin clearance is maintained at 22 mL/min, 32 L of plasma can be cleared per day. However, the D/P ratio for middle molecules such as myoglobin tends to decrease overtime probably from protein coating and/or blood clotting of the hemofilter. This process may cause a decrease in pore diameter, principally affecting convection and clearance of middle but not small molecules. Hemofilters should optimally be changed frequently if CVVH is used for myoglobin removal. However, it remains unknown at this point if CVVH, applied early, can prevent the occurrence or shorten the course of myoglobinuric acute renal failure.
95/023: CONTINUOUS HEMOFILTRATION IN CHILDREN WITH ABDOMINAL COMPLICATIONS OF HEMOLYTIC UREMIC SYNDROME

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Hemolytic uremic syndrome (HUS) continues being the most frequent etiology of oliguric acute renal failure among infants and small children in our country. In order to treat adequately the disturbances from renal failure, approximately one third of these patients will require a dialytic therapy, mainly peritoneal dialysis (PD). In a low percentage of these cases, PD may have relative or absolute contraindications, usually when HUS is associated to severe intra-abdominal complications. We describe our experience with pediatric patients affected by HUS and abdominal complications that required continuous hemofiltration.

Over the last three years we have admitted five (2 M:3 F) children (median 18, months, range 9–64 months) with HUS, oligoanuria and severe intra-abdominal complications: colonic necrosis and partial colectomy in three, intestinal intussusception and colonic ischemia in one, and severe enterococcal peritonitis post failed PD in one. In four patients, continuous arteriovenous hemofiltration (CA VH) from femoral artery to contralateral femoral vein was performed; in the fifth patient, we used continuous veno-venous hemofiltration (CVVH) trough a dual lumen catheter in the femoral vein. The hemofilters utilized were Renaflo 0.25 m² (Renal System, Minneapolis, USA), with continuous anticoagulation with heparin and prefilter dilution with a replacement solution in all of them; only one patient had a bleeding severe enough to require blood transfusion. No others important complications were attributed to the procedure. The duration of hemofiltration was x 47 hours (range 12– 80 hrs), requiring 1.2 filters per patient. Adequate control of volemia was achieved in every patient, and diafiltration was added in one patient to improve azotemia. The procedure was terminated due to improvement of renal function (diuresis) in three cases and transfer to PD in two. All patients were discharged from the hospital after an average of 30 days (range 12–55) from admission, including x 20.6 days in ICU (range 5–39). The follow up is still to short to evaluate long term renal outcome (<6 months in 2 cases).

In conclusion, our brief experience allow us to consider continuous hemofiltration (CAVH and CVVH) as a good alternative for acute renal replacement in children with intra abdominal complications associated to HUS.
95/024: FLUSH RESUSCITATION FOR TOXIC STREP. SYNDROME: CONTINUOUS HEMODIAFILTRATION FOR GAS TOXIC SHOCK

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University of Maryland/R Adams Cowley Shock Trauma Clinical Center, 22 S. Greene Street, Baltimore, Maryland, USA

Two patients with Group A streptococcus (gas) toxic shock syndrome have been successfully treated with continuous hemodiafiltration (CHD). The first patient, a male in profound septic shock from a leg wound, was very aggressively treated with fluids. He required CHD for management of fluid overload. Once CHD was initiated, he showed remarkable improvement in his cardiovascular performance and rapid reduction in the need for cardiotonic drugs.

A second patient was deliberately placed on CHD for refractory toxic shock. His pulmonary and cardiovascular performance improved almost immediately. Both patients survived.

Streptococcal toxins are of a size should be removable by CHD (molecular weights of 13,000–26,000). Further work is required to confirm the observation that CHD is effective for Toxic Strep Syndrome and to define the mechanism of its action.
**95/025: CONTINUOUS ARTERIOVENOUS HAEMOFILTRATION (CAVH) AND THE TREATMENT OF ADULT RESPIRATORY DISTRESS SYNDROME (ARDS) IN SEPTIC PATIENTS**

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**Objectives:** Evaluate the efficacy of CAVH in septic patients with ARDS and multiorgan dysfunction or failure.

**Material and Methods:** All the patients with sepsis, complicated with ARDS, were submitted to CAVH. All were ventilated with muscular relaxants and sedation with propofol. The thermodilution haemodynamic evaluation using a Swan-Ganz Corodyn™ catheter and the CAVH in femoral veins Gambro FH66 Kit™ were used in all of them. We analyse in general the age and sex, SAPSH, stay, admission diagnosis, PaO₂/FiO₂, cardiac index (IC), median blood pressure (PAM), pulmonary wedge pressure (PAWP), systemic vascular resistances (SVR), VO₂, DO₂, O₂ extractions (OER) and haemofiltration time. The evaluation was done in three phases: Phase 1 before the CAVH, phase 2 after 12 h with dobutamine and CAVH, and phase 3 after ending CAVH. We consider two patients groups: the survivors (S) and non-survivors (NS). We analysed and compared them.

**Results:**

<table>
<thead>
<tr>
<th></th>
<th>phase 1</th>
<th></th>
<th>phase 2</th>
<th></th>
<th>phase 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S</td>
<td>NS</td>
<td>S</td>
<td>NS</td>
<td>S</td>
</tr>
<tr>
<td>MAP</td>
<td>103.8 ± 25</td>
<td>91 ± 15</td>
<td>96.8 ± 27</td>
<td>91 ± 21</td>
<td>95 ± 23</td>
</tr>
<tr>
<td>CVP</td>
<td>16.2 ± 4.9</td>
<td>14.7 ± 7.4</td>
<td>12.1 ± 4.7</td>
<td>12.2 ± 3.7</td>
<td>15.8 ± 5.5</td>
</tr>
<tr>
<td>PAWP</td>
<td>15.2 ± 2.6</td>
<td>16.4 ± 4.3</td>
<td>14.6 ± 4.3</td>
<td>13.7 ± 4.4</td>
<td>17 ± 4.8</td>
</tr>
<tr>
<td>IC</td>
<td>7.5 ± 2.2</td>
<td>7 ± 3</td>
<td>6.9 ± 1.9</td>
<td>6 ± 2.5</td>
<td>7.7 ± 2.3</td>
</tr>
<tr>
<td>VO₂</td>
<td>191 ± 73</td>
<td>223 ± 87</td>
<td>208 ± 97</td>
<td>147 ± 18</td>
<td>240 ± 60</td>
</tr>
<tr>
<td>DO₂</td>
<td>834 ± 267</td>
<td>851 ± 345</td>
<td>760 ± 267</td>
<td>669 ± 174</td>
<td>1058 ± 267</td>
</tr>
<tr>
<td>OER</td>
<td>22.5 ± 7.8</td>
<td>23.7 ± 4.8</td>
<td>26.4 ± 4.2</td>
<td>24.5 ± 7.1</td>
<td>22.1 ± 3.2</td>
</tr>
<tr>
<td>PaO₂/FiO₂</td>
<td>141 ± 68</td>
<td>119 ± 62</td>
<td>231 ± 80</td>
<td>168 ± 28</td>
<td>231 ± 80</td>
</tr>
<tr>
<td>UF/H</td>
<td>885 ± 196</td>
<td>794 ± 109</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAVH</td>
<td>59.6 ± 23</td>
<td>180 ± 136</td>
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<td></td>
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</tbody>
</table>

**Conclusions:** When we met the Shomaeker objectives, the mortality and the prognosis were better. Those criteria were obtained with the traditional factor like dobutamine, but CAVH was an important measure. They seem to act...
synergistically in the optimization of the left ventricular work index, and fundamentally CAVH seems to have an important role in the improved respiratory evaluation. It is comproved the elimination of sepsis mediators, like FNT and IL-6 with haemofiltration. With our serie, we could say that CAVH, seems to be an optimal support or treatment measure, by preventing the evolution to multiorgan failure syndrome, and for that reason a better outcome.
95/026: CONTINUOUS RENAL REPLACEMENT THERAPY OF ACUTE RENAL FAILURE IN BURNS PATIENTS
Hans Furuland, Anders Hedlund1, Bjorn Wikstrom, Bo G. Danielson;
Renal Unit, Department of Medicine; 1Department of Plastic Surgery, University Hospital, Uppsala, Sweden

Between 1981 and 1992 30 patients with burns suffered acute renal failure. They were treated with either continuous arteriovenous hemofiltration or continuous arteriovenous hemodialysis (CAVH or CAVHD). The aim was to investigate retrospectively the effect of dialysis, the need for anticoagulation and survival. Outcome, complicating factors and mode of dialysis were studied.

**Method:** 26 patients were males, 4 females (mean age 43 and 40 years, respectively). 21 patients were treated with CAVH and 9 with CAVHD. 13 patients received additional intermittent hemofiltration. The following parameters were recorded: s-creatinine, s-urea, amount of anticoagulation, APTT, blood pressure, urine output, filtration volume, duration of dialysis and interval between burn accident and start of dialysis. Patient survival was investigated in relation to type and degree of burn injury, need for artificial ventilation and inotropic drugs, and the presence of septicemia and pulmonary burns.

**Results:** Mean time between accident and start of dialysis was 7.4 days. The duration of dialysis was 25.5 days. 80% of the patients were anuric/oliguric when dialysis started and remained so during dialysis treatment. S-creatinine was kept between 350 and 450 mmol/l, and s-urea was between 20 and 30 mmol/l. CAVH showed slightly lower values than CAVH. Mean systolic blood pressure at start was 105 mm Hg. There were great variations in filtration volume, mean value was 15000 ml/day. Amount of heparin needed for anticoagulation varied between 500 and 2000 IE/hour, while APTT was 45–50 seconds. There were no significant difference in patient survival regarding type of burn injury, need for artificial ventilation and inotropic drugs. 67% had burn injuries exceeding 40%, of which 45% survived. 77% had septicemia and 45% of those were survivors. 40% had pulmonary burns of which 67% died. Overall mortality was 50%. Mortality for patients treated with CAVH and CAVHD was 57% and 33%, respectively.

**Conclusion:** Continuous renal replacement therapy may maintain a good uremic control for severely catabolic burns patients with multiorgan dysfunction. Treatment is possible despite cardiovascular instability and total parenteral nutrition can be given. CAVHD appears to give somewhat better uremic control, but the difference in mortality is not significant. Large burns, pulmonary burns and septicemia seems to be bad prognostic signs.
95/027: CONTINUOUS VENO-VENOUS PRECOCIOUS HEMOFILTRATION (CVVPH) AS ELECTED TREATMENT IN ACUTE RESPIRATORY DISTRESS SYNDROME (ARDS) AND MULTIORGAN FAILURE (MOF)

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During the last two years we have treated with continuous veno-venous hemofiltration (CVVH) twelve patients with ARDS/MOF, with the following basic diseases; acute pancreatitis (2); bronchopneumonia on pulmonary interstitial fibrosis (1); poly-trauma (1); and sepsis (8).

All the patients have had mechanical ventilation and requirement of vasoactive drugs. In all cases we have employed high permeability polysulfone membrane. An active presence of a nephrologist was permanent for the management and coordination of all the procedure. In the described conditions we could appreciate that there was a direct relationship between earlier start of the hemofiltration (HF) and the clinic, radiologic and gasometric satisfactory evolution of the patients.

The mean survival was 83%. Mean CVVH duration was 30 (+/-) 6 hours. Based on the previous observation and to verify the relationship, the patients have been retrospectively classified in three groups in a score according to the seriousness of the manifestations.
<table>
<thead>
<tr>
<th>Pulmonary score</th>
<th>Cardiovascular drugs</th>
<th>Renal creat</th>
<th>Hepatic normal</th>
<th>hematologic normal</th>
<th>neurologic normal</th>
<th>Gastro enterologic</th>
<th>Time between the diagnosis ARDS/MOF and HF</th>
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</thead>
<tbody>
<tr>
<td>basic group</td>
<td>no</td>
<td>&lt;2</td>
<td>normal</td>
<td>Glasgow 9-15</td>
<td>normal</td>
<td>0-6 HS.</td>
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<tr>
<td>moderate group</td>
<td>vaso-active</td>
<td></td>
<td></td>
<td>fibrinogen 150-100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td>dopamine &lt;10 δ/Kg/’</td>
<td>creat &gt;2</td>
<td>bil 2-4 MG%</td>
<td>platelets 190,000/50,000</td>
<td>≤R</td>
<td>gastrointestinal haemorrhages 6-12 HS.</td>
<td></td>
</tr>
<tr>
<td>serious</td>
<td>oliguric</td>
<td>ALB &gt; 3</td>
<td>TP &gt; 75%</td>
<td>MM3 leucocytes 5000-1,000</td>
<td>↓Hb &lt; 1G/DIA</td>
<td>gastrointestinal</td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td>dopamine &lt;10 δ/Kg/’</td>
<td>creat &gt;2</td>
<td>bil 4</td>
<td>platelets &lt;50,000</td>
<td>≤R</td>
<td>Hb &gt; 1G/DIA &gt;12 HS.</td>
<td></td>
</tr>
<tr>
<td>serious</td>
<td>oliguric</td>
<td>ALB &lt; 2</td>
<td>TP &lt; 60%</td>
<td>MM3 leucocytes &lt;1000</td>
<td>colecistitis pancreatitis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The three groups were: A) Basic group with precocious ARDS/MOF manifestations; B) Group A, with moderate ARDS/MOF manifestations; C) Group B, with serious ARDS/MOF manifestations. It has been shown that the patients who evolutioned satisfactorily were those included in the basic group and group A (83%).

These results suggest that indication of precocious HF, that we call CVVPH, can be considered an adequate treatment in patients with ARDS/MOF using this score.
95/028: CONTINUOUS HEMODIALYSIS AND CONTINUOUS HEMODIAFILTRATION IN THE TREATMENT OF MASSIVE THEOPHYLLINE OVERDOSE

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Extracorporeal therapy using charcoal hemoperfusion is recommended for the management of patients with severe theophylline toxicity. We report on the use of continuous venovenous hemodialysis and hemodiafiltration in the treatment of a patient in whom severe theophylline toxicity persisted despite the use of charcoal hemoperfusion following a massive overdose of theophylline.

A sixty-eight year old white male presented with an overdose of approximately 72 grams of slow release theophylline, 108 grams of cimetidine and 1.8 grams of haloperidol. He was comatose with sinus tachycardia and hypotension. Recurrent ventricular arrhythmias including both ventricular tachycardia and ventricular fibrillation developed following admission. Gastric lavage and treatment with enteral activated charcoal was initiated, however a catharsis could not be induced as the result of a severe ileus. The initial serum theophylline level was 98.5 mg/mL, and rose to 106 mg/mL prior to the initiation of charcoal hemoperfusion. The serum theophylline level was rapidly lowered by charcoal hemoperfusion, but rapidly rebounded, in part as the result of continued theophylline absorption from the gastrointestinal tract. In addition to repeated treatments with charcoal hemoperfusion, continuous venovenous hemodialysis and continuous venovenous hemodiafiltration were instituted to augment theophylline clearance. The combination of continuous hemodialysis and charcoal hemoperfusion was attempted but could not be maintained secondary to repeated clotting episodes.

Theophylline clearance measurements were obtained on the basis of blood disappearance during charcoal hemoperfusion and on the basis of both blood disappearance and dialysate appearance during continuous renal replacement therapy. Theophylline extraction across the charcoal cartridge during charcoal hemoperfusion was >95%; the theophylline clearance at a blood flow of 300 ml/minute was 291 ± 2.8 mL/min. Fractional removal of theophylline during continuous venovenous hemodialysis (Q B = 150 mL/min, Q D = 33.3 ml/min) using a Hospal Multiflow 60 hemofilter was 12.5 ± 3.1% and theophylline clearance was 18.7 ± 4.7 ml/min. A single measurement of theophylline clearance based on dialysate appearance yielded a value of 20.7 ml/min. Theophylline clearance based on dialysate appearance during continuous venovenous hemodiafiltration (Q B = 150 ml/min, Q Di = 16.7 ml/min, Q Do = 33.3 ml/min) was 21.9 ± 5.4 ml/min.

The observed theophylline clearance rates during continuous venovenous hemodialysis and continuous venovenous hemodiafiltration were an order of magnitude less than those observed during charcoal hemoperfusion. Although these modalities do not provide adequate clearance for the acute therapy of theophylline intoxication, they may be of value in preventing rebound toxicity in patients with persistent absorption following massive theophylline ingestion.
95/029: EFFECT OF CONTINUOUS VENO-VENOUS HEMOFILTRATION ON SEPSIS

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Much controversy exists concerning the beneficial effects of continuous veno-venous hemofiltration (CVVH) on sepsis. We studied the effects of CVVH application on septic patients with reference to the following parameters: i) survival rate ii) cytokines’ removal and iii) timing of CVVH onset.

Twenty patients with sepsis (criteria according to ACCP/SCCM, 1992) underwent CVVH as soon as they developed renal failure or dysfunction (urinary output <250 ml/8 h, Cr >=2.5 mg/dl and BUN >=60 mg/dl). Specimens were collected: Blood samples before CVVH and thereafter both blood and ultrafiltrate (UF) samples on 24, 48 and 72 hours. Cytokines TNFα, IL-1 and IL-6 were measured by the immunoassay method in all specimens (UF and plasma - P) and sieving coefficient ([UF]/[P]) and 24 h solute mass transfer of TNF and IL-6 were calculated (V 24 h ´[UF]). The APACHE II score before CVVH onset, the duration of ICU stay and the timing of CVVH application related to the sepsis onset in days (TA) were recorded. With respect to the mortality rate we formed two groups, i.e. Group A (survivors) and Group B (non-survivors). The morbidity period, in days, of those septic patients who died in the past year and were not subjected to CVVH (Group C) was compared to that of Group B.

Group A included 8 pts and group B 12 pts with mean ±SD age (65 ±19 vs 64 ±9, NS) and APACHE scores (24 ±2 vs2 ±2.2, NS). The mean TA ±SD was 3.6 ±2 vs 1±6, p <0.05. The mean ±SD morbidity period of Group B vs Group C was 20 ±4 vs ±0.8 p <0.05. The mean values of cytokines are presented in the following figures. The sieving coefficient for TNF was 0.2 and for IL-6 was 0.25. The solute mass transfer was 6-fold the actual plasma content at a given time.
In conclusion, it seems that early application of CVVH favorably affects the outcome of septic patients and that cytokine plasma levels do not decrease although cytokine removal is substantial. It also seems that CVVH application in sepsis at any stage helps to buy time for further treatment.
95/030: THE ROLE OF CONTINUOUS VENO-VENOUS HEMOFILTRATION (CVVH) IN THE MANAGEMENT OF ACUTE RESPIRATORY DISTRESS SYNDROME (ARDS) – A RANDOMIZED PROSPECTIVE TRIAL
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The acute respiratory distress syndrome is still a major cause of morbidity and mortality in the intensive care unit despite major technical advances in critical care medicine. Since its description in 1967 different modalities of therapy have been applied without changing overall mortality. Pulmonary edema resulting from an increase in alveolocapillary permeability produces interstitial and alveolar edema that causes hypoxemia. Release of cytokines by inflammatory cells causes endothelial damage and capillary leaks. Removal of these mediators and also fluid by CVVH may improve oxygenation and thereby, long term outcome. The purpose of this study is to determine if CVVH applied to patients within 48 hours of diagnosis of ARDS can improve outcome.

**Methods:** Six patients (3/group) were randomized within 48 hours of diagnosis of ARDS to receive CVVH in addition to standard therapy (mechanical ventilatory support, PEEP, hemodynamic monitoring, antibiotics, intravenous fluid, vasopressors) or standard therapy alone. Informed consent was obtained by next of kin. To be eligible to enter the study patients had to be >18 years of age, have an identifiable cause of ARDS (sepsis, pancreatitis, aspiration, trauma, etc.), a Murray’s score for lung injury (based on chest x-ray, hypoxemia, PEEP and compliance) >2.5, a pulmonary capillary wedge pressure <18 mmHg, a PaO₂ /FIO₂ ratio <200 mmHg and bilateral infiltrates on chest x-ray. Patients were excluded if they were on chronic hemodialysis or if there was no identifiable cause of ARDS. The long term outcome variables were ventilatory days and ICU stay. Short-term outcome variables included gas exchange and lung compliance.

**Results:** Data are represented as mean ±SD. No statistically significant differences were detected between groups.
Conclusion:

These preliminary data demonstrate that CVVH can be used safely in patients with ARDS. There was a trend toward improvement in gas exchange in the CVVH treated group. The number of days requiring mechanical ventilation and length of stay tended to be shorter in patients treated with CVVH despite more severe lung injury at entry into the study. The use of CVVH as adjuvant therapy during the acute exudative phase of ARDS may prove to be beneficial.
95/031: CONTINUOUS VENOENOUS HEMODIALYSIS IN CHRONIC LITHIUM INTOXICATION

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Continuous renal replacement therapy (CRRT) is not a usual measure in the therapy of exogenous intoxications. In general, intoxications need a highly effective method to treat patients within a very short time. Intermittent hemodialysis can provide these criteria. Some substances, however, are characterized by redistribution processes demonstrating rebound phenomena in the patient. Lithium, a widely used drug in the treatment of psychiatric disorders, is transported very slowly by cell membrane. Therefore, elimination of the small molecular substance by intermittent dialysis could be difficult when intoxication occurred over long period, i.e. chronically. We present two different cases with acute and chronic lithium intoxication respectively. Adequacy and efficacy of continuous venovenous hemodialysis treatment in the case of chronic intoxication is documented.

A 53 year old woman ingested more than 100 Lithium carbonate tablets. Serum level was 3.1 mmol/l after gastric lavage. Serum lithium level raised to 3.4 mmol/l and a worsening of clinical signs was observed, i.e. tremor of the left arm and muscle fasciculation. A treatment by intermittent hemodialysis over 4 hours containing a bicarbonate bath lowered lithium serum levels to 1.2 mmol/l. Clinical symptoms disappeared. No further renal replacement therapy was necessary. A second case presents a 66 year old woman receiving lithium therapy since 15 years. During the last few weeks she showed a lot of clinical signs, i.e. progressive losing of vigilance, polyuria, a drop attack at home. She had no orientation in place and time, showed bradycardia of 35 bpm, muscle fasciculation, tremor and hyperreflexia. Lithium level was only 2.35 mmol/l. Intermittent hemodialysis by 4 hours reduced serum lithium level to 1.32 mmol/l, clinical symptoms remained nearly unchanged. Continuous venovenous hemodialysis (CVVHD) followed over the next 36 hours. No rebound phenomenon could be observed and serum level was 0.83 mmol/l at the end of the treatment period. Clinical symptoms slowly improved during continuous renal replacement treatment.

Our data demonstrate that continuous renal replacement, i.e. CVVHD, is advantageous in the therapy of chronic lithium intoxication in combination with intermittent hemodialysis. This therapeutic concept could also be used for other dialysable substances which have to be eliminated over a longer period, e.g. ethyleneglycol, methanol, or demonstrating redistribution phenomena.
95/032: ULTRAFILTRATION (UF) IN SEVERE CONGESTIVE HEART FAILURE (CHF) REFRACTORY TO CONVENTIONAL MEDICAL TREATMENT

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Nephrology and Critical Care Department, Hospital de la Beneficencia Espanola de Puebla, Puebla, Mexico

The combination of diet, diuretic, inotropics, vasodilators and angiotensin converting enzyme inhibitors (ACE), are the main components of CHF and arterial Hypertension Therapy. However, the azotemia in these patients limits their applications because on increased toxicity of the drugs and diminished effectiveness of ACE. We report eight patients in class IV (NYHA), with refractory heart failure, hypertension and azotemia unresponsive to medical treatment, submitted to hemodialysis (HD) and UF for 3 and 1 hr sessions respectively once a week in our Unit. (Table 1).

<table>
<thead>
<tr>
<th>Pt</th>
<th>Sex</th>
<th>age (years)</th>
<th>diag</th>
<th>creat-</th>
<th>Urea</th>
<th>MAP</th>
<th>NYHA</th>
<th>survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>male</td>
<td>82</td>
<td>DMII</td>
<td>6/3.5</td>
<td>148/100</td>
<td>123/110</td>
<td>IV/II</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
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<td>61</td>
<td>DMII</td>
<td>4/3.2</td>
<td>140/120</td>
<td>126/106</td>
<td>IV/II</td>
<td>15</td>
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<tr>
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<td>63</td>
<td>DMII</td>
<td>3.4/2.8</td>
<td>100/84</td>
<td>116/113</td>
<td>IV/I</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
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<td>65</td>
<td>DMII</td>
<td>6.0/3.2</td>
<td>120/168</td>
<td>126/110</td>
<td>IV/II</td>
<td>16</td>
</tr>
<tr>
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<td>70</td>
<td>DMII</td>
<td>2.8/2.3</td>
<td>140/100</td>
<td>113/111</td>
<td>IV/I</td>
<td>3</td>
</tr>
<tr>
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<td>68</td>
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<td>3.2/2.8</td>
<td>104/88</td>
<td>116/93</td>
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<td>9</td>
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<tr>
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<td>75</td>
<td>ERCD</td>
<td>10/3.0</td>
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<td>126/112</td>
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</tr>
<tr>
<td>8</td>
<td>male</td>
<td>68</td>
<td>DMII</td>
<td>2.4/2.8</td>
<td>175/128</td>
<td>96/96</td>
<td>IV/II</td>
<td>3</td>
</tr>
</tbody>
</table>

Results:

We observed improvement of the cardiac failure based on the NYHA classification in all 8 patients (100%), with a better control of Hypertension and diminished drug intake. The renal function was stabilized in 62.5% of the group, and 37.5% improved the median reported survival for this patients.

Conclusions: This initial report shows that HD and UF in a selected group of patients is a viable alternative in the Treatment of CHF refractory to medical therapy, with improvement in functional class.
95/033: THE OUTCOME OF RENAL REPLACEMENT THERAPY IN THE CRITICALLY ILL

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Renal failure occurred in 10.1% of 4926 patients admitted to a university attached tertiary referral ICU over 8.5 years. 174 patients (3.5%) received renal replacement therapy. 94% of these had 3 organ system failures.

Results:
1. Increased ICU stay (and cost) in dialysed vs non-dialysed patients. (18 vs 4.8 days: p <0.00001; at US$1,200/day, $21,600 vs $5,760). ICU length of stay was longer for survivors compared to non-survivors. (21 vs 16 NS).
2. Survivors had significantly lower OSFs (4.6 vs 6.2: p <0.0005) and APACHE II scores (25 vs 28 p = 0.003). There was no difference in sex, age or diagnostic category.
3. Best predictors of outcome were the number of OSF (odds ratio 2.21, p <0.00005) APACHE II (p = 0.032) and age >65 (odds ratio: 2.3, p = 0.039) but none were predictive in the individual.
4. APACHE II predicted risk of death matched actual mortality (54% vs 59%; NS), but was a poor predictor of outcome in individuals (p = NS).
5. Overall survival rates of 41%, 37% for 3 OSFs and 19% for 7 OSFs are better than previously reported by Knaus (37% vs 20% p <0.01).
6. Survival for patients age >65 was 34.3% whilst for age <65 it was 44.9% (p = NS). The distribution of OSFs and survival per OSF were similar in both groups.
7. At hospital discharge, 52% of survivors recovered baseline renal function, 18% had mild renal impairment, 17% moderate impairment and 13% deterioration to end stage disease or dialysis-dependence.

Conclusion: Renal failure in critical illness should be treated aggressively. The increased cost is justified by good survival rates. Although number of OSF, age >=65, and APACHE II predicted risk of death were good overall indicators of outcome, none could be used to predict outcome in the individual.
95/034: APPRAISAL OF INTERMITTENT HAEMODIALYSIS IN CRITICALLY ILL PATIENTS BEFORE USING CONTINUOUS RENAL REPLACEMENT THERAPY

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Purpose: We prospectively analyzed during one year those critically ill patients needing acute renal replacement therapy in our intensive care unit (ICU) treated with intermittent haemodialysis, in order to introduce the continuous renal replacement techniques in the future.

Methods: Eligibility was accordingly to clinical judgment of the attending intensivists in charge, who were blind to the development of this observational study. Epidemiological and clinical data of the patients such as age, main diagnoses at admission, Acute Physiology Score and Chronic Health Evaluation II (APACHE II), Therapeutic Intervention Scoring System (TISS), and length of stay were routinely collected. Haemodialysis was always performed by nephrologists disclosed of the daily care of the patients.

Results: From 202 critically ill patients admitted in our six-bed medical intensive care unit during the one-year study period, only seven patients underwent intermittent haemodialysis. There were two survivors and five non-survivors. Among the survivors mean age was 68 ±4 years, APACHE II 16 ±4.2, TISS score 18 ±11.3, and length of stay was 1 and 2 days respectively; the main diagnoses were lithium intoxication in one case, and hydroelectrolytic disturbances in the other. Among the five non-survivors mean age was 65.4 ±13.4 years, APACHE II 24 ±8, TISS score 34.6 ±5.1, and length of stay was 14.8 ±19.4 days; the main diagnoses were involved with multiple organ dysfunction including acute renal failure.

Conclusion: Patients with greater levels of severity of illness, therapeutic effort, and length of stay undergoing intermittent haemodialysis in the ICU have a very high mortality, which approximates 100%. Continuous renal replacement techniques in our ICU may demonstrate to be a promising alternative method in the management of critically ill patients.
95/035: HEMODYNAMIC CHANGES DURING CONTINUOUS VENO-VENOUS HEMODIALYSIS IN SEPTIC PATIENTS

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There is some evidence that continuous veno-venous hemodialysis (CVVHD) can remove septic shock mediators such as TNF or IL-1 from the blood. We studied the effect of CVVHD on mean arterial pressure (MAP) in ten patients with sepsis and acute renal failure. CVVHD was performed with polysulfone membranes (F5 or F6, Fresenius, Germany), Q B = 120 ml/min, Q D = 1,000 ml/hr, UFR = 80–150 ml/hr. MAP was continuously recorded through an arterial line for 12 hrs (4 consecutive three-hr periods) before CVVHD (Pre4-Pre1) and for 18 hrs (6 three hrs periods) during CVVHD (D1–D6). Mean MAP in mmHg for each patient was:

<table>
<thead>
<tr>
<th>Patient</th>
<th>Pre4</th>
<th>Pre3</th>
<th>Pre2</th>
<th>Pre1</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
<th>D5</th>
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<td>82</td>
<td>79</td>
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<td>65</td>
</tr>
</tbody>
</table>

Summary 62 ± 8 65 ± 9 63 ± 9 64 ± 13 68 ± 12 71 ± 13 77 ± 13 * 73 ± 11 * 69 ± 10 67 ± 10

[p < 0.05 if compared to Pre1].

We observed a pronounced improvement in MAP 4–6 hrs after initiation of CVVHD, which peaked significantly after 7–9 hrs and then returned gradually to the baseline over the following 9 hrs. There was no significant change in administered vasopressors, volume or inotropes which could have accounted for this change. If the observed increase in MAP were caused by factors other than membrane absorption of cytokines (e.g., volume removal or lower body temperature), we would not expect the observed, self-limiting effect.
We conclude that polysulfone membranes may absorb septic shock mediators with a rise in MAP and become saturated after 7–9 hrs. Frequent membrane changes or larger surface areas might lead to persistent hemodynamic improvement in sepsis.
95/036: A COMPARISON OF CONTINUOUS VENO-VENOUS HEMODIALYSIS AND INTERMITTENT HEMODIALYSIS IN ACUTE RENAL FAILURE

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It has been suggested that intermittent hemodialysis (IHD) may adversely affect the residual kidney function in acute renal failure (ARF) (Sigler, JASN 5: 277, 1994). We measured creatinine clearance (Ccr), urine volume (Uvol) and fractional excretion rates for sodium (FeNa) for 3 consecutive three hr periods (pre dialysis, during dialysis and post dialysis for IHD/pre, 0–3 hrs and 4–6 hrs during CVVHD) in 43 non-randomized, critically ill pts with ARF. Hemodynamic (in)stability was assessed by continuous blood pressure monitoring through an arterial line. Hypotensive burden (HB), as a time dependent quantitative measure of hypotensive episodes (MAP <90) was calculated as (90-MAP)´180 min for each study period. MAP >=90 were regarded as equal to 90 (Normal HB = 0 if all MAP >=90; if all MAP’s during a 180 min interval are 80 mmHg than HB = (90 80)´180 = 1800). Twenty-seven pts were treated with IHD and 16 pts with CVVHD and polysulfone dialyzers. Student t test was employed in log units to compare IHD vs CVVHD. Mean and 95% CI are:
The decline in Cr correlated with the fall in MAP during IHD ($r = 0.72$). We conclude that renal hypoperfusion causes a decline of residual kidney function during IHD. Less hemodynamic instability during CVVHD is associated with better preservation of the residual kidney function. However, dialysis efficiency is substantially less during the first 6 hrs of CVVHD and further comparisons using comparable dialysis prescriptions in regard to urea clearance and volume removal are necessary to confirm this advantage.

<table>
<thead>
<tr>
<th></th>
<th>Pre-Dialysis</th>
<th>Dialysis</th>
<th>Post-Dialysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>IHD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cr</td>
<td>10.4 cc/min</td>
<td>23.9% [16–31]</td>
<td>25.4% [18–32]</td>
</tr>
<tr>
<td>Uvol</td>
<td>1.2 cc/min</td>
<td>48.9% [41–55]</td>
<td>50.3% [43–57]</td>
</tr>
<tr>
<td>FeNA</td>
<td>4.4%</td>
<td>43.8% [32–54]</td>
<td>45.7% [34–55]</td>
</tr>
<tr>
<td>MAP</td>
<td>84 mm Hg</td>
<td>6.9% [4–10]</td>
<td>1.9% [5 –+ 4]</td>
</tr>
<tr>
<td>HB</td>
<td>678 mm Hg xmin</td>
<td>+29.0% [17 –+ 101]</td>
<td>+5.7% [41 –+ 43]</td>
</tr>
</tbody>
</table>

**CVVHD**

<table>
<thead>
<tr>
<th></th>
<th>Pre-Dialysis</th>
<th>Dialysis</th>
<th>Post-Dialysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ccr</td>
<td>11.3 cc/min</td>
<td>9.2%* [22 –+ 5]</td>
<td>7.0%* [23 –+ 13]</td>
</tr>
<tr>
<td>Uvol</td>
<td>0.85 cc/min</td>
<td>18.4%* [33 – 0]</td>
<td>10.2%* [31 –+ 16]</td>
</tr>
<tr>
<td>FeNA</td>
<td>1.3%*</td>
<td>21.3%* [40 –+ 3]</td>
<td>1.6%* [50 –+ 57]</td>
</tr>
<tr>
<td>MAP</td>
<td>74 mm Hg*</td>
<td>2.3%NS [9 –+ 5]</td>
<td>1.0%NS [12 –+ 13]</td>
</tr>
<tr>
<td>HB</td>
<td>910 mm Hg xmin</td>
<td>+1.5%NS [22 –+ 47]</td>
<td>+2.4%NS [34–53]</td>
</tr>
</tbody>
</table>

*p < 0.05 if compared to IHD*
95/037: CONTINUOUS VENOVOUS HEMOFILTRATION: AN ALTERNATIVE THERAPY FOR ACUTE RENAL FAILURE. A 10-YEAR EXPERIENCE

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Critically ill patients often cannot tolerate conventional hemodialysis because of hemodynamic instability. In most centers these patients are now treated with continuous treatment.

In 1987 we have published our modest experience about continuous arteriovenous hemofiltration. Following this experience, from this period we have started to use in the critically ill patients CVVH, considering this an alternative to CAVH. Our study included 30 patients treated by CVVH from 1986.

The treatment modality functioned well technically without serious complications or side effects. Hematoma and blood leakage was noted only in a patient. In all patients the treatment was well tolerated and treatment duration varied from 1 to 32 days. Heart rate and arterial pressure showed fairly stable values. Only five episodes of volume-responsive occurred. Metabolic acidosis was well corrected when present by using bicarbonate containing replacement solutions. The serum creatinine and urea levels were controlled in all patients during CVHD. Only in two instances additional hemodialysis was required to adequately control of urea generation. The ultrafiltrate losses were sufficient to allow appropriate nutrition and fluid administration and still maintain a negative fluid balance (the daily ultrafiltrate volume was 7.4 l/day). Renal function returned in 8 patients (26%), of whom five (16%) survived to be discharged home whereas 3 (10%) survived the acute phase of their illness dying later from other complications.

In conclusion, CVVH is an effective means of managing acute oliguric renal failure in critically ill patients. The good tolerance, the technically well functioned without serious complications or side effects, the adequately controlled uremia and fluid overload (the large amount of filtrate always enables adequate detoxification), the lower frequency of the disadvantages of other continuous techniques (in evaluation of the recent literature and from our experience), such as hematoma and blood leakage, made CVVH more effective modality in the management of acute renal failure in critically ill patients.
95/038: CONTINUOUS VENOVENOUS HEMOFILTRATION AND CONTINUOUS VENOVENOUS HEMODIALYSIS IN ACUTE RENAL FAILURE

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Continuous Venovenous Hemofiltration (CVVH) and Continuous Venovenous Hemodialysis (CVVHD) are forms of renal replacement therapy used to manage critically ill acute renal failure patients (pts.). This study describes our experience with 76 pts. treated with these therapies for 6,930 total hrs. (avg. 91 hrs.). Vascular access was obtained through a dual lumen catheter (femoral in 56 pts., subclavian in 19 pts.) and a bovine graft in 1 pt. A premixed dialysate solution was infused counter current to the blood flow in 12 pts. for CVVHD while 64 pts. received prefilter fluid replacement for CVVH. Heparin was infused pre-filter (avg. 520 u/hr) in 27 pts. The desired WBPtt was 150–180 seconds. Twenty pts. with coagulopathies received regional anticoagulation with a pre-filter trisodium citrate infusion (avg. 170.5 cc/hr) and a 10% CaCl2 systemic infusion. Anticoagulation was not required for 25 pts.

Metabolic waste production was controlled in all but 8 pts. (10.5%) who required intermittent hemodialysis (IHD). Ultrafiltration rates varied from 50–300 cc/hr. Four pts. were converted from heparin to trisodium citrate due to bleeding complications. Twenty-two pts. (29%) survived the acute phase of their illness. Six of those later died from their primary disease.

Based on the survival rate and low incidence of IHD and bleeding complications, this therapy is an effective treatment for a select acutely ill population.
95/039: ACUTE RENAL FAILURE IN MULTIPLE ORGAN FAILURE; PREDISPOsing FACTORS AND OUTCOME

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**Purpose of the Study:** To describe 1) the frequency and prognosis of other organ failures related to acute renal failure (ARF) treated with renal replacement therapy (RRT) 2) the outcome (mortality, recovery of renal function) of patients with ARF and 3) to identify factors related to increased mortality among patients with ARF.

**Subjects & Methods:** 63 patients who were treated with RRT (35 subjects with CVVH, 1 with CAVH, 21 with conventional hemodialysis (HD), and 6 with both CVVH/HD) during 1992–93 were included. 6 cases were excluded due to pre-existing chronic renal failure. Organ failure criteria were based on validated definitions for cardiovascular, respiratory, CNS, hematologic, hepatic and renal failures (Bernard et al., 1995). Data was collected at three time points (3–4 days before RRT, at the start of RRT and 3–4 days after the start of RRT). Chi-square, Mann-Whitney U-test and Kruskall-Wallis-test were used for statistical analyses.

**Results:** Only 15.8% (n = 9) of cases had an isolated ARF whereas a majority of patients (63.2%, n = 36) had a failure in 3 or more organ systems at the start of RRT. The number of failing organs was higher in non-survivors at all time points (before RRT p = 0.001, at the start of RRT p = 0.001 and during or after RRT p = 0.015). The number of failing organs was highest (3.5 ±0.58) in subjects with severe hemodynamic impairment and lowest (1.7 ±1.20) in subjects admitted due to intoxication or acid-base disturbances (p = 0.004). The severity of pulmonary (p = 0.014) and CNS (p = 0.013) failures at the start of RRT contributed to the survival. The within group mortality was highest in patients with hepatic (66.7%, N = 6) and CNS failures (62.2%, n = 37). The mortality during RRT on ICU and in hospital were 29.8% and 45.6%, respectively. The overall 6 month-mortality was 50.9% (N = 29). The mortality of patients treated with CVVH (61.8%, N = 34) did not differ from those treated with conventional HD (41.2%, N = 17). 82.1% (n = 23) of survivors had a complete recovery of renal function. A hypotensive period within 48 h prior to ICU admission (p = 0.004), use of vasoactive drugs (p = 0.005), mechanical ventilation (p = 0.041), low mean arterial pressure (p = 0.001) and high PCO₂ (kPa) (p = 0.025) at the start of RRT were associated with increased mortality.

**Conclusions:** The severity of organ failure, especially circulatory and respiratory, is an important independent determinant for the outcome of ARF. The prognosis for patients with ARF as a part of MOF may be determined by the number and severity of pre-existing organ failures. The additive effect of ARF in MOF could be more important than the renal dysfunction per se.
**95/040: COMPARATIVE EFFICACY OF PERITONEAL DIALYSIS AND CONTINUOUS RENAL REPLACEMENT TECHNIQUES IN PEDIATRIC PATIENTS WITH MULTIORGAN FAILURE SYNDROME**

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Peritoneal dialysis (PD) and continuous renal replacement techniques (CRRT) are available to support pediatric patients with acute renal failure (ARF). Many case reports and series use survival data to document the success of either PD or CRRT in children. However, survival in pediatric ARF depends, in part, on etiology. Children can develop ARF from a primary renal abnormality where mortality is less than 10% or as part of multiorgan failure syndrome (MOFS) in which mortality is much higher. The clinical goals of renal replacement therapy (RRT) in MOFS are to prevent fluid overload, uremia, acidosis and electrolyte derangement to allow time for healing and treatment of the underlying disease process. We have therefore reviewed our experience with PD and CRRT in children with MOFS, analyzed the success or failure of fluid and metabolic control and compared the number of complications occurring with these modalities.

**Methods:** All charts of patients treated with any type of RRT in the Pediatric Intensive Care Unit at Rainbow Babies and Children’s Hospital from 1/1/86–6/30/88 and 1/1/91–12/31/94 were reviewed. Records from the intervening 2.5 years could not be reliably retrieved. Charts were excluded from study if the patient was older than 21 years of age, had chronic renal failure, received only conventional hemodialysis or was on extracorporeal membrane oxygenation. MOFS was defined as needing mechanical ventilation, inotropic support and RRT. Control of fluid overload was studied only in those patients treated longer than 24 hours who were documented to need therapy specifically for severe fluid overload. Fluid control was defined as more fluid output than input during RRT. Metabolic control was defined as a stable or decreasing serum BUN during RRT in patients starting RRT with a BUN >=50 mg/dl. Significant complications of RRT were events leading to discontinuation of RRT. Chi-square was used for statistical analysis.

**Results:** Thirty-seven of 96 charts met exclusion criteria leaving 59 for study. All patients had MOFS. Overall survival was 12% (7/59). CRRT was used in 34 patients (58%), median age 32 (range 0.2–284) months, for 4259 hours (average/patient, 101 hours). PD was used in 25 patients (42%), median age 4 (range 0.1–182) months, for 3613 hours (average/patient, 145 hours). PD failed in 8 children who were switched to CRRT. Successful fluid control occurred in 16/23 (70%) CRRT patients and in 5/22 (23%) PD patients (p <0.005). Metabolic control occurred in 4/7 (57%) CRRT patients and in 8/8 (100%) PD patients (p <0.1). Complications occurred in 2/42 (5%) CRRT runs and 9/25 (36%) PD runs (p <0.005).

**Conclusions:** CRRT is more effective than PD in treating and preventing fluid overload in children with MOFS with fewer complications. Metabolic control as defined in this study is similar for both modalities.
95/041: BETTER SURVIVAL ON INTERMITTENT VERSUS CONTINUOUS HEMODIALYSIS IN ACUTE RENAL FAILURE

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Intermittent hemodialysis of intensive care patients may cause hemodynamic problems. Continuous dialysis techniques such as CAVH/D or CVVH/D have been introduced to reduce these problems. Existing data comparing the survival rate of patients treated with continuous and intermittent dialysis are however scarce and conflicting. In addition, data have not always been correlated to clinical condition. The present retrospective study comprises 231 intensive care patients with acute renal failure (ARF) and compared the patients survival in continuous dialysis (n = 83) and intermittent dialysis (n = 148) patients in relation to: 1) preexisting disease, 2) contributing factors to ARF, 3) the APACHE II score at the day of admission on intensive care and at the day of ARF diagnosis and 4) the number of organ failure (coagulation abnormalities, need for vasopressors or ventilation, liver- or heart failure).

Fisher’s Exact Test and Student’s T-Test were used when appropriate. Mean age of the intermittent dialysed patients was 61.0 ±14.5 years, that of the continuously dialysed patients was 55.1 ±14.6 years (p = 0.0036). Global survival rate was 35%. Intermittent dialysis had a better survival rate compared to continuous dialysis (45.9% versus 15.6%; p <0.0001). There were more diabetics in the patients treated with intermittent dialysis (15% versus 2%; p = 0.04). Hypertension, heart, lung, kidney and liver diseases were equally distributed in both groups. There was a trend towards a higher presence of sepsis (86% versus 72%; p = 0.07) and use of aminoglycosides (37% versus 20%; p = 0.06) prior to the development of ARF in continuous dialysis patients. Cardiac failure, contrast- and pigment-induced ARF was not significantly different in both groups of patients. Continuous and intermittent dialysis patients had a comparable mean APACHE II score on admission (27.1 ±9.2 versus 28.1 ±8.7) and at the time of developing ARF (29.9 ±8.3 versus 29.1 ±8.0). Continuously dialysed patients had more coagulation abnormalities (56% versus 26%; p = 0.002), elevated bilirubin (75% versus 51%; p = 0.01), need for ventilation (98% versus 72%; p <0.0001) and vasopressors (94% versus 64%; p <0.0001) than patients treated with intermittent dialysis.

We conclude that patients with ARF in the intensive care unit treated with intermittent dialysis had a better survival rate than patients treated with continuous dialysis, despite of being older and a similar mean APACHE II score, on admission and at the day of ARF diagnosis. The difference in survival rate can however entirely be explained by the worse clinical condition and the higher frequency of multiorgan failure of continuously dialysed patients. Therefore the APACHE II score was not very helpful in predicting the outcome.
95/042: SURVIVAL OF ACUTE RENAL FAILURE IS NOT AGE DEPENDENT IN CONTINUOUS DIALYSIS

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Depts of Nephrol. and of Intens. Care, Univ. Hosp., Gent, Belgium

Data in the literature suggest that the survival rate of acute renal failure (ARF) is similar in all age groups. Due to recent developments in modern intensive care and dialysis strategies, immediate intensive care unit (ICU) patient survival is higher leading to more frequent and more serious complications, including ARF. The question arises whether the survival of ICU patients developing ARF under these circumstances is still the same for older and younger patients. This retrospective study includes 83 continuously dialysed patients with ARF. The survival in patients younger than 65 years and patients older than 65 years was compared in relation to: 1) preexisting disease, 2) contributing factors to ARF, 3) the APACHE II score, and 4) the number of extrarenal organ failure (heart failure, liver failure, coagulation abnormalities, need for ventilation and vasopressors). The APACHE II score was determined twice: at the day of admission and at the day of ARF diagnosis.

Fisher’s Exact test and Student’s T-Test were used when appropriate. Mean age of the patients was 55.1 ±14.6 years, with 58 patients younger than 65 years (mean age 48.3 ±11.7 years) and 25 patients older than 65 years (mean age 71.0 ±4.8 years). The global survival rate was 15.6%. Survival for older patients was comparable to that of younger (12.5% respectively 15.5%; p = 1.0). Older patients had more cardiac disease in their medical history (54% versus 19%; p = 0.0289). Preexisting diabetes, hypertension, lung, kidney and liver disease was not significantly different in both age groups. ARF in younger patients was more frequently associated with aminoglycoside therapy (45% versus 14%; p = 0.056). In older patients cardiac failure (most commonly post cardiac surgery) contributed more to the genesis of ARF (43% versus 73%; p = 0.068). Sepsis, contrast- and pigment-induced ARF was evenly distributed among both age groups. Mean APACHE II score on ad mission was lower in younger patients (26.5 ±9.4 versus 29.6 ±8.1; p = 0.28) and similar for younger and older patients at the day of ARF (29.3 ±9.3 versus 31.8 ±5.3). From all extrarenal organ dysfunction only coagulation abnormalities were more frequent in younger patients (69% versus 20%; p = 0.0018). There was however no significant difference in liver failure, vasopressor, inotropic- and ventilation need between age groups.

It is concluded that older patients have the same survival rate for ARF when treated with continuous dialysis therapy. This occurs despite of a better APACHE II score on admission in the younger population. APACHE II score at the day of diagnosis of ARF was similar. The younger patients had more coagulation abnormalities.
95/043: ADEQUACY OF DIALYSIS IN ACUTE RENAL FAILURE: A COMPARISON OF INTERMITTENT HEMODIALYSIS WITH CONTINUOUS VENO-VENOUS HEMODIAFILTRATION

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Introduction: Continuous hemofiltration is the preferred treatment for acute renal failure in Australia. Its superiority over traditional intermittent hemodialysis, however, remains a matter of controversy. In particular, it is unknown whether continuous techniques provide superior control of uremic toxemia. Objectives: to study the degree of uremic control in two cohorts of critically ill patients treated with intermittent hemodialysis (IHD) or continuous veno-venous hemodiafiltration (CVVHD).

Methods: Setting: Intensive care unit of tertiary institution Patients: Forty-seven consecutive critically ill patients with multiorgan and acute renal failure treated with IHD and forty-six consecutive similar patients treated with CVVHD Intervention: Retrospective review of daily urea and creatinine concentrations during the period of renal replacement therapy in the ICU.

Results: The two groups of patients were comparable: mean age 55 years (IHD) vs. 60 years (CVVHD); NS), number of failing organs 4.2 for IHD vs. 3.7 for CVVHD; NS). Illness severity, however, appeared greater for patients receiving hemofiltration (mean APACHE II score: 25.7 for IHD vs. 29.4 for CVVHD; p <0.003). Despite this and the lack of a significant difference in uremic control at the time of start of therapy, CVVHD was associated with significantly lower plasma urea (p <0.0001) and serum creatinine (p <0.012) levels at 24 hours of treatment. This persisted throughout the duration of therapy (p <0.0001), with mean urea levels of 35 mmol/L for IHD vs. 23.4 mmol/L for CVVHD (p <0.0001), and 513 (IHD) vs. 263 (CVVHD) micromol/L (p <0.0001) for creatinine, despite significantly higher protein intake in CVVHD patients.

Conclusions: CVVHD provides better control of uremic toxemia than IHD. The greater adequacy of dialysis achieved during CVVHD provides yet another biological rationale for its preferential use in the treatment of acute renal failure in the ICU.
95/044: LONG TERM OUTCOME AND QUALITY OF LIFE IN SURVIVORS OF CONTINUOUS VENO VENOUS HAEMOFILTRATION/ HAEMODIAFILTRATION

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Introduction: The long term survival and quality of life of patients with combined multi organ and acute renal failure treated by continuous veno venous haemofiltration/haemodiafiltration is unknown. Knowledge about such outcome measures has important implications for resource allocation and perception of appropriateness of care. Accordingly, we conducted a retrospective study based on a postal questionnaire mailed to survivors of acute renal failure in the Intensive Care Unit (I.C.U.).

Method: Setting: Intensive care unit of tertiary institution. Patients: 85 patients treated with CVVH/CVVHD from 2/90 to 3/95. Protocol: Anonymous questionnaire based on an activity index, mental index and a modified version of the Nottingham Analysis Profile Results for general health index.

Results: From a patient of pool 250 patients, 85 survived to be discharged from hospital. (survival = 34%) Of these 85 patients, 57 were male (67.0%) and 28 female (33.0%). Mean age was 56.9 years (range 13.4–81), mean I.C.U. stay 10.4 days (range 2–52), mean APACHE II score 24.15 (range of 15–41), and mean duration on CVVH/CVVHD 6.16 days (range 1–37). Mean follow up time was 2.4 years (range 0.1–5.3) 35 patients were alive at time of questionnaire response (41.2%), and 17 were deceased (20.0%). 33 did not reply (38.8%).

Of the 35 responders, 68.5% were satisfied with their current health state, despite 60.6% stating that their mobility was affected with 41.9% unable to walk more than 200 meters. 94.2% felt that their treatment had been worthwhile and 91.2% said that they would go through the treatment again if necessary.

Conclusion: Despite the highly invasive nature of their I.C.U. management, most long term survivors felt that they had an acceptable quality of life and that treatment was justified by outcome. Our findings support the notion that, given the nature of their illness, survivors of combined multi organ and acute renal failure have an acceptable quality of life.
95/045: PEDIATRIC RENAL REPLACEMENT THERAPY: MORTALITY BY AGE, DISEASE AND MODALITY

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With the expanded use of continuous renal replacement therapy (RRT) in pediatrics, the options for the type of RRT in acutely ill children have increased significantly over the last several years. Experience with 241 RRT treatments in 187 children (ages 1 day–22 years, weights 1.0–74 kg) at Mott Children’s Hospital of the University of Michigan Hospital from 1/91–7/95 is reported. Primary diagnoses included: primary renal failure (44%), sepsis (17%), congenital heart disease (16%), bone marrow transplant (7%), urea cycle defects (6%), heart or liver transplant (5%), HUS (3%), and renal transplant (1%). Choices for type of RRT were based on the clinical judgment of the nephrologist and included: peritoneal dialysis (99/241 treatments, 41%), hemodialysis (71/241 treatments, 30%), continuous hemofiltration (49/241 treatments, 20%), and hemodiafiltration while on ECMO (22/241 treatments, 9%).

Sixty four percent of patients were receiving pressor support at initiation of therapy. Acute access (either PD, HD or hemofiltration) were placed in 71% of patients while 29% received chronic catheters. Treatment duration was 13.7 ±0.9 days (range 1–223 days). Complications during treatment occurred in 27% of patients, but none were life-threatening.

Overall patient survival to hospital discharge was 56%, but varied greatly among diagnoses: HUS and renal transplant (100%), primary renal failure (84%), bone marrow transplant (73%), urea cycle defects (73%), heart or liver transplant (33%), congenital heart disease (29%), and sepsis (19%). Further survival inversely was related to age of the child in that a child less then 10 kgs had an overall survival rate of only 31%.

In the 167 patients who received only one type of RRT, survival to discharge was 62% for those treated with peritoneal dialysis, 53% for hemodialysis, 37% for hemodiafiltration while on ECMO, and 20% for continuous hemofiltration. These outcomes compare favorably to reported survival rates for adults. They furthermore confirm the utility and safety of each type of RRT in pediatric patients. Prospective, controlled studies are needed and are being planned to investigate the apparent diagnosis- and modality-related survival differences.
95/046: REDUCED MORTALITY OF ACUTE RENAL FAILURE FOLLOWING CARDIOPULMONARY BYPASS. THE POTENTIAL ROLE OF CONTINUOUS HEMODIALYSIS TREATMENT

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Continuous renal replacement has been established as an alternative method for treatment of acute renal failure (ARF) over the last decade. There are now various forms having major advantages relative to intermittent hemodialysis (IHD) in the treatment of the critically ill patient with acute renal failure. One of the most important benefits is improved cardiovascular stability which plays an excellent role for survival of ARF after cardiopulmonary bypass operation (CPB). Therefore, the following study was undertaken to compare the effects of continuous venovenous hemodialysis (CVVHD) and IHD on the outcome of ARF after CPB.

A trial of patients with ARF following CPB were prospectively analyzed and treated by CVVHD (Hospal, BSM-22, AN69 membrane, dialysate flow 16 ml/min). These data were compared with a previous group treated by IHD (daily treatment for 3 hours by conventional hemodialysis). CVVHD group consisted of 24, IHD of 17 patients. Distribution of age and gender were not significantly different. Incidence of ARF was also comparable (CVVHD: 1.5%; IHD: 1.9%). Mortality was significantly reduced in CVVHD group (62%; 15 from 24 patients) compared with IHD group (71%; 12 from 17). Significant changes in blood pressure during hemodialysis were only observed in IHD to a decrease of 42 ± 10 mmHg, CVVHD led to a small increase of blood pressure. This is in accordance with the hemodynamic situation characterized by a classification in respect to the need of catecholamines. Only patients belonging to Class I and II survived. Improvement of hemodynamic situation was only registrated in CVVHD patients.

The data clearly demonstrate that cardiovascular stabilization is one of the most important factors determining outcome of ARF after CPB. Only continuous renal replacement (CVVHD) demonstrates stabilizing effects which are likely to result in improved survival rates.
95/047: REDUCED MORTALITY OF CRITICALLY ILL PATIENTS WITH SEPSIS UNDER CONTINUOUS RENAL REPLACEMENT THERAPY COMPARED WITH INTERMITTENT TREATMENT

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Over the last decade significant advances have been made in techniques available for treatment of acute renal failure by using continuous renal replacement therapies (CRRT). Amelioration of fluid control, superior metabolic control and improved hemodynamic stability are some of the factors involved. In spite of this it is not clear whether these improvements have resulted in a decrease in mortality of these patients. Therefore we performed a retrospective analysis of 64 consecutive patients treated either with continuous venovenous (CVVHD) or intermittent hemodialysis (IHD).

64 critically ill patients with a wide spectrum of diagnosis leading to acute renal failure were investigated within 26 months. Half of the patients (n = 32) were treated by CVVHD using Hospal BSM-22, AN69 membrane and a dialysate flow of 16 ml/min. The other 32 patients were treated 3 hours daily by a conventional intermittent hemodialysis method (IHD). There were no differences in patient’s age or in kind of diseases underlying acute renal failure. The severity of disease was compared between the two groups of patients and demonstrated in CVVHD group elevated APACHE scores, higher amounts of catecholamines and oxygen. Additionally, they had a lower mean arterial blood pressure and diminished diuresis compared with IHD. Overall mortality rate was not different in both groups in spite of stronger severity of disease in CVVHD group. In contrast, analysing patients suffering from sepsis as a cause for acute renal failure (n = 14 in each group) lower mortality rate could be found in patients treated continuously: CVVHD 7/14 (50%), IHD 12/14 (86%).

Our data are in good agreement with previous reports showing similar survival rates in patients treated with CRRT and IHD despite greater illness severity in those treated with CRRT. The reasons for lower mortality in septic patients treated by CVVHD are speculative. Improved hemodynamic stability could be one of the most important. It is also notable that the results were gained by CVVHD which is a method with high efficacy in diffusion but low in convection. The data further demonstrate that critically ill patients suffering from acute renal failure have a different benefit of CRRT depending on the underlying diagnosis.
95/048: ONE YEAR EXPERIENCE WITH CONTINUOUS VENO-VENOUS HEMOFILTRATION AND HEMODIAFILTRATION: PATIENT OUTCOMES AND CLINICAL ISSUES

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Indications, clinical progress, outcomes and clinical issues of the first 42 adult patients who received continuous veno-venous hemodiafiltration (CVVH) and continuous veno-venous hemodiafiltration (CVVH/d) at UCSF Medical Center were reviewed. During the first year 29% of the sample received CVVH therapy and 71% received CVVH/d therapy. The most common diagnosis of patients receiving CVVH/d therapy was liver failure and/or liver transplantation with renal insufficiency (69%). Other diagnoses included sepsis or acute lung injury post kidney transplantation or bone marrow transplantation and post-cardiac or vascular surgery multiorgan dysfunction. The most common indications for therapy included hypotension (71%), anuria/oliguria (69%), uremia (67%), large volume (blood product) requirements (60%) and metabolic acidosis (55%). Only 36% of the therapies required heparinization since most patients had prolonged prothrombin times and thrombocytopenia. The average hemofilter circuit life was 24–48 hours. Average duration of therapy was 4 days.

These therapies were prescribed by nephrology attendings and fellows and were initiated, monitored and managed by critical care nurses with a 1:1 (RN:patient) staffing ratio. Anesthesiology attendings managed CVVH therapy intraoperatively. Twenty six percent of the patients received CVVH therapy intraoperatively during liver and/or kidney transplantation. The average ultrafiltration rate was 750 to 1,000 mL per hour during surgery.

The leading clinical issues were inadequate flow through the circuit resulting in clotting and hypothermia. Inadequate flow was a result of a kinked or clotted access catheter, agitation, patient movement, coughing and/or nursing care (turning, suctioning, etc.) Advanced training in troubleshooting and more experience through frequent CVVH/d patient assignments for a core group of critical care nurses has been instituted. Hypothermia coincided with initiation of CVVH/d in 10% of the patients and some febrile patients became normothermic. Fluid warmers were used on the replacement fluid and/or dialysate infusion circuits and warming blankets were placed on these patients with positive results.

Fifty percent of the patients who received therapy were discharged from the critical care unit and 45% survived to discharge from the hospital. Of the patients who survived, 89% recovered renal function and 11% required conventional hemodialysis post-hospital discharge. The majority of survivors (84%) who also recovered renal function were liver transplant patients.

This data suggests that liver failure patients with renal insufficiency awaiting liver transplantation benefit from CVVH/d and/or CVVH in the pre-, intra-, and post-operative period if dialysis or fluid management is indicated. Nurses managing and monitoring CVVH/d circuits require training to be able to troubleshoot the access, circuit, blood pump and patient’s volume status to prevent hemofilter and circuit clotting. Further analyses of cost and which patients benefit from these therapies will help guide appropriate utilization of these resource intensive therapies.
95/049: ACID-BASE STATUS AND CARDIOVASCULAR HAEMODYNAMICS IN PATIENTS WITH ARF AND CONTINUOUS VENO-VENOUS HAEMOFILTRATION

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Introduction: The present trial was designed to investigate the impact of a lactate to an acetate based haemofiltration replacement fluid (HF) on acid-base disturbances and on cardiovascular haemodynamics in patients with acute renal failure (ARF) and continuous veno-venous haemofiltration (CVVH).

Patients and Methods: 102 patients were allocated to treatment with lactate based (group 1, n = 70) or acetate based (group 2, n = 32) replacement fluid. Cardio-vascular haemodynamics, creatinine, BUN, lactate and APACHE-II were documented daily. 54 patients had a septic, 48 a cardiovascular origin for ARF.

Results: Group 1 and group 2 did not differ for main clinical parameters. Mean CVVH-duration was 9.8 ± 8.1 days, mortality was 65%. 24 hrs after initiating CVVH-treatment HCO₃ was significant higher in group 1 (23.6 ± 4.1 mmol/l) compared to group 2 (20.2 ± 4.4, p < 0.01). These findings were maintained throughout therapy, pH showed concomitant significant changes. Lactic acidosis occurred in 8 patients without preference to substitution fluid. Cardiovascular haemodynamics prior and throughout therapy did not differ between both groups, though initiating CVVH-treatment lead to a significant fall in central venous pressure (16.2 ± 6.2 - 13.2 ± 5.7 mmHg, p < 0.05), pulmonary capillary wedge pressure (24.2 ± 8.2 - 19.5 ± 6.5 mmHg, p < 0.05), pulmonary artery pressure (43.0 ± 11.5 - 36.5 ± 10.1 mmHg, p < 0.05) and heart rate (119.3 ± 22 - 107.5 ± 17, p < 0.05) within the 24 hrs starting CVVH.

Conclusions: The choice of either a lactate or an acetate based HF did not show to have an influence on cardiovascular haemodynamics, but their is a significant difference in the acid-base status, with the lactate based HF leading to higher HCO₃ and pH values compared to acetate based HF. The impact on clinical outcome needs further investigation.
95/050: CONTINUOUS RENAL REPLACEMENT THERAPY IN ACUTE RENAL FAILURE ON INTENSIVE CARE UNIT PATIENTS. COOPERATIVE STUDY OF MADRID

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Continuous Renal Replacement Therapy (CRRT) has become an accepted method for treating Acute Renal Failure (ARF) in critically ill patients hemodynamically unstable.

128 adult patients (94 M 34 F) (mean age 56 ±16 years) with ARF admitted into medico-surgical Intensive Care Units (ICU) were treated by Renal Replacement Therapies (RRT) and prospectively analyzed. 96 patients were treated by CRRT (Group A) (continuous veno-venous or arterio-venous hemodialysis or haemofiltration) and the other 32 (Group B) were treated with intermittent RRT (IRRT) (hemodialysis n = 29 or isolated ultrafiltration n = 13). Multivariate analysis was performed for prediction of outcome.

There were no differences in sex, age, incidence of cardiovascular diseases, pre-dialysis creatinine values, number of days on RRT or diuretic prescription between both groups. Incidence of both acute tubular necrosis and multiorgan failure (MOF) were higher in Group A than in Group B patients (91% vs 73% p <0.01, and 98% vs 78%, p <0.01 respectively). Individual Severity Index (ISI) calculated according to Liano index (Nephron 1993), was 0.72 and 0.63 (p <0.05) in Group A and Group B respectively.

Mortality was well correlated with ISI, but no differences were observed in mortality rate between both groups of patients (82% vs 73%). Age >=65 years was not associated with higher mortality rates. Using a multiple logistic regression we found that persistent oliguria, mechanical ventilation, acute tubular necrosis and coma were significant predictors of death in both group of patients.

We can conclude that CRRT is a useful method to treat ARF in critically ill patients. The high mortality rate observed may be due to a multiorgan failure independently of the different kind of renal replacement therapy. Instead the more severe disease in Group A patients the mortality rate was no different than this observed in Group B patients. This may imply a better prognosis of ARF on ICU patients with continuous renal replacement therapies.
95/051: PRELIMINARY EXPERIENCE WITH THE PRISMA CONTINUOUS VENOVENOUS RENAL REPLACEMENT THERAPY SYSTEM

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University of Toronto, Toronto, Canada

The use of continuous renal replacement therapy (CRRT) in the ICU setting has gained increasing acceptance over the past decade. Recently, a commercial manufacturer has developed a sophisticated machine dedicated to the delivery of various pumped CRRT modalities in the critical care unit (Prisma-Hospal-Gambro). This paper describes our initial experience using Prisma to deliver continuous venovenous hemodialysis (CVVHD), at The Toronto Hospital (TTH), a large academic tertiary care teaching hospital. Implementation issues are the subject of a separate report at this meeting.

We retrospectively reviewed the medical records of all 16 consecutive patients treated with CVVHD from implementation of this program on March 14 to July 14, 1995. Data collected from these patients included APACHE II scores; number of failing organs; presence of sepsis; type of vascular access; need for inotropic support, ventilation, or total parenteral nutrition (TPN); and various dialysis parameters. APACHE II scores were either recorded on entry to the ICU or reconstructed from the patient’s medical records retrospectively. One patient, initially discharged from the ICU, was later readmitted and restarted on CVVHD; in the subsequent analysis she will be considered as two separate treatments (i.e. 17 treatments).

Our current CVVHD protocol is as follows. The Prisma machine uses a 0.5 m² AN 69 hollow fibre filter which is changed every 48 hours. Standard dialysate is Hemosol. Standard anticoagulation regimen consists of heparin infused at a rate of 500 U/h. Standard dialysate flow rate is 1 L/h, although one person required 2 L/h during one 24 hour period. The standard blood flow rate is 100 mL/min. The amount of net ultrafiltration is sufficient to achieve an appropriate fluid balance and there is no infusion of physiological replacement fluid. Vascular access was achieved via femoral vein in 14 patients, while three utilized subclavian venous access.

Eight male and eight female patients have been treated thus far. Their mean age was 57.9 years (range 28 to 84). The mean APACHE II score was 30.2 (range 22 to 45). The mean number of failing organs was 2.2 (range 1 to 4). Sepsis was present in 7 patients. On commencement of CVVHD, 13 patients required inotropic support (dopamine, epinephrine, or norepinephrine), 12 required ventilator support, and 3 required TPN. During CVVHD therapy, 2 additional patients required inotropes, 1 was ventilated, and 1 began TPN.

Five patients survived to be discharged from the ICU; of these, two were later discharged home, one eventually died on the ward, and two are still in hospital. Nine patients died in the ICU, while two continue in intensive care. Total time spent by patients on CVVHD was 2467 hours, with a mean time of 154.2 hours; treatment length ranged from less than 1 day to 26 days. Mean filter life was 35.2 hours. Of the 70 filters used, 40 were changed for protocol reasons (57%), while the rest were changed early due to clotting or other problems.

Five patients were on CVVHD for less than 24 hours and are not included in the clearance data reported below. The mean values for plasma urea, serum creatinine, and serum potassium on commencement of CVVHD were 30.3 mmol/L (84.9 mg/dl), 450 mmol/L (5.1 mg/dl), and 4.6 mmol/L respectively. Mean urea levels dropped to 24.3 mmol/L (68.1 mg/dl) by the third day of treatment and to 23.0 mmol/L (64.4 mg/dl) by the fifth day. Mean creatinine levels
dropped to 348 mmol/L (3.9 mg/dl) and 267 mmol/L (3.0 mg/dl) over the same time period. Mean potassium levels were maintained in the normal range throughout. Mean actual (delivered) ultrafiltration rate was 120 ml/h (range 0–400). No vascular access related complications were seen.

In conclusion, a CVVHD program using the Prisma system has been successfully implemented at TTH. In the 16 patients treated thus far, uremia was satisfactorily controlled, ultrafiltration requirements were met, and appropriate renal replacement therapy was provided to this difficult patient population. Whether benefits will extend to reducing non-vascular access related morbidity and mortality in this high risk group awaits future studies.
95/052: A PROPOSED TRIAL OF CONTINUOUS VENOVENOUS HEMODIALYSIS OR CONTINUOUS VENOVENOUS HEMODIAFILTRATION

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Mortality from acute renal failure (ARF) in the critical care setting remains 50–70%, and has not changed in the past 20 years despite many advances in renal replacement therapy (RRT). There is still controversy as to whether there is any advantage in using convective or diffusive clearance – hemofiltration (H) or hemodialysis (HD).

The major potential benefit of H which has been proposed is that it is better at removing toxic cytokines and other middle molecular weight substances, whose biological activity may be deleterious to the multiorgan failure patient. Secondly, H with pre-dilution replacement may cause less clotting in the hollow-fibre filter because of the haemodilution effect on the incoming blood and consequently less viscosity. The main disadvantages of H are the added complexity and cost of large volumes of replacement solutions.

We propose to initiate an unblinded, multicenter, prospective, randomized, controlled clinical trial. The primary research question is “does the substitution of H for a component of HD in continuous venovenous hemodialysis (CVVHD) in critically ill patients with acute renal failure confer any survival advantage?” The primary outcome is patient survival. Secondary outcomes include incidence of iatrogenic bleeding, filter clotting and qualitative assessment of clearance of B2 microglobulin and urea. Inclusion criteria are such that all patients with ARF (oliguric and non-oliguric) admitted to intensive care units would be eligible for entry. Exclusion criteria include lack of informed consent, mobile patients, ESRD, and patients with contraindications to continuous RRT.

The experimental manoeuvre is as follows. Continuous RRT commencement would be left to the discretion of the nephrologist, but must be started before the [urea] reaches 40 mmol/L (112 mg/dL). The patient is randomized to therapy with either CVVHD or continuous venovenous hemodiafiltration (CVVHDF). The CVVHD protocol is: The dialysate is run at a rate of 2 litres per hour. The amount of net ultrafiltration is sufficient to achieve an appropriate fluid balance and there is no infusion of physiological replacement fluid. The filter is the 0.5 m² AN 69 hollow fibre dialysers, changed every 48 hours. A standard maximal blood flow rate of 125 ml/min is to be used. Heparin is the standard anticoagulant. The CVVHDF protocol is: As a substitute for a component of dialysis, hemofiltration is performed. To achieve this, the dialysate flow rate is reduced to 1 L/hr. An extra 1 litre of UF is removed per hour, which is replaced by pre-dilution infusion of physiological solution. All other dialysis parameters are identical to CVVHD.

Power calculations are based on a null hypothesis that CVVHD and CVVHDF are equivalent therapies, and that survival with each therapy will not be different. To detect a 20% difference in mortality (from 70 to 50%), with 80% power and at a 0.05 significance level would require 103 patients in each treatment group. The 4 currently participating centers (The Toronto Hospital, Wellesley Hospital, Sunnybrook Health Science Center and Ottawa General Hospital) would require 3 to 4 years to complete the study.

There are several alternative study designs, all with advantages and disadvantages compared to the one proposed. These include: 1) mandating standard and absolutely equal effluent volumes in the CVVHD and CVVHDF groups (e.g. 2 L/hr), 2) using filtration as an adjunctive therapy (e.g. CVVHD with 2 L/hr dialysate flow vs CVVHDF with 2
L/hr dialysate flow + 1 L/hr of filtration) and 3) pure CVVHD vs pure CVVH. We seek discussion about the protocol and invite centers interested in participating in this multicenter study to indicate this to us.
*95/053: CVVH-D IN COMBINATION WITH TOTAL HEPATECTOMY AND PORTOCVAL SHUNTING – BRIDGE TO LIVER TRANSPLANTATION*  
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*Departments of Pediatrics, Anesthesiology and Transplantation, Stanford University Medical Center, Stanford, California, USA*

Children who develop acute liver failure following liver transplantation (LT) have a high rate of mortality unless retransplantation can be performed. These patients develop refractory coagulopathy, metabolic acidosis, and respiratory, circulatory and renal failure. Despite listing these patients as United Network for Organ Sharing (UNOS) Status 1, a second liver graft may not become available for several days or longer. Transplant hepatectomy with portocaval shunting has been described as a bridge to LT in such patients as well as those with fulminant liver failure who have not undergone LT. In addition, continuous hemofiltration may be employed in patients with acute liver failure to facilitate fluid, circulatory and metabolic balance. We used continuous venovenous hemofiltration with dialysis (CVVH-D) in a patient who remained anephric for 66 hours in order to achieve control of serum electrolytes, pH and ammonia levels as well as fluid and circulatory homeostasis prior to successful retransplantation.

**Case Report:** The patient was a 3 1/2 year old boy with acute liver failure due to giant cell hepatitis who underwent LT. Coagulopathy, metabolic acidemia, hyper-ammonemia and renal failure developed on the first post-operative day due to graft non-function. Severe circulatory failure ensued, including cardiac arrest. Transplant hepatectomy and portocaval shunting were performed on post-operative day 1, and CVVH-D was initiated on the same day via an 8 french double lumen catheter inserted in the left femoral vein. An Amicon 20 filter and custom dialysate with bicarbonate were used. Dialysate flow was 500 ml per hour and ultrafiltration rate was 200 ml per hour. Heparin was infused at 0–10 units per kilogram per hour to maintain an activated clotting time of 180–200 seconds. Fluid, circulatory and metabolic stability as well as neurologic responsiveness were maintained for the ensuing 56 hours until a donor liver became available, at which time successful LT was performed. Patient data prior to and during CVVH-D were as follows:
**Conclusion:** CVVH-D was employed following hepatectomy with portocaval shunting to facilitate fluid, circulatory and metabolic balance in a 3 1/2 year old boy who was anhepatic for 66 hours. 18 months following retransplantation, he is healthy with normal liver, kidney and neurologic function.

<table>
<thead>
<tr>
<th>Patient Data</th>
<th>Pre-</th>
<th>0–24 Hours</th>
<th>24–56 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na mEq/L</td>
<td>143</td>
<td>153</td>
<td>145</td>
</tr>
<tr>
<td>K mEq/L</td>
<td>3.4</td>
<td>2.7</td>
<td>3.3</td>
</tr>
<tr>
<td>HCO3 mEq/L</td>
<td>23.5</td>
<td>26.3</td>
<td>24.6</td>
</tr>
<tr>
<td>Glu mg/dL</td>
<td>118</td>
<td>175</td>
<td>165</td>
</tr>
<tr>
<td>Ca mg/dL</td>
<td>7.5</td>
<td>9.4</td>
<td>9.3</td>
</tr>
<tr>
<td>Cr mg/dL</td>
<td>1.3</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Phos mg/dL</td>
<td>6.3</td>
<td>4.2</td>
<td>3.9</td>
</tr>
<tr>
<td>NH3 μMol/L</td>
<td>351</td>
<td>207</td>
<td>160</td>
</tr>
<tr>
<td>PT sec</td>
<td>32.7</td>
<td>21.7</td>
<td>19.9</td>
</tr>
<tr>
<td>pH (arterial)</td>
<td>7.47</td>
<td>7.44</td>
<td>7.45</td>
</tr>
<tr>
<td>Inotropes (μg/kg/min)</td>
<td>0.4–0.6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Epinephrine</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dobutamine</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Dopamine</td>
<td></td>
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</table>
95/054: CONTINUOUS VENOVENOUS HEMODIALYSIS CLEARANCE OF VANCOMYCIN IS HIGHLY MEMBRANE DEPENDENT

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The clearance of endogenous substrates and some drugs by continuous venovenous hemodialysis (CVVHD) has been reported to be membrane dependent. Furthermore, the contribution of diffusion and convection to drug clearance has rarely been systematically evaluated. This investigation was designed to evaluate the effect membrane composition has on vancomycin disposition during CVVHD. Fifteen stable patients with end stage renal disease underwent a controlled CVVHD procedure with one of three filters during which blood (BFR), dialysate (DFR), and ultrafiltrate flow rates (UFR) were incrementally adjusted. Each patient received 500 mg of vancomycin (vanco) approximately 24 hours prior to CVVHD. Three filters that differed in membrane composition and surface area were evaluated: acrylonitrile copolymer 0.6 m² (AN69, Hospal), polymethylmethacrylate 2.1 m² (PMMA, Toray), and polysulfone 0.65 m² (PS, Fresenius). The CVVHD clearance of vanco (Clvanco) and urea (Clurea) was determined as the interval amount recovered in dialysate/ultrafiltrate divided by the interval midpoint plasma concentration. Linear regression analysis was utilized to assess the relationship between Clvanco and DFR or Clurea. The Clvanco slope and r² values observed with each filter were as follows:

<table>
<thead>
<tr>
<th>Filter</th>
<th>DFR</th>
<th>Clurea</th>
</tr>
</thead>
<tbody>
<tr>
<td>AN69</td>
<td>0.48, r² = 0.87</td>
<td>0.65, r² = 0.88</td>
</tr>
<tr>
<td>PS</td>
<td>0.66, r² = 0.89</td>
<td>0.71, r² = 0.92</td>
</tr>
<tr>
<td>PMMA</td>
<td>0.85, r² = 0.97</td>
<td>0.89, r² = 0.90</td>
</tr>
</tbody>
</table>

The Clvanco by CVVHD at DFR of 8.3 ml/min averaged 5.8, 5.3, and 7.0 ml/min for the AN, PS, and PMMA filters, respectively, and increased to 12.9, 22.1 and 27.0 ml/min at DFR of 33.3 ml/min. Although no significant relationship was observed between Clvanco and BFR for any of the filters, significant relationships were observed between Clvanco and DFR, as well as Clvanco and Clurea. The Clvanco by the AN69 and PS filters were similar to the PMMA filter at low DFR values, however the Clvanco for each filter did not increase proportionally and the slopes of these relationships were significantly different. The CVVHD Clvanco with all three filters was highly correlated with Clurea. The slope of the relationship between Clvanco and Clurea for the AN69 filter was significantly smaller than the PMMA slope. These Clvanco values are equal to or substantially larger than the 5 ml/min average residual Clvanco reported in patients with end stage renal disease. These relationships may be used for vanco dosage individualization in patients receiving CVVHD therapy.
**95/055: INTERMITTENT HEMOFILTRATION FOR ACUTE RENAL FAILURE TREATMENT IN CRITICAL PATIENTS**

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Continuous therapies are preferred methods for renal function replacement in hemodynamically unstable patients even though these methods require intensive medical attention and have serious potential complications. We performed intermittent automatic veno-venous hemofiltration (IHF) in 10 critical hemodynamically unstable patients suffering acute renal failure. We assessed efficiency and final outcome.

Patients were 67.3 ±12 years (average ±s.d.), 7 males, all of them in medical or surgical ICU. Before starting with IHF their APACHE II score was 24 ±0.7 and SAPS score was 15.3 ±4.4. According to our local statistical model - developed in 1993- estimated mortality risk from acute renal failure for these patients was 66 ±45%. In this series 9 had sepsis, 8 were on mechanical ventilation and 8 required vasoactive drugs to support MAP (mean arterial pressure) and COI (cardiac output index). Four patients received also CAVH or CAVHD after or before IHF due to persistent hypotension. IHF was performed with a Gambro HFM-10 ™hemofiltration monitor exchanging 20 liters of Gambrosol HF-33 ™in 274 ±80 min. (minutes). The procedure was done on a daily basis, 3.6 times per patient (range: 1–7) according to clinical status.

Results are shown in the table. Data is expressed as 24 hours before the procedure against average values during all IHF sessions.

<table>
<thead>
<tr>
<th></th>
<th>BUN</th>
<th>CREAT</th>
<th>K+</th>
<th>LACT</th>
<th>ART pH</th>
<th>Hct</th>
<th>MAP</th>
<th>COI</th>
<th>SVRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>102.4</td>
<td>5.9</td>
<td>4.6</td>
<td>2.4</td>
<td>7.3</td>
<td>32.3</td>
<td>84.3</td>
<td>3.9</td>
<td>732.6</td>
</tr>
<tr>
<td>During</td>
<td>119.0</td>
<td>5.1</td>
<td>4.1</td>
<td>2.3</td>
<td>7.4</td>
<td>30.1</td>
<td>85.3</td>
<td>4.1</td>
<td>604.0</td>
</tr>
</tbody>
</table>

*BUN = blood urea nitrogen, mg/dl; CREAT = serum creatinine, mg/dl; K+ = serum potassium, mmol/l.t.; LACT = arterial lactic acid, mmol/l.t.; ART pH = arterial pH; Hct = hematocrit, %; MAP in mmHg; COI in lt./min/m²; SVRI = systemic vascular resistance index, dyne./sec/cm⁻⁵.*

Patients remained hemodynamically stable all throughout the procedure and no increase in vasoactive drugs was necessary. No complications were observed related to IHF. Nine patients died, none of them from acute renal failure nor from the procedure.

IHF is a useful and safe treatment for acute renal failure in critically ill patients and may be used as an alternative or complementary to CRRT with adequate tolerance and no more complications than other modalities of renal replacement therapies.
95/056: CONTINUOUS VENOVENOUS HEMOFILTRATION IN PATIENTS WITH HEPATIC FAILURE AND ORTHOTOPIC LIVER TRANSPLANTATION


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Continuous venovenous hemofiltration (CVVH) and hemofiltration with dialysis (CVVHD) have several potential benefits to patients with fulminant hepatic failure (FHF) or following orthotopic liver transplantation (OLT). These patients are hemodynamically unstable and often have renal insufficiency secondary to either acute tubular necrosis (ATN), hepatorenal syndrome (HRS) or immunosuppressive therapy. They may also be affected by fluid, electrolyte and acid-base imbalances. In addition, their ICU course may be complicated by sepsis and the systemic inflammatory response syndrome. Therefore, these patients are poor candidates for conventional hemodialysis (HD). We report our experience using CVVH/CVVHD in 55 surgical ICU patients admitted with FHF or following OLT.

Methods: Retrospective analysis of a computerized database. CVVH was performed using the Baxter BM-11 pump and the Amicon Diafilter-20. Volumetric pumps were used to accurately preset the amounts of fluids exchanged. Fluid warmers were used to decrease heat loss. CVVH was accomplished using a double lumen shiley catheter inserted into either the femoral, jugular, or subclavian vein.

Results: Fifty-five patients with FHF or following OLT were treated with CVVH/CVVHD between November 1993 and June 1995. Thirty male and 25 female patients underwent CVVH/CVVHD. The mean age was 48 ±14 years. All were critically ill with an APACHE II score of 27 ±8. Ten patients had sepsis/septic shock, and 4 had ARDS. The indications for CVVH were massive fluid overload (30%), ATN (35%), HRS (20%) and others (15%). The average length of time on CVVH was 4 ±3 days. Dialysis was added to CVVH in 27% of the cases. Hemodynamic and metabolic data are presented below.
CVVH/CVVHD was well tolerated in all patients. Complications attributed to CVVH included: one episode of hyperchloremic acidosis and one episode of hyperglycemic hyperosmolality. These complications were attributed to inappropriate replacement fluid. There were four cases of worsening hyperlactatemia that contrasted with the overall clinical improvement of the patients. These four patients were receiving CVVHD with lactate in the dialysate.

**Discussion:** The use of CVVH/CVVHD provided precise control over the fluid, electrolyte and acid base balance in hemodynamically unstable patients with FHF or following OLT. In addition, the use of hemofiltration may be beneficial because of fluid and cytokine removal.
95/057: INFLUENCE OF VENOVENOUS HEMOFILTRATION ON POSTTRAUMATIC INFLAMMATION AND HEMODYNAMICS

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Multiple organ failure after severe trauma is a result of a complex inflammatory process, which is induced after shock or trauma. Humoral factors, e.g. cytokines, mostly with a molecular weight smaller than 30 kD, are involved. Therefore, the aim of this study was to evaluate the effect of venovenous hemofiltration (CVVH) on the elimination of inflammatory factors, to measure products of plasma lipid peroxidation and to determine hemodynamic parameters.

Twenty four patients with an Injury Severity Score >27 were enrolled in this prospective, randomized trial. Exclusion criteria was contraindication against low-dose heparin, e.g. intracranial hemorrhage. All patients were monitored by means of Swan-Ganz-Catheter for five days and received standard intensive care therapy. In the treatment group isovolemic veno-venous hemofiltration was performed over five days. Mean arterial blood pressure, mean pulmonary artery pressure, central venous pressure and pulmonary capillary wedge pressure did not differ between both groups. In contrast, in the group undergoing CVVH the substantially increased cardiac output was significantly attenuated. Systemic vascular resistance was decreased substantially in both groups compared to normal values but less by CVVH. Oxygen delivery (DO₂) was significantly lower from day 1 to day 5 in the CVVH group. However, oxygen consumption remained constant. Hence, oxygen extraction rate was increased in the CVVH group. PMN-Elastase and Myeloperoxidase were significantly diminished in CVVH group, also TNF-alpha and Malondialdehyde indicating lower membrane toxicity. In contrast, C-reactive protein was stimulated.

The data demonstrate that early treatment of polytrauma patients by venovenous hemofiltration leads to an attenuation of a hyperdynamic circulatory situation. Enhanced cardiac output and oxygen delivery were attenuated towards normal values while oxygen consumption remained constant. These effects are probably due to a reduced posttraumatic inflammatory response which is characterized by reduction of some inflammatory markers in CVVH patients. Moreover, the significant reduction of plasma lipid peroxidation products gives evidence of reduced organ injury in polytrauma patients undergoing CVVH treatment.
95/058: NON-THROMBOGENIC HEMOFILTRATION SYSTEM FOR ACUTE RENAL FAILURE TREATMENT

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Continuous arteriovenous hemofiltration (CAVH) has become an accepted therapy for patients with acute renal failure. A major technical concern with CAVH is clotting of hemofilter, resulting from blood-material interactions. This study compares the performance characteristics of Duraflo II heparin immobilized CAVH circuit with those of untreated control circuit. Duraflo II heparin was immobilized onto polysulfone hemofilter, tubing sets, and catheters. The ultrafiltration rates and sieving co-efficients of the heparin immobilized and untreated control filters were compared in-vitro. No changes in performance were noted with the Duraflo II heparin treatment.

The effectiveness of the heparin treatment was evaluated ex-vivo using an ovine model without systemic anticoagulant. Dual circuits, one with Duraflo II heparin treatment and one control circuit, were evaluated simultaneously on one animal to eliminate the animal to animal variation. A total of five ovines were tested. Typical ex-vivo test results are shown in the following table. In all cases, the control circuits clotted off much earlier than the heparin immobilized circuits, which were electively terminated at 24 hours. The results suggest that (a) the heparin treatment does not alter the mass transport properties of the hemofilter and (b) the heparin treatment significantly prolongs the work life of the hemofilter and allows the CAVH to be performed without the use of systemic anticoagulant.

<table>
<thead>
<tr>
<th>Time (hr)</th>
<th>Duraflo II treated circuit</th>
<th>Control circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TMP mmHg</td>
<td>UFR ml/min</td>
</tr>
<tr>
<td>0.5</td>
<td>65</td>
<td>26</td>
</tr>
<tr>
<td>2.0</td>
<td>63</td>
<td>21</td>
</tr>
<tr>
<td>5.0</td>
<td>66</td>
<td>19</td>
</tr>
<tr>
<td>12.0</td>
<td>67</td>
<td>14</td>
</tr>
<tr>
<td>16.0</td>
<td>73</td>
<td>12</td>
</tr>
<tr>
<td>24.0</td>
<td>71</td>
<td>9</td>
</tr>
</tbody>
</table>
95/059: INTERLEUKINS 6 AND 8 AND TUMOUR NECROSIS FACTOR ALPHA ADSORPTION BY POLYACRYLONITRILE AND POLYSULPHONE MEMBRANES DURING HAEMOFILTRATION IN SEPTIC PATIENTS

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There is much speculation as to whether inflammatory mediators are activated, adsorbed and/or filtered by haemofilters in septic patients. It is also uncertain whether any such changes influence the patient’s haemodynamic status. This study aimed to detect adsorption of interleukins 6 (IL-6) or 8 (IL-8), or tumour necrosis factor alpha (TNF) on to polyacrylonitrile (PAN) and polysulphone (PS) membranes in septic patients, and determine any significant haemodynamic changes.

18 critically ill patients with Systemic Inflammatory Response Syndrome, who required haemofiltration, were randomised to either a PAN (AN69, Hospal, France) or a PS (Diafilter 30, Amicon, Ireland) filter. The ultrafiltrate (UF) line was clamped for the first hour, preventing filtration. All circuits were anticoagulated with heparin 200 iu/hr and prostacyclin 5 ng/kg/min. Blood was sampled immediately pre and post filter at 0, 5, 10, 15, 30 and 60 mins and UF was sampled proximal to the line clamp at 60 mins. All samples were assayed for IL-6, IL-8 and TNF (ELISA, National Institute of Biological Standards and Control, Potters Bar, UK). Vital signs, cardiac output, oxygen consumption, blood gases and lactate were measured at 0, 15, 30, 45 and 60 mins. Data was analysed using Wilcoxon signed-rank and Mann-Whitney U tests. 10 patients received PAN filters and 8 patients PS. The two groups were well matched for age, APACHE II and TISS points. There was no significant difference between pre and post filter IL-6, IL-8 and TNF levels with either membrane, and no change in pre/post filter levels over time. The only trend in clinical parameters was a fall in the mean arterial pressure from 0 to 60 mins: PAN, median 5 mmHg, p = .0367; PS, 4 mm Hg, p = .0759.

There is no evidence for significant net removal of IL-6 IL-8 and TNF by adsorption on to PAN or PS membranes.
95/060: MEASUREMENT OF RESPIRATORY QUOTIENT IN MECHANICALLY VENTILATED PATIENTS WITH ACUTE RENAL FAILURE TREATED WITH CITRATE ANTICOAGULATED CONTINUOUS RENAL RE replacement THERAPY

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Indirect calorimetric measurements of oxygen consumption and carbon dioxide production have been used to determine energy expenditure and respiratory quotient \((R = VCO_2 / VO_2)\) in critically ill mechanically ventilated patients. R values reflect the predominant substrate oxidation based on the known molar ratios of oxygen consumption and carbon dioxide production with normal R values ranging from 0.67 to 1.2. Periodic measurement of R assists in monitoring the appropriateness of calorie and substrate delivery in this patient population. The delivery of citrate via blood products and citrate anticoagulation in continuous renal replacement therapy (CRRT: CAVHDF/CVVHDF) may result in R values inconsistent with substrate delivery due to increased carbon dioxide production from the conversion of citrate to bicarbonate. We have investigated the effect of citrate delivery on R in mechanically ventilated patients with acute renal failure treated with CRRT using an open circuit real-time metabolic monitor (Puritan Bennett 7250) integrated into the ventilator (PB 7200 ae). Continuous indirect calorimetry measurements were performed over 38 days for a total of 810 hrs in 4 patients (3 F, 1 M, Ages 34–37) to determine daily values for VO_2, VCO_2, R, and energy expenditure. Daily delivery of non-protein calories via parenteral, enteral, and dialysate sources was recorded and classified as adequate/underfed \(\leq 105\%) and overfed >105\%) of measured energy needs. Citrate delivery from CRRT anticoagulation and blood products was also recorded.

<table>
<thead>
<tr>
<th>Energy Needs</th>
<th>(\leq 105%))</th>
<th>&gt;105%</th>
<th>(p) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>0.94</td>
<td>1.04</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>% Energy Needs</td>
<td>79</td>
<td>150</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Citrate mEq/d</td>
<td>40</td>
<td>38</td>
<td>0.3</td>
</tr>
</tbody>
</table>

In the adequate/underfed group (19/38 days), the measured R was \(\geq\) expected, inconsistent with nutrient delivery. As expected, R values exceeded 1.02 in the overfed group (19/38 days) and differed significantly from the adequate/underfed group. Elevations of R in the adequate/underfed group may be attributed to citrate delivered. In the overfed group, the delivery of excessive calories, resulting in increased CO_2 production, may have masked any elevation in R due to citrate. Modification of nutrient delivery may assist in identifying elevations in R due to citrate delivery versus calorie overfeeding. Continuous indirect calorimetry permits accurate measurement of R, yet R values should be interpreted with caution in the presence of citrate as values may not reflect substrate delivery.
95/061: INTRAOPERATIVE DIALYSIS IN COMBINED LIVER-KIDNEY TRANSPLANTATION
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Between October 1987 to December 1994 we performed ten combined liver/kidney transplantation in patients suffering from end-stage hepatic and renal diseases. The causes of renal failure were chronic transplant nephropathy (6/10), glomerulonephritis (3/10), and polycystic kidneys (1/10). Eight of these patients were on chronic dialysis prior to transplantation. The indication for kidney transplantation in the other two patients was low GFR <30 ml/min. The end-stage liver diseases were chronic active C hepatitis (8/10) and alcoholic cirrhosis (2/10). In nine of these patients “heparin-free” hemodialysis and continuous veno-venous hemofiltration was performed according to time of surgery and hemodynamic parameters. The length of dialysis was 6.8 ± 1.9 h (5–10). Mean ultrafiltration was 8300 ± 2900 ml and the ultrafiltration rate was 1284 ± 559 ml/h. A total of 18 ± 11 (9–47) packed red cells and 34.7 ± 26 (11–96) plasma units were transfused at the time of surgery.

<table>
<thead>
<tr>
<th></th>
<th>Pre-OLT</th>
<th>Anhepatic phase</th>
<th>Reperfusion</th>
<th>End OLT</th>
<th>End KT</th>
</tr>
</thead>
<tbody>
<tr>
<td>s.Urea</td>
<td>15.9 ± 7.2</td>
<td>8.24 ± 3.3</td>
<td>7.06 ± 2.24</td>
<td>6.1 ± 1.7</td>
<td>8 ± 2.8</td>
</tr>
<tr>
<td>Na</td>
<td>138 ± 3.4</td>
<td>140 ± 3.3</td>
<td>140 ± 4</td>
<td>142 ± 4.2</td>
<td>140 ± 4</td>
</tr>
<tr>
<td>K+</td>
<td>4.3 ± 0.9</td>
<td>4.1 ± 0.7</td>
<td>4.1 ± 0.7</td>
<td>3.6 ± 0.4</td>
<td>4.1 ± 0.4</td>
</tr>
<tr>
<td>HCO3</td>
<td>21.1 ± 3.8</td>
<td>21.3 ± 4.3</td>
<td>22.4 ± 2.9</td>
<td>24.4 ± 3.6</td>
<td>23 ± 3.4</td>
</tr>
<tr>
<td>Ionic Ca</td>
<td>1.3 ± 0.4</td>
<td>1.16 ± 0.66</td>
<td>1.59 ± 0.79</td>
<td>1.63 ± 0.64</td>
<td>1.31 ± 0.25</td>
</tr>
<tr>
<td>Lactate</td>
<td>1.17 ± 0.61</td>
<td>3.7 ± 1.2</td>
<td>5.6 ± 2</td>
<td>5.4 ± 1.8</td>
<td>4.9 ± 2</td>
</tr>
<tr>
<td>Protrombine time</td>
<td>1.27 ± 0.3</td>
<td>1.24 ± 0.2</td>
<td>1.29 ± 0.2</td>
<td>1.26 ± 0.3</td>
<td>1.20 ± 0.4</td>
</tr>
</tbody>
</table>

s.Urea, Na, K, Ca, an lactate in mMol/L. HCO3 in mEq/L. Protrombine Time in Ratio; OLT = liver transplant. KT = Kidney Transplant

All of them recover renal function at the end of surgery. Diuresis at first day after transplantation was 3567 ± 576 ml.

In conclusion, intraoperative hemodialysis in combined liver-kidney transplantation is mandatory. Allows a rapid correction of ionic disorders, permits and excellent control of volume despite of large amounts of hemoderivates are transfused. We consider that intraoperative hemodialysis plays an important role in one-year patient survival (90%) of combined liver and kidney transplantation at our institution.